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THE BIOLOGY, WILDLIFE USE AND MANAGEMENT OF SUMAC IN THE LOWER PENINSULA OF MICHIGAN

By

Hanley Kerfoot Smith

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ABSTRACT

THE BIOLOGY, WILDLIFE USE AND MANAGEMENT OF SUMAC IN THE LOWER PENINSULA OF MICHIGAN

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The purpose of this study was to evaluate critically three similar plants, staghorn sumac (*Rhus typhina* Torner), smooth sumac (*Rhus glabra* L.), and a hybrid sumac (*Rhus typhina>glabra*), in regard to their biology, their importance to wildlife and their potential use in wildlife management programs. These species were chosen for study because they were heavily utilized wildlife food plants and because their abundance in Michigan was believed to be threatened by recent changes in that area's agricultural and forest land-use practices.

The principal study area comprised four square miles located in the Manistee National Forest in northern Lower Michigan (about 17 miles west of Cadillac, Michigan). This area was characterized by well drained podzol soils, second-growth northern hardwoods, cold winters and mild summers, with fairly evenly distributed precipitation. Field and nursery experiments were also conducted in southern Lower Michigan, near the Michigan State University campus at East Lansing. This region, about 120 miles SSE of the study area, was characterized by podzolic soils, oak-hickory and beech-maple forest associations, and a more moderate climate than that of the study area. The study began in November 1966, and terminated in August 1969.

Taxonomic studies revealed that the sumac species on the study area may have been a hybrid of smooth and staghorn sumac. It was demonstrated that the suspected hybrid was intermediate in key taxonomic characters to smooth and staghorn sumac. Additionally, it was demonstrated that cross fertilization can occur between smooth and staghorn sumac. The specimens on the study area were therefore designated as *Rhus typhina*> *glabra*.

It was found that the four square miles of the study area contained thirty-three separate concentrations of sumac, covering an area of 28.7 acres. Virtually all of the sumac occurred on abandoned farmlands which had been planted to red pine (*Pinus resinosa*) within the past ten years. The most common woody associates were *Rubus allegheniensis*, *Fragaria virginiana*, *Quercus rubra*, *Rhus copallina*, *Amelanchier arborea* and *Populus tremuloides*. The most common herbaceous species in sumac areas were *Antennaria plantaginifolia*, *Anaphalis margaritacea*, *Asclepias syriaca*, *Physalis heterophylla*, *Rumex acetocella* and *Solidago canadensis*. The cryptogamic layer was characterized by the mosses *Polytricum juniperinum* and *Ceratodon purpureus*.

Considerable differences were found in the productivity, in terms of numbers of fruits and stems, among the various groups of sumac on the study area. Data gathered in the summer of 1968 by randomly placed quadrats indicated that the 28.7 acres of sumac produced about 2,300 pounds (oven-dry weight) of fruit and 400 pounds (oven-dry weight) of stem tips. Only fruits greater than 3 inches in length and the first 2.5 inches of each stem were considered in these estimations.

Forty-nine percent of the plants on the study area were one year old, and ninety-five percent were five years old or less; the oldest being 20 years old. Sumac was demonstrated to approach maximum productivity, in terms of numbers of fruits and stems, at about seven years, but there were insufficient data to reach a conclusion about the age at which productivity begins to decline. Some fruits were produced on two-year-old plants but significant fruit production did not begin until the fourth year.

An extensive literature survey revealed that smooth and staghorn sumac are important wildlife food species throughout their ranges. These plants appear to be of most significance in the diets of white-tailed deer (*Odocoileus virginianus*), cottontail rabbits (*Sylvilagus floridanus*), sharp-tailed grouse (*Pediocetes phasianellus*) and ruffed grouse (*Bonasa umbellus*). The plant was shown to be heavily browsed by white-tailed deer on the study area from November through March. In the winter of 1968-69 approximately half of the stems on the study area were browsed, totaling about 200 pounds (oven-dry weight) of sumac stems or about seven pounds of stems browsed per acre of sumac. The average stem length browsed was 2.4 inches. All of the sumac fruit on the study area were browsed in the winter of 1968-69. This totaled about 2,300 pounds (oven-dry weight) of fruit, or about 82 pounds of fruit of sumac browsed per acre. When a sumac fruit was browsed, the entire fruit was eaten.

The stems and fruit of smooth, staghorn and the hybrid sumac were analyzed for nutrient composition, and the apparent digestibility of the fruit of smooth sumac was determined. Sumac stems and fruits were low in crude protein, high in ether extract, and similar in gross energy as compared on an oven-dry weight basis to three other Michigan deer browses: northern white cedar, jack pine, and big-tooth aspen. Six deer were fed a diet consisting only of smooth sumac fruits. The digestibility data obtained indicated that sumac fruits were a good energy source, but a poor source of protein, compared, on a dry-weight basis, to sprays of northern white cedar.

It was found that sumac is rather easily grown from seed, and that it may be transplanted with a high rate of success. Mowing was also demonstrated to be an acceptable method of reclaiming, as a deer browse, clones which had exceeded the reach of deer.

ACKNOWLEDGEMENTS

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INTRODUCTION

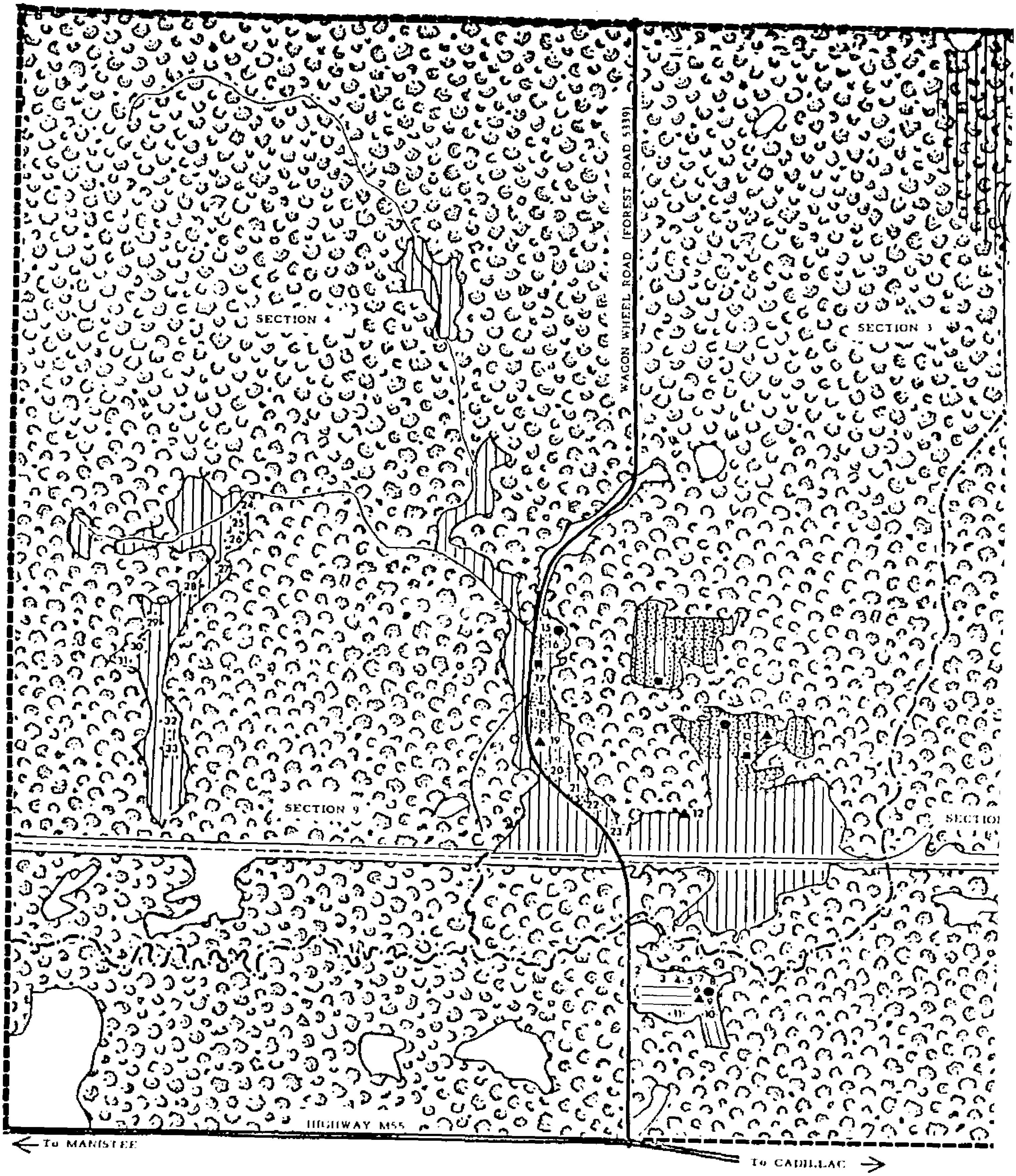
The purpose of this study was to evaluate critically three similar plants, staghorn sumac (*Rhus typhina* Torner), smooth sumac (*Rhus glabra* L.), and a hybrid sumac (*Rhus typhina*>*glabra*), in regard to their biology, their importance to wildlife and their potential use in wildlife management programs. These species were chosen for study because they were heavily utilized wildlife food plants and because their abundance in Michigan was believed to be threatened by recent changes in that area's agricultural and forest land-use practices.

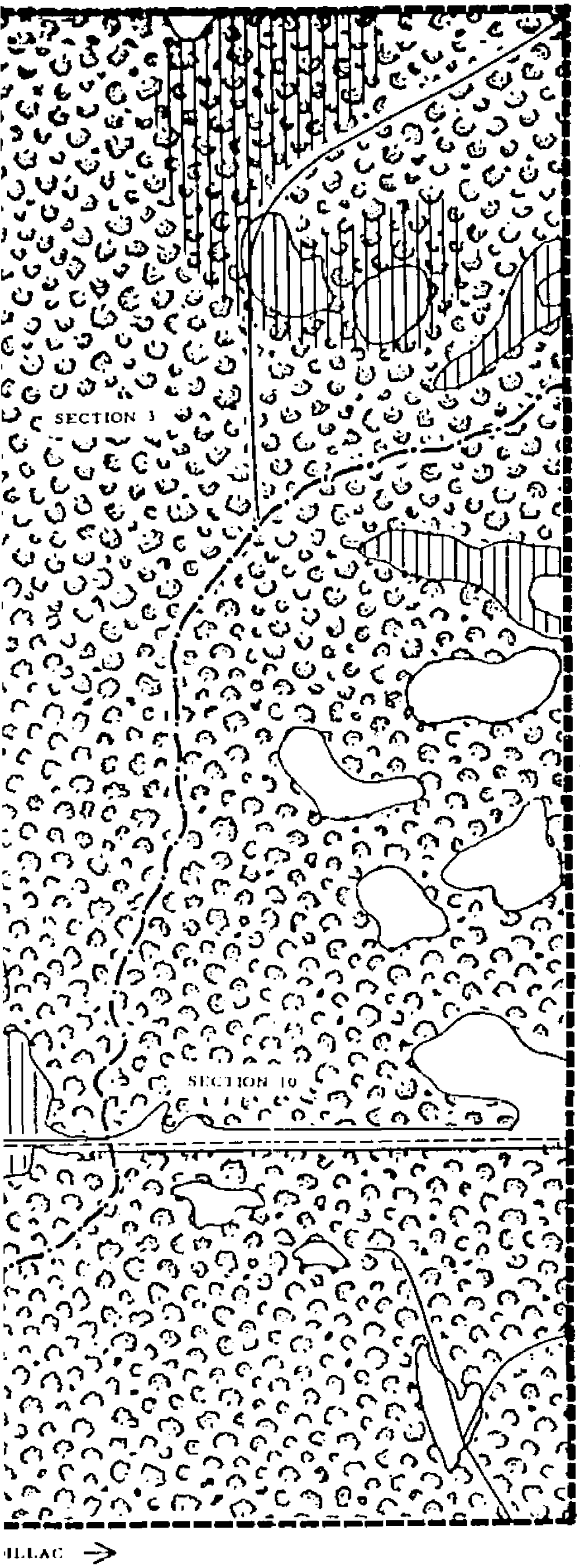
The study is presented in four sections: the general biology of the plant, its use by wildlife, its nutritional value, and nursery and establishment techniques. Although the topics are discussed separately, each is meant to complement the others. Hopefully, this study will present a perspective which wildlife biologists and foresters may use in evaluating the importance of sumac in their land management programs.

Study Area

The principal study area comprised four square miles (T21N-R12W, sections 3, 4, 9 and 10) in the Manistee National Forest in Wexford County in northwestern lower Michigan (Figure 1). Characteristic topographic features of this region are hilly moraines dissected by small streams. The sumac on the study area is found on Blue Lake and Kalkaska sands. Both soils are well drained podzols developed on glacial drift, originally supporting northern hardwoods, hemlock and white pine.

Figure 1. Map of the study area.


WAGON WHEEL ROAD (FOREST ROAD 5339)
SECTION 4
SECTION 3
SECTION 9
HIGHWAY M55
To MANISTEE
To CADILLAC



THE STUDY AREA, 1969

T. 21 N., R. 12 W., Michigan Meridian
Sections 3, 4, 9, and 10
Wexford County, Michigan

LEGEND

Northern hardwood forest................................

Forest opening..

Forest opening planted to pine since 1958...............

Sumac area.. 18

Study plots:

100' x 50' permanent browse plot.................. ■

fruit duration study.............................. ●

length of stem browse study....................... ▲

Study area boundary.....................................

Hard surfaced road......................................

Improved maintained road................................

Unimproved road...

Stream..

Powerline...

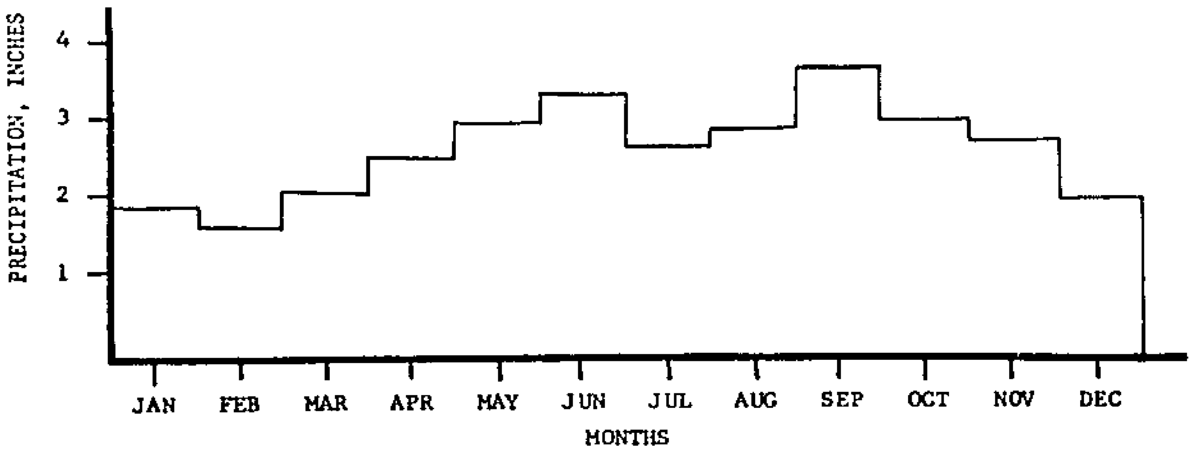
1320'

Blue Lake soils differ from Kalkaska soils in that the former possess a Bt horizon and fine textural bands in the subsoil (personal communication, H. L. Weber, U. S. Soil Conservation Service, Traverse City, Michigan).

