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TECHNICAL WILDLIFE BULLETIN NUMBER 7

Wisconsin Conservation Department
Game Management Division
Madison 2, Wisconsin

1953

SOME WINTER HABITS OF WHITE-TAILED DEER AND THE DEVELOPMENT OF CENSUS METHODS IN THE FLAG YARD OF NORTHERN WISCONSIN

by

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RALPH C. GUETTINGER

Pittman–Robertson Project 4-R

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The field observations were made by Nicholas Collias and Raymond Kyro, and the interpretation of habitat conditions by Ralph Guettinger. The behavior observations were written by Collias. The design of the study and the analyses of census techniques and population data were prepared by Cyril Kabat and Ralph Guettinger.

The photographs were taken by B. L. Dahlberg.

Edited by Ruth L. Hine and James B. Hale

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FOREWORD

The Wisconsin Conservation Department and the public in general have recognized the need for objective study and management of their deer herd. Deer range conditions have been intensively studied by the department. For several years the big game committee of the Wisconsin Conservation Congress, a group appointed by this state-recognized sportsmen's organization, has also observed winter range conditions, and their observations have sustained those of the conservation department. In the interests of the management of the deer resource they have given invaluable time to the study of departmental problems and findings. This group of sportsmen are now recommending intensive range management. In order to blueprint such a range management program, however, a careful study of deer behavior is necessary. In accordance with the plans of the department and the recommendations of the sportsmen, observations were made on the winter habits of deer in the Flag yard, Bayfield county during February, 1952.

W. F. GRIMMER
Superintendent of Game

INTRODUCTION

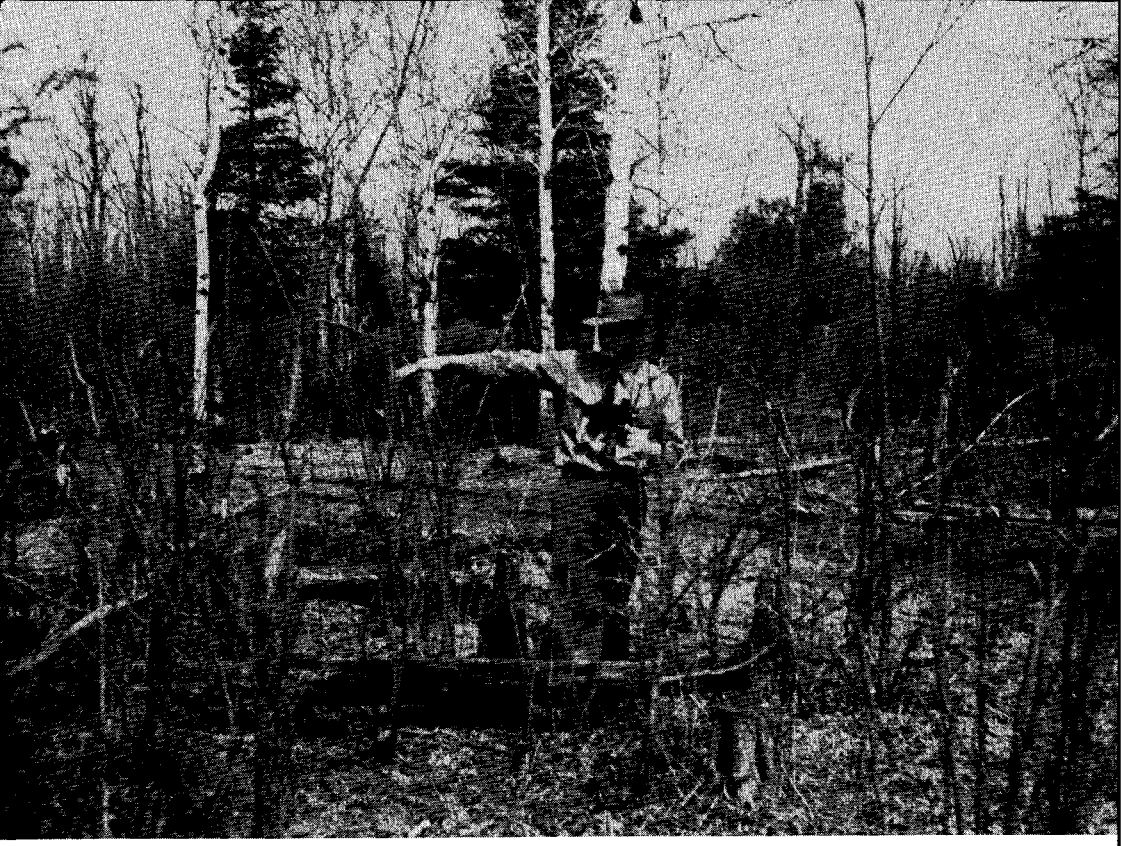
One of the first phases of intensive deer range management is to get specific information on the behavior of deer in winter in problem areas. Chances for making studies of deer behavior in the wild are somewhat limited. The winter of 1952, however, presented us with a unique opportunity for such a study, both from the standpoint of yarding conditions and trained personnel to make observations on deer.

A series of intensive observations on the winter habits of deer were therefore made in the Flag yard, Bayfield county, during February 21–29, 1952. Our objectives were, first, to obtain information on the feeding habits and general behavior of deer in the Flag yard, and second, to devise a method by which we might census the deer herd in the yard. For example, at what time of day do most deer attend feeding stations? To what extent are fawns allowed to feed when larger deer are present? Can deer be separated into sex and age classes in winter yards? How many individual deer can be recognized by markings and can this information be used in making censuses? Can these data be used in managing deer in a given winter yard? If so, how?

The Flag is a seriously over-browsed yard, which has been supplied with artificial feed for many years during the winter. The behavior of deer in this area will not necessarily be typical of the habits of deer in winter yards in general, particularly if natural feed is abundant. This study therefore was not intended to outline standard procedures; the results presented in this report merely represent an exploration into a relatively unknown situation to find out, under one set of existing conditions, what type of information could be obtained which would help define management needs.

CHARACTERISTICS OF THE FLAG YARD

A deer yard refers to a discrete local area in which deer concentrate in winter. Movement within the yard is facilitated by a network of trails which are packed firm by the continual traffic. When the snow depth becomes less than about 18 inches, the deer tend to disperse from a winter yard.



Browse line on balsam in the Flag Yard. All available natural browse has been eaten as high as deer can reach. This yard is one of the most severely over-browsed yards in the state.

The Flag yard has existed as a winter concentration area for deer in about the same locality for many years. The condition of the yard and the general welfare of the deer have been under the surveillance of the conservation department for more than a decade. Ranger John Hanson and Warden Fred Minor first reported that the yard was over-browsed and that starvation was occurring in the winter of 1935–36. This was the year in which large-scale artificial feeding was undertaken in the Flag.

At the present time the central part of the yard is between three and four square miles in extent. Plant succession is in an intermediate state. The birch-aspen pioneer trees are pole-size or larger. Among the birches and aspens are many groves of balsam fir and white cedar. The cedar once supplied a good natural source of food to the deer, but now is almost entirely browsed as high as the deer can reach, or else grown up out of the reach of the deer. But both conifer species are still a source of selective cover, since practically all deer beds found were under clumps or groves of these trees. Beneath and among the

conifers and aspens, particularly in the more open places, are hardwood seedlings and small saplings. However, dense deer concentrations over a period of years have severely over-browsed these preferred food species.

