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SOME WINTER RELATIONS OF THE WHITE-TAILED DEER TO THE FORESTS IN NORTH CENTRAL MASSACHUSETTS

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Although the white-tailed deer, *Odocoileus virginianus virginianus*, has been used by the white man as an important source of food and leather since the first New England settlements and is the only large game animal to maintain itself following the settlement of the region, little exact knowledge of its habits and requirements has been recorded. Considerable popular literature is to be found on the species, but little is of a specific nature. Within the past few years a beginning of studies has been made in Pennsylvania (Clepper, '31; Forbes and Overholts, '31; Forbes and Bechdel, '31; Frontz, '30) and in the Adirondacks (Townsend, Smith and Spiker, '33). The habits of the animal vary so widely in different regions that local studies are necessary to make an intelligent approach to its management. With this in mind the present study was undertaken as a start toward determining some of the factors necessary for the best local development of the species and of the means by which forestry can contribute to the attainment of this development.

Specifically the objects were to find for north central Massachusetts (1) what food was eaten by the white-tailed deer during winter, (2) how its feeding habits were correlated with ecological succession, (3) whether preferences were shown for various forest types for food or shelter, (4) the general characteristics and habits of the animal. The study had two main divisions: field observations and stomach analysis. The general field practice was to follow the deer tracks on snow, examining and tallying all feeding along the route. All forest types passed through were noted, as were cases of bedding, loafing, etc. The stomachs were secured principally during the hunting season in early December, with some over the period from November to April. These were tagged as collected, a standard mimeographed form was filled out recording pertinent data for each, and they were placed in a formalin solution until

examined. A total of 24 stomachs was analyzed. Stomachs were mainly secured by cooperation with state game officials and with local residents of Petersham.

With one exception field observations were confined to the town of Petersham. This exception was an examination of Rattlesnake Mountain in the town of Erving, which was the winter rendezvous of a large number of deer.

Description of Region

The town of Petersham, covering some 24,000 acres, is situated in northern Worcester County, Massachusetts, and is quite typical of much of the surrounding region. It is part of what foresters call the "transition zone." This term describes the overlapping of the northern forest as represented by such species as beech, *Fagus grandifolia,* yellow birch, *Betula lutea,* and hard maple, *Acer saccharum,* and the central forest in which oak predominates. Species representing both forest regions are to be found in Petersham. For the purpose of this study the areas were divided into nine types which do not strictly conform to the standard as set up by the Society of American Foresters (Hawley, R. C. et al, '32) for this region. A rigid adoption of that standard was impractical because some of the more important ones were not strictly forest types.

The forest history of Petersham will give some conception of the present composition and condition of the forest. The original forest was composed largely of hemlock, *Tsuga canadensis,* and hardwood with an interspersion of white pine, *Pinus strobus.* This original forest was cut and much of the land cleared for farming between the years 1700 and 1830. Farming extended rapidly in this period. With the impetus given western settlement by the development of the railroads, however, farming in the Petersham region became increasingly less profitable, and land abandonment set in. At the peak of farming around 70 per cent of the land area of the town was cleared, but at the present time only about 25 per cent is in village and agricultural use. As the fields and pastures were left to nature, white pine seeded in and reclaimed the areas thus abandoned. As the pine matured, important industries grew up, using the lumber produced. Its principal uses were in box manufacture, match stock, and sash and blind construction. Fortunes were made in the heyday of harvesting the pine woodlots. Today most of this type has been logged off.

Pine did not follow pine on the better soils of this region, and after pine cuttings the next great forest succession was hardwood, of which the first crop was often of valuable species. The more valuable ones were present under the pine as advance growth. This first hardwood crop was cut largely for cordwood, although many stands are still left and are of sawlog size. When the good hardwood was removed, the stand sprouted with characteristic persistence. All would have been well silviculturally except that the second crop of hardwood did not have as good composition as the first, and forest

weeds were present to a much greater degree than before. Sprouts from the larger stumps were coarse and often defective. The most serious of the weeds were gray birch, *Betula populifolia*, fire cherry, *Prunus pennsylvanica*, and red maple, *Acer rubrum*. These are fast growing and got their first real foothold in some of the original pine cuttings where hardwood advance growth was lacking. When the first hardwood crop was removed, the weeds increased their percentage composition of the stand; and in the usual present hardwood stand, two cuttings removed from the old field pine type, they form a large and ever increasing proportion. Were the forest allowed to grow unmolested, the short-lived weeds would eventually drop out. In the main, we find the forests at present dominated by poor quality hardwood with a sprinkling of pine and hardwood with prospective sawtimber value.

The forest has not always followed the same trend since Colonial days. Some isolated blocks were not cut at all, some were lightly culled, and some heavily cut. Much of the area of Petersham was long maintained in field or pasture, and some of this still remains in the stage known as the old field pine type. Since, at the present time, it requires at least ten and often thirty years for an old field to revert to pine, much of the area is now in old fields covered with brush and small clumps of trees.