The climate of this region of Michigan is characterized by cold winters and mild summers, with fairly evenly distributed precipitation. Climatological data from the U. S. Weather Bureau at Cadillac, 18 miles east of the study area, are summarized in Figure 2. The area averages 110 freeze-free days per year, with the last freeze usually occurring between May 20 and May 30 and the first freeze usually occurring between September 10 and September 20 (Eichmeier *et al.*, no date). Average annual precipitation is 30.8 inches; 8.4 inches being the water equivalent of the 60.2 inches of annual snowfall.

Of primary interest in this study were the abandoned farmlands on which the sumac was found. These openings comprised about seven percent of the area, the remainder being medium to well stocked stands of aspen and northern hardwoods. Berner (1969) listed the following as common trees in the area: American elm, black ash, white ash, red maple, sugar maple, big-toothed aspen, quaking aspen, basswood, red oak and black cherry. Ubiquitous in the forest openings were plantations of red pine, white pine, and white spruce. These plantations, which covered nearly 400 acres, had been established since 1961.

Many field and nursery experiments with sumac were conducted in Ingham, Shiawassee and Clinton Counties near the Michigan State University campus at East Lansing. This region, about 120 miles SSE of the study area, is characterized by a more moderate climate than that of the study area, podzolic soils, and oak-hickory and beech-maple forest associations.



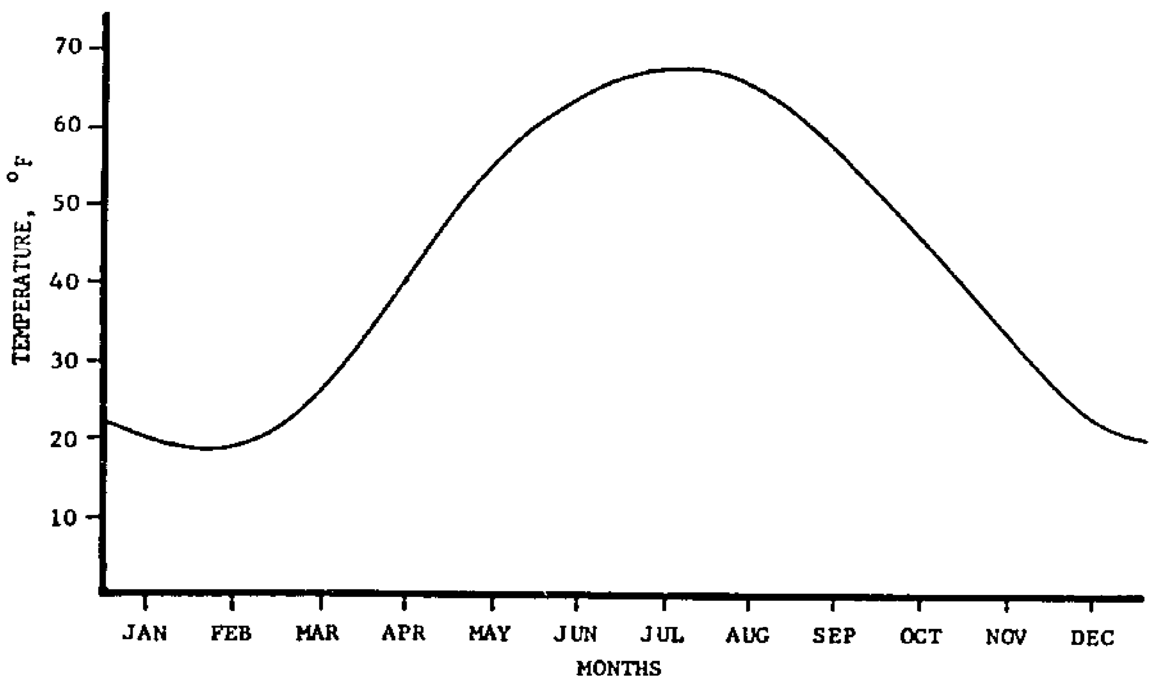


Figure 2. Average monthly precipitation and temperature at Cadillac, Michigan (Climatological Data, Michigan, 1928-1962).

BIOLOGY OF THE PLANT

Range

Smooth sumac is native throughout southern Canada, and all of the 48 contiguous states, except California. Staghorn sumac occurs naturally from Nova Scotia south to North Carolina, and west to Minnesota and Iowa (Barkley, 1937; West and Arnold, 1956). Additionally, these plants have been widely introduced in the United States and southern Canada as ornamentals and for erosion control (Boyd, 1943b). Staghorn sumac is cultivated in Europe and Asia where it is a source of tannin (Baczuk and Bukiewicz, 1961; Quraishi *et al.*, 1964).

Site Requirements

Both species are pioneer shrubs or small trees usually found in open areas on well drained sands and sandy loams. Typical sites include abandoned fields, roadsides, railroad rights-of-way, fence rows, burned or denuded areas, and young forest plantations (Bingham, 1937; Boyd, 1943b; Clements, 1920; Dice, 1923; Hirth, 1959; Verts, 1957). Smooth sumac is characteristic of the forest-prairie ecotone of the midwestern United States (Bray, 1960; Ewing, 1924; Shelford and Winterringer, 1959), and both species are common on the abandoned farmlands of the northeastern United States and southeastern Canada (Hirth, 1959).

Taxonomy

Rhus typhina and *Rhus glabra* are quite similar morphologically, the principal differences being that the fruit and stem of the former are densely pubescent, while those of the latter are glabrate or nearly so. Several authors have suggested that they may hybridize, but this has never been proved (Barkley, 1937; Green, 1906; Little, 1945; Sargent, 1891). Both species are polymorphic and have been subjected to considerable nomenclatural subdivision. As a result, three names, which may represent hybrids of *Rhus typhina* and *Rhus glabra*, remain in the literature today: *Rhus pulvinata* Green, *Rhus borealis* Green, and *Rhus glabra var. borealis*. The sumac species on the study area was a hybrid and was described adequately by any of these latter names.

Two approaches were used to determine the taxonomic position of the sumac plants on the study area. The first was cross-fertilization between staghorn and smooth sumac and the second was the development of a hybrid index.

In June of 1969, ten pistillate flowers of *Rhus typhina** and ten pistillate flowers of *Rhus glabra** were covered with white, water-resistant paper bags prior to their blooming. When the flowers of each began to open, they were dusted with the pollen of the opposite species. The lower flowers of the inflorescence opened first, with about a six-day period between the first and last bloom on each stem. The flowers were dusted each day that they were observed to be in bloom, and the stems were unbagged only during the few moments that were required to dust them. These plants are believed to be insect pollinated (Heimsch, 1940) and care was taken that they not be contaminated by insects during the dusting process. Viable seed stock has been obtained from the crosses, indicating that the two species can hybridize.

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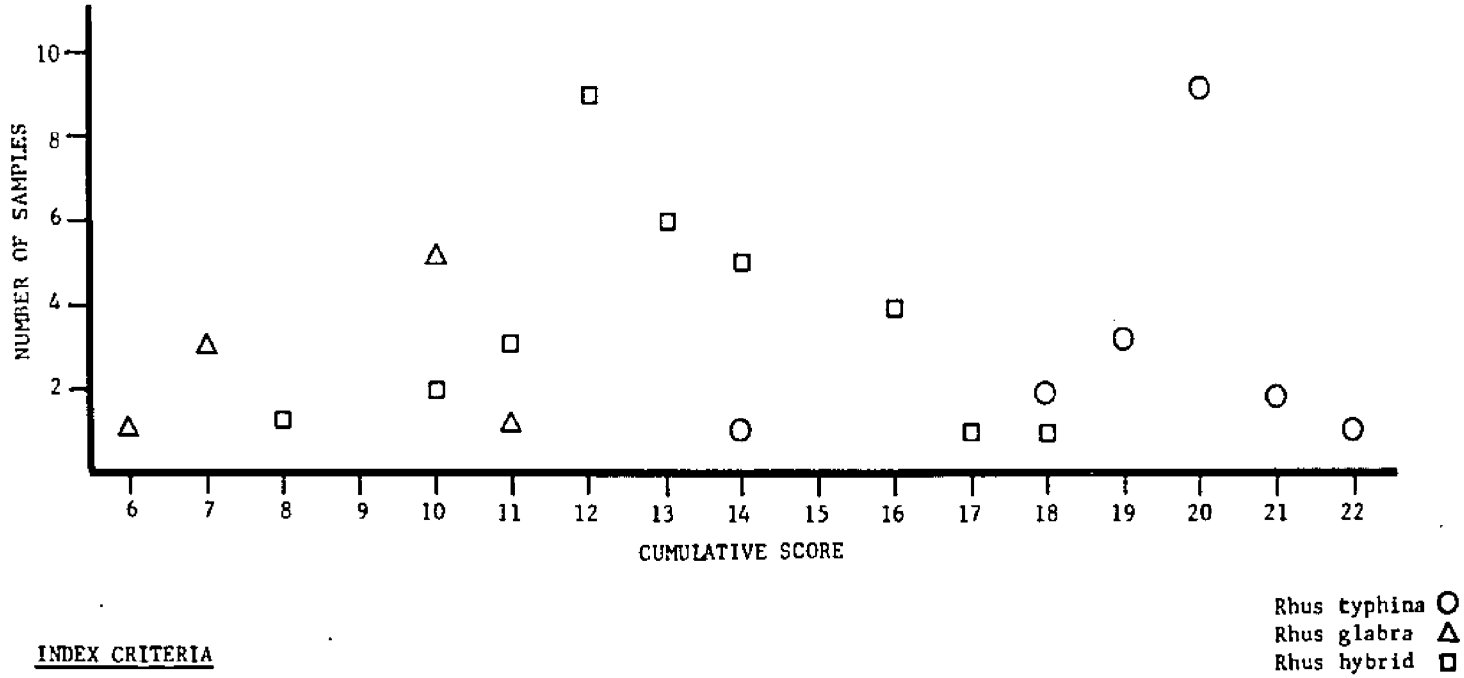
*The experimental clones were located in Ingham County, T3N-R1W-S6, and vouchers of each clone were deposited in the Beal Herbarium, Michigan State University.

The hybrid index, as discussed by Anderson (1949) and Rollins (1957), provides a semiquantitative method of ranking suspected hybrids. Contrasting characters are chosen on the parent species and these characters are given numerical scores, with an intermediate score provided for characters that are common to both. An index results when the scores of several specimens are summed. Five contrasting characters were chosen for smooth and staghorn sumac: (1) the length of the pubescence on the fruit, (2) the presence or absence of an abscission zone on the fruit stalk, (3) the density of the pubescence on the stem, (4) the length of the pubescence on the stem, and (5) the density of the pubescence on the petiole. Seventeen specimens identified as *Rhus typhina* and ten identified as *Rhus glabra* from the Beal Herbarium at Michigan State University were scored and used as standards for their species. Forty specimens, randomly collected on the study area, were also scored. The results appear in Figure 3. According to the descriptions of Barkley (1937), the monographer of the genus *Rhus*, *Rhus glabra* would receive a score of seven or less and *Rhus typhina* would have a score of 16 or more. The names assigned to some of the museum specimens, those with intermediate scores, did not correspond to their accepted descriptions, indicating that they were hybrids that had been misidentified. The characters of the specimens collected on the study area appear to be intermediate to those of *Rhus typhina* and *Rhus glabra*. The forty specimens from the study area had a mean score on the hybrid index of 13.4 and were thus judged to demonstrate a tendency toward greater expression of the characters of *Rhus typhina*.

These observations suggest that the plants on the study area are a hybrid swarm. The symbol ">" has been suggested by Li (1957) to



INDEX CRITERIA

A. Length of hair on fruit (mm.)

fruit (mm.)	Score
< 0.25	1
0.25 - 0.50	2
0.50 - 1.00	3
1.00 - 1.50	4
1.50 - 2.00	5
2.00+	6

B. Abscission zone on fruit stem

fruit stem	Score
obvious	1
obscure	2
none	3

C. Density of hair on stem (mm.)

stem (mm.)	Score
none	1
scant	2
medium	3
heavy	4

D. Length of hair on stem (mm.)

stem (mm.)	Score
no hair	1
< 0.50	2
0.50 - 1.00	3
1.00 - 1.50	4
1.50 - 2.00	5
2.00+	6

E. Density of hair on petiole

petiole	Score
none	1
scant	2
medium	3
heavy	4

Figure 3. A hybrid index, demonstrating the expression of the taxonomic characters of *Rhus glabra*, *Rhus typhina*, and a suspected hybrid sumac.

indicate the probable direction of gene flow in an introgressant population. From the information available, I have designated the sumac population on the study area as *Rhus>typhina glabra* (Figure 4).

Phenology

Sumac in southern lower Michigan remains dormant until about the first week in May, when bud elongation occurs. *Rhus glabra* and *Rhus typhina* flower concurrently during the latter part of June and the first two weeks of July. The first fruits appear in mid-July and are ripe by mid-September. The phenological events of the sumac on the study area occur about one week later than the corresponding events in Ingham County, 120 miles to the south. Gilbert (1961) has fully documented the phenology of sumac in southern Michigan.

Reproduction, Root System and Growth Form

Although sumac plants produce an abundance of seeds, reproduction occurs primarily by root sprouts. The root system spreads laterally from the center, frequently branching and sending up shoots. Duncan (1935) found that *Rhus copallina* roots spread outward at a rate of about 24 inches per year. Gilbert (1959) reported that the annual spread of several smooth and staghorn sumac clones varied from 27 to 76 inches. Sumac roots are primarily shallow, but some plants have been found to send tap roots as deep as 90 inches (Weaver, 1919).

Fifteen small clones were excavated on the study area in August of 1967. Most of the roots were found from just below the surface litter to a depth of about 4 inches, but a few were traced to depths of almost 36 inches. In all cases some part of the root had been severed by a plow when the area was planted to pine. Five clones

Rhus typhina

Rhus typhina>glabra

Rhus glabra

Figure 4. Stem and fruit of *Rhus typhina*, *Rhus glabra*, and their hybrid *Rhus typhina>glabra* (X 2/3).

which are considered illustrative are diagrammed in Figure 5. Stems arise from swollen nodes along the roots. The fact that new stems may arise from dormant root system is demonstrated by the presence of long-dead aerial portions on the same root as one-year-old plants. Several of the older, rotten nodes had been colonized by ants.

