



SOME EFFECTS OF DEER BROWSING ON
NORTHERN MICHIGAN FOREST PLANTS

Thesis for the Degree of M. S.
MICHIGAN STATE COLLEGE
Jerry Paul Duvendek
1952



3 1293 10096 0594

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SOME EFFECTS OF DEER BROWSING
ON NORTHERN MICHIGAN FOREST
PLANTS

By
JERRY PAUL DUVENDECK

A THESIS

Submitted to the School of Graduate Studies of Michigan
State College of Agriculture and Applied Science
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Zoology

1952

4/11/52
(2)

SOME EFFECTS OF DEER BROWSING ON NORTHERN MICHIGAN FOREST PLANTS

According to Bartlett (1950), Michigan has a herd of approximately 1,000,000 whitetail deer (Odocoileus virginianus borealis), and he estimates that 600,000 of these are in the northern portion of the Lower Peninsula. He believes that the herd reached this peak in 1939 and that it has fluctuated thereabouts since.

As early as 1930 Bartlett found that portions of this part of Michigan were overpopulated with deer, and by 1936 winter starvation was common in these areas. His records indicate that the overpopulated, or starvation, areas have continually expanded until they now cover the area shown in Figure 1.

In order to study and evaluate the damage that deer do to forest plants and their reproduction, the Game Division of the Michigan Conservation Department built 16 deer exclosures. These exclosures are one acre or less in size, surrounded by an eight foot fence designed to exclude deer. Six were completed in 1937, and 10 in January 1950. During the summer of 1950 the vegetation of these exclosures and of nearby unfenced control areas were studied in an effort to determine the effect of deer browsing in these areas.

Methods

The designations, sizes, locations, and year of construction for each exclosure studied are listed in Table 1. Their