The size of the yard at the time of our study coincided closely with the occurrence of conifers. Walks to the edge of the yard along six representative compass directions showed that in each case deer trails disappeared with the conifers, although birch and aspen trees and red maple seedlings were still numerous. Shrubs also became much more frequent at the edge of the yard.

A tributary of the Flag river which flows through the Flag yard contained many sites of open water at the time of our visit; the considerable trampling and convergence of deer trails to these water holes indicated that these places served to supply the deer with drinking water, although deer were not actually seen drinking.

Severe over-browsing in the Flag Yard. These are red maple saplings at the end of a hard winter. Twigs have been eaten off up to the thickness of a man's thumb. High deer populations over a period of years produce these extreme conditions.

What's left in the Flag Yard after the snow goes—one of the many starved deer that did not make it through the winter. A combination of a large deer herd and limited natural and artificial feed has made starvation common for many winters. Starvation has been less frequent since the advent of liberal hunting seasons in 1949.

METHOD OF STUDY

In the center of the yard are a series of eleven feeding stations located along a narrow, winding road approximately two miles long. Observations on deer were made at six of these feeding stations from February 21–29, 1952. The observers were concealed in cabins that had been placed in the yard for the storage of emergency supplies of hay and food concentrate pellets. Binoculars were used to aid in the observations.

A total of 730 deer was tallied during the nine-day observation period. Twenty-three different individuals were identified and "marked" by means of old injuries, scars, and pelage peculiarities,

including four deer with crippled legs. Fourteen of these individuals were seen on subsequent days for a total of 20 repeat observations. These observations on both "marked" and "unmarked" deer were used in the study of behavior and in the development of the census methods described in this report.

BEHAVIOR OF DEER WITHIN THE FLAG YARD

Movement

The highest density of deer occurred within the central portion of the Flag yard in the neighborhood of the feeding stations. This was shown by the fact that the network of trails was most dense in the central part of the yard, the most traveled trails or "main highways" were almost all here, and so were the largest aggregations of deer beds. As one moved towards the edge of the yard the trails became less numerous and were not so well packed down.

A Flag Yard feeding station in early spring at the end of a winter's artificial feeding. Observations in this study were made from feed-storage shacks like the one in the background of this picture. The grassy-looking area in the foreground is unusable waste from alfalfa hay fed in winter. Deer will eat only the more leafy and tender parts of alfalfa, even if they are in a starving condition.

Individual deer may further tend to localize their activities about particular feeding stations; at least this appeared to be true during our nine-day observation period. Table 1 shows that 16 of our 20 repeat observations on individual deer were made at the same or adjacent station as the initial observation. The road distance between the six feeding stations varied from 0.2 to 0.6 miles, as measured by the mileage recorder of an automobile. The 16 repeats at the same or adjacent stations were all within 0.2 miles of the original site of observation. Four deer for which longer movements were recorded averaged 1.3 miles.

Such tendency of individual deer to concentrate their movements near a particular feeding station was by no means absolute. The counter tendency toward random dispersal within the yard no doubt also existed, but over short periods of time seemed to be less important (Table 1). One buck with a distinctive stub tail first observed at Station 6 was observed four days later at Station 1, which is 1.9 road miles away and at the opposite end of the yard. The four leg-crippled deer showed a somewhat greater propensity to return to the same feeding station. Of five repeat observations on leg-cripples, four were made at the same station as the initial observation and one was made at the adjacent station. However, enough healthy deer returned to the same feeding stations repeatedly to indicate that this habit was either inherent or due to chance as well as debilitation.

Table 1

Repeat Observations on Individual Deer in the Flag Yard

Place Observed	*Number of Repeat Observations*
Same Station	13
Adjacent Station	3
Two Stations away	2
Three Stations away	1
Four Stations away	0
Five Stations away	1

In their study of the Jawbone deer herd, Leopold *et al.* (1951) reported that their observations on 99 tagged mule deer indicated that deer winter movement was very limited. The average distance that marked animals were observed away from the traps was 0.2 miles for bucks and 0.09 miles for does.

Grouping habits

Grouping tendencies of the deer varied with their daily routine. The daily routine was not thoroughly worked out, because we did not make many observations at night, and because of the difficulty of observing the deer away from the feeding stations. Of all the daylight hours, the last hour before sunset on the average was the best time to observe the deer, for it was then that the largest numbers of deer could usually be seen at or near the feeding stations (Table 2 and Figure 1.)

Table 2

Deer Seen at or Near a Feeding Station at Any One Time During Various Hours of the Day

Time	*No. Counts Made*	*Ave. No. Deer Seen Per Count*
6 A.M.	1	16*
6–9	4	6
9–12	2	2
12–3 P.M.	7	10
3–4	9	15
4–5	8	28
5–6 (sunset)	14	35
6–7 (dusk)	10	22
7–8 (dark)	2	20

*Number of deer flushed upon approaching the feeding station; counts after 6 A.M. were made by observers concealed in cabins.

Few early morning observations were made. However, the low point between 9 A.M. and 12 noon checked with an absence of tracks at all feeding stations when these were cruised at 10 A.M. one day on which a light snowfall occurred between the hours of 7 and 9 A.M. By 1 P.M. of this same day tracks at the feeding stations were still few in number. These observations agree with those of Hahn (1949) who wrote that the last hour of daylight was best for making counts of deer. Counts made by Hahn in the middle of the day were variable and generally low.

Figure 2 gives some idea of the variations in evening feeding routine at the same feeding station on different days (Station 3, February 27–28) and at different feeding stations. The jagged curve of February 28 for Station 3 depicts a series of successive retreats and returns of the deer after being alarmed. The causes of such alarm behavior were not always evident. Generally the observers entered and left their stations only once during each period of watching.

The aggregation pattern of the deer at the evening feeding period depended in part upon their degree of fearfulnss or wariness and their

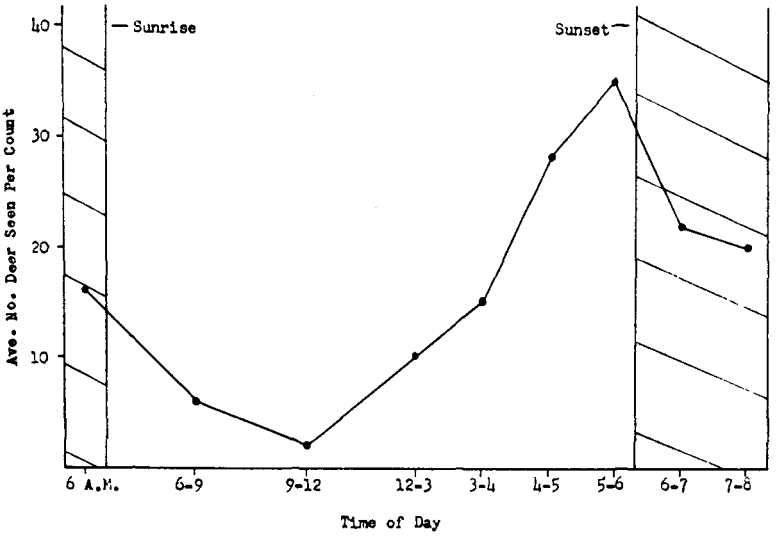


Figure 1. DEER OBSERVED AT OR NEAR A TYPICAL FEEDING STATION

degree of hunger. Wariness was indicated by their hesitation in approaching the food site, and by their readiness to take alarm and flee into the woods. As the deer came toward the food site there was a "zone of decision" some 20–50 yards from the food clearing, where the deer would pause and stand alert, sometimes for ten minutes or even longer, neck erect and ears turning this way and that, listening for the slightest suspicious sound. The animal might then come in to feed, or else turn about and walk or run back into the woods. Sometimes it would vacillate, coming and going a number of times. In past years such wariness was unobserved. Deer allowed cars to approach feeding stations with little or no sign of fear being evident. This wary behavior was apparently directly related to the better physical condition of the deer during the 1952 winter, and will be further explained in a following section.

