

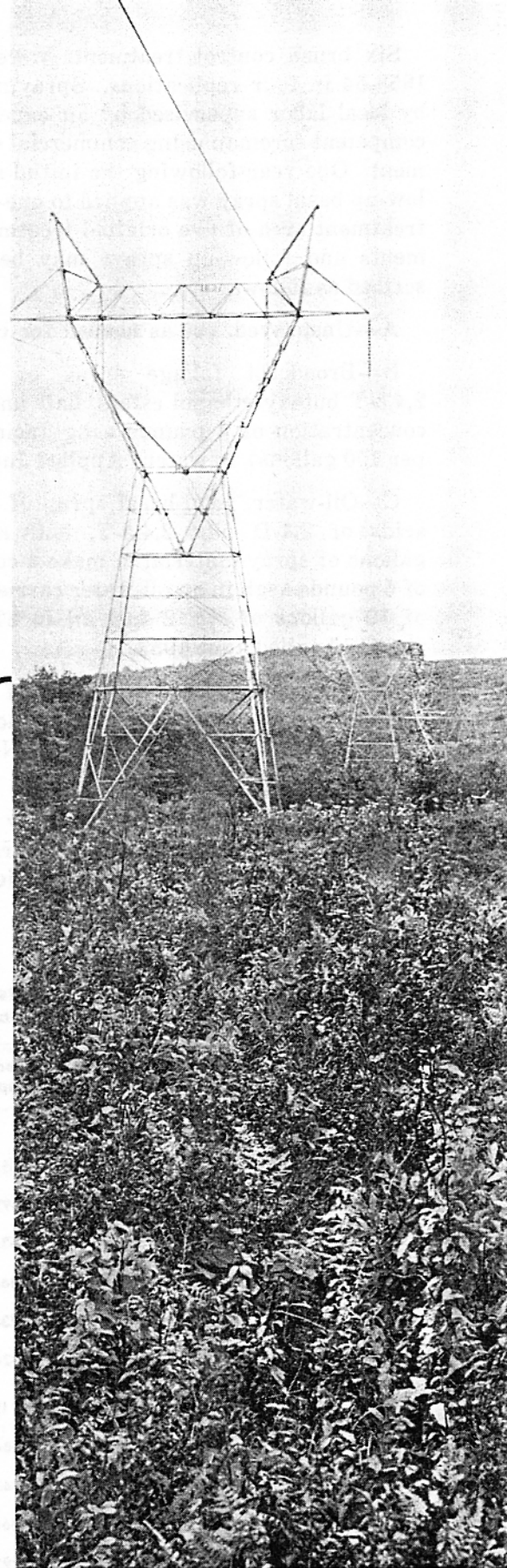
ECOLOGICAL ASPECTS OF BRUSH CONTROL

*—a long term study
on a utility right-of-way*

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IN THE SPRING of 1953, a large-scale test of common brush control techniques was initiated on a section of a Penelec power line right-of-way in central Pennsylvania. This right-of-way had been given an initial capital clearance in the winter of 1951-52 through a typical upland oak forest on state game lands (Figure 1). The principal objectives of the test were, (1) to determine the effects of chemical brush control on game food and cover, (2) to study the game usage of the treatment areas and, (3) to follow the effectiveness of the original treatment in brush control with and without subsequent follow-up sprays. Particular attention was given to development of a stable, low plant cover on the right-of-way.

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Six brush control treatments were applied in 1953-54 in four replications. Spraying was done by local labor supervised by an experienced and competent foreman using commercial spray equipment. One year following the initial spray, a follow-up basal spray was applied to one-half of each treatment area of five original treatments. Treatments and follow-up sprays may be briefly described as follows:

A—Unsprayed, cut as needed for control.

B—Broadcast foliage spray of 2,4-D plus 2,4,5-T butoxy ethanol esters, half and half; at a concentration of 4 pounds aehg (acid equivalent per 100 gallons) in water. Applied June 1953.

C—Oil-water, semi-basal spray of emulsifiable acids of 2,4-D plus 2,4,5-T, half and half; 3 gallons of spray material to make a concentration of 6 pounds aehg in an oil-water carrier consisting of 10 gallons of No. 2 fuel oil in 87 gallons of water. Applied June 1953.

