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WHITE-TAILED DEER SUMMER HABITAT

USE IN NORTHERN LOWER MICHIGAN

presented by

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has been accepted towards fulfillment
of the requirements for

M.S. degree in Wildlife

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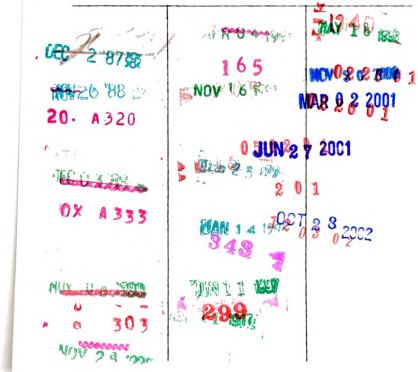
Date Feb. 18, 1985



WHITE-TAILED DEER SUMMER HABITAT USE IN NORTHERN LOWER MICHIGAN

By

David Charles Cue

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Fisheries and Wildlife

1985

Dedicated to my loving wife, Diane, for her support, patience, and perseverance, and to my parents for their continual support.

ACKNOWLEDGMENTS

I would like to express my great appreciation to Dr. Jonathan Haufler for taking me on as his graduate student, and for his guidance and assistance throughout this study. Thanks is given to my committee members, Carl Bennett, Jr., Dr. Harold Prince, and Dr. Carl Ramm, for their assistance. I would also like to thank Dr. Stanley Zarnoch for his guidance in initiating my graduate program, and for helping to initiate this study; and Dr. Rollin Baker for his aid at the beginning of the study.

Special thanks are due Richard Moran, Houghton Lake Wildlife Research Station, who handled much of the field work, for helping to initiate this study, offering his assistance, and his many helpful suggestions; James Terry for conducting much of the field work, and for handling the monumental task of coding the data; and the many other Department of Natural Resources personnel who assisted with the track counts.

This study was financed in part through Federal Aid to Wildlife Restoration, Michigan Pittman-Robertson Project W-117-R.

TABLE OF CONTENTS

LIST OF TABLES v

LIST OF FIGURES vii

INTRODUCTION 1

STUDY AREAS 3

METHODS 6

RESULTS 10

Influence of Cover Type and Stand Maturity 10

Townline Creek Study Area 11
M-18 Study Area 14
Lanes Lake Study Area 17
Russell Lake Study Area 19
9-Mile Study Area 22
Sharon Study Area 25

DISCUSSION 30

LITERATURE CITED 34

LIST OF TABLES

Table 1. Results of analysis of summer deer use on the Townline Creek Study Area, 1975-1980 12

Table 2. Mean summer use by deer of forest cover type and size class (1 = reproduction, 2 = pole or saw) combinations on the Townline Creek Study Area, 1975-1980. Sample sizes: four counts in 1978 and 1979, and three in each of the remaining years 13

Table 3. Results of analysis of summer deer use on the M-18 Study Area, 1975-1980 15

Table 4. Mean summer use by deer of forest cover type and size class (1 = reproduction, 2 = pole or saw) combinations on the M-18 Study Area, 1975-1980. Sample sizes: two counts in 1975, three in 1977, five in 1978, and four in each of the remaining years 16

Table 5. Results of analysis of summer deer use on the Lanes Lake Study Area, 1975-1980 18

Table 6. Mean summer use by deer of forest cover type and size class (1 = reproduction, 2 = pole or saw) combinations on the Lanes Lake Study Area, 1975-1980. Sample sizes: four counts in 1979 and 1980, and three in each of the remaining years 20

Table 7. Results of analysis of summer deer use on the Russell Lake Study Area, 1975-1980 21

Table 8. Mean summer use by deer of forest cover type and size class (1 = reproduction, 2 = pole or saw) combinations on the Russell Lake Study Area, 1975-1980. Sample sizes: three counts in 1975 and 1977, five in 1978, and four in each of the remaining years 23

Table 9. Results of analysis of summer deer use on the 9-Mile Study Area, 1975-1980 24

Table 10. Mean summer use by deer of forest cover type and size class (1 = reproduction, 2 = pole or saw) combinations on the 9-Mile Study Area, 1975-1980. Sample sizes: two counts in 1975, four in 1978, and three in each of the remaining years 26

Table 11. Results of analysis of summer deer use on the Sharon Study Area, 1975-1980 27

Table 12. Mean summer use by deer of forest cover type and size class (1 = reproduction, 2 = pole or saw) combinations on the Sharon Study Area, 1975-1980. Sample sizes: two counts in 1975, three in 1976, and four in each of the remaining years 29

LIST OF FIGURES

Figure 1. Geographic location of the study areas and cover treatment patterns 4

ABSTRACT

WHITE-TAILED DEER SUMMER HABITAT
USE IN NORTHERN LOWER MICHIGAN

By

David Charles Cue

White-tailed deer (Odocoileus virginianus) habitat use was studied on six areas in northern Lower Michigan during the summers (July-August) of 1975-1980. A given percentage (25%, 50%, or 75%) of each area had been treated (clearing all standing trees) just prior to the inception of this study. Roadside track counts were utilized for measuring habitat use on each study area. The mature oak-pine mixture, and the mature oak with a sapling pine understory received consistently high use. Immature oak and oak-pine mixture stands appeared to be avoided to some extent, while immature stands of most other cover types, particularly aspen or aspen-maple mixture, were used fairly heavily, except on the 75% treatment level study areas. All the immature stands which regenerated after treatment on the 75% areas were avoided somewhat. However, the edges between immature and mature forest stands on these areas were used extensively, regardless of cover type.