When several deer were already congregated at the food, subsequent arrivals, although they would usually pause and look over the situation for themselves, were likely to be less suspicious and to enter the food site with less delay. Alarm behavior was contagious, however, and should one deer suddenly dash away from the food site, its alarm would quickly spread and soon the entire throng would be rushing into the woods. These retreats were not in an orderly compact group such as one might observe among elk or sheep, but usually involved a

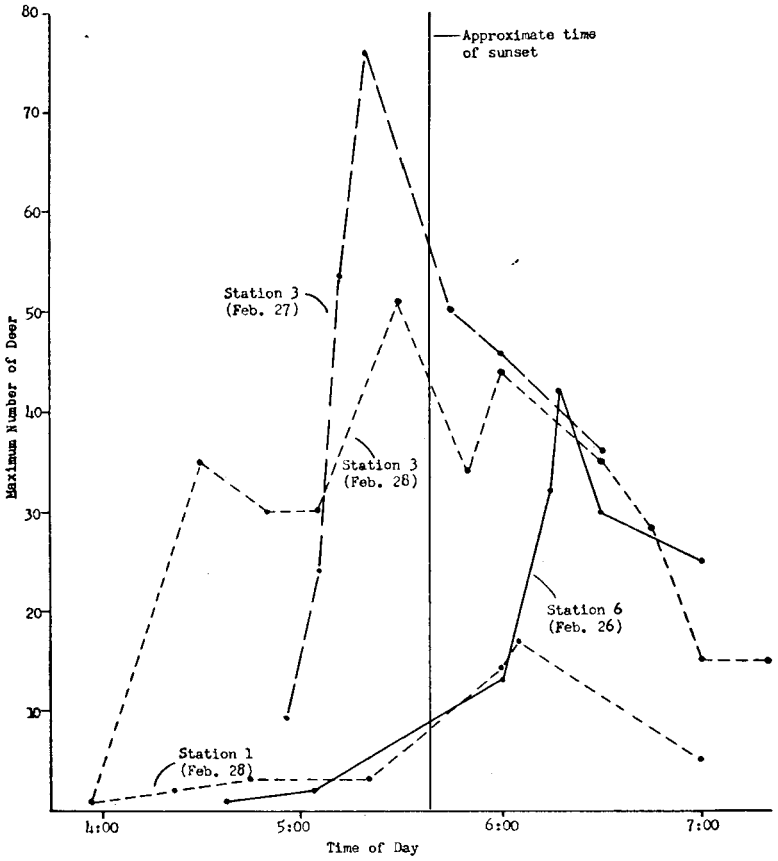


Figure 2. DEER OBSERVED AT FEEDING STATIONS

scattering of individuals and small groups in various directions down the network of trails. This behavior probably makes for a more rapid general retreat down the narrow trails in the forest.

The largest feeding assemblages observed at any one time for any given station varied in size from 17 to 76 deer. Although our field of vision covered only about 225°, this included all or most of the food sooner or later and probably also the great majority of the deer in the immediate vicinity of the feeding station.

Feeding assemblages were generally heterogeneous in sex and age composition, although there was a slight tendency to segregate into roughly the same sex and age classes. Bucks (yearlings and adults)

were identified by scars left on the head where the antlers had been dropped. Often partially-concealed scars were revealed by paired bumps or differences in pelage coloration. Does were distinguished from fawns by the usually greater size of the former and the shorter muzzle and shorter body of the latter.

The sex and age ratios of deer observed in the Flag yard are shown in Table 3. Since adults could not always be identified as to sex, the counts of the sex and age groups are stratified in Table 3 to show the

Table 3

Sex and Age Ratios of Deer in the Flag Yard, February 21–29, 1952

	Number Seen				*Per Cent*			
No. Counts	*Adult Bucks*	*Adult Does*	*Unidentified Adults*	*Fawns*	*Adult Bucks*	*Adult Does*	*Adults*	*Fawns*
31	69	117	0	80	26	44	70	30
19	75	110	140	140	--	--	70	30
17	---	---	231	93	--	--	71	29
Totals 67	144	227	371	313	39	61	70	30

types of information which can be obtained under differing conditions. Over the yard as a whole, we observed a ratio of 30 per cent fawns and 70 per cent adults. Of the adults 39 per cent were bucks. However, the age and sex ratios varied greatly at different stations. The ratio of adults to fawns varied from 5 to 1 at Station 2 to a ratio of 5 to 3 at Station 3. The approximate sex ratio varied from 1 buck to 1 doe at Station 4 to a ratio of 1 buck to 2 does at Station 5.

Age and sex ratios also varied at the same station at different times. Thus the numbers of adults and fawns counted at any one time at Station 3 varied from 30 adults to 18 fawns, to 12 adults to 13 fawns. Similarly, the numbers of bucks and does at any one time at Station 4 varied from 12 bucks to 3 does, to 4 bucks to 10 does.

The most common and consistent type of group was that of a doe and her fawn. We noted 22 such family groups that appeared to be definite and consistent. At least one doe had two fawns with her. The evidence for the existence of doe-fawn groups was the close association of the two, their movement about together, the extreme wariness of the doe and the strong tendency of the fawn to follow her when she fled in alarm.

On the other hand, many fawns were *not* with does. Twenty-two of these lone individuals were identified, which was equal to the

number of fawns definitely identified as being with does. Sometimes fawns fed alone at a station, and sometimes they came in with other deer. They did not, however, consistently associate with other individuals. In addition, they were strikingly lacking in alertness. Frequently such fawns would disregard the alarm behavior of older deer and continue feeding after the other deer had gone, and when they joined a group of deer in fleeing the food area, the lone fawns as a rule were the last to leave the food area and the first to return.

Deer probably tend to rest or bed down in groups. This was suggested by the grouping pattern of beds in the snow. The most frequent grouping of beds which were within 15 feet of each other, was in pairs. The most common herd unit directly observed was also that of pairs, i.e., a doe and a fawn together. Many beds also occurred in groups of three and four and more rarely in larger groups. The largest close aggregation of beds was that of 30 found near Station 6 in a grove of balsam fir surrounded on three sides by partially cleared areas. "Solitary" beds, more than 15 feet away from any other bed, were also frequent.