The topography of Petersham is much broken. The main ridges run north and south with a wide valley between them. These ridges are dissected by many local variations and cross drainages. The main drainage is to the south. In the southeast part of the town a series of minor ridges run parallel in a general northwest-southeast direction. The elevations run from 700 to 1,400 feet with the main ridges over 1000 feet.

The soils found in this region are divided into but two classes for the purpose of this work. A sandy loam, which occupies the ridges, is predominant. The other soil, which forms a distinct minority, is a sand outwash type found in the valley bottoms in the western part of the town. It is realized that this soil division is a broad one, but the purpose of including soils is to give a picture of the future for broad forest types. Soil depth is extremely variable. The entire region is underlain with granitic rock and has been heavily glaciated.

The winter during which the study was made, 1933–34, was one of the most severe in the memory of the oldest inhabitants. Temperatures down to twenty-eight degrees below zero were recorded at the Harvard Forest Headquarters and as low as —35 degrees at lower elevations about the town. Snowfall was well over the November–March average for the past ten years. During the period of this study the snowfall was 87.75 inches, while the average for the past ten years was 52.25 inches. Not only was the snow deeper than usual, but it remained on the ground for a longer time. The ground was snow-covered from early in December until late in March.

Description of Types and Their Use by Deer

As has been stated, the cover types used in this study are broadly defined and are nine in number. In order of relative area in the town, they are: pure pine, young hardwood, old hardwood, pine-hardwood, old field, hemlock-hardwood, pine-hemlock, Scotch pine plantation, and old orchard.

Pure white pine is found either as a remnant of the stands which developed on old fields with heavier soils or, as occasionally happens, as a permanent pine type on the more dry and sandy soils. Due to increasing side light beneath the crowns and to a breaking up of the canopy, a heavy understory of hardwood usually develops in these stands at about fifty years of age, providing abundant deer food. No feeding by deer was observed in pine stands under thirty years old.

The hardwood types together form the greatest part of Petersham's forest cover, but the young stands vary widely from the older ones in point of deer food. These stands below the age of approximately fifteen years furnish abundant browse for the deer. Many of the intolerant species such as sumac and pasture juniper which are present up to this point are later overtopped and disappear. As the stands close in and the lower branches die, deer are unable to reach food in them. These stands are often too densely stocked to allow any except the most tolerant species to grow beneath them until the main crop trees are quite old. Then, as the crowns of some trees wear down, light is admitted enough to bring in advance growth, and deer can again reach browse.

Pine-hardwood usually occurs where stands were cut during unusually favorable years for pine reproduction, or where a pure pine stand has been cut leaving the worthless trees to grow along with the sprout hardwoods. Due to their mixed composition, these stands are often irregular in height and, as a result, produce a good variety of deer foods.

The old field type occurs as land which has been completely abandoned but which has not yet reached the forest stage. Herbaceous growth covers a large part of the type, while shrubs, light-seeded hardwoods, and volunteer pine are usually present. During the fall and early winter the old fields furnish a large part of the deer's food. Apple trees are often abundant, and these are apt to be accompanied by a rank growth of wintergreen, *Gaultheria procumbens,* dwarf raspberry, *Rubus hispidus,* pasture juniper, *Juniperus communis,* and sumac, *Rhus* spp., producing food enough in a small area to support a herd of several animals.

Hemlock-hardwood is found scattered over the town, usually on the more moist sites. The hemlock may or may not form the dominant stand. The type normally occurs on areas which were never clear cut. Due to the varying elements, this type shows more unevenness in canopy than is the case with pure stands of pine or hardwood and so it has a good variety of deer foods. This is one of the two types in which ground hemlock, *Taxus canadensis,* is found in quantity.

The pine-hemlock type occurs commonly on steep rock ledges where moisture conditions are favorable and where the remnant pine was left either by accident or because of inaccessibility. Ground hemlock is found in this type and, in point of the number of important deer foods found in it, this is one of the best.

The Scotch pine plantation type around fifteen years of age was a haunt of the deer during the severe winter, although it might be said in this connection that the species is probably not so important as the topographic location of the plantation and the cover afforded. It could probably just as well have been white pine of the same age. Although this type furnished food for the deer over a period of a week at a time, feeding was confined almost entirely to the openings and borders where hardwood trees and shrubs were present.

The old orchard type is used to describe those areas where the orchards are no longer cultivated or otherwise cared for. This is quite common on abandoned farms throughout the region. From the early trees the apple seed was spread to the surrounding country, and today escape trees are found scattered through practically every forest type. Taken together these trees furnish an abundant supply of food which was found to be very important in both fall and winter.

In any of these forest types, openings have a flora which is similar to that of the old field type.