INTRODUCTION

Historically, much of the research on white-tailed deer (Odocoileus virginianus) in the northern Lake States has focused on the fall and winter periods. There were two major reasons for this. First, during the fall period the fat reserves, which are essential for breeding and winter survival, are accumulated. Second, the limitations of winter range in the region were quite obvious, and there was great concern with overwinter losses.

In more recent years, great strides have been made in the management of winter deer range (Verme 1965, Krefting and Phillips 1970) and the understanding of wintering deer (Silver et al. 1969, Ullrey et al. 1970, Silver et al. 1971, Moen 1976, 1978; Karns 1980). There has also been an increased interest in the year-round requirements of deer and research emphasis on the remaining segments of the year. Karns (1980), in his discussion of overwinter mortality, stressed that the rest of the year could not be ignored.

Studies by Verme (1969) and McCaffery and Creed (1969) have indicated that summer range could be extremely vital to a deer population, especially in areas where forests are maturing and converting to more tolerant types. There has been a general trend in the region of conversion to later

successional types and thus, a growing concern with summer range for deer. Several studies of the summer food habits and/or habitat use of white-tailed deer in the region have found a general preference for intolerant forest types, most notably aspen, and have recommended that such types be maintained for summer range (McCaffery and Creed 1969, Kohn and Mooty 1971, McCaffery et al. 1974, McCaffery 1976, Stormer and Bauer 1980, Rogers et al. 1981).

This study of summer habitat use was conducted to determine the key components of summer deer range in northern Michigan for use in improving management guidelines. The influences of cover type, stand maturity, and juxtaposition of stands on use by deer were examined. Habitat use was assumed to reflect use by deer for both forage and cover.

STUDY AREAS

This study was part of a larger project supported by the Michigan Department of Natural Resources and designed to evaluate the effects of various levels of intensive habitat treatment on wildlife, vegetation, and the public (Bennett et al. 1980). The study was conducted on six research units, 23.3 km^2 (one-quarter-township or 3X3 miles) each, which are a part of the larger project. The six units which served as study areas are all located in the central portion of the northern Lower Peninsula of Michigan (Figure 1). The Townline Creek, M-18, Lanes Lake, Russell Lake, and 9-Mile units are located in Roscommon County (SE¼ T21N R4W, SE¼ T21N R3W, SE¼ T22N R2W, NE¼ T23N R2W, and SE¼ T22N R1W, respectively); the Sharon unit in the southeastern portion of Kalkaska County (SE¼ T25N R6W).

The topography of the areas is generally characterized by rolling uplands and flat outwash plains. Soils are predominantly Roselawn sand, Grayling sand, and Rifle peat (Veatch et al. 1924, Veatch et al. 1927). The major upland canopy species on the areas include aspen (primarily *Populus tremuloides*), oak (*Quercus* spp.), jack pine (*Pinus banksiana*), and red pine (*P. resinosa*). Representative lowland species are northern white cedar (*Thuja occidentalis*), balsam fir