In summary, the grouping habits of white-tailed deer in the Flag yard revealed them to be sociable animals. They were found more often in groups than not, with a tendency to aggregate in places that supplied food and cover. But, apart from the doe-fawn relationship, there was little consistency in group composition. The grouping patterns were fluid and variable, and considerable individualistic behavior existed. Many fawns seen were not in the company of does.

Social intolerance

The deer competed aggressively for food. One animal would approach another, neck erect and ears laid back, and, should the other fail to retreat, would rap it sharply with one front hoof, or even rear up on both hind legs, bringing both front hooves down on the other deer. Sometimes, the attacked deer would fight and both animals would rear up on their hind legs and slap at each other with their forefeet. Occasionally, a smaller deer would attack a larger deer from behind, but at once retreat when the larger individual turned upon it. Rarely when one deer was about to attack another, a low harsh bleat or threat sound from the latter would cause the former to "change its mind" and suddenly veer off. The deer also showed a tendency to pass along

punishment received. Occasionally one deer, after being driven from a particular pile of food, would at once attack some subordinate animal in its vicinity.

Habitual subordination of the smaller or less aggressive animals leads to the establishment of a dominance order, in which the adult bucks generally dominate the other deer, while does dominate the fawns (Table 4). The larger animals, whether bucks, does or fawns, usually dominated smaller animals.

Table 4

Dominance Reactions of Deer at Feeding Stations in the Flag Yard

No. Encounters	*Dominant Animal*	*Subordinate Animal*		
		Buck	*Doe*	*Fawn*
132	Buck	50	45	37
85	Doe	13	26	46
28	Fawn	0	2	26

The dominance order appeared to be consistent, as has been shown for captive deer by more extended observations on known individuals (Collias 1950). Two individuals did not seem to take turns dominating each other, but as a rule one always dominated the other, insofar as this could be observed without having many marked individuals available. Aggressive competition for food increased with the number of deer concentrated at the feeding station (Table 5). It is possible that with extreme crowding aggressive tendencies decrease, but the present data are too limited for a definite conclusion. When food competition is extreme it seems natural that the fawns, being of low dominance, will suffer first and the most from hunger. Although there was an adequate supply of artificial food in 1952, in previous years

Table 5

Frequency of Dominance Reactions in Relation to the Number of Deer Feeding

No. Deer Present	*No. Dominance Reactions Seen*	*Time Observed (Minutes)*	*Dominance Reactions Per Hour Per Deer*
5– 7	6	60	1
10–20	20	60	1.3
23–30	51	27	4.4
50	32	15	2.6

it has been observed at the Flag yard, as elsewhere, that of all classes the fawns suffered the greatest loss from starvation when food supplies were inadequate.

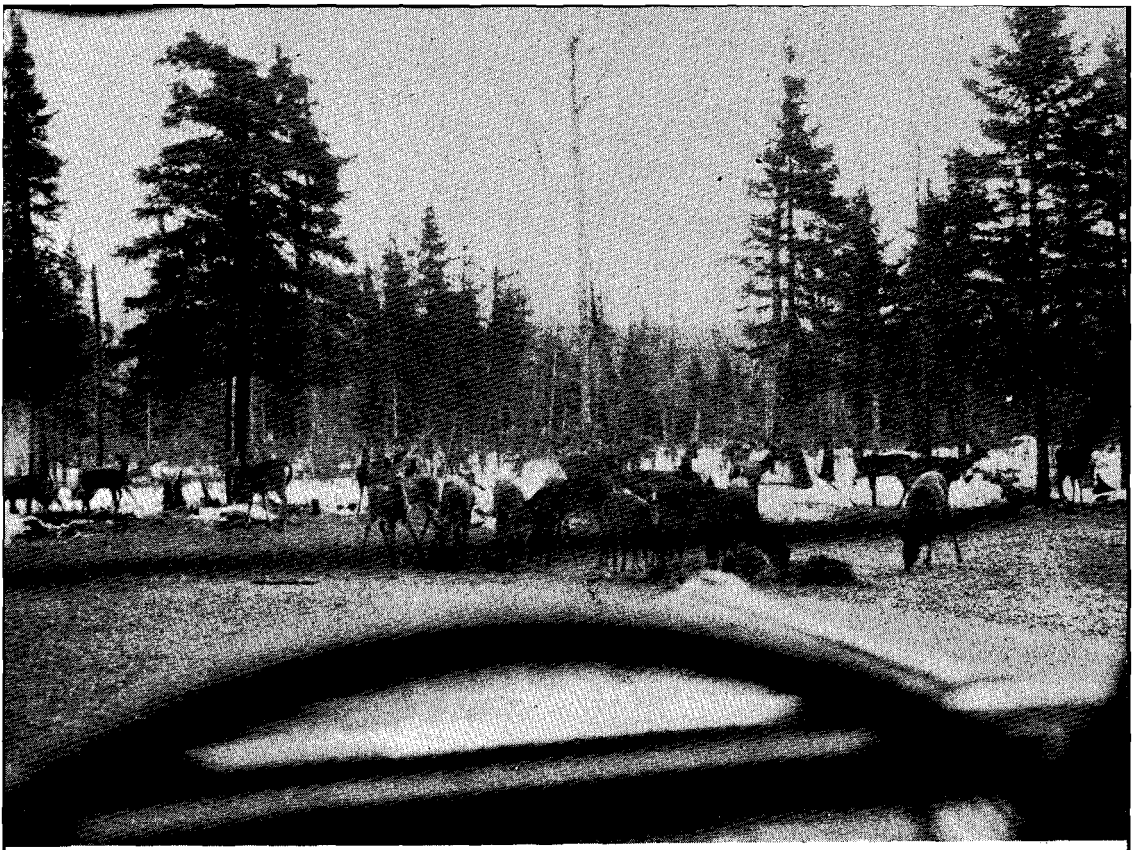
Behavior at different levels of food availability

The deer density in the Flag yard, if estimated alone on numbers seen at the feeding stations, was generally lower in the 1952 winter than in the two previous years. Two years ago, on March 24, 1950, one of us (Collias) visited the Flag yard in company with John Keener, deer research project biologist. From concealment in a food storage cabin, we counted 125 deer at or near our station. In contrast, in February 1952, the greatest count for any one station from a similar observation post was only 76 deer. The reduced number of deer observed at feeding stations was confirmed by the recollections and impressions of the deer feeding crew and local residents.

To what extent did the Flag yard herd actually reduce? Rather than a striking reduction in numbers, the observed lesser density of deer in 1952 as compared to the previous two years seems directly related to a change in behavior. Observations from the food storage cabins have shown that an outstanding characteristic of the deer during the winter of 1952 was their greater alertness and wariness. We repeatedly observed that the deer that were congregated at a feeding station as a rule would flee the vicinity at the sound of an approaching car long before the car came close enough for its occupants to see the deer or to more than glimpse a few of the stragglers. In fact, the deer heard approaching cars long before we did. Once so disturbed the deer frequently took from one-half to one hour to return. It is evident that a succession of seven or eight cars in one afternoon, such as is common on feeding days (three a week), means that fewer deer will be seen. According to the feeding crew leader (Bill Diamond) who fed the deer for the past two years, the deer last year came in to feed while the crew was still in the immediate vicinity. However, this was not true during the past winter; the deer did not come in to feed until after the truck and crew had departed.