MICHIGAN
DEPARTMENT OF CONSERVATION
DEER ENCLOSURES

SCALE OF MILES
0 10 20 30 40

FIGURE 1

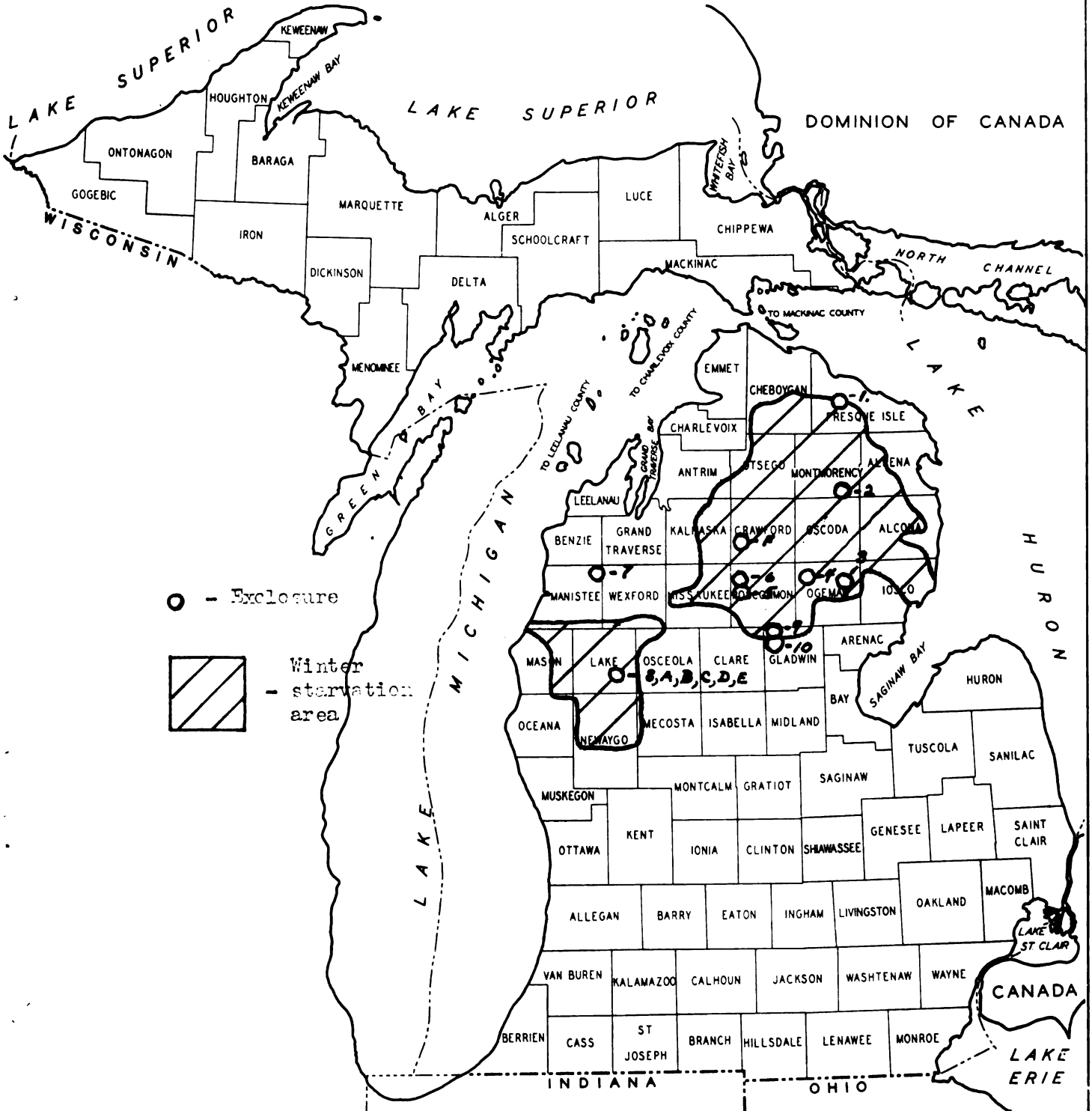


TABLE 1

DEER EXCLOSURES IN THE NORTHERN PORTION OF THE LOWER
PENINSULA OF MICHIGAN, THEIR DESIGNATION, SIZE,
LOCATION AND DATE ESTABLISHED

Designa- tion	Size in acres	County	Location Subd.	Sec.	TN	R	Date Estab- lished
A	1	Lake	S $\frac{1}{2}$ SE $\frac{1}{4}$	4	18	12W	1937
B	1	"	S $\frac{1}{2}$ SE $\frac{1}{4}$	4	18	12W	"
C	1	"	S $\frac{1}{2}$ SE $\frac{1}{4}$	4	18	12W	"
D	1	"	N $\frac{1}{2}$ NE $\frac{1}{4}$	9	18	12W	"
E	1	"	N $\frac{1}{2}$ NE $\frac{1}{4}$	9	18	12W	"
F	.25	Crawford	SE $\frac{1}{4}$ SW $\frac{1}{4}$	16	26	4W	"
1	.5	Presque Isle	NW $\frac{1}{4}$ SW $\frac{1}{4}$	27	34	3E	1950
2	1	Montmorency	SW $\frac{1}{4}$ SE $\frac{1}{4}$	15	29	3E	"
3	.1	Ogemaw	SW $\frac{1}{4}$ NE $\frac{1}{4}$	2	23	3E	"
4	.05	"	NW $\frac{1}{4}$ SE $\frac{1}{4}$	6	23	1E	"
5	1	Roscommon	SW $\frac{1}{4}$ NW $\frac{1}{4}$	20	24	4W	"
6	.5	"	SW $\frac{1}{4}$ SE $\frac{1}{4}$	34	24	4W	"
7	1	Manistee	NE $\frac{1}{4}$ SE $\frac{1}{4}$	30	24	13W	"
8	1	Lake	SW $\frac{1}{4}$ NW $\frac{1}{4}$	10	18	12W	"
9	.05	Gladwin	SW $\frac{1}{4}$ NW $\frac{1}{4}$	10	20	2W	"
10	1	"	NW $\frac{1}{4}$ SW $\frac{1}{4}$	10	20	2W	"

locations in relation to the starvation area is shown in Figure 1.

For each exclosure an unfenced control area was staked out. The controls were established parallel to one side of the exclosures where the same major vegetation types present in the exclosures were found, and placed 6.6 feet away from the exclosures to eliminate the deer runways that were frequently found along the exclosure fences. Thus each exclosure and its control presented a comparison between an area available to deer and a similar area not available.