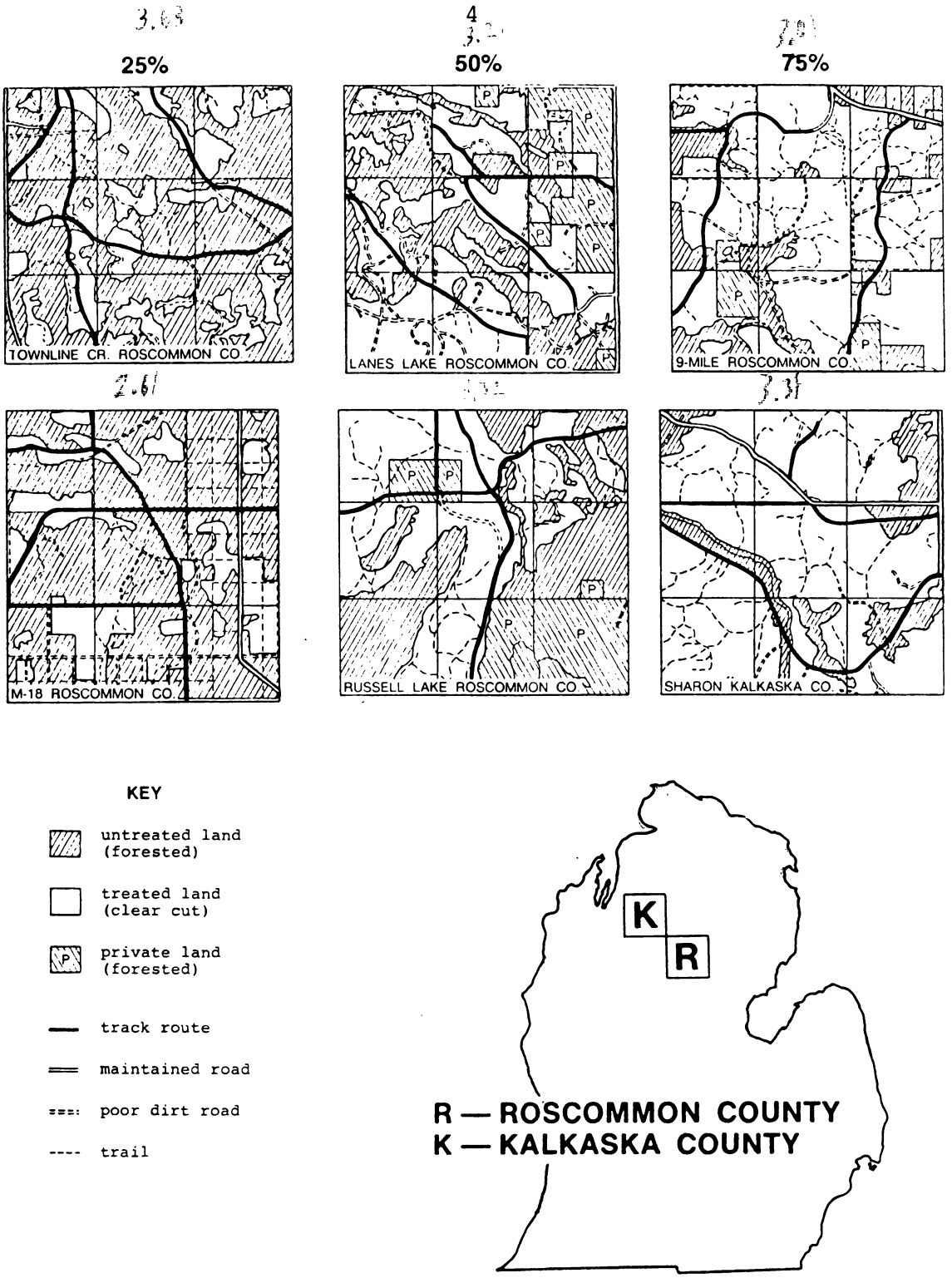


Figure 1. Geographic location of the study areas and cover treatment patterns.

(Abies balsamea), and black spruce (Picea mariana). The areas are interspersed with numerous marshes and bogs.

The six research units were divided into pairs and each pair was assigned one of three levels of habitat treatment. Treatment consisted of clearing all standing trees over 5.1 cm dbh (2 in) from a given percentage of each unit. The three treatment levels were 25%, 50%, and 75% of the entire unit. The Townline Creek and M-18 units were paired and assigned the 25% treatment level; the Lanes Lake and Russell Lake units were assigned the 50% level; and the 9-Mile and Sharon units were assigned the 75% level. Blocks of various sizes within each unit were cleared until the assigned treatment level for the unit was reached. Treatment began in the fall of 1972 and was completed before the summer of 1975.

The blocks of area to be treated on each unit were selected on the basis of cover type. Mature aspen was the first to be treated, followed by upland hardwood, oak, jack pine, mixtures, and upland brush. All lowland (swamp) conifers were left intact for winter cover. The shape and size of the resulting clearings were variable (Figure 1). The size was generally related to the treatment level of the unit. The 25% treatment units had several small treated blocks, while the 75% units tended toward much larger, continuous blocks of treated area. Prior to treatment, the six units which serve as study areas were all fairly continuously canopied.

METHODS

Summer roadside track counts were conducted by Michigan Department of Natural Resources personnel as part of an effort to monitor the deer populations on the six study areas for the larger project (Bennett et al. 1980). Data collected on these track counts were utilized for estimating habitat use in this study. Track counts have been used previously to measure use by deer in several other studies (Krull 1964, McCaffery and Creed 1969, Kohn and Mooty 1971, McNeill 1971). Data were collected on track counts conducted during the summer (July-August) of 1975, after completion of all habitat treatment, and each summer following that, through 1980. The technique which was used for the counts is very similar to that developed by Daniel and Frels (1971). Counts were conducted on an established route, 11.3-17.7 km (7-11 miles) in length, on each study area. Each route was comprised of existing roads and vehicular trails with surfaces suitable for the detection of deer tracks. The surface of the route was prepared, erasing old tracks and smoothing the surface, in the late afternoon by dragging with a heavy chain apparatus. The count was then made the following morning from the hood of a slow-moving vehicle beginning at approximately 0600 hours. The location of each

group of deer tracks crossing the route was recorded, along with some additional data. A group of deer tracks crossing the route meant those tracks made by a group of deer traveling together, such as a family group, and was termed a crossing group. When a single set of deer tracks crossed the route the crossing group was actually an individual deer (still a crossing group). When more than a single set of tracks crossed the route an effort was made to determine how many groups had crossed, if more than one, and data were recorded separately for each of these crossing groups.

Information on habitat use was obtained by noting the combination of the cover type and size class of the forest stand traversed by the route at each crossing group location. Often the track routes did not traverse stands but followed the edge between two stands, i.e., the cover type and/or size class of the stand on one side of the route differed from that of the stand on the other side. When the route followed an edge at the point of crossing, the cover type and size class combinations of the two juxtaposed stands were recorded together, and the type was noted as an edge. Size class was used as a measure of stand maturity, and was divided into two categories. The first category was reproduction size class (< 12.7 cm dbh). These immature stands were almost exclusively the result of regeneration after treatment (clearing). The other category was pole (≥ 12.7 and < 25.4 cm dbh) or saw (≥ 25.4 cm dbh) size class stands. The vast majority of this mature category was comprised of pole size

class stands on each area, for very little saw size occurred on any of the areas.

Following a count an index of use was computed for each of the various vegetation types occurring along the route. Vegetation type was defined by the cover type and size class combination(s), and whether the area was an edge. The use index was: $\sqrt{(C/M) + 0.5}$, where C = number of crossing groups found in a cover type and size class combination on the count, and M = miles of route along which the combination occurred. The index was a transformation of the number of crossing groups per mile (C/M), used so the assumptions of the subsequent analyses were met. Crossing groups were used because the group acts as a unit when selecting vegetation types for use. Thus, location of a crossing group in a particular cover type and size class combination was assumed to indicate use by the group of deer of that combination, and the index was assumed to reflect the level of use on the study area for the time period from late afternoon (dragging) until the count the following morning. The length of occurrence along the route was determined from area forest cover maps. When very little of a cover type and size class combination occurred along a route some combinations had to be grouped together. The grouped combinations were treated as a single, unique combination for use index computations.