Furthermore, there apparently was a shift in feeding habits, which affected the number of deer seen. There was great variation in the daily number of deer using each one of the feeding stations. Some deer tended to return almost daily to the same feeding station. Some appeared at different stations. It is possible that some deer failed to appear at a feeding station during the daylight hours and came in to feed after dark when accurate counts could not be made.

The reason for this change in behavior toward a greater wariness and less regular feeding habits is apparently directly related to the better



Deer concentration at a Flag Yard feeding station in the late winter of 1948, photographed from inside an automobile. These deer were not wary because they were hungry. A picture like this was not possible in the winter of 1951–52 when the deer were less numerous and better fed, and stayed away from feeding stations if they knew people were near.

physical condition of the deer in the 1952 winter. This healthy state resulted from: a milder winter, shorter yarding period, and sufficient amounts of artificial feed supplies being placed in the yard. By sufficient, we mean adequate amounts of feed, well provided to prevent starvation in the yard. Deer starvation was found to be almost nil last winter compared to previous years. Healthy deer would be expected to be naturally wary.

It is important to point out, however, that an operation sufficient to provide enough feed to prevent starvation in a yard as seriously over-browsed as the Flag yard requires considerable expenditure for feeding and distribution costs.

CENSUS METHODS

One of the important needs in deer management is a method for accurately estimating the number of deer in a given area. Once these animals move out into their summer range, estimates of herd size in given areas becomes more difficult. It would appear that the most accurate method of estimating deer herd size would be to trap and mark a number of individuals and then derive an area figure by making repeat observations, obtaining a ratio of marked to unmarked animals. However, this method is rather costly and before using it as the only acceptable method, other simpler estimations of density were attempted in this study. The three methods used to estimate the Flag yard deer herd size were: (1) actual counts of total deer seen; (2) application of the Lincoln Index; and (3) daily feed consumption.

(1) Actual counts

Counts of the number of deer observed at the six observation stations were recorded each day of the observation period. Maximum counts for each station for each day of observation are presented in Table 6. The average daily maximum, usually observed shortly before sunset, was 43 deer.* Since there are a total of 11 feeding stations in the Flag yard, there were an estimated 473 deer feeding at the same

Table 6

Largest Number of Deer Seen at Any One Time During Each Day of Observation at the Feeding Stations

Date (February)	*Station*	*Maximum Count*
28	1	17
27	2	41
25	3	52
27	3	76
28	3	51
22	4	45
25	4	34
22	5	42
23	5	40
24	5	40
26	5	54
29	5	30
24	6	45
26	6	42
29	6	35
Total		644

Average daily maximum count for stations 1–6 was 43. The standard error of mean (43) was 3.6.

* Confidence limits at the 95% level = 43 ± 7.7 or 35.3—50.7.

time during the height of the daily feeding period in the Flag yard. A few counts were made which are not listed in Table 6. They were not believed to have been accurate maximum counts due to disturbance at the time the count was being made.

This is of course a minimum estimate of the deer present in the Flag yard, since 1) it does not take into account deer not visible to the observer, including deer at the back of the cabin or farther than about 0.1 mile from the cabin; 2) some deer may not come to the feeding station daily; 3) deer using feeding stations only after dark would not be tallied; and 4) some deer may come in to feed only at times when there are no large concentrations present.

While this method cannot be used to accurately compute the number of deer in the entire Flag yard, it can be used to compare the number of deer using the feeding stations on a year-to-year basis. Logically such observations could be best made in yards in which artificial winter feeding was being conducted. However, it might also be applied to areas where deer have concentrated to browse on fallen tree tops and branches produced during logging operations or at points where a number of trails converge.

(2) Lincoln index

The second census method involved identifying deer with characteristic markings. By getting repeat observations on these naturally marked (identifiable) deer and comparing these with the number of unmarked deer seen with them, it was possible to obtain a second estimate by use of the Lincoln index:

$$\frac{\text{Repeat observations on identifiable deer}}{\text{Total identified deer}} = \frac{\text{Total deer observed}}{\text{Total deer population}}$$

Ideally it would have been better to first make observations at all feeding stations simultaneously, identify a significant sample of deer with characteristic markings, and then obtain a ratio of marked to unmarked deer in a follow-up simultaneous observation of all feeding stations. However, rather than expend the time and energy of a large crew of men, when the possible results to be obtained using such a procedure were unknown, the field work was performed by two men, N. Collias and R. Kyro. Since the time was limited when observations of the required type could be made, Collias and Kyro obtained data on the ratio of identifiable (characteristically marked deer) to non-identifiable deer on a day-to-day basis at two to four stations daily

over a period of nine days. The results that were obtained using this experimental design, although more difficult to analyze, appeared to provide a method of random sampling on the observed deer.

Thus the total number of deer observed, 730, was obtained through a series of separate samples taken at six observation stations. Twenty-three deer were definitely recognizable to us from other deer by means of distinctive scars, crippling injuries, size, sex, and pelage peculiarities (Table 7). Although the characteristics listed in Table 7 were the primary ones used, the observers actually relied on several asso-

Table 7

Individually Recognizable Deer Seen in the Flag Yard, February 21–29, 1952

Date (February)	*Station*	*Observation Period*	*Deer No.*	*Marked Deer (Characteristic Markings)*
21	1	11:30-1:30		None.
	2	2:30-4:00	1	Doe—walks 3-legged; right hoof missing.
	3	2:35-4:10	2	Doe—furrow (bullet) crosswise through middle of back.
22	4	10:40-6:00	3	Fawn—crippled left front leg (walks on wrist).
			4	Medium-sized deer—left ear tagged.
			5	Medium-sized deer with torn right ear (big notch)
	5	1:15-6:00	6	Small crippled buck; right hind leg lame.
			7	Doe with very black nape.
			8	Doe with erect mane.
23	4	1:30-5:20	3	(Repeat)
			9	Buck—white tuft on left ear.
24	5	12:35-5:35	7	(Repeat)
	5	3:30-6:15	10	Buck—white mark back left ear.
	6	3:45-6:15	11	Big doe—white spot on right rump.
			12	Medium-sized buck—lame left front leg.
			13	Medium-sized doe—stub tail with a square tip.
			14	Medium-sized buck—stub tail with a forked tip.
25	3	1:15-6:00	1	(Repeat)
			15	Gray doe—patch torn out of left side (like a fresh wound).
			16	Doe—white scar between eyes (not snow).
	4	1:00-6:00	3	(Repeat)
			17	Medium-sized doe—white, woolly spots on head, base of each ear.
			18	Big buck—very grey face, dark forehead with tan streak and dark center.
	3	1:45-3:45		None.
26	4	2:00-4:00	18	(Repeat)
	5	4:10-6:50	19	Dark buck—scar left side below spine, and two orange scars between eyes.
	6	4:15-7:00	12	(Repeat)
			11	(Repeat)
			14	(Repeat)
			5	(Repeat)
27	2	3:35-6:30	16	(Repeat)
	3	4:45-6:30	13	(Repeat)
			15	(Repeat)
			2	(Repeat)
			20	Doe—longitudinal scar down center of back.
			21	Big buck—scar across top anterior back.
28	1	3:15-7:15	14	(Repeat)
			22	Buck—dark grey with a mane.
	3	3:00-7:20	15	(Repeat)
			20	(Repeat)
29	5	3:00-6:30	8	(Repeat)
			13	(Repeat)
			11	(Repeat)
			23	Big buck—continually holds tail horizontally.
	6	12:45-6:45	12	(Repeat)

ciated features for each identifiable deer. Of the 23 deer, we made 20 repeat observations at about the time of maximum feeding concentration. These observations are summarized in Table 8. Since there are not many opportunities to make these types of observations, a considerable amount of detail is presented in Tables 7 and 8.