D—General summer basal spray of emulsifiable acids of 2,4-D plus 2,4,5-T, half and half, at a concentration of 12 pounds aehg in No. 2 fuel oil. Applied June 1953.

E—Selective winter basal spray of 2,4,5-T butoxy ethanol esters at a concentration of 12 pounds aehg in No. 2 fuel oil. Applied February 1954.



Figure 1. Upland oak forest with a sparse ground cover of bracken-sedge-herb-blueberry adjacent to the right-of-way.

F—Broadcast foliage spray of Ammate at a concentration of $\frac{3}{4}$ pound per gallon of water; 4 ounces of DuPont sticker-spreader were added per 100 gallons of spray. Applied June 1953.

B-D, C-D, D-D, E-D, F-D—A follow-up basal spray (D) applied in June, 1954 (June, 1956, for E-D) to one half of each replication of treatments B, C, D, E, and F. The follow-up consisted of a summer basal spray using ACP formula 1054-E containing 2 pounds of 2,4-D and 2 pounds of 2,4,5-T per gallon, used at the rate of 16 pounds aehg in fuel oil.

Table 1. Total number of woody sprouts and seedlings per acre in the ground layer, under 3 feet in height; in August 1961, 9 seasons after initial treatment.

Treatment	Bear Oak	Other Oaks	Red Maple	Sassafras	Witchhazel	Cherry	Misc. Hardwoods	Total	Total Minus Sassafras
SINGLE INITIAL SPRAY									
A Unsprayed	94	730	452	10,328	750	26	74	12,454	2126
B Broadcast D + T	96	68	592	620	74	4	30	1,484	864
C Semi-basal	52	48	634	1,532	36	28	52	2,382	850
D Summer Basal	144	134	264	9,622	450	70	106	10,790	1168
E Winter Basal	120	482	736	12,986	413	20	78	14,835	1849
F Broadcast Ammate	54	72	326	1,468	84	38	58	2,100	632
INITIAL SPRAY WITH FOLLOW-UP BASAL									
B-D Broadcast D + T	42	34	384	1,064	88	10	22	1,644	580
C-D Semi-basal	38	44	442	836	46	58	62	1,526	690
D-D Summer Basal	56	90	468	1,150	358	222	32	2,376	1226
E-D Winter Basal	111	228	192	1,338	37	6	102	2,014	676
F-D Broadcast Ammate	82	54	342	1,140	68	18	68	1,772	632

Effect of Sprays on Original Woody Brush

After clearance of the forest cover on the right-of-way during the winter of 1951-52, a woody shrub layer developed consisting primarily of clumps of tree sprouts. One growing season following clearing, and prior to spraying in 1953, this layer had attained a height ranging from 3 to 6 feet and covered 20 to 34 percent of the ground surface. All sprays were applied in June 1953, except Treatment E (selective winter basal) which was applied in February 1954. Top-kill in September, 1954, ranged from 94.1 percent for Treatment B to 99.7 percent for Treatment F; all were highly satisfactory.

Redevelopment of Woody Brush

Vegetation on the test area was left without further chemical treatment until 1966. Recutting of brush on the control plots was done in 1958. Observations have been made periodically for 13 years to determine the long-term effects of chemical treatment on brush control. Data have been taken on small sprouts and seedlings existing in the *ground layer*, less than 3 feet in height, and in the *shrub layer*, more than 3 feet in height. The most recent evaluation in June 1965 was restricted to woody plants in the shrub layer.

Woody Plants in the Shrub Layer

Although a large number of small, woody plants were present in the ground layer in 1961 (Table 1), data on the taller shrub layer 4 years later reveal that relatively few of them had emerged to