A two-way analysis of variance model was utilized to test the effects of cover type and size class combination, and time-since-treatment (year) on use by deer, separately

for each study area. The analysis was done separately by area because the combinations which occurred along the route on each area differed a great deal. Also, a preliminary analysis examining use across the study areas by size class category (ignoring cover types) had revealed a significant interaction between study area and size class, indicating that further analysis should be done separately by area. Grouping of some combinations was necessitated on each area by short lengths of occurrence. Use, as measured by the index, was found to be normally distributed using the Kolmogorov-Smirnov test ($P > 0.10$) (Sokal and Rohlf 1981) for each study area. The assumption of homogeneous variance was tested using Bartlett's test ($P > 0.20$) (Sokal and Rohlf 1981) for the Townline Creek and 9-Mile Study Areas, while it was assumed to be valid for the other four study areas after examination of the cell variances for each area. Data were unbalanced due to the varying number of counts from year to year, however the cell sizes were proportional. Thus, the two main effects were orthogonal to each other, but neither was orthogonal to their interaction (Searle 1971). The sums of squares were obtained by fitting the two main effects and then their interaction. The resulting F-statistics provided approximate tests for the main effects and a test of the hypothesis that interactions were zero (since all cells were filled).

RESULTS

One hundred twenty-four track counts were conducted in the July-August periods of 1975-1980 on the six study areas. Of these, the greatest number were done on the Russell Lake Study Area (23), and the fewest on the 9-Mile Study Area (18). Over 1600 km (1000 miles) of route were covered on these counts, providing habitat use information on more than 15,000 groups of deer crossing the routes.

Influence of Cover Type and Stand Maturity

The possible influence of cover type and stand maturity (or size class) on habitat utilization was of interest, and more specifically, how stand maturity and cover type might interact. Thus, differences in use among the cover type and size class combinations were examined for each study area. Twenty-nine different cover type and size class combinations occurred along a sufficient portion of track route on one or more of the study areas to be analyzed. Of these only one was found on five of the study areas, the remainder on three or fewer, with the majority (18) on just one area. The lack of replication of cover type and size class combinations across study areas necessitated analysis separately by study

area. For each study area two or three groups of combinations had to be formed for analysis because of small occurrences.

Townline Creek Study Area

Eleven cover type and size class combinations were found along the track route on the Townline Creek Study Area, three of which were actually groups of combinations. Results of the analysis of variance indicated that there were significant ($P < 0.01$) differences in use among the combinations (Table 1). To determine which cover type and size class combinations differed in use, Tukey's honestly significant difference (HSD) test (Steel and Torrie 1960) was used to compare mean use across years of the combinations. Comparisons of all pairs of combinations were also made by year, although there was little evidence to suggest that differences were dependent on time-since-treatment, or year (interaction $P > 0.10$). Focusing then on mean utilization across years, the immature (reproduction size class) oak-pine mixture and the grouped combination comprised of mature (pole or saw size class) stands of various cover types and edges between types were used the least (Table 2). The immature oak-maple-aspen-cherry mixture, edge between reproduction aspen and mature swamp conifers, pole size oak with a sapling pine understory, edge between reproduction oak and mature oak-pine mixture, and the edge between mature oak-pine mixture and mature jack pine were used to a greater extent ($P < 0.01$ for the first two, remaining three $P < 0.05$) than the first

Table 1. Results of analysis of summer deer use on the Townline Creek Study Area, 1975-1980.

Source of Variation	df	Mean Square	F	Significance
Main effects				
Cover and size combination	10	4.1487	5.404	P < 0.001
Year	5	3.1812	4.144	P = 0.001
Interaction				
Cover and size X year	50	0.8494	1.106	P = 0.315
Residual error	154	0.7677		

Table 2. Mean summer use* by deer of forest cover type and size class (1 = reproduction, 2 = pole or saw) combinations on the Townline Creek Study Area, 1975-1980. Sample sizes: four counts in 1978 and 1979, and three in each of the remaining years.

Forest Cover Type and Size Class Combination	1975	1976	1977	1978	1979	1980	Mean
Oak-pine (1)	2.7	2.3	3.7	3.3 a**	2.9	2.9 a	2.9 a
Various types and edges between types, all (2)	2.9	2.8	3.6	3.1 a	2.6	3.4 ab	3.1 a
Edge between (1) and (2) of various types	3.5	3.3	3.4	4.2 ab	3.2	3.4 ab	3.5 ab
Aspen or aspen-maple (1)	3.0	3.3	3.6	4.1 ab	3.8	4.2 ab	3.6 ab
Miscellaneous other combinations, includes edges with marsh-bog	3.5	3.0	4.2	3.6 ab	3.8	4.9 ab	3.8 ab
Oak-pine (2)	4.1	3.9	4.3	3.8 ab	3.5	3.5 ab	3.9 ab
Edge between oak-pine (2) and jack pine (2)	3.2	3.4	5.1	4.0 ab	4.4	4.1 ab	4.0 b
Edge between oak (1) and oak-pine (2)	3.6	3.6	5.2	4.5 ab	3.3	4.2 ab	4.1 b
Oak (2) with a sapling pine understory	4.5	4.3	4.6	3.6 ab	3.4	4.1 ab	4.1 b
Edge between aspen (1) and swamp conifer (2)	4.8	3.9	4.0	3.2 a	4.3	5.5 b	4.3 b
Oak-maple-aspen-cherry (1)	4.1	3.5	4.6	5.4 b	4.3	3.9 ab	4.3 b

* Use = $\sqrt{(C/M) + 0.5}$, where C = number of crossing groups found in the combination on the count, and M = miles of route along which the combination occurred.

** Presence of letters in a column indicates significant differences. Means that do not have a letter in common differ significantly at the 5% level by Tukey's HSD test.

two combinations mentioned. Also, utilization of the mature oak-pine mixture exceeded ($P < 0.10$) that of immature.