Table 8

Summary of Observations on Marked Deer and Total Deer Seen

Date (February)	*Station*	*Marked Deer*			*Total Deer Seen*
		New	*Repeats*	*Total*	
21	1	0	0	0	0
	2	1(1)*	0	1	17
	3	1(2)	0	1	29
22	4	3(3,4,5)	0	3	45
	5	3(6,7,8)	0	3	42
23	4	1(9)	1(3)	2	21
	5	0	1(7)	1	40
24	5	1(10)	0	1	40
	6	4(11,12,13,14)	0	4	45
25	3	2(15,16)	1(1)	3	52
	4	2(17,18)	1(3)	3	34
26	3	0	0	0	10
	4	0	1(18)	1	9
	5	1(19)	0	1	54
	6	0	4(5,11,12,14)	4	42
27	2	0	1(16)	1	41
	3	2(20,21)	3(2,13,15)	5	76
28	1	1(22)	1(14)	2	17
	3	0	2(15,20)	2	51
29	5	1(23)	3(8,11,13)	4	30
	6	0	1(12)	1	35
		23	20	43	730

*Figures in parentheses refer to the identification numbers of the individual deer observed

A direct summation of the terms in the Lincoln Index formula, i. e. total deer identified, total repeats, and total deer observed could not be used as the only analytical method because it would not result in as accurate a measurement of the population as would be desirable for management purposes. Such a computation does not take into account the fact that due to the method of sampling all the identified deer were not "available for repeating" throughout the observation period. There are three methods of analysis which may be used to adjust for this difficulty.

(a) Simple proportion. A simple proportion, summing the terms of the Lincoln Index formula directly, may be used if one assumption is made at the outset. If we consider that all the marked deer (that is,

marked by having recognizable characteristics) were marked at the beginning of the experiment, and if we assume they were recognizable on the first day of observation, then all observations of marked deer could be considered as "repeats" (23 "new marked" and 20 "repeats"). The proportion could be written as follows:

$$\text{Total population} = \frac{(\text{Total deer seen})\ (\text{Total identified deer})}{(\text{Repeats})}$$

$$= \frac{(730)(23)}{(43)}$$

$= 390$ or an average of 65 deer at each of the six stations.

The assumption that all of the marked deer were recognizable at the beginning of the observation period would not be entirely a valid one if many complicated characters were used to identify individuals, for experience gained from successive days of observation undoubtedly enables better recognition of marked deer. However, the characteristics relied upon for positive identity were of the type that allowed detection readily.

(b) "Marking" and "observing" periods. We can divide the observation period into two classes, the first to be considered as a marking period, i.e., the period when deer were being identified, and the second as one when repeat observations on the identified deer were being made. In this way, most of the marked deer had a chance to repeat. Essentially this is an analysis similar to the "ideal" situation mentioned previously. But to do this in this study it was necessary to sacrifice some of the data, as the two periods overlapped. However, by the end of February 25, the major portion of the deer had been identified and the major portion of the repeats remained to be observed. The projection required to estimate the total population on this basis is as follows:

$$\text{Total population} = \frac{(\text{Total deer observed})\ (\text{Total identified deer})}{(\text{Repeats})}$$

$$= \frac{(365)(18)}{(15)}$$

$= 438$ or an average of 73 deer at each of the six stations.

(c) Schnabel method. A modification of the Lincoln Index has been used by Schnabel (1938) in estimating fish population size over a period of days during which new fish were being marked on succes-

sive days. Calculations of population size, adjusted for the number of tagged fish in the population available for repeating, can be made each day. This method may also be used in estimating the number of deer using the Flag yard feeding stations. The analysis used and the daily population estimates are shown in Table 9. The estimates of population size may be expected to vary at the beginning of the experiment, and to level off after a few days of observation. The estimate obtained on the last day of observation (489) becomes the final estimate of the number of deer using the six feeding stations which were observed (an average of 82 deer per station).

Table 9

The Schnabel Method for Estimating Deer Population Size*

Date (February)	*(S) Total Deer Seen*	*(T) Marked Deer Available Each Day*	*(t) Repeat Observations*	*TS*	*ΣTS*	*Σt*	*P***
21	46	0	0	0	0	0	---
22	87	2	0	174	174	0	---
23	61	8	2	488	662	2	331
24	85	9	0	765	1427	2	714
25	86	14	2	1204	2631	4	658
26	115	18	5	2070	4701	9	522
27	117	19	4	2223	6924	13	533
28	68	21	3	1428	8352	16	522
29	65	22	4	1430	9782	20	489

*The data used in this analysis are drawn from Table 8 for each day of observation. The marked deer available for repeating each day represent a cumulative total of the "new marked deer" observed on the previous days.

$$**P = \frac{\Sigma TS}{\Sigma t}$$

A possible source of error in all three computations lies in the overestimation of marked deer because cripples which were included in the recognizable class might not move away as readily from the artificial feeding stations to browse. Hence they would be counted more times than the unhandicapped deer, resulting in an overestimate of the marked deer. Table 10 shows the breakdown on the number of cripples (deer with crippled legs) and non-cripples repeating in the counts. If their behavior were normal, the crippled deer would naturally be expected to repeat at feeding stations in the same ratio as did healthy marked deer. Although the data seem to indicate that crippled deer repeated more frequently than did other marked deer, a chi square analysis showed that the difference between cripples and non-cripples in the number of times they repeated was not statistically significant.

Table 10

Repeat Observations on Crippled and Non-Crippled Marked Deer

	Marked Deer	*Repeats*	*Ave. No. Times Repeating*
Cripples (leg)	4	5	1.3
Non-cripples	18	15	0.8

$X^2 = 0.181$ (X^2 value of 3.841 required for significance at the 95% confidence level).

Another source of error in the use of the Lincoln Index lies in the possible underestimation of marked deer. If some marked deer, other than cripples, were not recognized initially or as repeats when deer were being counted at feeding stations, then this category would be underestimated and the calculations for the total Flag yard herd size would be affected accordingly. Eight of the marked deer were observed only once despite the fact that each station was observed two or more times. Did the eight deer observed only once repeat at stations but escape observation because of obscure marking? Distinctive scars may be difficult to see unless the animal is viewed from the proper angle. The importance of this discrepancy as a source of error appears to be minor, however, since it was usually possible to study most of the deer from various angles when they came in to feed and the identifying characteristics used were conspicuous. On the other hand, if some identifiable deer were not recognized when they repeated, the same error in observation was probably made before they were positively identified for the first time. In other words, factors which affected recognition in the first place would probably affect subsequent recognition, and would therefore not tend to upset the ratio between marked and unmarked animals.