Table I shows the foods taken by the deer or present in these types and

TABLE I. *Cover types of the town of Petersham and the important deer foods found in them*

Type	% town area	Eleven Most Important Species of Deer Food											
		a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*	Totals
Pure pine	30	X	X		X	X	X	X		X	X	X	9
Young hardwood	25	X	X		X	X	X		0	X	X	0	9
Old hardwood	18	X	X		X	X	0	0	X		0		8
Pine-hardwood	10	0	X		0	0	0	0			0	0	8
Old field	5	X	X		X	X	X	X	0	0	X	X	10
Hemlock-hardwood	1		0	X	0	0	X	X	X		X		8
Pine-hemlock	1	X	X	X	0	X	X	X	X		X		9
Scotch pine plantation	1	0				X	X		X		X		5
Old orchard	trace	X	0		0					0			4
Village and farm	9												
Totals	100	8	8	2	8	8	8	6	6	4	8	4	70

X indicates observed feeding.
0 indicates species present but not observed to be eaten.

a. *Malus* sp. (Apple fruit)
b. *Rubus hispidus* (Dwarf raspberry)
c. *Taxus canadensis* (Ground hemlock)
d. *Gaultheria procumbens* (Wintergreen)
e. *Acer rubrum* (Red maple)
f. *Prunus serotina* (Black cherry)
g. *Tsuga canadensis* (Hemlock)
h. *Corylus rostrata* (Hazelnut)
i. *Rhus hirta* (Staghorn sumac)
j. *Quercus borealis* (Red oak)
k. *Juniperus communis* (Pasture juniper)

the percentage of the total town area occupied by each. These figures are taken from a survey of the town made in 1923 (Averill, Averill and Stevens, '23) and corrected as nearly as possible to the present.

Field Observations

Feeding observations were made during the months from November through March in various parts of the town. All observations were made with snow on the ground and only fresh feeding was considered so there would be no confusion with the work of other animals. The general procedure was to follow tracks and note the species eaten. The greatest number of observations was made in February, followed by January and March. A total of 1,103 feeding observations were made on 62 plant species, as shown in table II. Individual tastes varied to a considerable degree. In one instance two deer traveled for some distance eating only ground hemlock. Another instance showed a deer repeatedly ignoring hazel, while others were noticeably fond of this plant.

Calculations in the table were made on the basis of the total number of observations. An explanation of the method of counting is necessary due to the varied growth forms of the species. In tallying apple fruit, each notation in the table signifies feeding under one tree, as it was impossible to determine how many individual apples were eaten. Browsing was counted by the number of trees or small sprout clumps fed upon. Dwarf raspberry, wintergreen, and other herbaceous plants were counted as one for each patch of plants. Juniper was counted as one for each clump of bushes. The ferns were tallied as single plants. Grass was not an important factor, as the deer did not dig under the snow to get it. It was tallied as a unit wherever fed upon. It is realized that the weight given to a single sprout does not compare to that for the apples often eaten under one tree, but no better method of tallying in the available time was suggested.

As can be seen from the tabulation, red maple was in this instance the most important of the browse species, followed by black cherry, white oak, red oak, and apple (see below). Of the shrubby and herbaceous species, dwarf raspberry is by far the most important, followed in order by wild raisin, hazel, and staghorn sumac. The coniferous trees most heavily browsed were Scotch pine and hemlock. The feeding on Scotch pine is probably given undue weight by many March observations in a temporary "yard" which had as its center a Scotch pine plantation. Both ground hemlock and pasture juniper are important foods, together forming ten per cent of the total feeding observations. Of these, ground hemlock was almost eight and one-half per cent. *Aspidium* followed by rock polypody was most important in the fern group, forming together 2.5 per cent of the total.

It seemed from observation borne out by comparative tallies in one cut-over lot that the extent of browsing on hardwood species was proportional to

the abundance of those species in the stand where the feeding was done. Exceptions to this are noted in the following paragraph. In analyzing the types in which feeding was most prevalent, it was found that nine of the eleven most important species were eaten in the pure pine type; eight were eaten in each of the pine-hemlock and old field types; seven were eaten in the young hardwood type; five in the old hardwood and hemlock-hardwood types; four in the Scotch pine plantation type; and one in the pine-hardwood and old orchard types. To present the picture in a slightly different way, it was found that apple fruit, dwarf raspberry, red maple, black cherry, and red oak were eaten in six of the nine types; wintergreen, hemlock, and hazel were eaten in four types; while ground hemlock, staghorn sumac, and pasture juniper were eaten in only two types. In point of numbers, red maple is undoubtedly the most common tree in the region.

As was to be expected, apples were eaten as long as they were available. The percentages by months show a constant decrease as follows: November, 70 per cent; December, 5.9 per cent; January, 3.2 per cent; February, 1.5 per cent; and in March none was observed to be eaten. Apple browse was not eaten until December, when it showed as 0.4 per cent. Some species were consistently refused in feeding. *Crataegus* sp. was repeatedly ignored. Alder, *Alnus incana*, was not only ignored, but, in one case, red maple sprouts were eaten out of a clump of young alders. *Spiraea latifolia* and *S. tomentosa* were common in old fields but were never observed to be eaten. *Lyonia ligustrina*, which is less common, was also ignored.