A standard procedure was used in examining all exclosures and control areas. Equally spaced transects 6.6 feet wide were established parallel to the ends of the areas. These sample strips comprised 10 per cent of the area in the exclosures and in control areas one-half acre or larger. They included 20 per cent of smaller plots. The entire plots of exclosure 4 and its control were studied. Permanent cedar stakes protruding three feet above the ground were placed at the ends of all of the sampled transects. Each stem of woody vegetation found in the sample strips was tallied on a standard form by species, size, class, and percentage of available browse remaining on the stem. Species, when unknown, were determined from Fernald (1950). Size was determined by actual measurement, and seven size classes were used. Available browse was considered to be leaves, buds, fruits, and live twigs up to one-quarter inch in diameter found between ground level and eight feet in height. The percentage

of available browse remaining was determined by a mental comparison of each stem with the probable normal stem of the same species growing without competition or damage. Four percentage classes were used. They were:

1. Browsed out: No available browse remaining.
2. Heavily browsed: 1 - 33 per cent remaining.
3. Moderately browsed: 34 - 66 per cent remaining.
4. Lightly or not at all browsed: 67 - 100 per cent remaining.

General notes were taken on herbaceous vegetation and its apparent effect on tree reproduction.

In analyzing the data collected the chi-square test was used frequently to determine whether differences were statistically significant. In this paper if the test indicated differences significant at the five per cent level the word "significant" has been used, and if the test found differences significant at the one per cent level the words "highly significant" have been used.

Acknowledgments

I take pleasure in acknowledging the generous cooperation and help of the following agencies and individuals. First I am indebted to the Game Division of Michigan's Conservation Department for assigning the study to me. Ben C. Jenkins contributed time and guidance in collecting data in the field. Ford Kellum contributed his knowledge concerning deer food preferences in compiling Table 2. William Laycock, Philip Baumgras, John Bye-lich, and Otto Failing, District Game Supervisors, aided with

advice and knowledge concerning individual exclosures in their districts. Dr. George A. Petrides assisted in editing the paper.

Findings

For convenience in reporting, the various woody species found in this study are classified (Table 2) according to their probable palatability to deer. This list, compiled by Ford Kellum and myself, is supported in part by Maynard, Bump, Darrow, and Woodward (1935), Davenport (1939), Petrides (1941), Manville (1947), and Swift (1948, 1950). The list indicates the probable order in which deer would choose the plants as food, and is not a list designating the value of these species from a nutritional standpoint.

Exclosures Built in 1937

The exclosures built in 1937 are all in deeryard swamps that had been heavily overbrowsed prior to construction of the exclosures. Five (A - E) are in the Luther Baldwin Swamp in Lake county and the sixth (F) is in the Bear Creek Swamp in Crawford county.

Exclosures A - E. During the winter of 1935-36 the Luther Baldwin Swamp was cut in a "checkerboard" pattern. Alternate two and one-half acre plots were cut over. The openings materially affected the resulting plant communities in and around the cut over areas. Before they were cut the dominant species were balsam fir, white cedar, red and silver maple, black ash, balm of Gilead, basswood, slippery elm, and aspen (Michigan Depart-

TABLE 2

PROBABLE ORDER OF PALATABILITY IN NORTHERN
MICHIGAN WOODY PLANTS FOUND

Preferred

1. American yew	<u>Taxus canadensis</u>
2. White cedar	<u>Thuja occidentalis</u>
3. Red-osier dogwood	<u>Cornus stolonifera</u>
4. Alternate-leaved dogwood	<u>Cornus alternifolia</u>
5. Staghorn sumac	<u>Rhus typhina</u>
6. Eastern hemlock	<u>Tsuga canadensis</u>
7. Mountain-ash	<u>Pyrus americana</u>
8. Red maple	<u>Acer rubrum</u>
9. Black ash	<u>Fraxinus nigra</u>
10. Juneberries	<u>Amelanchier</u> spp.