M-18 Study Area

On the other 25% treatment level study area, M-18, 15 cover type and size class combinations were found along the track route, two of which were groups of combinations. The analysis of variance (Table 3) revealed a significant ($P < 0.01$) combination main effect, which indicated differences in utilization among the combinations, and some evidence that the differences were dependent on time-since-treatment ($P < 0.10$). The edge between reproduction size oak-maple-aspen-cherry mixture and mature oak with a sapling pine understory had the highest mean use index across years (Table 4). Next highest was the immature aspen, followed by the edge between immature oak-maple-aspen-cherry mixture and pole size oak cover type, and the edge between immature aspen or aspen-maple and immature oak-maple-aspen-cherry mixture. All four combinations were used to a significantly ($P < 0.05$) greater extent than the least used group of miscellaneous combinations (primarily mature), and the edge between mature aspen-oak mixture and mature aspen-maple mixture. Also, the difference in use between the first combination and mature jack pine was moderately significant ($P < 0.10$). While not significantly different than any of the other combinations, the mature oak-pine mixture and mature oak with a sapling pine understory combinations had moderately high levels of use.

Table 3. Results of analysis of summer deer use on the M-18 Study Area, 1975-1980.

Source of Variation	df	Mean Square	F	Significance
Main effects				
Cover and size combination	14	5.1266	4.333	P < 0.001
Year	5	9.5117	8.040	P < 0.001
Interaction				
Cover and size X year	70	1.5238	1.288	P = 0.084
Residual error	240	1.1831		

Table 4. Mean summer use* by deer of forest cover type and size class (1 = reproduction, 2 = pole or saw) combinations on the M-18 Study Area, 1975-1980. Sample sizes: two counts in 1975, three in 1977, five in 1978, and four in each of the remaining years.

Forest Cover Type and Size Class Combination	1975	1976	1977	1978	1979	1980	Mean
Misc. other combinations, primarily (2)	2.3	3.0	2.8	2.6	3.0 a**	2.9	2.8 a
Edge between aspen-oak (2) and aspen-maple (2)	0.7	2.7	4.0	3.1	2.8 a	3.5	2.8 a
Jack pine (2)	3.0	2.7	3.2	3.4	3.1 ab	3.4	3.1 ab
Edge between aspen (1) and oak (2) with a sapling pine understory	1.4	3.1	4.7	3.7	3.1 ab	3.6	3.3 ab
Edge between (1) and (2) of various types	2.4	2.8	3.6	2.8	4.1 ab	4.0	3.3 ab
Edge between jack pine (2) and red pine (2)	2.8	3.8	3.1	3.4	2.8 a	3.8	3.3 ab
Aspen-oak (2)	2.8	2.9	5.2	2.9	3.0 a	3.2	3.3 ab
Edge between oak-maple-aspen-cherry (1) and aspen-oak (2)	2.4	2.5	3.9	3.7	3.3 ab	4.3	3.4 ab
Edge between aspen (1) and aspen (2)	2.8	4.7	4.0	4.1	2.7 a	2.9	3.5 ab
Oak (2) with a sapling pine understory	3.7	3.3	3.5	3.0	3.3 ab	5.2	3.7 ab
Oak-pine (2)	2.5	4.0	5.1	3.9	2.5 a	4.6	3.8 ab
Edge between aspen or aspen-maple (1) and oak-maple-aspen-cherry (1)	1.9	3.9	2.9	4.6	5.6 b	5.3	4.0 b
Edge between oak-maple-aspen-cherry (1) and oak (2)	3.6	4.5	4.0	3.8	3.7 ab	4.6	4.0 b
Aspen (1)	3.2	3.9	5.1	4.4	4.1 ab	4.2	4.1 b
Edge between oak-maple-aspen-cherry (1) and oak (2) with a sapling pine understory	3.7	4.6	3.5	4.4	4.6 ab	4.8	4.3 b

* Use = $\sqrt{(C/M) + 0.5}$, where C = number of crossing groups found in the combination on the count, and M = miles of route along which the combination occurred.

** Presence of letters in a column indicates significant differences. Means that do not have a letter in common differ significantly at the 5% level by Tukey's HSD test.

Given the evidence of interaction, comparisons of the combinations were also done by year. For all years except 1979, no significant ($P > 0.10$) difference in use among the combinations was found. In 1979 the edge between immature aspen or aspen-maple mixture and immature oak-maple-aspen-cherry mixture was used to a significantly ($P < 0.05$) greater extent than six of the other combinations, including mature oak-pine which had the lowest mean use index. Any consistent change in the pattern of relative use of the combinations with time-since-treatment was not readily discernible.

Lanes Lake Study Area

At the 50% treatment level, 11 cover type and size class combinations were found along the track route on the Lanes Lake Study Area, three of which were groups of combinations. Results of the analysis of variance showed evidence of significant ($P < 0.01$) differences in use among these combinations (Table 5). Strong evidence of interaction ($P < 0.01$) was also found, indicating that differences were dependent on time-since-treatment. First looking at the comparisons of mean use across years, the three combinations used most, edge between reproduction aspen and various mature cover types, reproduction aspen or aspen-maple, and mature oak-pine, had significantly ($P < 0.01$) higher use indices than the four least used combinations, mature oak, edge between immature oak and immature oak-pine mixture, reproduction oak-pine or edge between reproduction and mature oak-pine,

Table 5. Results of analysis of summer deer use on the Lanes Lake Study Area, 1975-1980.

Source of Variation	df	Mean Square	F	Significance
Main effects				
Cover and size combination	10	12.5844	11.761	P < 0.001
Year	5	2.1341	1.994	P = 0.082
Interaction				
Cover and size X year	50	3.2929	3.077	P < 0.001
Residual error	154	1.0700		

and edge between immature aspen-oak mixture and immature oak cover type (Table 6). The edge between reproduction aspen and reproduction oak was used to a greater extent ($P < 0.05$) than the two least utilized combinations. Note the prevalence of oak and oak mixtures, particularly reproduction size class, in the least used combinations, and the prevalence of immature aspen in the preferred combinations. An exception was the highly used mature oak-pine mixture.