The number of miles traveled while on the actual tracks of deer was calculated by months. These are "deer miles," *i.e.*, two deer followed one mile is recorded as two deer miles. This does not include the many miles spent in hunting for tracks or in general observations. In November 13.0 miles were recorded, in December 18.5, in January 14.5, in February 13.5, and in March 1.5. From this it can be seen that the lack of feeding observations in November was not due to the scarcity of deer. At this time the rut was still on and the bucks traveled long distances without feeding. Also, due to this factor, most of the tracks followed were made by bucks. No sure means of identifying sex by a few tracks is known, but at this season a buck was usually pawing the ground, hooking a small sapling, or fighting with another buck. Size and shape of tracks is of some help but is not conclusive and depends somewhat upon the depth and condition of the snow or ground. For this reason the obvious mating signs mentioned above were used as positive proof. Had more does been followed, more feeding might have been observed during November. During the very deep snow in March, the animals could not be located until a group was finally discovered in a Scotch pine plantation. Due to their very restricted movements mileage did not count up very fast during this time. Mileage was determined by means of notes detailing the route covered, which were later converted to distances by means of maps. For this

TABLE II. *Field observations on deer feeding*

Species	Month of Observation					Totals	
	November	December	January	February	March	No.	%
	Per cent of observations						
Broad-leaved trees							
Red maple, *Acer rubrum*		31.4	22.1	12.8	18.8	219	19.9
Black cherry, *Prunus serotina*		3.4	15.7	4.6	14.6	90	8.2
Apple fruit, *Malus* sp	70.0	5.9	3.2	1.5		39	3.5
Apple browse, *Malus* sp		.4	6.4	2.4	4.2	36	3.3
White oak, *Quercus alba*		.8	4.7	4.6	2.1	40	3.6
Red oak, *Quercus borealis*		2.9	5.8	2.0	4.2	38	3.4
Poplar, *Populus* sp		.4	2.0	2.8	2.1	22	2.0
Mountain maple, *Acer spicatum*				4.6		21	1.9
Hard maple, *Acer saccharum*			.3	4.1		20	1.8
Striped maple, *Acer pennsylvanicum*		1.3		2.6		15	1.4
White ash, *Fraxinus americana*		2.5		1.7		14	1.3
Hickory, *Hicoria ovata*				3.0		14	1.3
Chestnut, *Castanea dentata*		.4	2.3	.7		12	1.1
Shadbush, *Amelanchier canadensis*		1.3	.9	.9	2.1	11	1.0
Gray birch, *Betula populifolia*		.8	1.2	.4		8	.7
Choke cherry, *Prunus virginiana*		1.3		.2	8.3	8	.7
Black birch, *Betula lenta*		1.3		.4		5	.5
Paper birch, *Betula papyrifera*		1.7		.2		5	.5
Yellow birch, *Betula lutea*		1.3				3	.3
Beech, *Fagus grandifolia*				.4		2	.2
Cherry, *Prunus* sp		.4	.3			2	.2
Basswood, *Tilia glabra*				.4		2	.2
Hop hornbeam, *Ostrya virginiana*				.2		1	.1
Fire cherry, *Prunus pennsylvanica*		.4				1	.1
Sassafras, *Sassafras variifolium*				.2		1	.1
Broad-leaved shrubs							
Dwarf raspberry, *Rubus hispidus*	30.0	22.2	3.5	1.3		74	6.7
Wild raisin, *Viburnum cassinoides*		1.7	2.9	4.6	8.3	39	3.5
Wintergreen, *Gaultheria procumbens*		2.1	4.7		12.5	27	2.4
Hazel, *Corylus rostrata*				6.3	14.6	36	3.3
Staghorn sumac, *Rhus hirta*		2.9	7.3			32	2.9
Smooth sumac, *Rhus glabra*			3.2			11	1.0
Witch hazel, *Hamamelis virginiana*		.8	.3	1.5		10	.9
Mountain laurel, *Kalmia latifolia*		.8	.6	1.1		9	.8
Alternate leaved dogwood, *Cornus alternifolia*			2.0	.2		8	.7
Diervilla, *Diervilla lonicera*				1.7		8	.7
Dogwood, *Cornus* sp		1.7		.4		6	.5
Sweet fern, *Myrica asplenifolia*			1.5	.2		6	.5
Viburnum, *Viburnum* sp			.3	.4	2.1	4	.4
Red berried elder, *Sambucus racemosa*		.4	.3	.4		4	.4
Sheep laurel, *Kalmia angustifolia*		.4	.3			2	.2

TABLE II. (*Continued*)