In order to definitely determine whether we missed marked deer during the observation periods due to chance in sampling, we need to demonstrate that the percentage of marked deer observed daily is constant within the expected sampling error. Theoretically the percentage of newly marked deer should shrink, while the percentage of repeats should increase. However, the percentage of *total marked* deer should remain the same each day if marked deer were not missed in the observations. Table 11 shows the per cent of marked deer seen during each day of observation. Chi square values of the daily percentages indicate that they are not different from the average per cent of deer observed daily (5.9%). Thus it may be concluded that possible bias caused by the method of sampling marked deer does not affect the use of this Lincoln Index method of estimating deer herd size.

Table 11

Per Cent of Marked Deer Observed Daily

Date (February)	Marked			Total Observed	Per Cent Marked		
	New	Repeat	Total		New	Repeat	Total
21	2	--	2	46	4.4	---	4.4
22	6	0	6	87	6.9	0	6.9
23	1	2	3	61	1.6	3.3	4.9
24	5	0	5	85	5.9	0	5.9
25	4	2	6	86	4.7	2.3	7.0
26	1	5	6	115	0.9	4.3	5.2
27	2	4	6	117	1.7	3.4	5.1
28	1	3	4	68	1.5	4.4	5.9
29	1	4	5	65	1.5	6.2	7.7
Totals	23	20	43	730			5.9†

†$X^2 = 1.263$ [9 d.f. = 16.919 (95%)]

(3) Feed consumption

The third check on numbers of deer in the Flag yard was based on daily feed consumption rates. An average of 11.2 tons of hay and 2.8 tons of pellet concentrate were fed each week from January 28 to April 4 during the 1951–52 winter. Feeding experiments have shown that there is a waste of about 50 per cent of the hay fed artificially and 6 per cent of the concentrate (Dahlberg 1947). Feeding experiments with penned deer have also shown that a deer eats an average of about two and one-half pounds of feed a day (Dahlberg 1949). With these figures, we can make the following population estimate:

Hay: 11.2 tons/week—50% waste = 5.6 tons/week
Concentrate: 2.8 tons/week—6% waste = 2.6 tons/week
Total feed: 8.2 tons/week

8.2 tons/week = 1.2 tons/day or 2400 lbs./day
2½ lbs./deer/day = 960 deer

Thus on the basis of the feed consumed, the Flag yard herd using the feeding stations numbered 960 animals. A prerequisite for this method of population estimation is a sufficient supply of feed which is being completely utilized by the deer. Also, from year to year, the amount of natural browse available must be evaluated.

Discussion

The results of the three census methods are shown in Table 12. The average number of deer per station, obtained from observations made at six stations, was multiplied by 11 to obtain the estimated total population using all the feeding stations in the yard. The lowest estimate of the number of deer using the artificial feeding stations was obtained by the "actual count" method. The weakness of this method

lies largely in the fact that all the deer using a feeding station could not always be seen on a given day. Many deer may not come in to feed during daylight hours each day, or possibly skip days between appearances at feeding stations, or shift from one station to the other between observation dates. Since only two to four stations could be observed on one day, this resulted in some counts being made when relatively few deer came to a given station. Such a method, however, could be used to measure trends between years.

Table 12

Comparison of the Three Census Methods Used in Estimating the Size of the Flag Yard Deer Herd Using the Eleven Artificial Feeding Stations

Census Method	*Average Per Station*	*Estimated Total Population*
Actual count (average daily maximum numbers of deer observed)	43	473
Lincoln Index (repeat observations on deer with characteristic markings)		
(a) Simple proportion	65	715
(b) "Marking" and "observing" periods	73	803
(c) Schnabel method	82	902
Daily feed consumption	87	960

These weaknesses were eliminated to a large extent in the use of the Lincoln Index. Of the three applications of the Lincoln Index used in this analysis, the least reliable is probably the one based on the breakdown into "marking" and "observing" periods. If an experiment were planned with this type of analysis in mind, and deer were not marked after a certain date, then this method would be reliable. Otherwise the splitting into the two periods is completely arbitrary and the resultant population estimate will vary greatly depending upon where the line is drawn. The best estimate of deer population size is probably that obtained using the Schnabel method, for the estimates are corrected daily for the availability of deer for repeating.

Daily feed consumption rates offer the highest estimate of deer population size, but one which shows fairly close similarity with that obtained by the Schnabel method. The use of this method depends upon the presence of sufficient feed supplies which are completely utilized by the deer.

Numerous methods for obtaining population estimates of deer are reported in the literature involving the use of direct counts, ratios, and indices of relative abundance. Examples of some of these methods

are: census drives (Bartlett 1950), cruising counts (Erickson 1940, Hahn 1949), aerial censuses (Morse 1946, Blomquist 1951), calculations based on total kill and the sex and age composition of the herd (Kelker 1940, Lauckhart 1951), trapping and tagging (Olson 1938), and pellet and track counts (Leopold 1951). In their review of methods that have been used in censusing deer, Rasmussen and Doman (1943) stated that direct counts have not proved successful in determining total numbers of mule deer. These authors believe that total populations can be determined more accurately by the use of ratios and indices.

Probably the most accurate method for estimating deer herd size in a winter yard would be to trap and mark a representative sample of animals with markings which could be identified from a practical distance. However, trapping deer is a relatively costly operation. This study shows that with a knowledge of behavior of deer at the feeding stations and with practice in identifying natural markings such as distinctive coloration, size and scars, it is possible to get information similar to that obtained through trapping and tagging.

MANAGEMENT IMPLICATIONS

The information on the habits of deer in a winter yard and the methods used to estimate population density are, at this time, applicable only to the Flag yard in northern Wisconsin. There has not been an opportunity as yet to repeat these observations in other winter yards. However, we feel that these data reveal certain patterns of deer behavior in at least one seriously overbrowsed yard, and may pave the way toward future comparative studies in Wisconsin and other states. An attempt is made in the following paragraphs to point up what a study such as this one, under the existing conditions, might reveal in the way of management possibilities.

The distribution of deer within a yard is significant from the standpoint of browse availability and the distribution of cover in the yard. In a seriously over-browsed and artificially-fed yard such as the Flag, the movement and daily activity of deer were apparently localized, not only to a winter yard, but within that yard. The majority of the deer observed at the feeding stations moved only 0.2 miles or less from the original observation point. Localized activity within the yard was also shown by the heavier density of tracks and deer beds in the center of the yard. Deer were found more often in groups than not, which

further indicates greater concentration of deer at certain spots rather than uniform distribution throughout the yard. The effect of this type of crowding is apparent in the yard; all available cover and browse has been damaged severely.

Although the composition of the groups of deer observed varied considerably, over the length of the observation period the sex and age classification of the portion of the herd observed at the feeding stations could be determined. Such data, combined with population tallies obtained before the hunting season, could provide information on the effect of the hunting season kill on the deer herd. A comparison of pre-season, hunting season, and post-season sex and age ratios is shown in Table 13. These data are presented merely as an indication of the possible value of such ratios, particularly in comparing the effect of a buck season or an any deer season on the deer herd, or in following herd composition over a period of years. For purposes of this paper, no attempt is made here to interpret this information as regards the Wisconsin deer herd in 1951–52.