The aerial portions of an undisturbed sumac clone are characteristically pyramidal with the oldest and tallest stems in the center. The stems sprout centrifugally until the clone is about 15 years old, at which time it loses vigor and the spread of new stems slows, while the older center stems die (Gilbert, 1966). In contrast, the sumac stems on the study area do not demonstrate a consistent size structure because virtually all of the clonal root systems have been fragmented by a pine planting plow. The possibilities of propagation by root cutting are discussed briefly in a later section.

Diseases and Insect Infestations

Sumac is of limited economic importance in the United States, and consequently reports of its diseases are rather uncommon in the literature. Judd (1963) reported infestations of the red pouch gall *Melophis rhois* on sumac in Ontario. Pirone *et al.* (1960) noted that several species of sumac are known to be infected by fungi of the genera *Pileolaria, Fusarium, Cryptodinporthe, Physalospora, Verticillium,* and *Sphaerotheca.* Heavy infestations of the chalcid fly *Idiomacromerus bimiculupemis* were found in smooth sumac fruits by Lovell (1964) in Kansas. Lovell also noted that a fungus of the genus *Pythium* commonly infected sumac seedlings raised in the laboratory.

In the summer of 1968, nearly 20 percent of all one-year-old stems on the study area were infested with the mite *Eriophyes rhois*

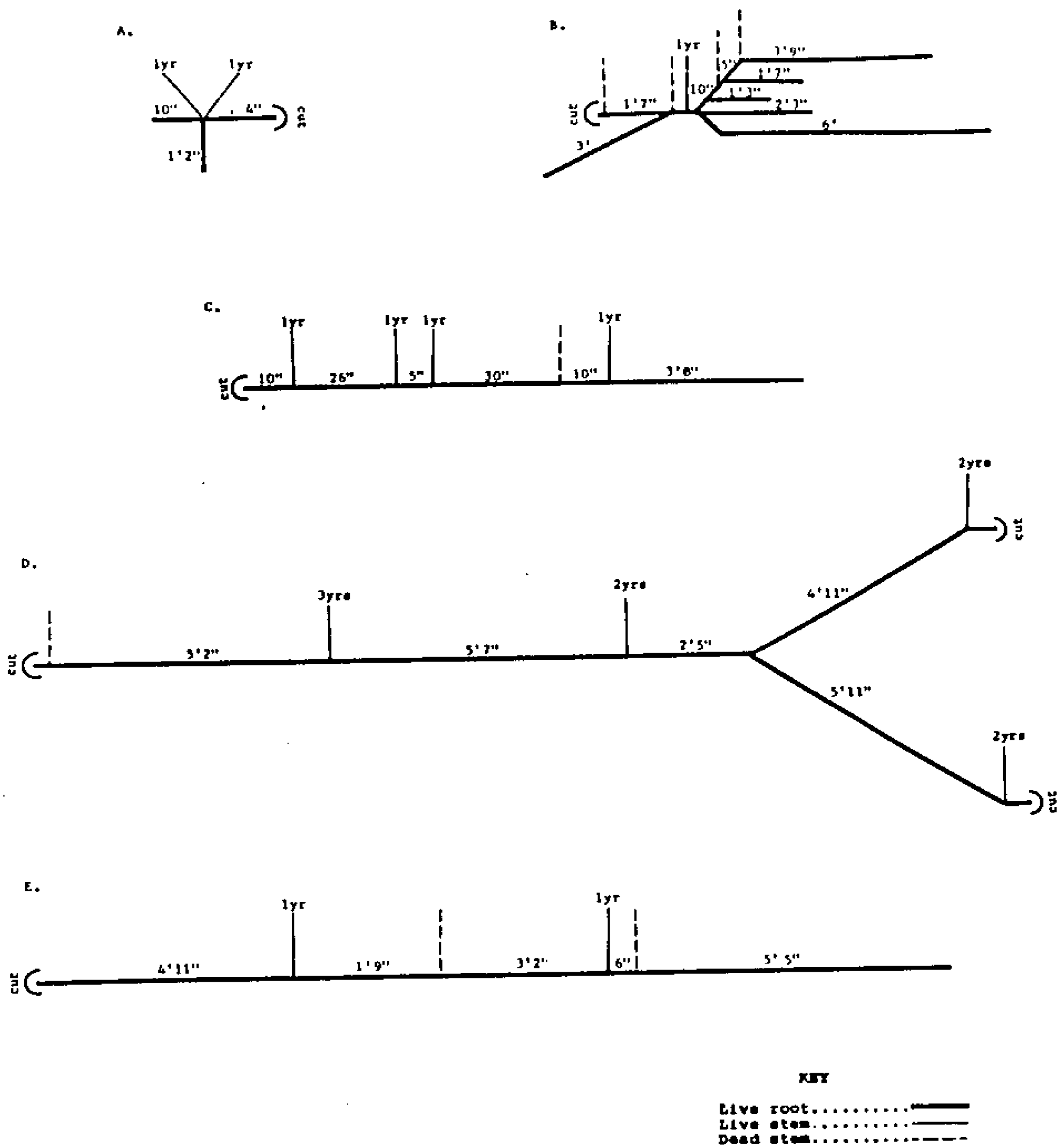


Figure 5. Diagrammatic drawings of the root systems of five sumac clones.

(Eriophyidae: Acarina). The disease was characterized by the deformation of leaves, the fleshy proliferation of tissues and the production of extremely aberrant foliage (Figure 6). The aerial portion of a plant infested with this mite dies, and is not browsed by deer. In some parts of the study area this disease approached a 100 percent infestation. I have also noticed this disease on museum specimens of *Rhus typhina* from New Hampshire and Massachusetts.

The larval stage of the moth *Holcocera chalcofrontella* (Blastobasidae: Lepidoptera) was observed to cause extensive damage to the fruit of staghorn sumac. Eight of ten randomly selected clones in Ingham County had sustained damage to more than 90 percent of their fruits from this insect in 1969. The larvae were found to be active in the fruits during the months of September and October, eating the fruit coats of the inner fruits, and leaving the inflorescences appearing outwardly undamaged. This insect and the mite previously discussed were identified by Dr. W. E. Wallner of the Entomology Department at Michigan State University.

It is believed that this is the first report of members of the genus *Rhus* being infested by either *Holcocera chalcofrontella* or *Eriophyes rhois*. However, *E. rhois* has been reported to infest another species of the family Anacardiaceae, *Toxicodendron radicans* (Felt, 1940).

Considerable problems resulted from the girdling of the hypocotyl of seedlings which were planted in unsterile soils in the laboratory. The disease was believed to be caused by a "damping off" fungus of the genus *Pythium*, but this was not verified. The girdling was easily prevented by dusting the seeds and seed bed with Captan, a commercial fungicide.

Figure 6. Stem and foliage of a normal sumac plant (r) and a sumac plant infested with the mite *Eriophyes rhois* (1).

Plant Associates, Productivity and Age Structure

In the summers of 1967 and 1968, the four square miles of the study area were thoroughly searched in order to locate the main sumac areas. Thirty-three separate sumac concentrations were found on the study area and these are indicated on Figure 1. For convenience, these separate concentrations are combined into five groups (A through E) on the basis of their proximity and the similarity of sites (Table 1).

Table 1. Size and grouping of sumac concentrations on the study area

Group	Area Number	Size (ft^2)	Group	Area Number	Size (ft^2)	Group	Area Number	Size (ft^2)
A	1	2,300	C	14	409,800	E	24	12,500
	2	9,000	Total		409,800		25	9,200
	3	10,400					26	5,000
	4	3,800					27	5,400
	5	5,800	D	15	5,600		28	6,300
	6	2,400		16	25,000		29	11,200
	7	13,500		17	12,600		30	7,400
	8	3,700		18	68,900		31	6,200
	9	16,400		19	7,500		32	5,500
	10	6,500		20	10,200		33	7,800
	11	6,500		21	4,800	Total		76,500
Total		80,200		22	26,000			
				23	6,800	Total sumac area		
			Total		167,400	in acres = 28.72		
B	12	3,100						
	13	514,500						
Total		517,600						

Groups A, D and E were each sampled by 60 milliacre plots, while Groups B and C were each sampled by 70 milliacre plots. The plots were square and randomly placed within each sumac area. The frequency and number of all woody species were recorded for each plot. The frequency by species of all herbaceous plants was noted in 100 plots randomly chosen from the total run. All sumac plants in the plots were aged and their height and stem lengths measured. Additionally, the numbers of fruiting, non-fruiting and diseased stems were tallied. Only those plants rooted in the plot were considered in any of the tallies.

The cryptogram layer in the sumac areas was measured by 19 randomly placed 60-foot line intercepts. The 60-foot line was composed of two perpendicular 30-foot lines crossed at the midpoint of each line. Only that portion of the ground cover actually traversed by the line was tallied.

Plant Associates: The frequency and density of woody plants growing in the sumac areas are presented in Table 2. *Rubus allegheniensis*

Table 2. Woody plants growing in association with sumac, as determined by 180 randomly chosen milliacre plots[+]

Species	Frequency (Percent)	Stems/ Acre
Rubus allegheniensis	22.2	*
Pinus resinosa	26.1	261
Quercus rubra	2.7	44
Rhus copallina	2.2	311
Amelanchier arborea	2.2	22
Populus tremuloides	1.6	27
Prunus serotina	1.1	11
Ulmus americana	0.5	16
Prunus virginiana	0.5	5
Fraxinus americana	0.5	5

Percent of plots with no woody plants except sumac: 49.4

[+]Source of botanical nomenclature: Gleason and Conquist, 1963
*Not counted

was by far the most common woody species, often exceeding 50 plants per plot, but because of time considerations the actual number of *Rubus* was not determined. *Pinus resinosa*, representing stock that had been planted during the previous ten years, was the next most common woody species. The eight remaining shrubs and trees were rather infrequent on the sumac areas and rarely reached a height of three feet there. Almost half of the plots were completely devoid of any woody species except sumac. The herbaceous layer consisted of 24 species, the most conspicuous of which were *Asclepias syriaca* and *Solidago canadensis* (Table 3). The cryptogamic layer was characterized by the mosses

Table 3. Frequency of herbs growing in association with sumac, as determined by 100 randomly chosen milliacre plots+

Species	Frequency (Percent)
Antennaria plantaginifolia	74
Anaphalis margaritacea	70
Asclepias syriaca	55
Physalis heterophylla	35
*Fragaria virginiana**	28
Rumex acetocella	27
Solidago canadensis	27
Hypernicum punctatum	21
Ambrosia artemisiifolia	18
Erigeron canadensis	14
Hieracium aurantiacum	12
Prunella vulgaris	12
Tragopogon dubius	11
Solidago sp.	7
Ranunculus septentrionalis	6
Anemone cylindrica	5
Pteridium aquilinum	3
Hieracium gronovii	2
Hieracium florentium	2
Apocynum cannabium	1
Erigeron annuus	1
Centaurea maculosa	1
Achillea millefolium	1
Vicia cracca	1

+Source of botanical nomenclature: Gleason and Cronquist, 1963
*Treated with herbaceous layer

Polytricum juniperinum and *Ceratodon purpureus*. The most common lichen was *Cladonia arbuscula*, followed in descending order by *C. chlorophaea*, *C. pyxidata* and *C. cristatella*. The ground cover was found to average four percent bare soil, fourteen percent mosses and lichens, and eighty-one percent grasses, litter and herbs.

Productivity: A compilation of the sumac productivity data collected in August of 1968 is presented in Table 4. Group A was the least productive area, perhaps because it was the only area that had not been disturbed by the pine planters' plow. Groups B and C were by far the largest and most homogeneous areas. Group B was also the most productive group, possibly because it was the only area with a predominantly southern aspect. It should be noted, however, that the effect of slope on sumac growth was not analyzed in this study.

A high proportion of the stems in Groups A, B and C were infested with the mite *Eriophyes rhois*, while relatively few of the stems in Groups D and E were diseased. Ninety-eight percent of the infested stems were one year old, and the remaining two percent were two years old. No explanation was found for the discrepancies in disease occurrence by group or age.

Considerable differences were seen between the per acre weights of stems and fruits of the various groups. These differences probably reflect the density, vigor and age structure of the sumac populations represented. Additionally, the differences seen between fruit weights could be a result of an unequal distribution of pistillate clones.

In terms of wildlife management, fruit and stem production are most important. The data in Table 4 indicate that the 28.7 acres of sumac on the study area in 1968 produced about 2,300 pounds (oven dry weight) of fruit

Table 4. Productivity of sumac groups on the study area in August of 1968

Group	Acres	Number of Plots	% Area Sampled	Plants/[1] Acre	Browse[2] Stems/ Acre	Diseased[3] Stems/ Acre	Good[4] Fruits/ Acre	Poor[5] Fruits/ Acre	Total[6] Stems/ Acre	Weight/[7] Acre (lbs.) a) Fruit	b) Stems
A	1.84	60	3.15	8,565	7,785	1,942	1,776	166	11,670	50	11
B	11.88	70	0.58	13,213	11,611	3,203	3,632	57	18,504	102	16
C	9.40	70	0.74	10,467	7,851	2,574	2,102	320	12,847	59	11
D	3.84	60	1.56	7,480	9,379	183	2,616	750	12,928	73	13
E	1.76	60	3.42	10,873	13,214	697	2,839	282	17,032	80	18

[1] Plants - discrete aerial portions
[2] Browse stems - non-fruiting, healthy new growth
[3] Diseased stems - stems infested with mites
[4] Good fruits - normal fruits exceeding 3 inches in length
[5] Poor fruits - damaged or diseased fruits, or fruits less than 3 inches in length
[6] Total stems - the sum of all fruiting and non-fruiting stems
[7] Weight (oven dry) of: a) all good fruits, b) first 2.5 inches of all browse stems

and 400 pounds (oven dry weight) of stem tips. Only fruits greater than 3 inches in length and the first 2.5 inches of each stem were considered in these estimations.* Dalke and Spencer (1944) and Krefting *et al.* (1955) have reported that deer may browse sumac plants so intensively that the plant may be killed. However, there were no indications that browsing hindered productivity on the study area, as there appeared to be no reduction in stem and fruit production on plants browsed the previous year.

Age structure: Sumac stems are straight and stout and new growth arises from lateral buds, thereby forming an angle with the axis of the old stem. Employing this information, Gilbert (1959) found that the plant may be aged by counting the greatest number of continuous branching angles. To determine the accuracy of this method, I estimated the age of 264 plants by counting the branching angles and compared this estimation with the age as determined by counting the annual growth rings of those plants. The annual ring count was assumed to represent the actual age of the plant. The results of these comparisons appear in Table 5. No errors were made aging plants three years old and younger. With plants older than three years, the estimation of age was correct to within one year in a high percentage of cases. Since the great majority of the plants fall into easily and accurately aged categories, the angle counting method was used in all of the age determinations in this study.