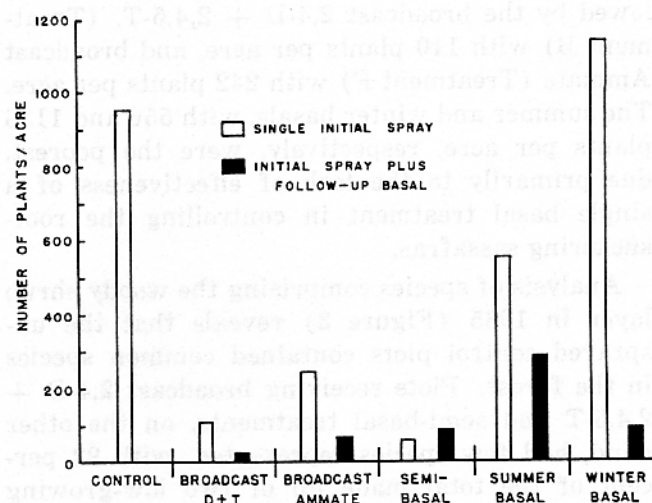


Figure 2. Total number of woody plants per acre over three feet in height on test areas in June 1965, thirteen growing seasons after initial treatment.

actually constitute a brush problem in 1965 (Figure 2). This is particularly true on the follow-up basal plots. Field observations in 1965 revealed that growth of woody plants in the ground layer continued to be suppressed by plant competition, severe browsing by deer and rabbits, and dieback because of frost damage.

Effect of a Single Initial Spray. Comparison among treatments in 1965, (Table 2 and Figure 2), 13 years after the single initial spray, reveals that the semi-basal (Treatment C), with 60 plants per acre in the shrub layer, was superior to all other chemical treatments in preventing redevelopment of a woody shrub layer. This was fol-

Table 2. Total number of woody plants per acre in the shrub layer, over 3 feet in height, in June 1965, 13 years after original treatment.

Treatment	Bear Oak	Other Oaks	Red Maple	Sassafras	Witchhazel	Cherry	Misc. Hard-Woods	Total	Total Minus Sassafras
SINGLE INITIAL SPRAY									
A Unsprayed	152	374	154	74	184	4	14	956	882
B Broadcast D + T	90	6	0	2	12	0	0	110	108
C Semi-basal	38	4	0	0	18	0	0	60	60
D Summer Basal	68	44	32	334	64	10	4	556	222
E Winter Basal	143	124	30	748	87	4	0	1136	388
F Broadcast Ammate	14	20	112	8	78	10	0	242	234
INITIAL SPRAY WITH FOLLOW-UP BASAL									
B-D Broadcast D + T	14	2	0	4	8	0	0	28	24
C-D Semi-basal	12	8	10	0	18	40	4	92	92
D-D Summer Basal	20	32	20	4	110	96	4	286	282
E-D Winter Basal	57	20	0	16	3	0	0	96	80
F-D Broadcast Ammate	6	4	2	2	56	0	0	70	68

lowed by the broadcast 2,4-D + 2,4,5-T, (Treatment B) with 110 plants per acre, and broadcast Ammate (Treatment F) with 242 plants per acre. The summer and winter basals, with 556 and 1136 plants per acre, respectively, were the poorest, due primarily to the lack of effectiveness of a single basal treatment in controlling the root-suckering sassafras.

Analysis of species comprising the woody shrub layer in 1965 (Figure 3) reveals that the unsprayed control plots contained common species in the forest. Plots receiving broadcast 2,4-D + 2,4,5-T and semi-basal treatments, on the other hand, had few species represented, with 93 percent of the total made up of two low-growing species, bear oak and witchhazel. The broadcast ammate areas were dominated by red maple, comprising 46 percent of the brush, and witchhazel. Sassafras dominated the basal spray areas, contributing 60 and 66 percent of the total on the summer and winter basal treatments, respectively, in 1965.

Effect of Initial Spray Plus a Follow-up Basal. The efficiency of the combination of an initial herbicide treatment plus a follow-up basal is readily apparent (Figure 2). The shrub layer, which was practically non-existent in 1956—two years after the follow-up treatment, had developed to fewer than 100 woody plants per acre in 1965 on all but Treatment D (summer basal) and were dominated by low-growing species such as witchhazel and bear oak (Figure 4).

The most outstanding long-term control was achieved by the broadcast 2,4-D + 2,4,5-T with a follow-up basal treatment (B-D), which had 28 woody plants per acre in the shrub layer in 1965,

only six of which were tall-growing tree species (Table 2). The follow-up basal after broadcast ammate (F-D) was also highly effective with 70 plants per acre in 1965. The semi-basal and winter basal plus a follow-up basal (C-D and E-D) with 92 and 96 plants per acre respectively, were only slightly poorer than other chemical treatments.