Comparisons of use among the 11 combinations were also made by year. Significant ($P < 0.05$) differences were found for all years but 1976. The magnitude of the differences between the higher and lower use combinations appeared to have increased somewhat with increasing time-since-treatment. Any other consistent changes were not evident.

Russell Lake Study Area

On the Russell Lake Study Area, the other 50% treatment level area, 10 cover type and size class combinations were found along the track route, three of which were groups of combinations. The analysis of variance (Table 7) revealed a significant ($P < 0.01$) combination main effect, indicating differences in utilization among the combinations. The combination by year interaction was also significant ($P < 0.01$), meaning the differences were dependent on time-since-treatment. Comparing mean use across years of the combinations, upland brush, one of the grouped combinations (various types and edges between types, all deciduous and

Table 6. Mean summer use* by deer of forest cover type and size class (1 = reproduction, 2 = pole or saw) combinations on the Lanes Lake Study Area, 1975-1980. Sample sizes: four counts in 1979 and 1980, and three in each of the remaining years.

Forest Cover Type and Size Class Combination	1975	1976	1977	1978	1979	1980	Mean
Oak (2)	1.6 a**	2.7	3.4 ab	2.4 a	2.0 a	2.2 ab	2.4 a
Edge between oak (1) and oak-pine (1)	3.6 ab	3.4	1.8 a	2.8 abc	4.0 ab	0.7 a	2.7 ab
Oak-pine (1) and edge between oak-pine (1) and oak-pine (2)	3.4 ab	4.3	1.8 a	1.4 a	1.9 a	5.2 cd	3.0 abc
Edge between aspen-oak (1) and oak (1)	2.9 ab	2.9	3.7 ab	2.6 ab	3.1 ab	2.9 abc	3.0 abc
Edge between oak (1) and oak-pine (2)	3.1 ab	4.9	2.4 a	1.8 a	3.4 ab	4.2 bcd	3.3 abcd
Oak (1)	2.8 ab	4.6	3.1 ab	4.0 abc	3.2 ab	2.4 ab	3.4 abcd
Miscellaneous other combinations	2.5 ab	3.4	3.7 ab	4.0 abc	4.7 b	2.8 abc	3.5 bcd
Edge between aspen (1) and oak (1)	2.9 ab	4.1	3.7 ab	3.5 abc	3.6 ab	5.2 cd	3.8 cde
Oak-pine (2)	4.6 b	3.6	4.1 ab	3.5 abc	3.7 ab	6.3 d	4.3 de
Aspen or aspen-maple (1)	3.4 ab	4.0	4.2 ab	5.5 c	4.9 b	4.2 bcd	4.4 de
Edge between aspen (1) and various types (2)	4.5 b	3.3	5.5 b	5.2 bc	5.2 b	5.7 d	4.9 e

* Use = $\sqrt{(C/M) + 0.5}$, where C = number of crossing groups found in the combination on the count, and M = miles of route along which the combination occurred.

** Presence of letters in a column indicates significant differences. Means that do not have a letter in common differ significantly at the 5% level by Tukey's HSD test.

Table 7. Results of analysis of summer deer use on the Russell Lake Study Area, 1975-1980.

Source of Variation	df	Mean Square	F	Significance
Main effects				
Cover and size combination	9	23.8223	26.103	P < 0.001
Year	5	5.1678	5.663	P < 0.001
Interaction				
Cover and size X year	45	1.9975	2.189	P < 0.001
Residual error	170	0.9126		

mature), and the mature swamp conifers were utilized to a significantly ($P < 0.05$) lesser extent than all seven remaining combinations (Table 8). The edge between various immature deciduous cover types and various mature cover types (swamp conifer, red pine, or upland hardwood) not only had a significantly ($P < 0.01$) higher mean use index than the three combinations just mentioned, but was significantly ($P < 0.01$) greater than the group of miscellaneous other combinations, primarily of reproduction size, and the edge between immature oak and immature oak-pine mixture. The reproduction size aspen or aspen-maple combination had the second highest mean use index.

In comparisons of use among the 10 combinations made by year, significant ($P < 0.05$) differences were detected for all six years. Use of immature oak appeared to have dropped somewhat, relative to the other combinations, after the initial two years. Also, use of the edge between upland grass and mature aspen-maple mixture was consistently high, with the exception of 1975 and 1980.

9-Mile Study Area

Considering the 75% treatment level areas, four cover type and size class combinations were found along the track route on the 9-Mile Study Area, two of which were groups of combinations. Results of the analysis of variance (Table 9) indicated that there were significant ($P < 0.01$) differences in use among the combinations, and that the differences were

Table 8. Mean summer use* by deer of forest cover type and size class (1 = reproduction, 2 = pole or saw) combinations on the Russell Lake Study Area, 1975-1980. Sample sizes: three counts in 1975 and 1977, five in 1978, and four in each of the remaining years.