The age profile (Table 6) indicated a young and vigorously growing population which appeared to have begun expansion within the last ten

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*One fruit = 12.8 grams, oven-dry weight, based on a sample of 200 randomly chosen fruits. One stem = 0.64 grams, oven-dry weight, based on a sample of the first 2.5 inches of 200 randomly chosen stems.

Table 5. Accuracy of estimating sumac age by counting the branching angles of plants 1 to 15 years old

Age (years)	Sample Size	Number Correct	Departure of estimate from actual age (years) ±1	±2	±3	Percent Correct (years) ±0	±1	±2	±3
1	25	25				100			
2	25	25				100			
3	25	25				100			
4	23	20	3			86	100		
5	20	13	6	1		65	95	100	
6	18	13	4	1		72	94	100	
7	17	12	4	1		71	94	100	
8	19	15	1	2	1	78	84	95	100
9	16	9	5		2	56	74	74	100
10	16	11	4	1		68	93	100	
11	13	5	5	2	1	38	76	92	100
12	9	7	2			78	100		
13	8	7	1			88	100		
14	4	1	3			25	100		
15	4	2	2			50	100		

years from clones that had lost vigor or become dormant. In Groups B, C and E, the beginning of the increase in growth rate corresponded roughly to the dates on which pine was established in the area. The origins of Groups A and D were more obscure, but may have been related to the movement of heavy machinery in 1958 and 1959 when Wagon Wheel Road, which paralleled Group D, was repaired, and when a pine enclosure was constructed near Group A. Group D had an elevated percentage of two-year-old plants, probably reflecting a response to the planting of pine in this area in 1967. The number of three-year-old plants appeared to be lower than expected from the general trend of the age profile. This inconsistency is probably best explained by the severe drought that occurred during the growing season of 1966, thus lowering the number of three-year-old plants. In that year only 1.99 inches of rain

Table 6. Age profile of sumac plants on the study area, as determined by 320 randomly chosen milliacre plots

Age (years)	Age Structure by Group A	B	C (Percent)	D	E	Composite (Percent)
1	64	47	61	20	33	49
2	14	17	13	40*	28	21
3	10	7	6	13	11	9++
4	9	8	8	16	18	11
5	2	6	5	5	7	5
6	1	3	2	2	3*	2
7	P	3	1	1	P	1
8	P	P*	1*	1	P	1
9	X	P	1	P	X	P
10	X+	P	P	P	X	P
11	X	P	X	X+	P	P
12	X	X	X	P	X	P
16	X	X	X	P	X	P
20	X	X	P	X	X	P

*Year in which pine was planted in area
+Year in which heavy equipment operated on area
++May be a result of severe drought in summer of 1966
P-Present in amounts less than one percent
X-Not present

fell at Cadillac during the months of May and June, as compared with the average for this period of 8.92 inches.

Eleven of the sample plots were 100 percent shaded by overtopping trees. The age distribution of the 49 plants in these plots was as follows: one year old, 14%; two years old, 27%; three years old, 21%; four years old, 12%; five years old, 18%; six years old, 4%; and seven years old, 4%. The trend here, as compared to the composited age structure of the area (Table 6) was a failure to reproduce under shaded conditions. Such a lack of reproduction was often noted when sumac was found growing under the semi-closed canopy of invading trees, and may be the result of competition for light or water or both.

The relationship between age and the production of stems and fruits is seen in Table 7. The older plants approach maximum productivity at about seven years, but there are insufficient data to reach a conclusion

Table 7. The relationship of age to stem and fruit productivity in sumac

Age	Sample Size (Plants)	Browse Stems	Browse Stems/ Plant	Total Fruit	Fruit/ Plant	All Stems*	Total Stems/ Plant*
1	1,620	1,615	1.00	5	.00	1,620	1.00
2	688	815	1.18	96	.14	911	1.32
3	292	372	1.27	102	.35	474	1.62
4	375	496	1.32	306	.82	802	2.14
5	171	290	1.69	237	1.39	527	3.08
6	66	96	1.45	93	1.41	189	2.86
7	33	77	2.33	45	1.36	122	3.69
8	26	63	2.42	22	.85	85	3.27
9	15	29	1.93	24	1.60	53	3.50
10	5	10	2.00	5	1.00	15	3.00

*Includes stems and fruit

about the age at which the plants begin to decline in productivity. Some fruits are produced in the second year, contrary to the statements by Boyd (1943b) and Spinner and Ostrom (1945) that sumac does not fruit until the third or fourth year.

SUMAC AS A WILDLIFE FOOD ITEM

Survey of the Literature

A partial list of references to the utilization of sumac as a food item by wildlife appears in Table 8. This survey treats only game species, and thus excludes the many songbirds and rodents that are known to eat this plant (Martin *et al.*, 1951).

Sumac fruits are eaten by many gallinaceous birds, but are believed to be of major importance only in the diets of the ruffed grouse (Bump *et al.*, 1947) and the sharp-tailed grouse (Ammann, 1957). Although several authors list sumac as a common food of the bob-white quail, it has been demonstrated that it is of low energy value to that bird (Errington, 1936; Newlon *et al.*, 1964), prompting researchers to suggest that this fruit may be sought for a specific nutrient (Nestler and Bailey, 1944). The fruit is also commonly mentioned in lists of wild turkey foods, but it seldom exceeds one percent of that animal's annual diet (Korschgen, 1967).

Reports of heavy rabbit and squirrel use of sumac bark are usually associated with deep snow conditions, suggesting that it is primarily an emergency food for these species (Brown, 1947; Packard, 1956). However, Hickie (1940) lists sumac among the preferred winter foods for cottontail rabbits in Michigan.

Various sumac species are utilized by deer throughout much of the United States. Preference of sumac appears to be somewhat regional as it is of secondary importance to deer in the southeastern states

Table 8. Partial list of authors reporting use of sumac by game species

Author(s)	Game Species	Sumac Species	Part Eaten	Season of Use	Preference or Importance	State
Allen, R. H., Jr., and A. M. Pearson (1945)	Cv	Rsp	F	Su	3	Ala.
Ammann, G. A. (1957)	Tc,Pp	Rsp	F	W,W	5,1	Mich.
Banasiak, C. F. (1961)	Ov	Rt,Rg	F-S	W	2	Me.
Brown, H. L. (1947)	Sf	Rg	B-S	NS	5	Kans.
Bump, G. *et al.* (1947)	Bu	Rsp	F	Sp,F,W	2	N.Y.
Crispens, C. G. *et al.* (1960)	Lc	Rg	F	W	3	Wash.
Dahlberg, B. L., and R. C. Guettinger (1956)	Ov	Rg	F-S	W	1	Wisc.
Dalke, P. D. *et al.* (1946)	Mg	Rsp	F	NS	4	Mo.
Errington, P. L. (1936)	Cv	Rsp	F	W	3	Io.
Errington, P. L., and F. N. Hamerstrom, Jr. (1936)	Cv	Rsp	F	W	3	Io.
Forbush, E. H. (1916)	Cv,Bu	Rt,Rg	F	NS	5	Mass.
Goodrum, P. D., and V. H. Reid (1962)	Ov	Rg	F-S	NS	3-4	Ala., Miss., La.
Hendrickson, G. O. (1938)	Sf	Rg	B	W	5	Io.
Hickie, P. (1940)	Sf	Rg	B	W	1	Mich.
Hosley, N. W., and R. K. Ziebarth (1935)	Ov	Rt	F-S	W	2	Mass.
Johnson, B. C., and A. M. Pearson (1948)	Cv	Rsp	F	W	3	Ala.
Korschgen, L. J. (1966)	Bu	Rg	F	W	3	Mo.
Korschgen, L. J. (1967)	Mg	Rsp	F	W,Sp	4	NS
Latham, R. M., and C. R. Studholme (1952)	Cv	Rsp	F	W	6	Penn.
Lay, D. W. (1965)	Ov	Rsp	F-S	NS	4	Tex.
Mosby, H. S., and C. O. Handley (1943)	Mg	Rsp	F	W	3	Va.

Table 8 (Cont'd)

Author(s)	Game Species	Sumac Species	Part Eaten	Season of Use	Preference or Importance	State
Murie, A. (1946)	Mg	Rg	F	W	5	Ariz.
Murphy, D. A. (1968)	Ov	Rg	F-S	W	1	Mo.
Nestler, R. B., and W. W. Bailey (1944)	Cv	Rg	F	W	3	NS
Packard, R. L. (1956)	Sn	Rg	B	W,Sp	6	Kans.
Parmalee, P. W. (1953)	Cv	Rsp	F	W	5	Tex.
Pearson, A. M. (1943)	Ov	Rsp	F-S	W	3	Ala.
Riegel, A. (1942)	Sf	Rg	B	W	6	Kans.
Stoddard, H. L. (1931)	Cv	Rsp	F	W,Sp,Su A	3	NS
Swank, W. G. (1944)	Pc	Rt	F	W	3-4	Mich.
Trippensee, R. E. (1938)	Sf	Rg,Rt	B	W	5	Mich.

<u>Game Species</u>:

Bu: Ruffed grouse
Cv: Bobwhite quail
Lc: California quail
Mg: Wild turkey
Ov: White-tailed deer
Pc: Ringed-neck pheasant
Pp: Sharp-tailed grouse
Sf: Cottontail rabbit
Sn: Fox squirrel
Tc: Prairie chicken

<u>Sumac Species</u>:

Rg: *Rhus glabra*
Rt: *Rhus typhina*
Rsp: *Rhus species* not specified

<u>Part Eaten</u>:

F: Fruit
S: Stem
B: Bark

<u>Season of Use</u>:

W: Winter
Sp: Spring
Su: Summer
A: Autumn
NS: Not specified

<u>Preference or Importance</u>:

1: Preferred
2: Important
3: Moderate
4: Low
5: Mentioned, not ranked
6: Emergency

(Goodrum and Reid, 1962), but of prime importance in the northeast. It is reported to be a highly preferred and important winter browse in Maine, Massachusetts, Missouri and Wisconsin (Banasiak, 1961; Dahlberg and Guettinger, 1956; Hosley and Ziebarth, 1935; Murphy, 1968).

Availability

About one percent of the study area, or 29 acres, was covered by sumac. Virtually all of the sumac present was in forest openings, and was short enough that it was within the reach of deer. Snow depth was the major factor that prevented the deer from browsing the plant. First, there were no large deer yards on the study area, and thus few deer were present during severe winter conditions. Second, snow occasionally covered some of the stems; a 14-inch snowfall, a typical winter snow depth in this area, covered about one half of the stems. Sumac fruits, however, were rarely covered by snow because they are terminal and usually present on older, taller plants.

The relative availability of several species of deer browse in forest openings during deep snow conditions was measured in February 1968. The results of that survey, summarized in Table 9, demonstrated

Table 9. Frequency and density of woody plants emerging from a 14-inch snow cover in forest openings, as determined by 50 randomly selected 60 square foot plots (6' x 10') sampled on the study area in the winter of 1967-68

Species	Frequency (Percent)	Stems/Acre
Rhus typhina>glabra	32	1587
Pinus resinosa	20	315
Rubus allegheniensis	6	86
Prunus serotina	3	43
Prunus virginiana	1	71
Salix humilis	1	43
Quercus rubra	1	14

that although many of its stems were covered by snow, sumac was the most plentiful browse species in openings on the study area during typical winter conditions.

Use

The use of sumac stems and fruits by deer was monitored on the study area from July 1967 until June 1969. The heaviest browsing occurred in winter and thus that season received the most attention during the study. The winter population (post harvest) of deer in the area was estimated to be 21 deer per section in 1967-68 and 22 deer per section in 1968-69 (personal communication, George Irvine, Wildlife Biologist, U. S. Forest Service, Cadillac). The population of deer undoubtedly changed throughout the winter, and these estimates are intended only as convenient reference points. Deer tracks and pellet groups were abundant on the study area during the relatively mild winter of 1967-68, and indicated that the area was being used by deer for the entire season. In contrast, very few deer signs were noted on the study area in the winter of 1968-69. This was probably caused by severe weather in January of that winter, which forced deer to seek the shelter of cedar swamps away from the study area. Perhaps a contributing factor to reduced deer use of the area was the establishment of a snowmobile trail along Wagon Wheel Road, and the power line right-of-way (Figure 1). This trail was heavily used by recreational snowmobiles during the winter weekends.

Length of stems and fruits browsed: Two hundred sumac stems, 50 in each of 4 clones on the study area, were measured and tagged in August of 1968 (Figure 1). Those tagged stems that had been browsed were remeasured in April 1969. A total of 100 of the 200 stems had been browsed and the average length browsed was 2.4 inches. Eighty-two percent of the browsed parts of the stems were between one and three inches in length and the greatest length browsed was ten inches. There was no apparent relationship between the length of the stem and the length of the browse.

Fifty fruits were tagged in order to determine how much of the stem was eaten when a fruit was browsed. Examination of these tagged specimens after browsing showed that the fruit stem is browsed only down to the proximal end of the fruit. The stem easily breaks at this point and observations of deer eating sumac indicated that they grasp the fruit in their mouths and break it loose with a snap of the head.

Use of stems: The seasonal use of sumac stems was measured in eight permanent plots (50' x 100') by periodically counting the number of stems browsed in those plots throughout the year. When a browsed stem was counted, it was clipped at a 50- to 60-degree angle to prevent a recount. Three of these plots are located on the study area and a fourth a few hundred feet north of the study area (Figure 1). The four other plots are located three miles ESE of the study area in sections 13 and 24 of T21N-R12W. The four latter plots were established before the study area had been narrowed to its final size.