Table 13

Deer Herd Composition, 1951–52

	Bucks	*Does*	*Fawns*
Pre-season population tally (Northwest area)	17%	39%	44%
Hunting season ("any deer") bag checks (Northwest area)	33	40	27
Post-season population tally (Flag yard)	27	43	30

An interesting fact which is brought out by this study is that a scarcity of deer seen does not necessarily mean a great reduction in the number of deer present in an area. A mild winter, shorter yarding period, and sufficient amounts of artificial feed in the Flag yard during the winter of 1951–52 resulted in better food conditions for the deer. The resulting better physical condition of the deer made them more alert and wary than they had been in previous years. Although people were seeing fewer deer while driving through the yard, as many as 76 animals were counted at a single station during the course of our observations.

The observations made from blinds in the Flag yard provide some information on crippling losses following the hunting season. Of the 730 observations made on deer at the feeding stations, 15 were on crippled deer (nine on deer with leg injuries and six on animals with scars possibly representing body wounds). If these observations suggest the true proportion of cripples in the herd at this time of year,

then two per cent of the deer feeding at the artificial feeding stations in the Flag yard were cripples. This estimate of deer surviving hunting season crippling does not include those deer surviving body wounds which left no visible external evidence of injury. Mortality from crippling during an antlerless deer season in areas of heavy deer concentration based on field checks has been estimated at 17 to 22 per cent of the legal kill (Guettinger 1950). If approximately two per cent of the deer seen in February are cripples, it appears that most deer that are crippled during the hunting season die within one or two months thereafter.

A major management objective of this study was to explore the possibility of estimating the deer herd size in the Flag yard by using several different methods, contrasting the results and evaluating the methods employed. Although at present range condition, browse and cover availability are the most basic factors in any management program, accurate estimates of the number of deer present in a given area are desirable for future herd management. From this type of information, we can detect changes in density within the yard, study range conditions, and also derive a figure for the total hunting kill.

The census methods used in this study have an advantage over some of the previously reported census techniques in that they involve less time, man-power, and cost. However, we have no guarantee of their usability elsewhere. These methods were dependent upon a concentration of deer. It remains to be seen whether deer concentrations under natural feeding conditions could be counted as reliably.

SUMMARY

In order to obtain specific information on the behavior of deer in the Flag yard, Bayfield county, a series of intensive observations on deer were made at six artificial feeding stations during February 21–29, 1952. This study was intended as a preliminary exploration into the winter habits of deer under one existing set of conditions. The Flag observations revealed certain patterns of deer behavior in a seriously over-browsed yard which is supplied with artificial feed during the winter. A total of 730 deer was observed. Twenty-three deer were identified by natural markings and 20 repeat observations were made on these individuals.

The majority of the "marked" deer observed to repeat during the study restricted their movements to within 0.2 miles from the point at which they were first observed. On the average the largest concentrations of deer could usually be seen at or near the feeding stations

during the last hour before sunset. The largest feeding assemblages observed at any one time for any given station varied in size from 17 to 76 deer. These groups were usually heterogeneous in sex and age composition. There was apparently a close association between a doe and her fawn, but there were many fawns seen which were not with does. Fawns not accompanied by does were much less wary than were fawns with does. Aggressive competition for food has resulted in the establishment of a dominance order, in which bucks rank as the dominant animal and the fawns as subordinates.

Observations at the feeding stations showed that in general an outstanding characteristic of the deer during the winter of 1952 was their greater wariness and alertness. Whereas in previous years the deer would tolerate the disturbance of passing motorists or feeding crews, this winter they would flee the vicinity at the sound of an approaching car. This greater wariness was believed to be related to the better physical condition of the deer during the winter of 1952, which in turn was related to better food conditions.

Observations on crippled deer showed that approximately two per cent of the deer observed in February were cripples. This suggests that most of the deer that are crippled during the hunting season die within one or two months thereafter.

Three methods were used to census the deer in the Flag yard: actual counts, Lincoln Index, and feed consumption. Actual counts of the maximum number of deer at each station gave the lowest estimate of the number of deer using the artificial feeding stations. The weakness of this method lies largely in the fact that all the deer using a feeding station could not always be observed on a given day or time.

A second estimate was obtained with the use of the Lincoln Index, by getting repeat observations on naturally marked deer and comparing these with the number of unmarked deer seen with them. The best estimate of deer herd size in the Flag yard was believed to be that obtained using the Schnabel method. The third estimate of the density of deer using the feeding stations based on feed consumption rates was in fairly close agreement with the previous estimates.

The methods used in this study to estimate deer herd size show that with a knowledge of behavior and with practice in identifying natural markings, it is possible to get information similar to that which might be obtained by trapping and tagging. These methods were dependent, however, upon concentrations of deer at artificial feeding stations. It remains to be seen whether deer concentrations under natural feeding conditions could be counted as reliably.

LITERATURE CITED

Bartlett, I. H. 1950. Michigan deer. Game Div., Mich. Dept. of Conservation, Lansing, 50pp.

Blomquist, Wallace 1951. Censusing techniques. N. D. Outdoors 13(10):6–8, 15.

Collias, N. C. 1950. Some variations in grouping and dominance patterns among birds and mammals. Zoologica 35(2):97–119.

Dahlberg, B. L. 1947. Deer management research project 4–R. Wisconsin Wildlife Research 6(3):7–15.

_____ 1949. Deer management research project 4–R. Wisconsin Wildlife Research 8(1):3.

Erickson, Arnold B. 1940. Notes on a method for censusing white-tailed deer in the spring and summer. Jour. Wildl. Mgt. 4(1):15–18.

Guettinger, Ralph C. 1950. Deer management research project 4–R. Wisconsin Wildlife Research 9(2):6–21.

Hahn, Henry C., Jr. 1949. A method of censusing deer and its application in the Edwards Plateau of Texas. Div. of Wildlife Restoration, Texas Game, Fish and Oyster Comm., Austin, 24pp.

Kelker, George Hills 1940. Estimating deer populations by a differential hunting loss in the sexes. Utah Acad. Sci., Arts and Letters XVII, pp. 65–69.

Lauckhart, J. B. 1951. Determining the big-game population from the kill. Trans. N. A. Wildl. Conf. 15:644–650.

Leopold, A. Starker, Thane Riney, Randal McCain and Lloyd Tevis, Jr. 1951. The Jawbone deer herd. Game Bull. No. 4, Calif. Dept. of Nat. Resources and Univ. of Calif., Berkeley, 139pp.

Morse, Marius A. 1946. Censusing big game from the air. Conservation Volunteer 9(52):29–33.

Olson, Herman F. 1938. Deer tagging and population studies in Minnesota. Trans. N. A. Wildl. Conf. 3:280–286.

Rasmussen, D. I. and Everett R. Doman 1943. Census methods and their application in the management of mule deer. Trans. N. A. Wildl. Conf. 8:369–380.

Schnabel, Zoe E. 1938. Estimation of the total fish population of a lake. Amer. Math. Monthly 45(6):348–352. (Original reference not consulted.)