Forest Cover Type and Size Class Combination	1975	1976	1977	1978	1979	1980	Mean
Upland brush	1.7 a**	2.7 ab	2.1 a	2.5 ab	2.2 ab	2.3 a	2.2 a
Various deciduous types and edges, all (2)	1.6 a	2.1 a	3.1 ab	2.0 a	2.5 abc	4.2 ab	2.6 a
Swamp conifer (2)	3.2 ab	2.8 ab	4.2 ab	2.3 a	1.0 a	2.8 ab	2.7 a
Misc. other combinations, primarily (1)	3.3 ab	3.4 abcd	4.0 ab	3.4 abc	3.1 abcd	4.9 b	3.7 b
Edge between oak (1) and oak-pine (1)	3.4 ab	4.4 bcd	3.9 ab	4.3 bcde	3.2 abcd	4.8 b	4.0 bc
Edge between aspen (1) and oak-maple-aspen-cherry (1)	4.0 ab	3.2 abc	3.5 ab	4.6 cde	4.3 bcd	4.5 ab	4.0 bc
Oak (1)	4.2 b	5.4 d	4.1 ab	3.7 abcd	3.8 bcd	4.5 ab	4.3 bcd
Edge between upland grass and aspen-maple (2)	2.9 ab	5.0 cd	5.0 b	6.0 e	4.6 cd	4.1 ab	4.6 bcd
Aspen or aspen-maple (1)	4.4 b	4.7 bcd	5.1 b	5.4 de	4.6 cd	4.4 ab	4.8 cd
Edge between various deciduous types (1) and various types (2)	4.5 b	5.3 cd	4.7 b	4.3 bcde	5.2 d	7.2 c	5.2 d

* Use = $\sqrt{(C/M) + 0.5}$, where C = number of crossing groups found in the combination on the count, and M = miles of route along which the combination occurred.

** Presence of letters in a column indicates significant differences. Means that do not have a letter in common differ significantly at the 5% level by Tukey's HSD test.

Table 9. Results of analysis of summer deer use on the 9-Mile Study Area, 1975-1980.

Source of Variation	df	Mean Square	F	Significance
Main effects				
Cover and size combination	3	3.0679	5.690	P = 0.002
Year	5	3.4260	6.355	P < 0.001
Interaction				
Cover and size X Year	15	1.0169	1.886	P = 0.049
Residual error	48	0.5391		

dependent on time-since-treatment (interaction $P < 0.05$). Focusing first on mean utilization across years, the edge between reproduction aspen-oak mixture or oak and various mature cover types (or a very small amount of marsh and bog), and the mature aspen-oak mixture combination were used to a significantly ($P < 0.01$ and $P < 0.05$, respectively) greater extent than the pole size red pine or oak-pine mixture combination (nearly all red pine), and to a greater extent, though not significant, than the reproduction aspen-oak mixture (Table 10). Given the presence of the interaction, comparisons among combinations were also made by year. A moderately significant ($P < 0.10$) difference in use was found for 1976, when the mature aspen-oak had the highest mean use index. A significant ($P < 0.05$) difference was also found for 1978 when use of the mature aspen-oak was lowest, and in 1980 when the mean use index for immature aspen-oak was lowest. Importantly, there was a large, relative increase in use with increasing time-since-treatment of the edge between reproduction and mature stands.

Sharon Study Area

On the final area, the Sharon Study Area, which was 75% treated (cleared), eight cover type and size class combinations were found along the track route, two of which were groups of combinations. The analysis of variance (Table 11) revealed a significant ($P < 0.01$) combination main effect, indicating differences in utilization among the combinations.

Table 10. Mean summer use* by deer of forest cover type and size class (1 = reproduction, 2 = pole or saw) combinations on the 9-Mile Study Area, 1975-1980. Sample sizes: two counts in 1975, four in 1978, and three in each of the remaining years.

Forest Cover Type and Size Class Combination	1975	1976	1977	1978	1979	1980	Mean
Red pine or oak-pine (2)	2.0	2.2	2.7	2.7 ab**	2.7	3.7 ab	2.7 a
Aspen-oak (1)	2.6	2.7	3.4	3.3 ab	3.4	3.4 a	3.1 ab
Aspen-oak (2)	3.4	3.7	3.9	2.0 a	2.9	4.2 ab	3.4 b
Edge between aspen-oak or oak (1) and various types (2) or bog	2.6	2.6	3.6	3.7 b	4.1	5.3 b	3.6 b

* Use = $\sqrt{(C/M) + 0.5}$, where C = number of crossing groups found in the combination on the count, and M = miles of route along which the combination occurred.

** Presence of letters in a column indicates significant differences. Means that do not have a letter in common differ significantly at the 5% level by Tukey's HSD test.

Table 11. Results of analysis of summer deer use on the Sharon Study Area, 1975-1980.

Source of Variation	df	Mean Square	F	Significance
Main effects				
Cover and size combination	7	19.9440	25.107	P < 0.001
Year	5	3.6768	4.628	P < 0.001
Interaction				
Cover and size X year	35	0.7850	0.988	P = 0.497
Residual error	120	0.7944		

There was no evidence to suggest that the differences were dependent on time-since-treatment (interaction $P > 0.10$). Examining then just the comparisons among the eight combinations of use averaged across years (Table 12), the edge between reproduction oak-maple-aspen-cherry mixture and mature aspen-maple-oak mixture had the highest mean use index, which was significantly ($P < 0.05$) greater than all the other seven combinations. The least utilized combination, edge between mature aspen-pine mixture and mature aspen-maple-oak mixture, was significantly ($P < 0.05$) different than all others also. The pole size jack pine had the second highest mean use index, which was significantly ($P < 0.05$) greater than that for most other combinations, including the two reproduction size combinations (oak-maple-aspen-cherry and aspen or aspen-maple). Utilization of the reproduction size oak-maple-aspen-cherry cover type was much higher when juxtaposed with mature stands.

Table 12. Mean summer use* by deer of forest cover type and size class (1 = reproduction, 2 = pole or saw) combinations on the Sharon Study Area, 1975-1980. Sample sizes: two counts in 1975, three in 1976, and four in each of the remaining years.