The results of the plot counts are shown in Figure 7. Some browsing occurred in the spring and early summer of 1967, but very little in the corresponding seasons of 1968. In the winter of 1967-68, the most intense browsing occurred between December and March, the peak months being January and February. Deep snow prevented counts in January and February of 1969, but a lower total for that winter indicated that fewer stems were browsed in that period. This lower total is probably a result

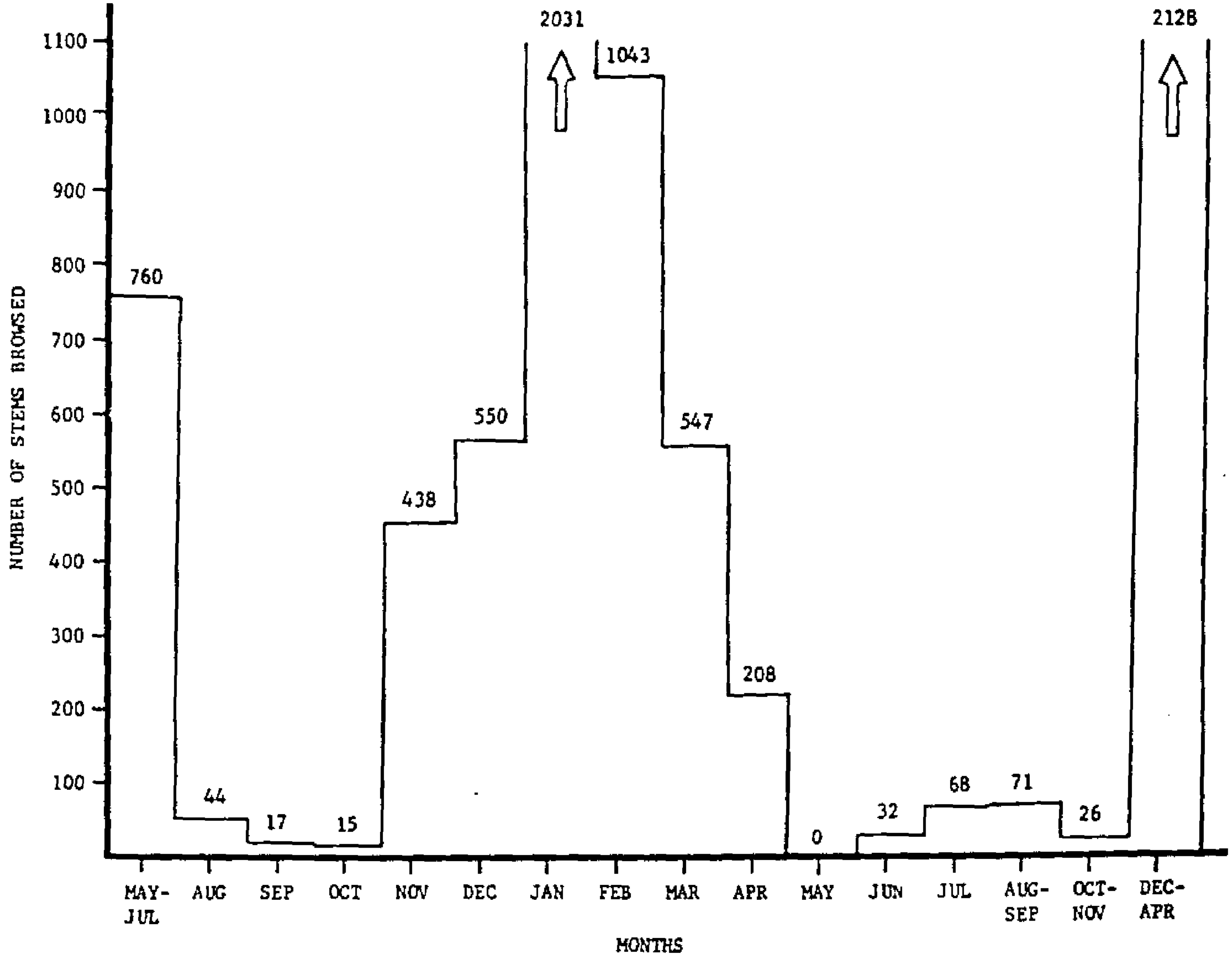

Figure 7. The monthly consumption by deer of sumac stems on the browse plots from May 1967 through April 1969.

of the deep snow, which covered many plants, and hindered the movements of deer.

An estimate of the percentage of sumac stems browsed on the study area from May 1967 through April 1968 was determined by tallying the percent of stems browsed in a random sample of 100 plots (3' x 10'). Sixty-three percent of all sumac stems examined had been browsed. This figure is comparable to the average of the percentages of browsed stems in the four permanent browse plots on the study area, 61 percent, and somewhat higher than the percent of stems browsed on the four plots east of the study area, 42 percent.

Early in May 1969, an estimate of the stems browsed on the study area during the previous year was made by tallying the percent of browsed stems in 100 randomly chosen semicircles four feet in diameter. Forty-eight percent of the stems were browsed, a result which compares closely with the number of stems browsed in the browse length experiment, 50 percent, but considerably higher than the number of stems browsed on the permanent browse plots, 27 percent. Assuming that 50 percent of all stems were browsed, and using the productivity data for browse stems derived from Table 4, it is estimated that the deer consumed about 200 pounds (oven-dry weight) of sumac stems on the study area during the winter of 1968-69. This averages out to consumption of about seven pounds of stems per acre of sumac.

Use of fruits: In September 1967, three groups of 100 fruits each were tagged on the study area (Figure 1). The fruits in each of these samples were below six feet in height. In another sample 100 fruits exceeding seven feet in height were tagged on an area two miles east of the study area. Additionally, 70 fruits were counted inside a deer-proof fence on the study area. The rate of disappearance of the fruits that were below six feet in height is shown in Figure 8. It appears that the fruits were lightly browsed in September and October, with most of the fruit eaten during November and December. The fruits that were above seven feet in height and thus out of the reach of deer, disappeared slowly, with 80 percent remaining at the end of April and 53 percent remaining by mid-June. Sixty-six of the 70 fruits in the enclosure remained at the end of the winter. These experiments were repeated in 1968-69 with very similar results (Figure 8).

According to the estimate of fruit production in 1968 (Table 4), nearly 2,300 pounds (oven-dry weight) of sumac fruit were browsed on the study area from November to mid-January of the winter of 1968-69. This averages out to a consumption of about 80 pounds of fruit per acre of sumac. The impressive statistic here is that all of the fruits available to deer were browsed, suggesting that the consumption of sumac fruits would have been even higher if more fruits had been available.

Summary

A survey of the literature indicated that smooth and staghorn sumac are important wildlife food plants throughout much of their ranges in North America. The present study demonstrated that sumac was heavily utilized as a winter food by deer in the Manistee National Forest in Michigan. The major findings of this study are outlined below:

(1) Sumac was the most abundant browse species available in forest openings during typical winter conditions on the study areas.

(2) The average length of stem browsed was 2.4 inches and in 82 percent of the cases the length of stem browsed was between one and three inches.

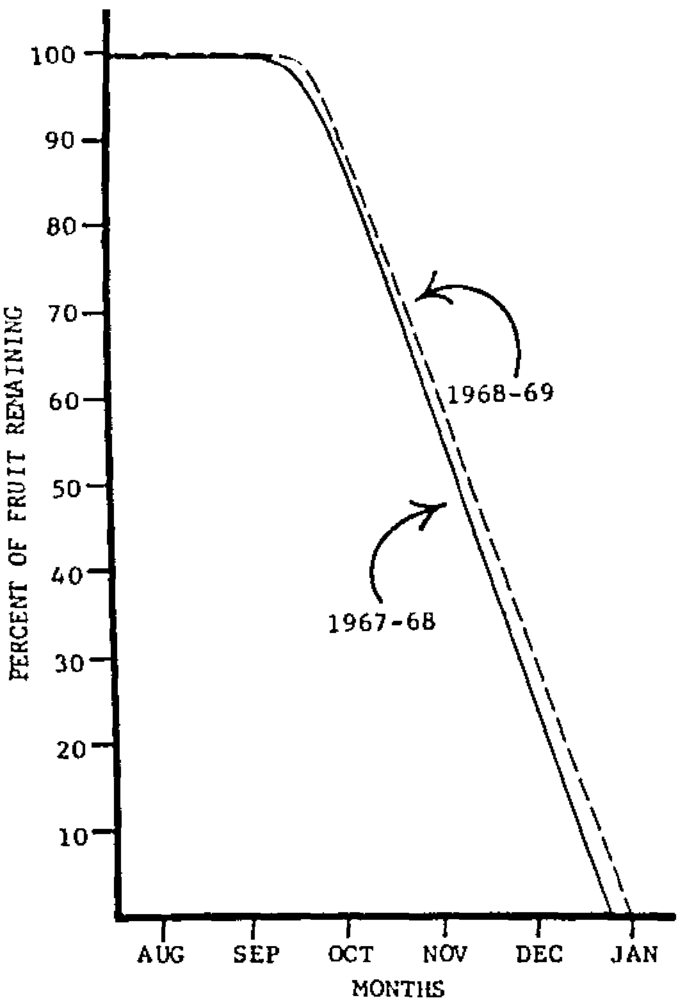

Figure 8. Rate of disappearance of sumac fruit susceptible to deer browsing, on the study area, in the autumn and winter of 1967-68 and 1968-69.

(3) In the winter of 1968-69, approximately half of the sumac stems on the study area were browsed. This totaled about 200 pounds (oven-dry weight) of sumac stems, or about seven pounds of stems browsed per acre of sumac.

(4) When a fruit was browsed, the entire fruit was eaten.

(5) All of the sumac fruit on the study area was browsed in the winter of 1968-69. This totaled about 2,300 pounds of sumac fruit browsed on the study area, or about 80 pounds browsed per acre of sumac.

THE PROXIMATE ANALYSIS AND APPARENT DIGESTIBILITY OF SUMAC

As demonstrated in Chapter 3, sumac may comprise a significant portion of the winter diet of deer in Michigan. In an attempt to correlate the use of this browse with its nutritional value, the stems and fruits of smooth and staghorn sumac, and the hybrid sumac, were analyzed for nutrient composition. Further, apparent digestibility trials were conducted with the fruit of smooth sumac.

Methods and Materials

Proximate analyses were conducted on a total of 19 samples: 13 stem samples, 3 fruit samples, 1 orts sample and 2 fecal samples. All samples were weighed fresh, air dried, and ground in a Wiley Mill with a #40 mesh screen. Subsequently, their percentages of crude protein, ether extract, ash and dry matter were determined by A.O.A.C. procedures (Horwitz, 1960). Percentages of the cell wall constituents, cellulose, hemicellulose, and lignin, were determined by processes outlined by Van Soest (1963) and Van Soest and Wine (1967). These methods differ from standard fiber determinations (Horwitz, 1960), but are believed to provide a more accurate determination of the fibrous and soluble carbohydrate fractions (Van Soest, 1963, 1967; Fonnesbeck, 1968, 1969). Calcium and magnesium content was determined by means of a Jarrell-Ash Atomic Absorption Spectrophotometer, and phosphorus content was determined by means of a Beckman Spectrophotometer. A Parr Isothermal Calorimeter was used to obtain gross energy values.

The letter designations (A through P) from Table 10 will serve to denote each sample. Samples A through C are each composed of stems from six clones of their respective species, and each clone is represented equally by weight. Sample D is represented by only two clones. Samples E and F were taken from the root sprouts of adjacent clones

Table 10. Location of sumac clones used in analyses

Designation	Species	Part	County (number of clones)	Date Collected (1969)
A	*R. typhina*	stem	Clinton (2); Ingham (2); Shiawassee (2)	Feb. 25
B	*R. glabra*	stem	Clinton (2); Washtenaw (2); Ingham (1); Shiawassee (1)	Feb. 25
C	*R. t>g**	stem	Wexford (6)	Feb. 28
D	*R. t>g*	stem	Ingham (2)	Feb. 26
E	*R. glabra*	stem	Ingham (1)	Feb. 26
F	*R. typhina*	stem	Ingham (1)	Feb. 26
G-M	*R. typhina*	stem	Clinton (1)	Feb. 25
N	*R. typhina*	fruit	Ingham (3); Clinton (3)	Feb. 25
O	*R. glabra*	fruit	Washtenaw (6)	Feb. 1-3
P	*R. t>g*	fruit	Wexford (6)	Feb. 26

**R. t>g* = *Rhus typhina>glabra*

that had been clearcut prior to the last growing season. Only the first 2-1/2 inches of each stem was utilized in samples A through F, as this length corresponds closely to the average length of stem browsed by deer. Samples G through M are consecutive one-inch segments of 50 stems taken from one clone with sample G representing the first inch and sample M the seventh.

The fruit samples N and P represent composites from six clones of their respective species. Sample O is a subsample of the fruit used in the apparent digestibility trials.

All samples were collected in February 1969, and represent the previous year's growth. The stems and fruits of all samples were randomly collected within each clone, and all diseased or otherwise damaged specimens were discarded. Upon collection all stem samples were placed in tared plastic bags, frozen, and their fresh weight was determined. The fruit samples, which were air dried naturally in the field, were placed in cloth bags upon collection. The samples used in the digestibility trials were stored in cloth bags inside an unheated barn until they were used.

Apparent digestibility trials, in which smooth sumac fruit was fed to deer, were conducted at the Houghton Lake Wildlife Research Station, Houghton Lake, Michigan. This study began on 28 January, 1969, and originally employed six deer. The deer, three 4-1/2-year-old does and three 1-1/2-year-old bucks, were born in captivity, and fed a commercial feed prior to the experiment.

The apparent digestibility study was divided into three consecutive phases. Phase I was a seven-day adjustment period, during which the deer were presented both sumac and the commercial feed. The commercial feed was gradually withdrawn until, at the end of seven days, the deer were being fed only sumac. Phase II, which followed immediately, lasted 17 days, during which the deer were fed only sumac. During Phases I and II the deer were segregated by sex and kept in open, outside pens. The average minimum and maximum temperatures during these periods were 2 and 29° F, respectively.

At the end of Phase II it was determined, by visual inspection, that the three does and one of the bucks had suffered severe weight loss and they were withdrawn from the experiment. The two remaining bucks were deemed healthy enough to continue on the experiment, although they also had suffered noticeable weight loss.

In Phase III the two bucks were placed in metabolism cages within a heated barn, for a period of 14 days. During this period they were fed sumac and water *ad libitum*, and were subjected to a minimum of disturbance. The temperature within the barn varied from 40 to 54° F.

The deer were fed and watered each morning, at which time the feces and urine which had accumulated over the past 24 hours were removed and weighed. The food and water were weighed in and weighed out to determine total consumption. Uneaten food from the previous day (orts) was saved and later analyzed to determine if the deer were selectively eating the fruit. Aliquots of the urine and feces for analysis were taken daily during the last seven days of Phase III. Ten milliliters of 0.1 N H_2SO_4 was added to the urine sample, thus lowering its pH, and reducing the loss of ammonia nitrogen.

The metabolism cages measured 4' x 4' x 4', and were entirely wooden except for a metal grill floor, through which feces and urine passed. Fecal material, after passing through the grill, was caught by a wire screen. Urine passed through both the grill and screen and was intercepted by a laquered wooden surface which funneled it into a collection pan. Panels in the roof of the cage permitted air circulation and the entrance of light.

Results

The results of the proximate analyses appear in Table 11. The composited stem samples, A through D, appear fairly similar, with no major differences occurring between the samples. The one-year-old stems from the clearcut area, E and F, differ principally in their percentages of hemicellulose. Samples E and F were higher in several categories of nutrients than samples A through D. However, this increase in nutrients was probably a reflection of the higher percentage of dry matter in those samples.

In stem samples G through M there was an obvious decrease proximally in the soluble fraction. Correspondingly, the fibrous fraction increased proximally except for lignin, which did not demonstrate a trend. The percentage of ash tended to decrease proximally, as did the percentage of calcium, but no trends were discernible for phosphorus and magnesium. The values for gross energy did not vary significantly among the stem segments.

The staghorn and smooth sumac fruit samples, N and O, appeared fairly similar, differing most notably in their cellulose and soluble carbohydrate fractions. The hybrid fruit, P, had a nutrient makeup which varied somewhat from the other fruits, the greatest difference occurring in the percentage of ether extract. There was little difference in the values of gross energy between the fruits. The orts, Q, were not considered to be sufficiently different from the presented food, O, to correct for selection on the part of the deer during the apparent digestibility trials.