Regardless of their relative position, the control attained by all treatments with a follow-up basal was exceptionally good. It is probable that these areas will require very little effort and expenditure to maintain the right-of-way in a brush-free condition for many years in the future.

Shrub Edge on Winter Basal Areas

A unique feature of the winter basal treatment technique was an intentional development of a woody shrub layer along the edge of the right-of-way (Figure 5). This was accomplished by avoiding spray application to low-growing shrub species such as bear oak and witchhazel on a 33-foot strip along each side of the right-of-way. All woody brush in the center of the right-of-way was sprayed. This aimed to produce a right-of-way with a low ground layer of grasses, herbs, and small shrubs under 3 feet in height in the center and a taller shrub layer along the edges, bounded by the adjacent forest.

After 13 years of growth, there were an average of 248 bear oak and witchhazel plants per acre, ranging from 3 to 8 feet in height, distributed along the 33-foot edge. In addition, mountain laurel, a flowering shrub, was prominent in many sections (Figure 6). The developing edge helps provide needed food and cover for wildlife.

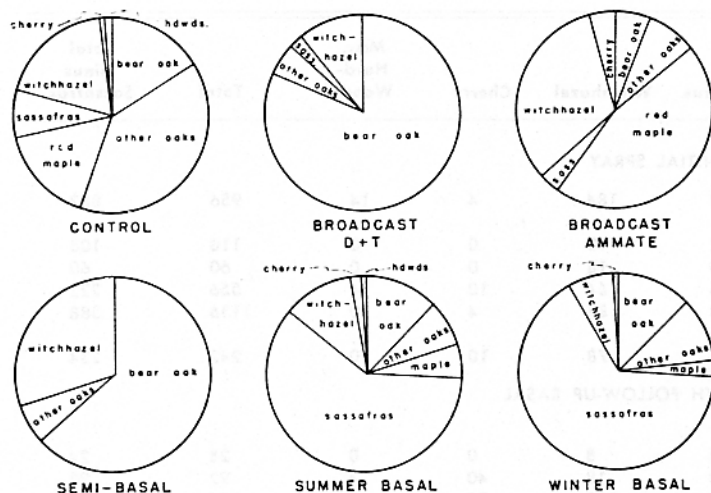


Figure 3. Species composition of the shrub layer, over 3 feet high, in June 1965 on spray areas given a single treatment in 1953 and without a follow-up basal spray.

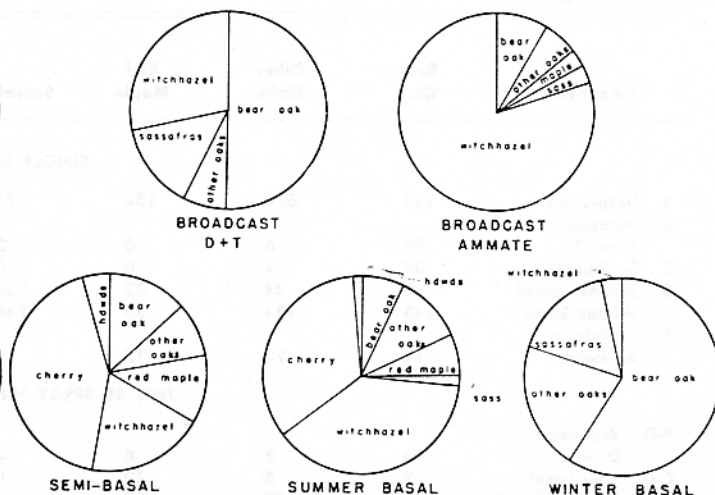


Figure 4. Species composition in June 1965 of the shrub layer on spray areas given a follow-up basal spray in the year following the initial spray in 1953-54.