Species	Month of Observation					Totals	
	November	December	January	February	March	No.	%
	Per cent of observations						
Broad-leaved shrubs (Cont.)							
High bush blueberry, *Vaccinium corymbosum*		.4	.3			2	.2
Arbutus, *Epigaea repens*			.3			1	.1
Blackberry, *Rubus allegheniensis*		.4				1	.1
Red raspberry, *Rubus aculeatissimus*		.4				1	.1
Low bush blueberry, *Vaccinium pennsylvanicum*		.4				1	.1
Coniferous trees							
Scotch pine, *Pinus sylvestris*				2.8	4.2	15	1.4
Eastern hemlock, *Tsuga canadensis*		.4		2.4		12	1.1
Red pine, *Pinus resinosa*					2.1	1	.1
White pine, *Pinus strobus*		.4				1	.1
Red cedar, *Juniperus virginiana*				.2		1	.1
Coniferous shrubs							
Ground hemlock, *Taxus canadensis*				20.2		93	8.4
Pasture juniper, *Juniperus communis*		1.7	3.5	.4		18	1.6
Herbs							
Aster, *Aster* spp.		.4	1.5	.2		7	.6
Goldenrod, *Solidago* spp.		.8	.9			5	.5
Grasses		.8				2	.2
Bunchberry, *Cornus canadensis*			.3			1	.1
Ferns							
Spiny shield, *Aspidium spinulosum*		3.4	.9	1.3		17	1.5
Rock polypody, *Polypodium virginianum*				2.4		11	1.0
Margined shield, *Aspidium marginale*			.3	.9		5	.5
Cinnamon, *Osmunda cinnamomea*		.4				1	.1
Brake, *Pteris aquilina*			.3			1	.1
Club mosses							
Lycopodium spp.		.4				1	.1
Fungi							
Several wood rotting species			.3	.2		2	.2
Total observations	10	254	377	479	50	1103	
Total percentages	100.0	101.2	100.4	99.8	100.2		100.5

reason the total mileage is probably conservative, as the deer wander a great deal while feeding. No evidence was found indicating that the deer drank from the springs and small streams remaining open while snow covered the ground.

Stomach Analysis

To insure a more complete checking of the species fed upon by the deer and to get the quantitative relations of these foods, stomach analyses were carried out through the five months of the study. No opportunity was available to compare this part of the study with other references, since, as far as could be discovered, no work has been done by any agency on the analysis of deer stomachs from New England. Twenty-four stomachs were secured from within the transition forest zone of the state. The area represented was a belt extending from Tolland and Stockbridge in the southern Berkshires eastward through Montague, Leverett, Erving, Petersham, Barre and Ware to Sterling. It was not easy to get a large number of stomachs, as the annual kill in Massachusetts is small. The absence of snow during the hunting season increased the difficulty of locating stomachs left where deer were dressed in the woods, because no well-defined trails were left where they were taken out. For stomachs taken outside the legal season, game wardens were depended upon to bring in those from deer killed by dogs, automobiles, etc. This resulted in a scarcity of data, especially in January and February, as only one stomach was found in each month. November and March had three each and December had sixteen. The first week in December was the open hunting season.

The stomachs, after remaining in formalin for at least a week, were opened and the contents measured in quarts. One quart was chosen as representative and kept for quantitative analysis. The analysis technique finally developed began with washing small quantities of the material on pieces of ordinary window screen about eight inches square and held in wire frames having handles. This separated out the very fine material. In order to get an idea of what was in the stomach as a means of identifying fragments and to prevent any species present only as a trace from being overlooked, the so-called recognition specimens were sorted out of all the material except the quart kept for detailed analysis. In doing this the washed material was picked over on the screens and only the specimens recognizable or capable of being identified were taken out. Leaves of this latter class were pressed between blotters and dried for future reference. In the case of the quart fully analyzed, the fine material washed through the screen was filtered through a piece of silk stocking to make sure no small seeds were lost. This material was later added to the other unidentifiable remains. In sorting over the material on the screens everything recognizable was picked out and the volume of each species measured in cubic centimeters. The stomachs containing less than a quart had their contents converted to a quart basis for use in the percentage computations. Any unknown specimens were sent to specialists for identification. The average vegetable debris unclassifiable as to genus in all stomachs was 67 per cent. Fawn stomach contents seemed to be much harder to recognize as the average unidentifiable material was 85 per cent.