Second Choice

11. Witchhazel	<u>Hamamelis virginiana</u>
12. Silver maple	<u>Acer saccharinum</u>
13. Hazelnut	<u>Corylus</u> spp.
14. Ninebark	<u>Physocarpus opulifolius</u>
15. Wild raisin	<u>Viburnum cassinoides</u>
16. Aspen	<u>Populus tremuloides</u>
17. White oak	<u>Quercus alba</u>
18. Nannyberry	<u>Viburnum Lentago</u>
19. Bush-honeysuckle	<u>Diervilla Lonicera</u>
20. Winterberry	<u>Ilex verticillata</u>
21. Swamp fly honeysuckle	<u>Lonicera oblongifolia</u>
22. White birch	<u>Betula papyrifera</u>
23. Basswood	<u>Tilia americana</u>
24. Willows	<u>Salix</u> spp.
25. Jack pine	<u>Pinus Banksiana</u>
26. American fly honeysuckle	<u>Lonicera canadensis</u>

Starvation

27. Balsam fir	<u>Abies balsamea</u>
28. Balm of Gilead	<u>Populus balsamifera</u>
29. Northern red oak	<u>Quercus rubra</u> var. <u>borealis</u>
30. Black cherry	<u>Prunus serotina</u>
31. Tamarack	<u>Larix laricina</u>
32. Red pine	<u>Pinus resinosa</u>
33. White ash	<u>Fraxinus americana</u>
34. Pin cherry	<u>Prunus pensylvanica</u>
35. Choke cherry	<u>Prunus virginiana</u>
36. Slippery elm	<u>Ulmus fulva</u>
37. Sheep laurel	<u>Kalmia angustifolia</u>
38. Swamp birch	<u>Betula pumila</u>
39. Speckled alder	<u>Alnus rugosa</u>
40. Black spruce	<u>Picea mariana</u>

ment of Conservation, Game Division, unpublished). Balsam fir and white cedar had not become reestablished in these areas at the time of the study. Deciduous species now make up the dominant forest cover. The five exclosures were built so that half of each was in a cutover area and each remaining half was in an uncut plot.

Plantings of red-osier dogwood, white ash, and basswood were made in the fall of 1936 in three of the cut over areas where exclosures were later placed. They were made, however, before the exclosures were built and thus were subject to browsing throughout before parts of them were fenced. The species composition of all exclosures, planted or not, was statistically similar.

Table 3 lists all the preferred deer foods found in these exclosures and controls and the percentages of each in the four classes of available browse.

American yew was found in the parts of the exclosures where no cuttings had been made. It did not occur in the control areas.

White cedar was present in both exclosures and controls, but only 5.1 per cent in the controls had available browse while 31.7 per cent of the stems in the exclosures had available browse remaining. No new white cedar stems in either area had grown beyond the height of two feet, but half of the new stems in the exclosures were between one and two feet tall while all of those in the control area were seedlings less than three inches high.

TABLE 3

PERCENTAGES OF TOTAL NUMBER OF STEMS OF PREFERRED BROWSE
PLANTS IN THE FOUR CLASSES OF AVAILABLE BROWSE PRESENT
IN 1950 IN ENCLOSURES AND CONTROLS A, B, C, D, E
LAKE COUNTY, MICHIGAN CONSTRUCTED IN 1937

Species	Total number of stems found		Percentage of available browse remaining			
			0	1 - 33	34 - 66	67 - 100
American yew	46	E*				100
	0	C**				
White cedar	139	E	68.3	10.8		20.9
	136	C	94.9	0.7		4.4
Red-osier dogwood	317	E		1.6	42.3	56.2
	426	C		12.0	40.1	47.9
Alternate- leaved dogwood	78	E		3.8	35.9	60.3
	41	C		22.0	34.1	43.9
Hemlock	23	E	34.8	13.0		52.2
	17	C	100			
Mountain- ash	148	E		7.4	61.5	31.1
	89	C		25.8	70.8	3.4
Red maple	332	E	7.8	7.2	15.4	69.6
	253	C	11.5	16.6	5.9	66.0
Black ash	327	E	18.7	26.3	33.0	22.0
	410	C	28.7	52.7	12.7	5.9

* - Enclosure

** - Control

Trees that had been heavily browsed before the exclosures were built showed some browse regeneration within the exclosures but none outside.