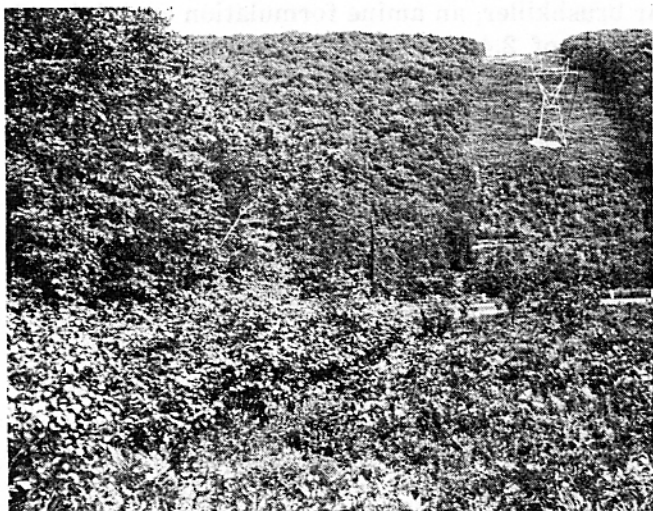


Figure 5. Shrub edge in June 1965 in the left foreground, predominantly witchhazel, created by not spraying low-growing shrubs on borders of the right-of-way adjacent to the woods (Treatment II E).

Retreatment of Test Areas in 1966

The first retreatment, after initial and follow-up basal applications, of the chemically sprayed areas was done between June 28 and July 11, 1966. Retreatment methods were selected to best fit existing brush conditions and applied to those replications, or parts of them, in need of brush control. The treatment in 1966 was primarily a selective basal spray owing to the small scattered brush present (Figure 7). Where a follow-up basal had been applied in 1954-55, there was usually no need for a respray in 1966 (Figures 8 and 9). Sassafras was a major problem species in localized areas in 1966 on basal spray areas (Figure 10). Retreatment techniques are described below and are compared on the basis of man hours and volume of spray applied in Table 3.



Figure 6. Mountain laurel in June 1965, preserved on the right-of-way following summer basal spraying (Treatment IV D-D).

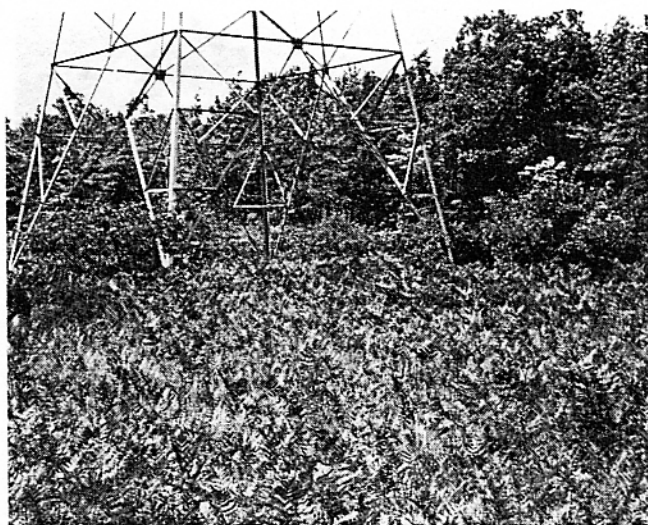


Figure 7. Bear oak brush in June 1965 on an oil-water, semi-basal spray area (Treatment III C). Typical of brush resprayed in 1966.

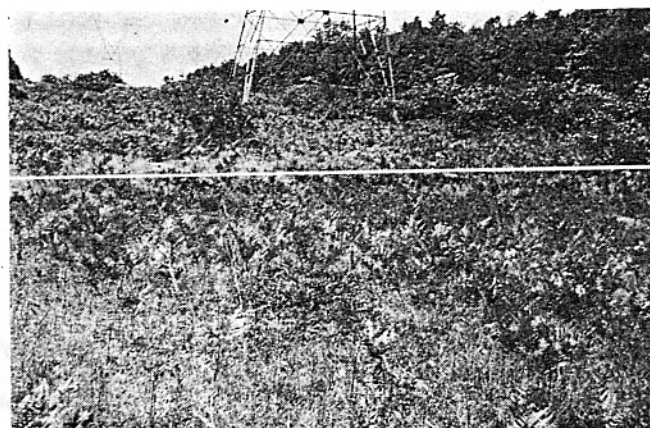


Figure 8. Oil-water, semi-basal spray area with follow-up basal (Treatment III C-D) in the foreground that is brush-free; and without follow-up (Treatment III C) in background with scattered bear oak brush.