The results of the apparent digestibility trials appear in Table 12. Both deer consumed similar amounts of food and water. The apparent digestibility of cellulose, soluble carbohydrate and ether extract was

Table 11. Proximate analyses of sumac stems and fruit, expressed on a fresh weight basis

	A Staghorn Sumac Stem	B Smooth Sumac Stem	C Hybrid Sumac Stem	D Hybrid Sumac Stem	E Smooth Sumac Stem	F Staghorn Sumac Stem	G Staghorn Sumac 1st Inch	H Staghorn Sumac 2nd Inch
Dry matter (Percent)	56.85	59.29	55.46	54.62	62.80	64.00	55.52	55.50
Fibrous fraction (Percent)								
Cell wall constituents	22.98	25.22	23.68	23.06	24.12	25.90	22.76	26.50
Cellulose	11.80	12.57	12.06	11.03	13.72	13.84	11.05	13.78
Hemicellulose	4.60	5.24	5.26	3.03	2.55	3.50	4.43	5.03
Lignin	6.58	7.41	6.36	9.00	7.85	8.56	7.28	7.69
Soluble fraction (Percent)								
Cellular contents	33.87	34.07	31.78	31.56	38.68	38.10	32.76	29.00
Soluble carbohydrates	20.61	21.01	19.06	20.04	23.38	23.10	19.81	17.67
Protein^{+}	3.85	3.45	3.90	4.04	4.26	4.38	3.80	3.64
Ether extract	6.22	6.54	6.08	4.82	7.46	6.93	5.71	5.04
Ash	3.10	3.08	2.74	2.66	3.58	3.60	3.44	2.65
Calcium	0.86	1.13	*	0.90	1.21	1.04	1.55	1.05
Phosphorus	0.12	*	0.14	0.09	0.09	0.11	0.12	0.14
Magnesium	0.16	0.17	0.15	0.15	0.17	0.24	0.21	0.18
Gross energy (kcal/g)	2.717	2.835	2.666	2.556	3.040	2.942	2.644	2.474

Table 11 (Cont'd)

	I Staghorn Sumac 3rd Inch	J Staghorn Sumac 4th Inch	K Staghorn Sumac 5th Inch	L Staghorn Sumac 6th Inch	M Staghorn Sumac 7th Inch	N Staghorn Sumac Fruit	O Smooth Sumac Fruit	P Hybrid Sumac Fruit	Q Orts
Dry matter (Percent)	55.37	55.87	55.38	55.85	55.75	94.06	94.06	94.10	93.35
Fibrous fraction (Percent)									
Cell wall constituents	27.91	30.27	30.94	32.19	32.48	49.77	53.59	47.78	51.53
Cellulose	14.68	15.28	17.23	17.37	18.59	18.88	21.68	17.76	22.33
Hemicellulose	5.54	6.84	6.70	7.11	6.66	15.23	14.05	16.83	12.30
Lignin	7.69	8.15	6.92	7.71	7.23	15.66	17.86	13.19	16.90
Soluble fraction (Percent)									
Cellular contents	27.46	25.60	24.44	23.66	23.27	44.69	40.49	46.28	41.82
Soluble carbohydrates	16.81	15.24	14.30	14.37	13.91	22.83	18.10	16.65	18.72
Protein[+]	3.63	3.41	3.37	3.17	3.07	5.01	5.24	6.42	4.79
Ether extract	4.64	4.45	4.46	4.15	4.10	13.89	13.80	20.65	15.33
Ash	2.38	2.50	2.31	1.97	2.19	2.96	3.35	2.56	2.98
Calcium	0.94	0.96	0.94	0.80	0.70	0.60	0.85	*	0.92
Phosphorus	0.13	0.11	0.12	0.10	0.09	0.17	0.13	0.15	0.20
Magnesium	0.16	0.17	0.18	0.19	0.15	*	0.23	*	0.24
Gross energy (kcal/g)	2.497	2.565	2.446	2.441	2.637	5.002	4.707	4.809	4.425

[+]N x 6.25
*Data missing

Table 12. Sumac browse and water intake, apparent digestibility and apparently digestible energy during the last seven days of Phase III

	Deer 1	Deer 2	Mean ± Standard Error
Average daily intake (Kg.)			
Sumac fruit*	0.563	0.521	0.542±0.021
Water	0.951	1.122	1.036±0.135
Apparent digestibility (Percent)			
Dry matter	52.6	39.7	46.1±6.4
Cell wall constituents	43.3	29.0	36.1±7.1
Cellulose	47.8	50.9	49.3±1.5
Hemicellulose	83.4	36.3	49.8±13.5
Lignin	19.9	-1.5	9.2±10.7
Cellular contents			
Soluble carbohydrates	68.7	71.2	69.9±1.2
Crude protein	24.2	-56.5	-16.1±40.4
Ether extract	85.5	81.9	83.7±1.8
Gross energy	50.8	37.5	44.1±6.6
Apparently digestible energy intake per day (kcal)***	1430	977	1204±227

*Oven-dry weight
**NX6.25
***Gross energy intake X apparent digestibility of gross energy

similar for the two animals, but large discrepancies occurred between the deer in the digestibility of protein and hemicellulose. Lignin was not considered to be a digestible fraction of a deer's diet.

The apparent digestibility data obtained for gross energy were further refined by determining the amount of energy lost in the urine and through methane production (Table 13). Methane production was estimated by the procedure outlined by Blaxter and Clapperton (1965). This refined gross energy determination was termed apparently metabolizable energy. Figures for both apparently metabolizable and

Table 13. Urine and methane output, nitrogen balance, and apparently metabolizable energy during the last seven days of Phase III

	Deer 1	Deer 2	Mean ± Standard Error
Average daily output			
Urine (ml.)	537	898	717±181
Nitrogen (gm.)	11.1	17.1	14.1±3.0
Energy (kcal)	164	202	183±19
Methane*			
Energy (cal)	192	156	174±18
Nitrogen balance** (gm.)	-9.8	-19.8	-14.8±5.0
Apparently metabolizable energy intake per day (kcal)***	1073	501	787±286

*Assumes maintenance level of feeding (Blaxter and Clapperton, 1965).

**Nitrogen intake - nitrogen output in feces and urine.

***Gross energy intake - gross energy output in feces, urine and methane.

apparently digestible energy were given because the latter, though less precise, is necessary for comparisons of work done by other investigators.

The nitrogen balance of the deer during the collection period was determined by comparing the total intake and output of nitrogen (Table 13). Both deer were in negative nitrogen balance, indicating that protein catabolism was proceeding more rapidly than protein synthesis.

From the beginning of Phase I until the end of Phase III, a period of 45 days, deer 1 and 2 lost 28.2 percent and 31.8 percent of their body weights, respectively. The weight losses during the 14-day period in the metabolism cages were 16.4 percent for both deer (Table 14).

Table 14. Weight losses during Phases I-III* of the digestibility study

Deer	Phases I-II Beginning Weight (kg.)	Final Weight (kg.)	Percent Weight Loss	Phase III Beginning Weight (kg.)	Final Weight (kg.)	Percent Weight Loss	Phases I-III Percent Total Weight Loss
1	64.4	55.3	14.1	55.3	46.2	16.4	28.3
2	61.2	49.9	18.4	49.9	41.7	16.4	31.9

*Phases I and II: January 28 to February 20.
Phase III: February 21 to March 7.

Discussion

The results obtained from the proximate analyses in this study were similar to analyses of smooth sumac fruits collected in Michigan, Virginia, and Washington by King and McClure (1944), and of smooth sumac stems collected in Missouri by Murphy (1968).

The reader is cautioned that the values presented in this paper represent only a relatively small number of vigorous clones. Time limitations prevented analysis of nutritional differences among the factors of site, season, age, vigor, genotype, or position on the plant. Nutritional differences in other species of deer browse due to such variables have been shown by Bailey (1967), Bissel and Strong (1955), Broadfoot and Farmer (1969), Einarsen (1946), Forbes (1941), Helmers (1940) and Swift (1948).

Proximate analyses are of importance from the standpoint of determining potential nutrient concentration. Such data are limited in determining the nutritional value of a browse unless accompanied by information on the preference, consumption, availability and digestibility of that browse. In the absence of digestibility data on smooth sumac stems and staghorn sumac stems and fruits, it is perhaps most instructive to compare their proximate analyses with those of deer browse from northern white cedar (*Thuja occidentalis*), big tooth aspen (*Populus grandidentata*), and jack pine (*Pinus banksiana*). The analyses of these browses and the sumac browses appear in Table 15. The data are

Table 15. A comparison of the proximate analyses of several winter browses. (All analyses except dry matter are expressed on an oven-dry weight basis.)

	Percent Dry Matter	Percent Crude Protein	Percent Ether Extract	Percent Ash	Gross Energy (kcal/g)
N. white cedar, sprays*	46.1	7.2	9.5	4.3	5.14
Big tooth aspen, stems**	51.7	9.7	6.8	3.7	5.01
Jack pine, boughs***	46.5	8.2	9.0	2.6	5.36
Smooth sumac, stems	59.3	5.9	10.9	5.2	4.77
Staghorn sumac, stems	56.8	6.7	10.9	5.6	4.78
Hybrid sumac, stems	55.5	7.0	10.9	4.9	4.80
Smooth sumac, fruits	94.1	5.5	14.6	3.5	5.00
Staghorn sumac, fruits	94.5	5.3	14.6	3.2	5.28
Hybrid sumac, fruits	94.1	6.8	21.9	2.7	5.11

*Ullrey *et al.*, 1968
**Ullrey *et al.*, 1964
***Ullrey *et al.*, 1967

expressed on an oven-dry basis to eliminate differences due to water content. Because of differences in analytical techniques among researchers, only the dry matter, protein, ether extract and gross energy fractions can be compared. The stems and fruits of all sumac species were lower in protein and higher in ether extract than the other browses. The ether extract of the hybrid fruit was especially high. The ash content of the sumac stems was comparatively high, while that of the fruits was intermediate. None of the browses differed greatly in gross energy content.

The stem segments (G through M) demonstrated a progressive decrease in the soluble fraction, and a corresponding increase in the fibrous fraction, proximally. Bailey (1967) has found a similar occurrence in the protein fraction of *Viburnum sp.* stems. Short (1963, 1966) has demonstrated that deer derive the most benefit from the soluble fraction of a food, and that the value of a browse is inversely related to its cellulose content. The distal increase in fiber of a sumac stem may partially explain why only the first few inches are browsed.

The intake and apparent digestibility of cedar and sumar are compared in Table 16. Although the consumption of cedar and sumac differ greatly when compared on a fresh weight basis, they are essentially the same on a dry weight basis and provide similar amounts of apparently digestible energy. These data also indicate that the protein fraction of cedar is more available to deer than that of sumac, while the reverse appears to be true in regard to the availability of ether extract.

Ullrey *et al.* (1969) have estimated that the apparently digestible energy requirement for the winter maintenance of deer in Michigan is about 160 kcal/kg $W^{.75*}$/day. Thus a deer of 138 pounds, the average beginning weight of the deer in this study, would require 3565 kcal/day of apparently digestible energy. Assuming a gross energy digestibility of 44 percent (Table 12), sumac fruit produced about 1000 kcal of apparently digestible energy per pound (oven-dry weight).

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*$W^{.75}$ refers to metabolic weight (Kleiber, 1961).

Table 16. A comparison of cedar sprays and sumac fruits in terms of intake, apparent digestibility, apparently digestible energy, and weight loss

	No. of Deer	Browse Intake per Deer per Day: Fresh Weight (kg.)	Browse Intake per Deer per Day: Oven Dry Weight (kg.)	Apparent Digestibility: Percent Dry Matter	Apparent Digestibility: Percent Crude Protein	Apparent Digestibility: Percent Ether Extract	Apparent Digestibility: Percent Gross Energy	Apparently Digestible Energy/ Deer/Day (kcal)	Percent Weight Loss
N. white cedar, sprays*	24	1.240±** 0.108	0.572± 0.049	44±4	14±4	47±5	39±3	1140	12.1±1.4
Smooth sumac, fruit	2	0.578± 0.021	0.542± 0.021	46±6	-16±40	84±2	44±7	1204	16.4±0.0

*Ullrey *et al.*, 1968

**Mean ± standard error

The deer in this study consumed enough food to supply about one-third of their maintenance energy requirements and, after 31 days on the pure sumac diet, they had lost about 30 percent of their original body weight. Additionally, both deer were in negative nitrogen balance. Continued protein and calorie malnutrition would have soon resulted in death from starvation.

Several authors have commented on the voluntary restriction of food intake by deer during the winter, resulting in considerable weight loss (French *et al.*, 1956; McEwen *et al.*, 1957; Silver *et al.*, 1969; Smith, 1950). Silver *et al.* (1969) have associated voluntary reduction in food intake during the winter with a reduced metabolic rate. They suggest that this response is a physiological and behavioral reaction of deer forced to exist in areas where food is limited during the winter. Ullrey *et al.* (1964, 1967, 1968) have consistently encountered under-nourishment, primarily due to inadequate food intake, in deer fed a diet consisting of only a single browse species. This may indicate that deer do not adapt easily to a monotypic diet.

The present study was not designed to explain the inadequate food intake, and no further attention will be given to that subject. The data from the digestibility trials do not lend themselves to statistical analysis because only two of the original six deer finished the experiment. However, they do seem to indicate that sumac fruit is a high energy food source, but offers little available protein.

<u>Summary</u>

The stems and fruits of smooth, staghorn, and the hybrid sumac were analyzed for nutrient composition, and the apparent digestibility of the fruit of smooth sumac was determined. The principal findings of the study are outlined below:

(1) There appeared to be little interspecific difference between the nutritional composition of the sumac stems and fruits.

(2) Sumac stems and fruits were low in crude protein, high in ether extract, and similar in gross energy as compared, on an oven-dry weight basis, to three other Michigan deer browses: northern white cedar, jack pine, and big tooth aspen.

(3) Proximate analyses of consecutive one-inch stem segments demonstrated that the soluble nutrient fraction decreased, while the fibrous fraction increased, proximally.

(4) Six deer were placed on a diet consisting only of smooth sumac fruit. Two of these deer had adjusted adequately to the sumac diet after three weeks, and these animals were used in the subsequent apparent digestibility trials.

(5) The two deer had similar apparent digestibility percentages for cellulose, 49.3 ± 1.5 (mean $\pm$ standard error); soluble carbohydrates, 69.9 ± 1.2; and ether extract, 83.7 ± 1.8. They differed somewhat in the apparent digestibility of gross energy, 44.1 ± 6.6, and differed greatly in the apparent digestibility of crude protein, -16.1 ± 40.4.

(6) Both deer voluntarily restricted their intake of sumac fruit to about one-third of that amount required to maintain their body weight. Accordingly, both deer were in negative nitrogen balance and both suffered severe weight loss.

(7) The digestibility data indicated that sumac fruits were a good energy source, but a poor source of protein, compared, on a dry weight basis, to sprays of northern white cedar.