Hemlock presented an even greater contrast with no available browse in the control areas and 65.2 per cent in the exclosures with available browse remaining.

The five other species of preferred deer foods listed in Table 3 also showed highly significant greater availability of browse in exclosures.

Aspen, silver maple, American and swamp fly honeysuckle, white birch, basswood, and willow were second choice deer foods found in these five exclosures and their control areas.

Most of the aspen stems (73 per cent) in both exclosures and controls were of the same size (about three inches DBH), and the majority of these were in areas that had been cut over. This would indicate that this species had reproduced well in the cut over areas for a few years and then had been unable to continue as other vegetation matured. The differences in total number of stems of this species found inside (117) and outside (70) the exclosures was highly significant. Deer had evidently reduced aspen reproduction in the control area. The amount of browse available on aspen stems in the exclosures was not significantly more than the amount per stem in the control areas. These data indicate that as aspen became mature self-pruning eliminated most low browse.

There were 11 times as many stems of American fly honeysuckle and over twice as many stems of swamp fly honeysuckle, basswood, and silver maple in the exclosures as there were in the controls. These differences all were statistically highly significant. The amounts of available browse on these species and on willow inside the exclosures was significantly more than outside in the control areas.

There were 76 stems of white birch under eight feet in height in the exclosure, and 47 of the same class in the controls. The difference in number of stems, and a greater amount of available browse on the stems in the exclosures were both found to be highly significant. The other larger stems of this species in both areas had little browse left available to deer.

Balsam fir was the only starvation food species in these areas that deer had used to a point where a definite difference could be shown. There were about four times as many stems of balsam fir as there were of balm of Gilead, red oak, black, choke and pin cherry, white ash, and slippery elm. This greater availability may indicate why it has been heavily browsed after more palatable foods were consumed. The greater amount of available browse per stem on the balsam fir in the exclosures, as well as the difference in numbers of stems, was highly significant.

Speckled alder was as abundant as balsam fir but it had not been heavily browsed. This would tend to confirm the placement of speckled alder near the bottom of the palatability list.

In those parts of the swamp that had been cut over, herbaceous ground cover was heavier than in the uncut portions. Currants (Ribes spp.), raspberries (Rubus spp.), and spotted jewelweed (Impatiens capensis) were common in the cut over areas. Ground dogwood (Cornus canadensis), currants (Ribes spp.), and various ferns were found in the uncut portions. This ground cover was apparently not inhibiting forest reproduction.

Exclosure F and its control. None of the area of exclosure F or its control had been cut over so it was considered separately from exclosures A - E.

Fifteen woody species were found in exclosure F, and eight were found in the control area. Table 4 lists these species and their abundance. The per cent of stems in browse percentage classes was not included in a table because of the small numbers of stems involved. Seven species were present in the exclosure and not in the control. Two were preferred foods, and five were second choice. The difference in number of species found in the two areas is significant just above the five per cent level.

There was no available browse on white cedar stems in the control area. Significantly, 10 of the 16 stems in the exclosure had available browse. Four small white cedar stems in the exclosure indicated that reproduction was taking place. None was found outside.

All 29 stems of red maple found in the control area were seedlings less than four inches in height. In the exclosure,

TABLE 4

SPECIES FOUND IN ENCLOSURE F, BUILT IN 1937, AND ITS
CONTROL AREA CRAWFORD COUNTY, MICHIGAN

Species	Numbers of stems	
	<u>Enclosure</u>	<u>Control</u>
Red maple	65	29
Sheep laurel	63	25
Balsam fir	42	4
Black spruce	39	31
Speckled alder	34	113
Red-osier dogwood	25	31
Swamp fly honeysuckle	19	--
White cedar	16	12
Ninebark	8	--
White birch	3	--
Winterberry	3	--
Juneberry	2	--
Aspen	2	--
Black ash	1	--
Red oak	1	3

30 of the 65 stems found were seedlings and the remaining stems ranged in height up to five feet. In the absence of deer, both white cedar and red maple apparently can reestablish themselves in this region, while in the area available to deer they had not been able to successfully reproduce.