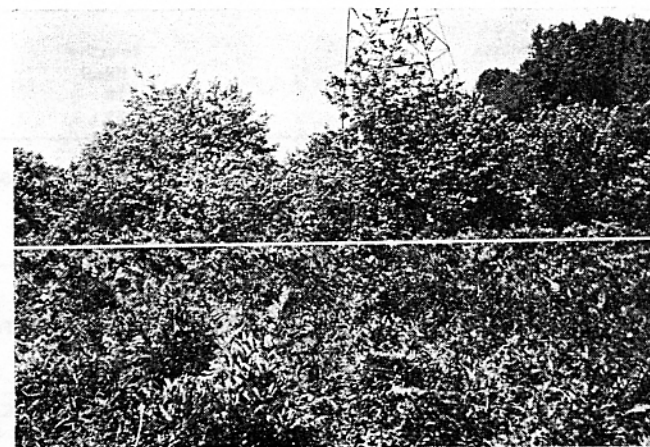


Figure 9. Broadcast ammate with follow-up summer basal spray area (III F-D) brush-free in June 1965 in foreground; Ammate without a follow-up basal (III F) in background with red maple sprouts 15 to 20 feet tall.

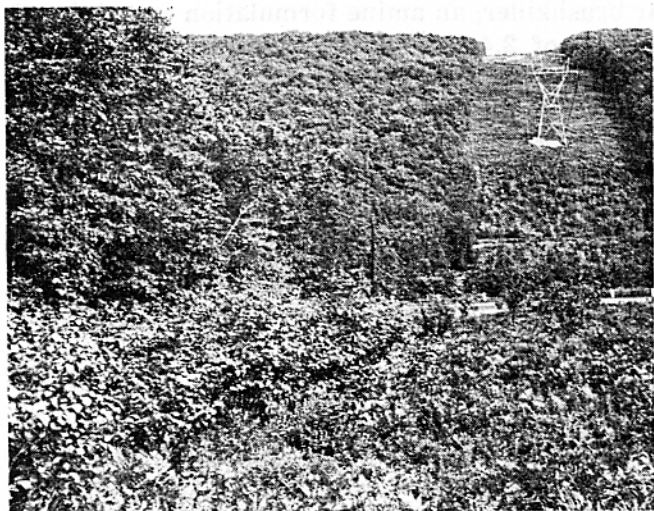


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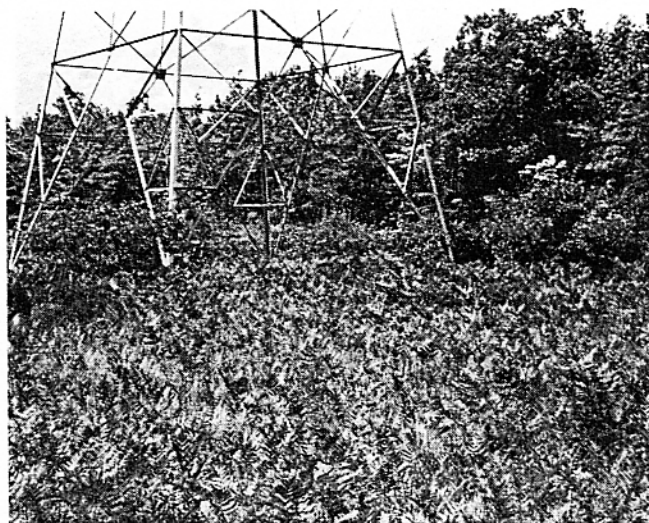


Figure 7. Bear oak brush in June 1965 on an oil-water, semi-basal spray area (Treatment III C). Typical of brush resprayed in 1966.