ESTABLISHMENT AND PROPAGATION OF THE PLANT

Methods of establishing sumac from both seed and transplants, and of rejuvenating established plants to render them more useful to wildlife, are described. All of these studies were conducted in Clinton, Ingham, and Shiawassee Counties and were concerned primarily with elementary nursery practices.

Collection and Germination of Seeds

Sumac seeds are oval, smooth, 2 to 3 mm. long, and have an extremely hard seed coat. They exhibit mechanical dormancy, and acid scarification is the most commonly recommended procedure employed to prepare the seeds for germination (Boyd, 1943a; Heit, 1967a; Krefting and Roe, 1949; Lovell, 1964). The seeds do not require special storage procedures either before or after scarification, and may be kept in a sealed container for several years without loss of viability (Heit, 1967b).

Methods: Sumac seeds were collected by harvesting ripe fruit in October. The seeds were removed from their leathery pericarp by drying them for three days at 110° F., placing them in a cloth bag (one-half pound of fruit in a 10" x 16" seed bag), and vigorously pounding the bag against a hard surface for a period of two minutes. The contents of the bag were then placed in a tray of water and stirred. The viable seeds, which had a greater density than water, sank to the bottom of the tray, while the fruit debris floated and was easily removed. The water was then decanted and the seeds were retrieved, air dried, and stored in a capped glass bottle. This process was repeated many times during the course of the study with all three sumac types.

In order to determine the optimum length of time for acid scarification, 50 grams of *Rhus typhina>glabra* seeds were placed in 500 ml. of concentrated sulfuric acid and stirred constantly with a magnetic stirrer. Aliquots of the seeds were removed from the acid at the following intervals: 10, 20, 30, 40, 60, 90, 120, 180, 240, 300, 360, 420 and 480 minutes. Upon removal from the acid the seeds were washed thoroughly in water and the burned portion of the seed coat was removed by gently rubbing the seeds over a fine wire screen. One hundred seeds from each sample were placed between two filter papers (Whatman #1) in a sterile petri dish. The seeds were kept under conditions of constant light and temperature (73-76° F), and sufficient distilled water was added to the filter paper to make it moist to the touch. Additional water was added when necessary, to maintain the moist condition. Each day for 42 days the dishes were opened and seeds which had germinated were removed. A seed was considered to have germinated when root hairs appeared on the root tip.

Results and discussion: There was considerable inter- and intraspecific variation in the size and weight of the seeds obtained. The seeds of *Rhus glabra* were significantly heavier than those of *Rhus typhina* ($P < .05$),* and the size of the seeds of *Rhus typhina>glabra* overlapped those of the parent species (Table 17).

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*Mann-Whitney Test, Siegel (1956), p. 312.

Table 17. Weight of sumac seeds per fruit and number of seeds per pound

Species	Clones Sampled	Pounds of viable seeds per 100 pounds fruit	Number of clean viable seeds per pound
Rhus glabra	4	13.7±5.1	46,400±3,200*
Rhus typhina	4	14.4±4.5	60,200±2,500
Rhus typhina×glabra	4	22.9±5.2	51,900±3,900

*Standard error of the mean

The results of the scarification-germination experiment are shown in Figure 9. Only two percent of the unscarified controls, and two percent of the seeds scarified for 10 minutes, germinated. The optimum time of scarification was 180 minutes, beyond which time the acid apparently penetrated the seed coat and damaged the seeds. None of the seeds scarified for 420 minutes germinated, and those scarified for 480 minutes were nearly dissolved. Seventy percent of all of the seeds that germinated did so within the first four days, and 93 percent of the total had germinated within seven days (Figure 10).

All of the seeds used in subsequent planting trials were scarified for 120 minutes, slightly less than the optimum time, to avoid possible damage to the embryo that may have gone undetected in the germination trials. Thus the optimum expected germination in all planting trials is only 88 percent (Figure 9).

Propagation from Seed

Sumac reproduces primarily from root sprouts, but natural original establishment must depend upon seeding. Several authors have demonstrated that seed germination in several sumac species, and hence reproduction

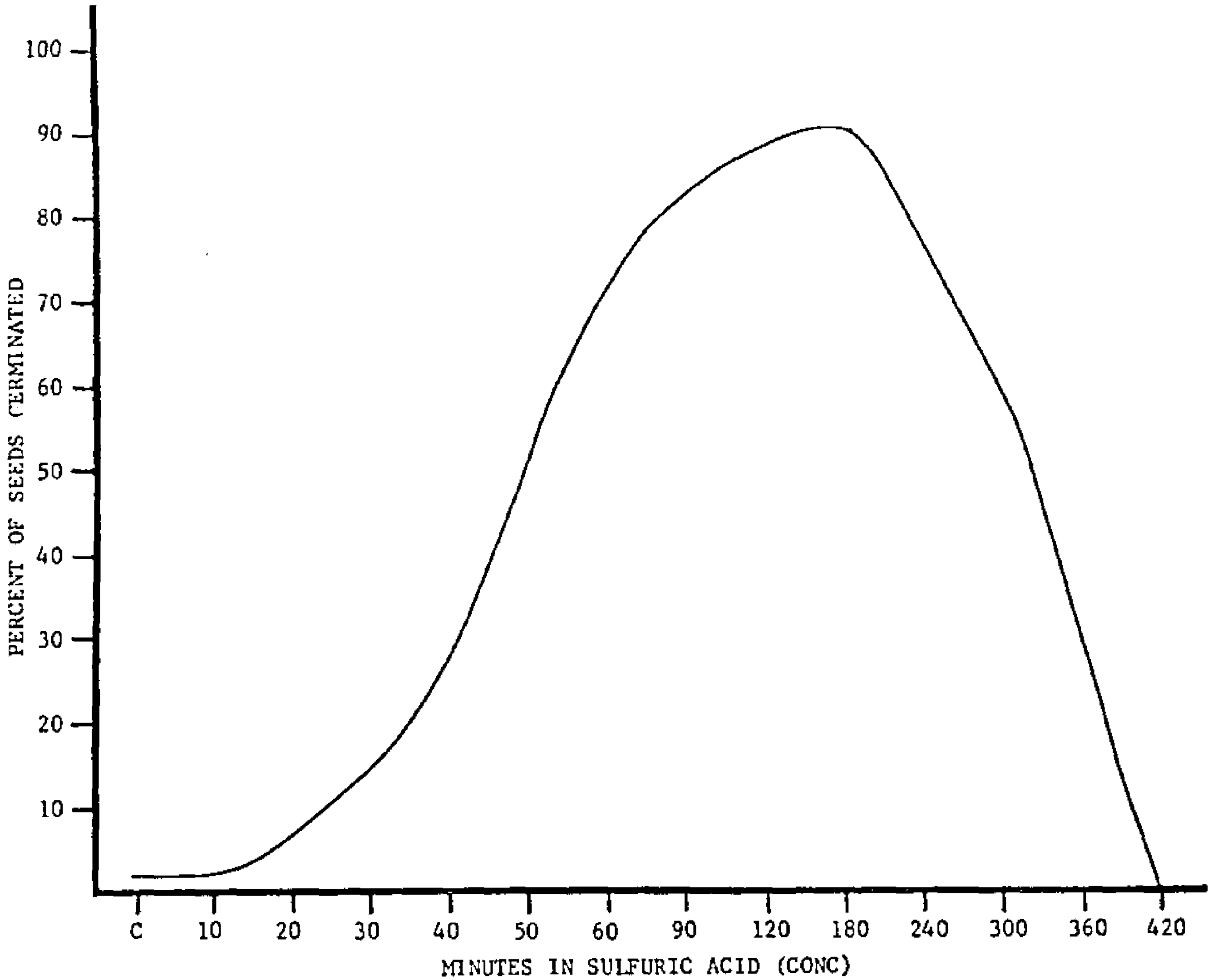

Figure 9. Percentage of sumac seeds germinating after various time intervals in concentrated sulfuric acid.

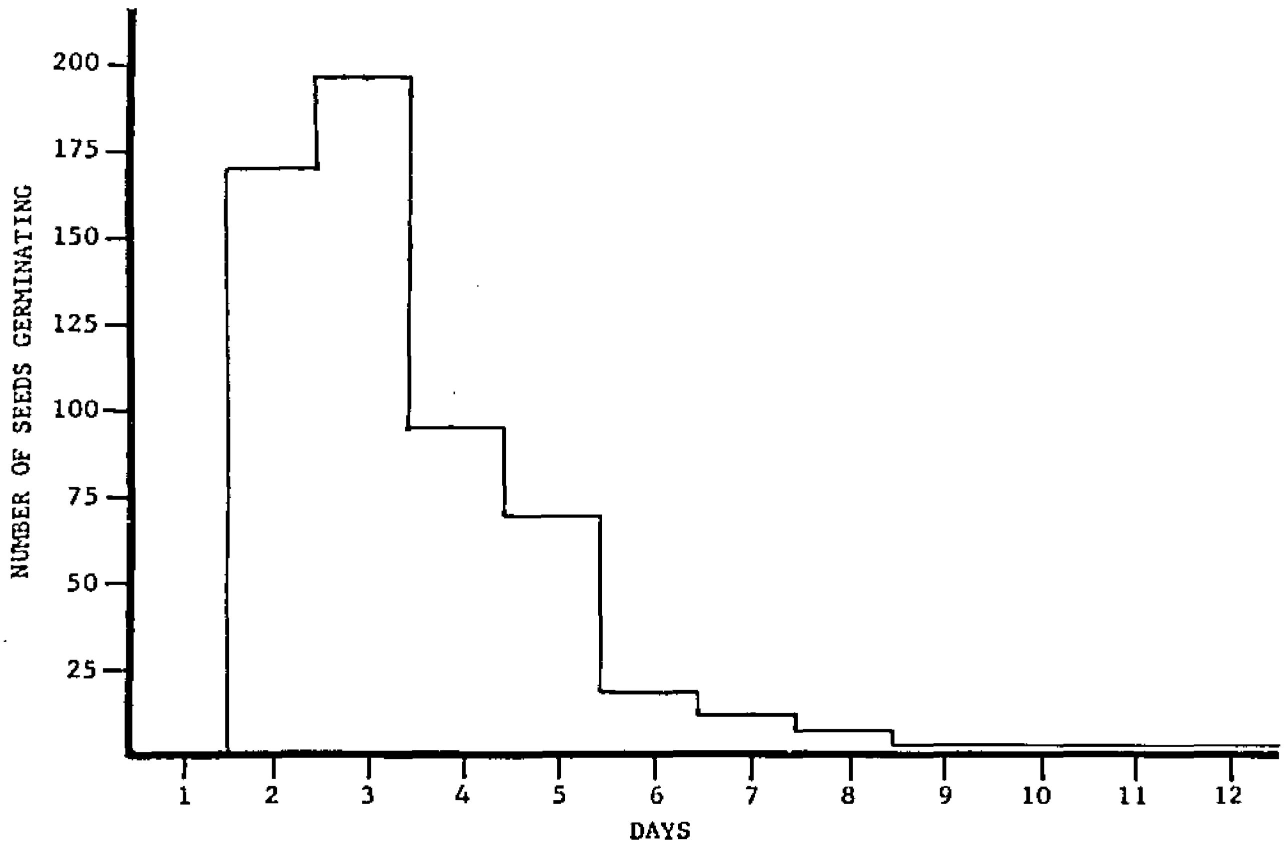

Figure 10. Rate of germination of seeds scarified in sulfuric acid.

from seed, is greatly enhanced by fire (Lovell, 1964; Stone and Juhren, 1951; Went *et al.*, 1952; Wright, 1931). Additionally, sumac seed germination has been shown to increase following ingestion by mammals and birds (Brown, 1947; Krefting and Roe, 1949; Swank, 1944). It appears that both animal ingestion and fire are natural methods of scarification and may be important means of sumac establishment in some parts of North America. However, in six months of daily field observations in sumac areas, I have noted only two seedlings growing in the wild. Certainly, a sumac management plan in Michigan cannot depend upon natural seeding and, therefore, this aspect of the study was approached from the standpoint of artificial establishment from seed.

Methods: In June 1968 three seeding techniques were tested at the Michigan State University Tree Research Center using scarified seeds of *Rhus typhina>glabra*. In two of these procedures the seeds were broadcast, and in the third the seeds were planted. Six 24 square foot plots (6' x 4') were raked and each was then broadcast with 3,500 seeds, approximately one seed per square inch. Subsequently, three of the plots were left undisturbed and three were raked by dragging a rake once over the entire plot, thus covering many of the seeds with soil. In another plot (4' x 10') one hundred seeds were planted at each of the following depths: one inch, two inches, three inches, and four inches. During the course of the summer the soil, a loamy sand, was kept moist by rainfall and irrigation.

Laboratory experiments were also conducted at the Michigan State University Plant Science Greenhouse in which scarified seeds of *Rhus typhina>glabra* were planted in a sandy loam soil at depths of 0.16 inches, 0.33 inches, 0.66 inches, and 1.00 inch. Fifty-seven seeds were planted at each depth. The soil in the greenhouse trays was kept moist, and lightly dusted with the fungicide Captan.

Results and discussion: The results of the seeding experiment at the Tree Research Center are shown in Table 18. These data strongly suggest that the seeds need to be covered with soil, but that the success ratio drops sharply if they are planted deeper than one inch. About 70 percent of all of the plants grown in the summer of 1968 survived the following winter.

The data from the greenhouse plantings indicated that the most successful planting depth is between 0.16 and 0.33 inches (Figure 11).

Table 18. The success of several seed planting trials at the Tree Research Center

Type of Planting	Number of Seeds Used	Number of Plants Established
Broadcast, not raked	3500	1
Broadcast, not raked	3500	10
Broadcast, not raked	3500	0
Broadcast, raked	3500	373
Broadcast, raked	3500	313
Broadcast, raked	3500	407
Planted at 1"	100	29
Planted at 2"	100	4
Planted at 3"	100	1
Planted at 4"	100	0

However, a high percentage of the seeds planted at 0.66 and 1.00 inches were successful. Planting as deep as one inch may be advantageous under uncontrolled field conditions, where shallow seeds would be more susceptible to drought.