Red-osier dogwood was not heavily browsed in the area. No statistical difference between protected and unprotected plots could be shown. All stems seen were under two feet tall.

No balsam fir reproduction and no available browse on the stems of this species were found in the control area. In the exclosure, 86 per cent of the balsam fir stems were under two feet tall and 75 per cent of the remaining stems had up to 33 per cent browse remaining. The differences were highly significant. Spruce stems under eight feet tall were browsed in the unprotected area. Little new growth was noted there, while small spruces within the fence had grown as much as six inches in the previous growing season.

Sphagnum moss covered much of the ground in this exclosure and its control. Ground dogwood (Cornus canadensis), showy lady-slippers (Orchis spectabilis), and various ferns were common. Forest reproduction was apparently not hindered by ground cover.

Exclosures Built in 1950

The exclosures built in 1950 were located in three general areas with respect to deer damage: (1) areas not damaged by deer; characterized by no browse line and little evidence of deer

cropping on any forest species; (2) areas moderately browsed; where the preferred deer food species had been moderately to heavily browsed, but usually with no definite browse line; and (3) overbrowsed areas with a definite browse line.

Areas not damaged by deer. Exclosures 1 in Presque Isle county and 7 in Manistee county were in swamps that deer had not damaged. Yew was present in similar numbers in exclosure 7 and its control. Red maple, juneberries, alternate-leaved dogwood, mountain-ash, and black ash were other preferred deer food species found there. Cedar and red-osier dogwood were common throughout exclosures 1 and 7 and their controls.

Most of the white cedar stems in these areas had available browse from the ground to the eight foot level. In one area of exclosure 7 and its control where forest cover was heavy, self-pruning had reduced the potential amount of available browse on the lower stems. Of the 229 white cedar stems found in exclosure 7 and its control, 15.7 per cent had been self-pruned to a point where no available browse remained, and an additional 16.6 per cent had less than 33 per cent available browse remaining. There were no white cedar stems in exclosure 1 and its control with less than 34 per cent available browse remaining. The second choice and starvation food species in both exclosures were similar in condition. Deer had not affected them. Ground cover in the two areas did not seem to be affecting forest reproduction.

Areas moderately browsed. Exclosures 5 and 6 in the Dead Stream Swamp in Roscommon county displayed no browse line.

White cedar, red-osier dogwood, red maple, black ash, juneberry, and hemlock were preferred species present there. All had been browsed but no statistical differences occurred between exclosures and controls. When the white cedar stems of exclosures and control areas 1 and 7, in areas of low deer numbers, were compared with white cedar in exclosures and control areas 5 and 6 where deer are more numerous, the following highly significant differences were found which indicate the differences which characterize the two deer range types:

	<u>Total no. of stems</u>	<u>Browsed out</u>	<u>Percentages of stems</u>		
			<u>Heavily browsed</u>	<u>Moderately browsed</u>	<u>Lightly browsed</u>
Exclosures 1 & 7 and controls	418	8.6	9.1	28.9	53.3
Exclosures 5 & 6 and controls	319	35.1	18.8	21.0	25.1

Deer had apparently reduced considerably the amounts of available browse in the areas of exclosures 5 and 6 and their controls. Other preferred food species in this area that had been similarly reduced in amounts of available browse were red-osier dogwood, red maple, and juneberry. Black ash and hemlock were not present in exclosures 1 and 7 and their controls.

Among second choice deer food species, winterberry, willow, swamp fly honeysuckle, wild raisin, white birch, hazelnut, witchhazel, and aspen were present in exclosures 5 and 6 and their controls. Deer had not browsed any of these species

heavily. The ground cover in these areas was not apparently inhibiting forest reproduction.

Overbrowsed areas. Exclosures 2, 3, 4, 8, 9, and 10 were built in 1950 in areas that had been overbrowsed by deer. There was a definite browse line in or near each of the exclosures. Each of the exclosures was different from the others.