TABLE III. *Stomach analyses in volumes and percentages by months*

	Months					Totals	
	November	December	January	February	March	Cc.	%
	Per cent of volumes						
Broad-leaved trees							
Apple fruit	85.72	63.94	90.00	8.51	3.42	2549	61.23
Apple browse			.15			6	.15
Hardwood browse		6.32	3.73		9.88	209	5.02
Hard maple		.52				14	.34
Red oak		.48			.38	14	.34
Red maple					2.66	7	.17
Black cherry	1.00	Tr.*				6	.15
White oak		.15				4	.10
				Totals		2809	67.50
Broad-leaved shrubs							
Wintergreen	3.32	7.65			63.49	395	9.49
Dwarf raspberry	1.82	7.83		.35	2.28	231	5.55
Sumac	.17	1.62				35	1.08
Mountain laurel		.22		2.13	.38	13	.31
Wild raisin	Tr.	.15				4	.10
Sheep laurel		.11				3	.07
Witch hobble, *Viburnum alnifolium*		.04				1	.02
Arbutus		Tr.				Tr.	
				Totals		692	16.62
Coniferous trees							
Eastern hemlock		1.69	4.41	88.65	1.14	312	7.49
White pine	Tr.	.55		.35	2.28	22	.53
Pitch pine, *Pinus rigida*					2.66	7	.17
Red cedar					1.90	5	.12
Jack pine, *Pinus Banksiana*					Tr.		
				Totals		348	8.36
Coniferous shrubs							
Ground hemlock	1.49	.88			Tr.	33	.79
Pasture juniper	.17	.07				3	.07
				Totals		36	.87
Herbs							
Grasses	1.49	2.24	1.36	Tr.	.38	75	1.80
Cabbage, *Brassica oleracea*		.96				26	.62
Plantain, *Plantago lanceolata*		.85				23	.55
False miterwort, *Tiarella cordifolia*		.70				19	.46
Hawkweed, *Hieracium* sp	2.49		.34			16	.38
Sorrel, *Rumex acetosella*	.66	.36				14	.34
Partridge berry, *Mitchella repens*	.17	.22			.38	8	.19
Shin leaf, *Pyrola elliptica*	Tr.	.04			1.90	6	.15
Red clover, *Trifolium pratense*	.50	.04				4	.10
Goldthread, *Coptis groenlandica*	Tr.	.04			1.14	4	.10
Pigweed, *Amaranthus* sp		.07				2	.05
Cinquefoil, *Potentilla canadensis*	.17					1	.02
Avens, *Geum* sp			Tr.				
Ragweed, *Ambrosia artemisiifolia*		Tr.	Tr.				
Strawberry, *Fragaria virginiana*		Tr.			Tr.		
Goldenrod		Tr.					
Knotweed, *Polygonum* sp		Tr.					
Canada mayflower, *Maianthemum canadense*		Tr.					
				Totals		200	4.80

* Tr. = Trace.

TABLE III. *(Continued)*

	Months					Totals	
	November	December	January	February	March	Cc.	%
	Per cent of volumes						
Ferns							
Spiny shield	.33	.19				6	.15
Rock polypody	Tr.						
Christmas, *Polystichum acrostichoides*					Tr.		
Cinnamon		Tr.					
Brake		Tr.					
				Totals		6	.15
Club mosses							
Lycopodium obscurum		.07				2	.05
Lycopodium complanatum		.04				1	.02
				Totals		3	.07
Mosses							
Sphagnum, *Sphagnum* sp.					Tr.		
Polytrichum moss, *Polytrichum* sp.		Tr.					
Fungi							
Panus stipticus, *Polyporus elegans*, *Daedalia confragosa*, *Stereum rameale*, *Scleroderma vulgare*	.50	1.91		Tr.	4.56	67	1.61
Lichen							
Unidentified					.38	1	.02
Grand totals							
Per cent	100.00	99.95	99.99	99.99	99.97		100.43
Cu. cm	603	2719	295	282	263	4162	

As shown in table III, a total minimum of 57 species was found in the stomachs. Apple fruit formed 61 per cent of the total volume. Wintergreen, hemlock and dwarf raspberry were next in order with 9, 7, and 5 per cent respectively. By groups, the hardwood trees composed 67 per cent of the total volume, broadleaved shrubs 16 per cent and coniferous trees 8 per cent.

As a monthly average, apple fruit decreased rapidly after January, which appears most logical as the apples are apt to be decomposed or buried under the snow. Unless the snow is too deep, the deer will go to some trouble to dig down to reach them. From December on, the stomachs showed a much higher percentage of hardwood twig and stem material than the earlier ones. The coniferous trees show the same trend. Dwarf raspberry diminishes in amount with increasing depth of snow. Wintergreen shows heavy feeding in March, but most of it came from one stomach. Probably this animal found an exposed patch of the plant and made its last meal on it.

Perhaps the most unusual thing brought out by this study was the amount of fungi eaten, 1.6 per cent of the total. It showed an increasing trend

TABLE IV. *Rating of most important plants in preference by months. Based on a combination of field observations and stomach analyses*

November	December	January	February	March
Foods in order of importance				
1. Apple	1. Apple	1. Apple	1. Hemlock	1. Wintergreen
2. Wintergreen	2. Red maple	2. Red maple	2. Red maple	2. Red maple
3. Dwarf raspberry	3. Dwarf raspberry	3. Staghorn sumac	3. Apple	3. Unidentified hardwood
4. Ground hemlock	4. Wintergreen	4. Hemlock	4. Hazelnut	4. Black cherry
5. ——	5. Unidentified hardwoods	5. Red oak	5. Mountain laurel	5. Hazel

from November to March. The species were largely the woody or corky varieties. These are found on dead or fallen trees and on stumps. Five species of fungi were found in a total of ten stomachs.

Some oddities which cannot be explained except as accidental were chips of wood in three stomachs, a grasshopper wing, a feather, two kinds of insect larvae, a stone one-fourth inch in diameter, several small bright quartz pebbles, and several wadded balls of the animal's own hair. With the exception of the hair, these were probably picked up in ground feeding.