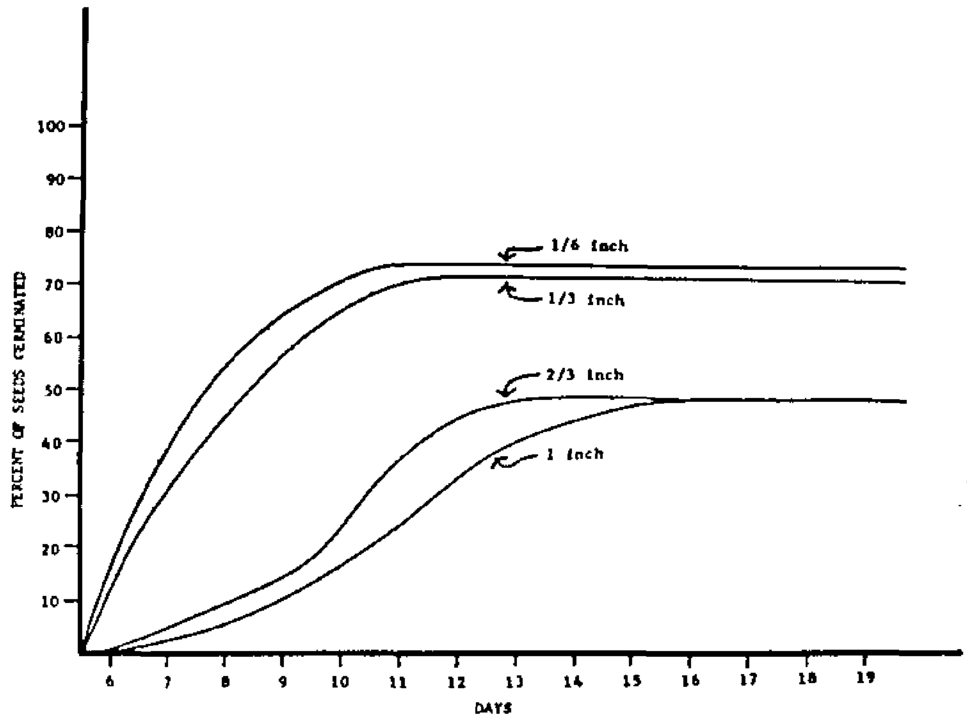

Figure 11. Percentage of seeds germinating when planted at various depths in soil trays, under greenhouse conditions.

The assessment of the value of these results in hampered by the absence of field data. However, from the information obtained, it appears that sumac could be established in the field from seed plantings. Perhaps the most efficient method would be to broadcast seeds prior to discing.

Transplants

Basically, two types of transplants were made. In one, seedlings were grown in a greenhouse and later transplanted to the Tree Research Center. In the second, plants grown from seed the previous year at the Tree Research Center were transplanted a distance of only a few feet from the site in which they were originally planted. The experiments were designed to determine successful methods of transplanting sumac.

Methods: Sumac plants were grown in soil trays from seed, and in Jiffy-7 peat pots in the Plant Science Greenhouse. In June 1969, five weeks after planting, 74 of the seedlings, 37 from each treatment, were transplanted to the Tree Research Center. The plants from the soil trays were transplanted bare rooted, and the peat pot plants were transplanted so that the entire pot was covered with soil.

In July 1969, 90 of the sumac plants established during the previous year were dug up and treated in one of three ways. Sixty of the plants had the soil removed from their roots. Thirty of these were replanted immediately, and 30 were replanted after their roots had been exposed to the air (at 78° F) and sunlight for one hour. The soil around the roots of the remaining 30 plants was left as intact as possible when these plants were transplanted. The roots of these plants were balled in approximately one cubic foot of soil.

Results and discussion: The results of the transplant experiments are shown in Table 19. All methods of transplanting were judged successful, with the best methods being those in which fewest of the plants lost their leaves. Only those plants that did not lose their leaves, or that resprouted, were considered survivors.

Table 19. Comparison of several transplant methods attempted at the Tree Research Center

Method of Transplant	Number of Plants	Percent Surviving in 2 months	Percent of Survivors that did not lose leaves	Percent of Survivors that lost leaves but resprouted
Peat pots, planted entire	37	81	100	-
Tray plants, planted bare rooted	37	86	100	-
Two-year-old plants, planted bare rooted, roots not exposed to drying	30	86	49	38
Two-year-old plants, planted bare rooted, roots exposed to drying for 1 hour	30	77	7	70
Two-year-old plants, planted with roots balled in soil	30	97	84	13

The peat pot transplants were somewhat less successful than the soil tray transplants, as a greater percentage of the latter survived. However, the survivors of the peat pot treatment were significantly larger in terms of stem length ($P < .05$),* and had considerably better

*Unpaired t-test, Li (1964), p. 104.

root development, in terms of root weight ($P < .05$)* than the survivors of the tray transplant treatment. Some of the peat pots were partially unearthed by the erosive action of rainfall. These pots, upon exposure to the air, lost moisture rapidly and the plants within them died as a result of the droughty conditions produced.

The most successful of the two-year-old transplant procedures was the method in which the roots were kept intact with the soil in which they had grown. Most of the plants in this treatment continued growing without losing their leaves or resprouting. The least successful was the method in which the roots were exposed to the air for one hour. However, even in this procedure, most of the plants did survive, and this may be the most practical method for large scale planting operations because it demands the fewest precautions.

Propagation by Physical Disturbance

Root severing experiments were conducted on several clones that appeared to be dormant, in an attempt to rejuvenate them; but no responses were noted, and it seems probable that those clones were either dead or of such reduced vigor that response was impossible. However, the 29 acres of sumac on the study area are evidence that sumac responds vigorously to physical disturbance of the roots. In that area, a vigorous growth response apparently occurred when the roots of sumac in the area were severed by a plow set at a depth of about 10 inches during pine planting operations. The furrows were spaced about six feet apart, and the operations were conducted primarily in April and May.

None of the hybrid sumac plants on the study area had grown out of the reach of deer. However, smooth sumac and, more commonly,

*Unpaired t-test, Li (1964), p. 104.

staghorn sumac, often reach heights far in excess of the reach of deer, and thus become useless as browse species. Mowing or cutting the stems to correct this situation is discussed below.

Methods: Twelve areas, six each of *Rhus glabra* and *Rhus typhina*, in which most of the stems had grown out of the reach of deer, were located in Ingham, Clinton and Shiawassee Counties. In April 1969 all plants were removed from one 400 square foot plot (20' x 20') within each of the 12 areas. Each plant was cut with a pruning saw at a height of four inches from the ground. The age of each plant was determined, and its new growth counted and weighed. In October 1969 the new sprouts on the area were counted, measured, and weighed.

Results and discussion: The results of this experiment are presented in Table 20. Each clone responded vigorously, and in each case the browse zone was successfully lowered. There were significant correlations* ($P < .05$) between the number of plants cut in an area and the number ($r = .88$) and weight ($r = .66$) of sprouts that grew back during the following growing season. Additionally, there were significant correlations ($P < .05$) between the number ($r = .67$) and weight ($r = .76$) of stems growing on the removed plants, and the weight of the sprouts that grew back in the following season. These correlations demonstrated a positive relationship between the vigor of the clone and its response to cutting, indicating that clonal vigor was important in determining the results of this management technique. Physical disturbance by mowing thus appears to be a useful method in lowering the height of browse in existing clones, and large scale sumac mowing

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*Li (1964), p. 301.

Table 20. Productivity of sumac before and after mowing

Clone Number	Species	Sex	Average Height (feet)	Number of Plants	Number of Stems	Weight* of Stems (grams)	Average Age	Number of Sprouts	Weight* of Sprouts (grams)	Average Height (feet)
1	*R. typhina*	F	6.5	18	72	125	7	23	1000	3.1
2	*R. typhina*	F	6.5	27	130	483	7	25	909	3.1
3	*R. typhina*	F	10.0	34	387	3328	9	102	3952	4.3
4	*R. typhina*	M	5.5	33	160	317	9	45	640	1.9
5	*R. typhina*	M	5.5	79	275	492	8	78	1012	2.1
6	*R. typhina*	M	7.0	135	406	1442	7	236	4477	3.8
7	*R. glabra*	F	5.5	52	173	490	6	64	1311	2.1
8	*R. glabra*	F	6.5	95	677	1598	6	112	3404	3.4
9	*R. glabra*	F	5.0	76	490	1980	10	73	1613	2.9
10	*R. glabra*	M	5.0	40	265	501	9	45	952	2.5
11	*R. glabra*	M	10.0	36	421	1309	17	50	1391	3.3
12	*R. glabra*	M	4.5	30	90	253	5	27	439	2.2

*Oven-dry weight, excluding weight of fruit if present operations should be an effective method of increasing sumac browse in areas where most plants exceed six feet in height.

Summary

It was found that sumac is rather easily grown from seed, and that it may be transplanted with a high rate of success. Mowing was also demonstrated to be an acceptable method of reclaiming, as deer browse, clones which had exceeded the reach of deer. The major findings of this section are outlined below:

(1) There was considerable interspecific variation in the size and weight of sumac seeds: about 46,000 seeds per pound of smooth sumac; about 60,000 seeds per pound of staghorn sumac; and about 52,000 seeds per pound of the hybrid sumac.

(2) Scarification in concentrated sulfuric acid was required to break seed dormancy, and the optimum length of time of scarification for the hybrid sumac was 180 minutes.

(3) Sumac was grown successfully from scarified seeds completely covered with soil and planted at depths of one inch or less.

(4) Seedlings grown under greenhouse conditions in soil trays and Jiffy-7 peat pots were successfully transplanted to a nursery site at the Tree Research Center. The peat pot plants were transplanted intact while those from the soil trays were planted bare rooted. Two months after transplanting, those transplants from the soil trays had a slightly higher rate of survival although those in the peat pots had a significantly greater degree of stem and root development.

(5) Two-year-old sumac plants were transplanted from one site to another several feet away. Three transplant methods were employed: planted bare rooted with minimal root exposure to air; planted bare

rooted after exposing the roots to air for one hour; and planted balled-in-soil with minimal disturbance to the roots. All transplant methods were successful, with the balled-in-soil method being the most successful.

(6) Sections of sumac clones in which the height of many plants exceeded six feet were cut at a height of four inches from the ground. All clones resprouted vigorously, and it was suggested that this method be used to lower the browse zone of tall sumac clones.

CONCLUSIONS

The results of this study indicate that sumac is a nutritious and heavily utilized deer browse in northern Lower Michigan. The importance of sumac on the study area is underscored by the fact that it is both highly productive and abundant in forest openings. The plant is easily cultivated in the nursery, and should respond well to establishment under favorable field conditions.

Because of the importance of sumac as a deer browse, it is suggested that planting sumac be considered as a part of a balanced vegetative management plan in the following situations on State and Federally owned forests in Michigan:

1. Along the berms of forest roads,
2. In clearings and old fields designated as wildlife openings,
3. In openings along the peripheries of established pine plantations, and
4. In newly planted and recently clearcut conifer plantations.

The last suggestion would be especially desirable as these areas are often nearly devoid of deer browse. It seems probable that such treatments could be integrated easily into a multiple-use forest management concept, and in many cases they would add appreciably to the wildlife value of commercial timber operations.

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APPENDIX

APPENDIX

INDEX TO COMMON AND TECHNICAL NOMENCLATURE

A. Vertebrate Animals

Technical Name:	Common Name:
Bonasa umbellus	Ruffed grouse
Colinus virginianus	Bobwhite quail
Lophortyx californica	California quail
Meleagris gallopavo	Wild turkey
Odocoileus virginianus	White-tailed deer
Pediocetes phasianellus	Sharp-tailed grouse
Phasianus colchicus	Ringed-neck pheasant
Sylvilagus floridanus	Cottontail rabbit
Sciurus niger	Fox squirrel
Tympanuchus cupido	Prairie chicken

B. Arthropod Animals

Technical Name:	Common Name:
Eriophyes rhois	... a mite
Holcocera chalcofrontella	... a lepidopteran
Idiomacromerus bimiculupemis	... a chalcid fly
Melaphis rhois	... a louse

C. Woody Plants

Technical Name:	Common Name:
Acer rubrum	Red maple
Acer saccharum	Sugar maple
Amelanchier arborea	Downy serviceberry
Fragaria virginiana	Virginia strawberry
Fraxinus americana	American ash
Fraxinus nigra	Black ash
Picea glauca	White spruce
Pinus banksiana	Jack pine
Pinus resinosa	Red pine
Pinus strobus	White pine
Populus grandidentata	Big-toothed aspen
Populus tremuloides	Quaking aspen
Prunus serotina	Black cherry
Prunus virginiana	Choke cherry

Quercus rubra	Red oak
Rhus copallina	Dwarf sumac
Rhus glabra	Smooth sumac
Rhus typhina	Staghorn sumac
Rubus allegheniensis	Common blackberry
Salix humilis	Upland willow
Thuja occidentalis	Northern white cedar
Tilia americana	American basswood
Toxicodendron radicans	Poison ivy
Tsuga canadensis	Eastern hemlock
Ulmus americana	American elm

D. Herbaceous Plants

Technical Name:	Common Name:
Achillea millefolium	Common yarrow
Ambrosia artemisiifolia	Common ragweed
Anaphalis margaritacea	Pearly everlasting
Anemone cylindrica	Thimbleweed
Antennaria plantaginifolia	Plantain-leaved everlasting
Apocynum cannabium	Indian hemp
Asclepias syriaca	Downy milkweed
Centaurea maculosa	Spotted star-thistle
Erigeron annuus	Wandering fleabane
Erigeron canadensis	Horseweed
Hieracium aurantiacum	Devil's paint brush
Hieracium florentium	Florentine hawkweed
Hieracium gronovii	Hawkweed
Hypernicum punctatum	Common St. Johns-wort
Physalis heterophylla	Downy ground-cherry
Prunella vulgaris	Common self-heal
Ranunculus septentrionalis	Swamp buttercup
Rumex acetocella	Sheep sorrel
Solidago canadensis	Canadian goldenrod
Solidago sp.	Goldenrod
Tragopogon dubius	Goat's beard
Vicia cracca	Tufted vetch

E. Ferns, Mosses, Lichens, Fungi and Rusts

Technical Name:	Common Name:
Ceratodon purpureus	... a moss
Cladonia arbuscula	... a lichen
Cladonia chlorophaea	... a lichen
Cladonia cristatella	... a lichen
Cladonia pyxidata	... a lichen
Cryptodiaporthe sp.	... a fungus
Fusarium sp.	... a fungus

Physalospora sp.	... a fungus
Piliolaria sp.	... a fungus
Polytricum juniperinum	... a moss
Pteridium aquilinum	Bracken fern
Pythium sp.	... a fungus
Sphaerotheca sp.	... a fungus
Verticillium sp.	... a fungus

VITA

Hanley K. Smith

Candidate for the Degree of Doctor of Philosophy

Final Examination: September 24, 1970

Guidance Committee: Drs. L. W. Gysel (Chairman), G. Schneider, D. E. Ullrey, and D. P. White

Dissertation: The Biology, Wildlife Use and Management of Sumac in the Lower Peninsula of Michigan

Biographical Items:

Born October 28, 1940, Washington, D.C.

Married Eleanor L. Haag, March 23, 1968

Education:

Tulane University, BS, 1963

Texas A&M University, MS, 1966

Michigan State University, Ph.D., 1970

Experience:

Zoo Keeper, New Orleans Zoo, New Orleans, Louisiana, 1962

Research Assistant, Texas A&M University, 1964-1965

Research Assistant, Michigan State University, 1966-1969

Ecologist, U.S. Army Engineer District, St. Louis, Missouri

Organizations:

American Fisheries Society

American Society of Mammalogists

Wildlife Society