Forest Cover Type and Size Class Combination	1975	1976	1977	1978	1979	1980	Mean
Edge between aspen-pine (2) and aspen-maple-oak (2)	2.3	1.9 a**	2.7 a	2.7 a	1.7 a	1.8 a	2.2 a
Oak-maple-aspen-cherry (1)	2.7	2.6 a	3.6 ab	3.7 ab	3.2 abc	2.8 ab	3.1 b
Aspen or aspen-maple (1)	2.6	3.1 a	3.2 a	3.4 ab	3.2 abc	3.3 abc	3.1 b
Misc. other combinations, includes edges with upland brush or marsh-bog	3.7	2.4 a	2.8 a	3.5 ab	3.8 bc	3.3 abc	3.3 b
Upland brush	2.8	3.4 ab	3.0 a	3.7 ab	3.6 abc	3.1 ab	3.3 b
Various types and edges between types, all (2)	4.1	2.6 a	4.2 ab	4.4 ab	2.5 ab	3.7 bc	3.6 bc
Jack pine (2)	4.3	3.4 ab	4.2 ab	5.2 bc	4.7 c	4.7 bc	4.4 c
Edge between oak-maple-aspen-cherry (1) and aspen-maple-oak (2)	4.6	5.4 b	5.6 b	6.8 c	4.7 c	5.1 c	5.4 d

* Use = $\sqrt{(C/M) + 0.5}$, where C = number of crossing groups found in the combination on the count, and M = miles of route along which the combination occurred.

** Presence of letters in a column indicates significant differences. Means that do not have a letter in common differ significantly at the 5% level by Tukey's HSD test.

DISCUSSION

The use index pertains to the period from late afternoon (dragging) until the following morning. Only a period of approximately 6-8 hours during the middle of the day is not sampled. The majority of feeding activity occurs during the daylight hours, with peaks associated with sunrise and sunset, a typical crepuscular feeding pattern (Bienz 1981). Bienz found that the greatest allotment of time for feeding occurred at sunset. Since the period for which use has been estimated encompasses the crepuscular feeding peaks typical of deer, movements to, from, and through vegetation types used for feeding should be reflected in the index. Therefore, the index should reflect the combinations used for feeding.

The use index is based on locations of deer crossing groups along a fixed route. Therefore, activities associated with movement will be emphasized. Movements to and from bedding or feeding sites should be well represented. Habitat used for bedding may, perhaps, be underrepresented. However, the use estimate cannot be broken down into the various activities. The index does have the advantage of not only representing use for feeding, but also use for cover and possibly fawning.

As mentioned, this study was part of a larger project

conducted by the Michigan Department of Natural Resources. A major effort was made by the Department to monitor the deer populations on the six research units used here, along with two others, and not solely by means of summer roadside track counts. These findings should be considered along with those forthcoming from other aspects of the larger study.

Cover type had a great influence on habitat use by deer, especially when considered with stand maturity. Examination of use of the various cover type and size class combinations on each study area bears this out. Several instances were found where combinations of the same maturity, but different cover types, differed significantly in terms of their use. Juxtaposition of stands was also found to influence use in some cases.

The use of cut or disturbed areas, such as the reproduction size stands produced by treatment on these study areas, and the high forage production in these areas have been reported in several studies (Westell 1954, Gysel 1957, Krefting 1962, Halls and Alcaniz 1968, Stormer and Bauer 1980, Bennett et al. 1980). The immature aspen or aspen-maple mixture combination, found on five of the study areas, had consistently high use across the areas with the exception of the Sharon Study Area. Most of the reproduction size stands were used fairly heavily, relative to the other combinations. However, the immature oak and oak-pine mixtures appeared to be avoided to some extent by deer, even on the 25% treated study areas where fewer immature stands were

available. All reproduction size combinations were avoided on the 75% treatment level study areas. Also, some evidence was found of increasing use of some of the reproduction size, or regeneration, stands with time-since-treatment. Because of the treatment, virtually all the reproduction size stands were 0-2 growing seasons old at the beginning of this study in 1975. Thus, these stands were 5-7 growing seasons old the final year of the study, and any time-since-treatment effect should be related to this progression of growth.

As mentioned, the immature combinations which regenerated after treatment were avoided somewhat by deer on the 75% treatment level study areas, 9-Mile and Sharon. However, the edges between immature and mature forest stands were used extensively, regardless of cover type. Remember, the 75% areas tended to have much larger, continuous blocks of treated area, and therefore less of the edge between reproduction and mature size stands was created. The reduced availability of the preferred edge may have resulted in more concentrated use of what was there.

Stormer and Bauer (1980) found that the size of a clear-cut may affect the degree to which it is used. Deer avoided the center of a 4.05 ha clear-cut in their study. While the relationship between use of reproduction size stands and the size of treated block was not examined in this study, use of the immature stands on the 75% treatment level study areas was low relative to the other combinations, even though forage production should have been high. The large,

continuous blocks of cleared area were avoided somewhat, but not necessarily because of their size. The high treatment level may have produced too much reproduction size forest on these areas. The immature stands were utilized, but at a low level relative to the vast amount available on these areas. Use of the immature stands on the 50% treatment level study areas, Lanes Lake and Russell Lake, was moderately high, depending on the cover type. The size of the treated blocks on these two areas were clearly not small (Figure 1), but the availability of reproduction size stands was reduced. However, treatment in small blocks is recommended for maintaining the desirable intolerant forest cover types. This will also provide a span of maturities, which will provide the desired edge, and a sufficient amount of immature stands with high forage production. Additional research on the optimal size for clear-cuttings is needed.

The mature oak-pine mixture combination, and the mature oak with a sapling pine understory received consistently high use. The reason for this, whether this use was either forage or cover related, is not clear. These types should also be promoted and preserved by management practices for summer deer range, though further research on their use may be needed. Of course, some of the types, which were avoided or at least not preferred in this study of summer use, are important components of year-round deer range. The mature swamp conifers and mature oak are two examples, important for winter cover and mast production in the fall, respectively.

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