BEDDING

During the whole period of observation the deer showed a strong preference in bedding habits for coniferous forest types. A total of 86 beds were observed, of which 39, or nearly one-half, were in natural white pine stands 15 to 70 years of age. Eighteen, or slightly less than one-fourth were in a Scotch pine plantation, which, for bedding, was essentially the same as the younger white pine stands. Only seven of the total were in hardwood stands or in the open. It appeared that only day beds were found here. This is undoubtedly due to the warmth of the sun's rays in these locations. Day beds in coniferous stands were often on the north side of openings where the sunshine reached the ground.

Usually the beds were placed where the lowest coniferous limbs were from five to ten feet above the ground. There appears to be no attempt on the part of the animal to locate beds where there is any particular degree of visibility. The ears and nose rather than the eyes are apparently relied on to warn the animal of danger. There seems to be no marked preference for bedding on a particular slope. The gradual west slope seemed to be used more than any other, but most of the town has a gradual west slope, so this factor would not appear to be significant. The beds were usually made on knolls rather than in depressions.

TABLE V. *Rating of plants in preference as winter deer food. Based on stomach analyses, feeding observations and judgment of the authors. The species listed as "very important" are ranked in order; but, within the other groups, no effort was made to rate the species*

Very Important

1. Apple fruit
2. Dwarf raspberry
3. Ground hemlock
4. Wintergreen
5. Red maple
6. Black cherry
7. Hemlock
8. Hazel
9. Staghorn sumac
10. Red oak
11. Pasture juniper

Important

White oak
Poplar
Mountain maple
Striped maple
Hard maple
Apple browse
Wild raisin
White ash
Hickory
Chestnut
Shadbush
Black birch
Yellow birch
Witch hazel
Dogwood
Mountain laurel
Sorrel
Partridge berry
Spiny shield fern
Fungi

Occasionally Eaten

Gray birch
Paper birch
Choke cherry
Fire cherry
Bush honeysuckle
Sweet fern
Viburnum
Witch hobble
Arbutus
Highbush blueberry
White pine
Scotch pine
Beech
Escaped cherry
Sassafras
Basswood
Poison elder
Willow
Blackberry
Red raspberry
Lowbush blueberry
Smooth sumac
Pitch pine
Red pine
Red cedar
Sheep laurel
Grasses
Aster
Goldenrod
Bunchberry
Rock polypody
Flowering fern
Shin leaf
Red clover
Goldthread
Five-finger
Margined shield fern
Brake fern
Christmas fern
Club moss

Rarely Eaten

(Includes several species found only as "recognition specimens" in stomachs)

Speckled alder, *Alnus incana*
Snowberry, *Symphoricarpus racemosus*
Jack pine
Cabbage
Plantain
Hawkweed
Pigweed
Avens
Ragweed
Polytrichum moss
Canada mayflower
Strawberry
Speedwell, *Veronica officinalis*
Knotweed
Pinweed, *Lechea* sp.
False miterwort
Sphagnum moss
Lichen—species unknown

Deer Habitat Change

The deer habitat change was very marked in the vicinity of Petersham during the winter. With the fall of the first snow, an effort was made to locate, as nearly as possible, the locality occupied by each small group of deer. During late October and early November when the deer were in the rutting period, they were constantly shifting. With the snows of early December they became rather localized in movement, and it was not difficult to find the local range. At this time, about 23 deer in seven groups, or one to approximately 200 acres, were located and usually observed several times. They appeared to be settled for the winter until the bitter cold weather and deep snows of late December occurred. Groups which had not moved out of an area of 40 or 50 acres during the early part of the month shifted, and for some time no trace of any of them could be found. In the middle of January two deer were found in the southern part of the town, but nightfall and a heavy snow during the night prevented tracking to note their movements. They had been in a thick pine-hemlock stand which bordered a pine cutting of three years previous. The locality in which they were found gave some clue as to the type of cover which they desired at this time of the year. Shortly afterward a trip was made to the town of Erving where a herd of 15 to 20 deer were using Rattlesnake Mountain as their winter range. Dogs were harassing this herd to a considerable degree, and yet they did not move, which led to the belief that such an area was very favorable to the herd under the weather conditions prevalent during the winter. The range was mainly on south and southeast slopes and was covered with young hardwood and occasional clumps of pine and hemlock.

Upon returning to Petersham an area was sought with the features apparently desired. Such a one was found in the southwest part of the town where precipitous ledges on the south and east sides of numerous short parallel ridges gave the proper topography and aspect. The cover was largely pine and hemlock with an admixture of hardwoods. A number of deer were found in this region, the total being about ten. In an effort to secure as much data as possible relative to feeding, these deer were apparently pursued too closely, as they promptly moved. Not until early March when the snow was about two feet deep were any found again, and these were discovered about a mile south of the original point in a fifteen-year-old Scotch pine plantation. Three deer stayed here in an area of about two and one-half acres for at least a week, making the nearest approach to a yard which was observed. Whether they were members of the same group could only be conjectured. Soon after these deer were found, the March thaws set in, making human travel next to impossible and putting an end to observations in the woods.