Exclosure 2 was in Montmorency county for ten years on the edge of the starvation area. White cedar and balsam fir comprised 62.2 per cent of the total number of stems in the exclosure, and 63.9 per cent of those in the control area. Both species had been heavily browsed by deer. Of the white cedar stems in the control only two per cent had available browse remaining while 24.2 per cent of the stems in the exclosure possessed suitable foliage. This difference is highly significant. It had apparently occurred in the previous six months.

Sixteen stems of American yew were found in the exclosure and three were present in the control area. The stems in the exclosure had been browsed before the exclosure was built, but in the past growing season they had produced new growth. The three stems of yew in the control area were heavily browsed and no new growth was found.

There were a few red maple stems over eight feet in height scattered through the areas, but none of these larger stems had available browse. There were 64 stems under five feet tall in the exclosure, and only seven in the control. These differences were highly significant. Red-osier dogwood was more abundant

in the exclosure than in the control area and alternate-leaved dogwood was absent in the control.

The second choice deer food species, white birch, swamp fly honeysuckle, aspen, and willow, were all twice as abundant in the exclosure as in the control. The greater amount of browse per stem on white birch stems was highly significant.

Balsam fir, though heavily browsed, was not significantly different in amount of browse available per stem between the exclosure and its control. The other starvation food species found had not been much browsed by deer.

Exclosure 3 and its control area, in the Rifle River State Game Area in Ogemaw county, were clearcut of all woody vegetation just prior to construction. Balsam fir and white cedar were the dominant forest species in the surrounding swamp. There was a definite browse line in this swamp.

Eight woody species were found in the exclosure and six were found in the control area. A total of 209 stems were counted in the sampled portion of the exclosure while only 61 stems were counted in the sampled part of the control. This difference in total number of stems is highly significant, and is tabulated by species as follows:

	<u>Exclosure</u>	<u>Control</u>
Red-osier dogwood	92	8
Black ash	89	29
Speckled alder	8	--
Red maple	6	2
Balsam fir	5	17
Winterberry	5	--
Red oak	3	1
Black spruce	1	--
White birch	--	4

All of the stems found inside the exclosure had more than 67 per cent browse remaining. Only 43 per cent of the stems in the control area were in this category. Of the other stems in the control area, 44 per cent were moderately browsed and 13 per cent were heavily browsed.

None of the stems in either area had grown beyond five feet tall. In the exclosure 56 per cent of the stems and in the control only 15 per cent of the stems were over two feet tall. The difference is highly significant. Black ash and red-osier dogwood were the species that contributed most to the difference.

The stems present in the area had developed as reproduction in the six months since the area had been clearcut. Deer had apparently reduced this reproduction in the control area to one third of that found in the exclosure. Ground cover was not inhibiting forest reproduction.

Exclosure 4 was on the Ogemaw State Game Refuge. The semi-tame deer herd here had overbrowsed the area. Jack pine was the only species found in the exclosure and its control area. Fourteen stems were found in the exclosure and nine in the control area. Two additional dead stems in the control area apparently had been recently killed by overbrowsing. New growth was noted on all of the stems in the exclosure, and none was found in the control area. The grass sod that formed the ground cover undoubtedly was a contributing factor in limiting reproduction.

Exclosure 8 was near the edge of the Luther Baldwin Swamp which had been in the starvation area for 15 years.

Twenty-eight stems of red maple and eight of juneberry were the only stems of preferred deer food found in the area. All of these had been browsed, but there was no significant difference between the exclosure and its control.

Bush-honeysuckle, aspen, witchhazel, white oak, willow, hazelnut, and white birch were second choice food species found. Bush-honeysuckle was not heavily browsed. Young aspen stems in both areas had been moderately browsed. Witchhazel, hazelnut, and white birch also had been browsed, but not in the past six months to where significant differences could be shown between fenced and unfenced areas.

Of the white oak stems under eight feet in height found in the exclosure, 82.9 per cent had more than 67 per cent available browse remaining. The other similar oak stems in the exclosure had between 34 and 66 per cent available browse remaining. In the control 57.8 per cent of the similar white oak stems had been lightly browsed, 33.3 per cent moderately browsed, and 8.9 per cent heavily browsed. The greater browsing of the control was statistically significant. It had apparently occurred in the past six months. Unfenced jack pine had been browsed heavily in this area, but new growth up to eight inches long prevailed on the stems in the exclosure. Starvation food species had not been much browsed.