Since the last tracks seen in several places after the first heavy snowfall headed south and the natural drainage of the town is down the Swift River Valley in that direction, it is presumed that the deer drifted on to the south

with the advent of cold weather; but no field observations were made beyond the town. During early April several deer tracks were noted on the cut-over area mentioned above as the last place where the deer were found in early December. Later observations and conversations with local people indicated that the animals were again back in the early winter ranges by late spring. In order to prove conclusively the deer habitat shift in the town, they would have to be followed over several seasons. It is also likely that they would not shift so far in a milder winter.

Ways in Which Forestry can be Expected to Improve Deer Range in the Region

This study indicates several ways in which forestry can create conditions favorable to the deer in this region. Mixed stands or small areas of hardwoods and softwoods interspersed furnish the variety necessary for food and cover. Apparently fairly dense coniferous stands in protected situations are necessary to hold a herd in a given locality during a severe winter. Planting of conifers with spacings six by six feet may create suitable cover by an age of fifteen years. These plantings should not be in extensive blocks, since they will constitute a practical desert for many years as far as game food is concerned. As these stands get older, thinnings allow more hardwood advance growth to come in, thus increasing the amount of winter deer food available. In young hardwood stands or in coniferous plantations on cut-over land, weeding to improve composition and form of the crop trees produces an abundance of the young sprouts on which the deer so largely depend during winter. The importance of the usual three weedings necessary to develop a satisfactory young stand on cut-over land and which result in young sprouts available over a period of ten to fifteen years can easily be seen. Hardwood sprouts in dense stands which are not weeded normally pass the point of furnishing much in the way of browse for deer in from six to ten years. Also, the creation of a wealth of young, tender sprouts tends to attract the deer away from the crop trees which are more difficult to reach and apparently less palatable. Sustained yield management of a given tract results in periodic cuttings which can be distributed over the area in such a way as to furnish the requisite interspersion of age classes for good deer range. Thrifty apple trees should be favored in weedings and thinnings. Fire line and road margins sown to clover or other plants relished by the deer can furnish abundant summer and fall food.

Summary

1. The study was made between November, 1933 and March, 1934 mainly in the town of Petersham which lies in the transition forest region of north-central Massachusetts.

2. The winter covered by the study was one of the most severe known in the region. Temperatures down to — 35° F. were recorded in the town and

the November–March snowfall was 87.75 inches compared to the past ten year average of 52.25 inches. The ground was snow covered from early December until late March.

3. Descriptions are given for nine cover types used by the deer during the winter and table I summarizes the more important deer foods present in each.

4. A total of 1,103 feeding observations were made on 62 plant species.

5. Individual tastes among the animals were found to vary widely.

6. Among the broad leaved trees red maple was the most important food species taken followed by black cherry, white oak, red oak and apple. Of the shrubs and herbaceous species dwarf raspberry was most used followed by wild raisin, hazel and staghorn sumac. The coniferous trees most heavily browsed were Scotch pine and hemlock that in Scotch pine being influenced by the presence of partial yarding of animals in a plantation of this species. Ground hemlock and pasture juniper were important also. *Aspidium* and rock polypody were most important in the fern group.

7. The extent of browsing on hardwood species seemed, in general, to be proportional to the abundance of these species in the stand where the feeding was done.

8. Of the eleven most important species observed to be eaten nine were found in the pure pine type, eight each in the pine-hemlock and old field types, seven in young hardwood, five each in old hardwood and hemlock-hardwood, four in the Scotch pine plantation and one each in the pine-hardwood and old orchard types.

9. Apple fruit was eaten whenever available decreasing from 70 per cent of the feeding observations in November to 1.5 per cent in February.

10. Species ignored in feeding were *Crataegus* spp., *Alnus incana, Spiraea latifolia, Spiraea tomentosa* and *Lyonia ligustrina.*

11. Twenty-four deer stomachs were collected between November and March from the transition forest region of central and western Massachusetts and their contents analyzed. Analysis methods are described.

12. A total of 57 species were identified from the stomachs. Apple fruit formed 61 per cent of the total food volume. Wintergreen, hemlock and dwarf raspberry were next in order. Hardwood tree species including apple produced 67 per cent of the total volume, broad leaved shrubs 16 per cent and coniferous trees 8 per cent.

13. The amount of apple fruit in the stomachs decreased rapidly after January while the amount of hardwood and coniferous browse increased after December.

14. A monthly rating of the five most important winter foods is given.

15. Wood rotting fungi formed 1.6 per cent of the total stomach contents.

16. Based on all the information available from the study, a rating of plants in preference as winter food was made separating them into four groups.

17. During the winter the deer showed a very strong preference for coniferous types for their beds.

18. The deer in the town shifted their habitat with the onset of deep snow and severe cold, but no real yards were found.

19. From the standpoint of deer, mixed stands or good interspersion of conifers and hardwoods are most desirable.

20. Thinnings, weedings and periodic cuttings produce a wealth of winter deer food in the locality studied.

21. Apple trees should be left to produce food for the deer wherever possible.

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