Forest reproduction did not seem to be inhibited by the ground cover of bracken (Pteridium sp.), strawberry (Fragaria sp.), a few grasses and other herbs.

Exclosure 9 was in the Gladwin State Game Refuge. The area had been overbrowsed by deer. Sumac was the only woody species in the exclosure and its control area. The greater amount of available browse per stem found in the exclosure was highly significant. Reproduction was apparently as good in the control as it was in the exclosure. Sweet fern (Comptonia peregrina), milkweed (Asclepias sp.), and grasses made up the ground cover. It did not seem to be affecting reproduction of other woody plants.

Exclosure 10 also was located in the Gladwin Refuge. Red maple, red-osier dogwood, white cedar, and black ash were the preferred deer food species present. Only two of the 112 white cedar stems in the exclosure and control had available browse, offering no basis for measurement. The amount of available browse per stem on red maple stems in the exclosure was enough greater to be significant. Red-osier dogwood had been browsed in both exclosure and control. Little available browse was left on the stems of black ash present in both areas. White birch, willow, aspen, hazelnut, jack pine, and basswood were second choice food species found. All had been browsed, but no significant differences could be shown between the exclosure and its control.

Balsam fir had been heavily browsed before the exclosure was built. There was no available browse on any of the stems over eight feet in height, and the only smaller balsam fir stems found were seedlings. The other starvation foods had not been heavily browsed in this area.

In parts of the exclosure and control, grasses had formed a heavy sod, and in these areas forest reproduction was lacking.

Conclusions

1. American yew has been almost extirpated by deer in overbrowsed areas.

2. White cedar and hemlock have become so heavily browsed as to produce little available browse through growth and regeneration. Little or no successful reproduction of these species occurred in overbrowsed areas.

3. Amounts of available browse on red-osier dogwood, alternate-leaved dogwood, sumac, mountain-ash, red maple, and black ash were usually highly significantly reduced in overbrowsed areas, and reproduction on these deciduous preferred species more often than not was significantly reduced.

4. In six months in some overbrowsed areas, deer significantly reduced the amount of available browse on such preferred deer food species as American yew, white cedar, and red maple.

5. In clearcut areas, deer reduced forest reproduction to one third of that prevailing in exclosures.

6. In previously overbrowsed areas, coniferous deer food plants did not produce any stems over two feet in height in 13 years, even when protected from deer.

7. Even in moderately browsed areas deer significantly reduced available browse on white cedar and other preferred deer food species. Second choice and starvation foods were not much damaged.

8. Self-pruning in one area of heavy forest cover significantly reduced the amount of available browse on white cedar.

Summary

The woody vegetation of 16 deer exclosures and of browsed but otherwise comparable nearby control areas were studied between June and October 1950 in the Lower Peninsula of Michigan.

Six exclosures built in 1937 were all in overbrowsed deer-yard swamps. Highly significant differences in amounts of available browse per stem were noted between the exclosures and their controls for nearly all preferred and second choice deer food species found there. American yew was absent from the control areas. Highly significantly less browse per stem was found on white cedar, hemlock, red-osier dogwood, alternate-leaved dogwood, mountain-ash, red maple, black ash, aspen, silver maple, swamp and American fly honeysuckles, white birch, basswood, and willow in the control areas. Balsam fir was the only starvation food species with significantly less browse per stem in the control areas.

Ten exclosures built in 1950 were scattered widely. In some areas where deer were evidently not numerous, self-pruning had significantly reduced the per cent of available white cedar browse. Where deer were moderately abundant, differences between browse conditions in excluded and control areas generally were not significant, but highly significant differences existed for preferred deer food species between these locations and unbrowsed areas. In heavily populated areas, as indicated by a definite browse line, all preferred, second choice, and even balsam fir of the starvation diet species had been severely browsed. Even during the six months since the exclosures had been built many significant differences were found in browse availability within and without the exclosures.

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