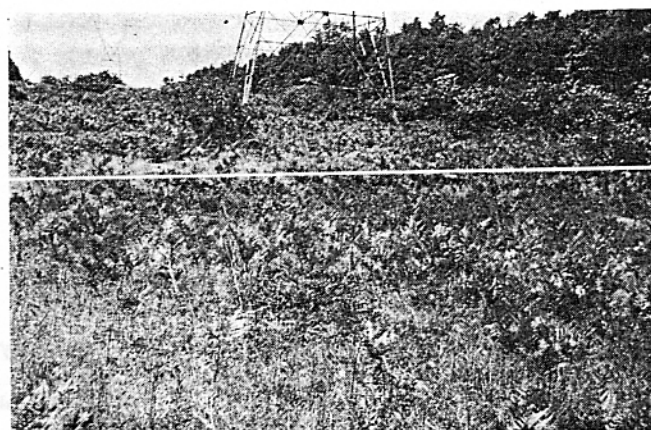


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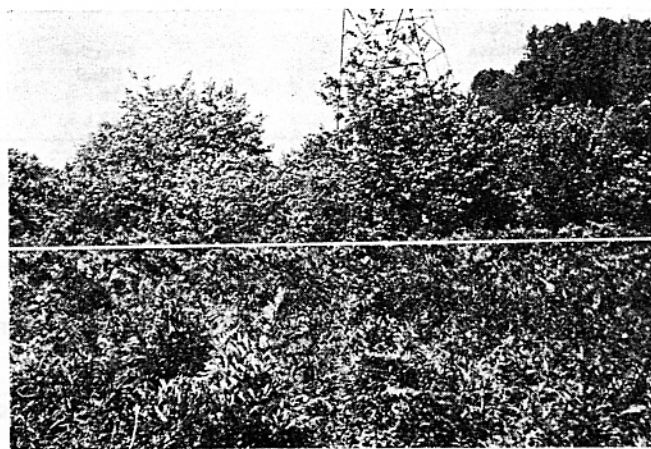


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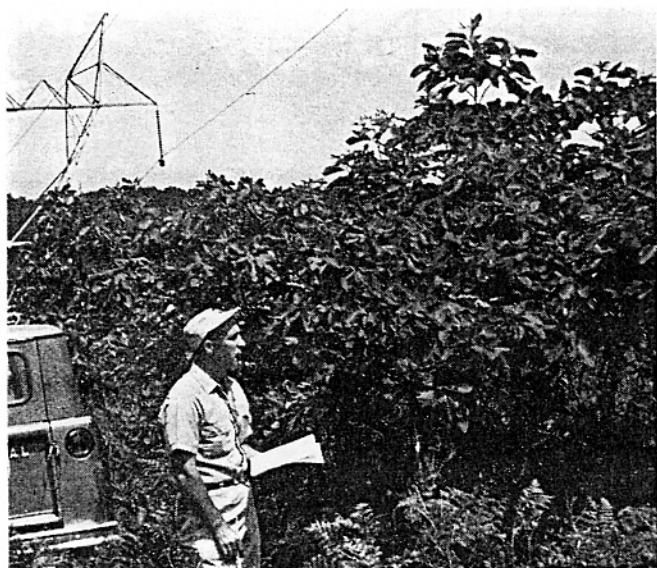


Figure 10. Sassafras on a winter basal spray area in June 1965 (Treatment IV E).

G—Selective basal and stump spray of 1054-E (Amchem) butoxy ethanol ester at 4 pounds ae per gallon. A concentration of 16 pounds ae/hg in No. 2 fuel oil was used. A standard basal and stump spray application was made, thoroughly wetting all exposed roots and stems to a height of about 10 inches.

H—Stem-foliage waterborne of Amchem Weed-

ar brushkiller, an amine formulation containing 2 pounds of 2,4-D and 2 pounds of 2,4,5-T amine salt per gallon. A concentration of 4 pounds ai/hg (active ingredient per 100 gallons) in water was used. A standard application was made, thoroughly wetting all foliage and stems.

The center portion of the right-of-way was sprayed to eliminate all woody growth, taking care to preserve the existing groundcover of sweetfern, bracken, blueberries, and grasses. Low growing species such as witchhazel, scrub oak, and hawthorn were left on a 33-foot strip along each edge of the right-of-way.

Where cutting and stump spraying was done, small stems 1 inch or smaller in diameter were left uncut for basal treatment. It was felt that stumps from such small material would be lost in existing groundcover and as a result not be sprayed. Numerous small, 4-6 inch tall sassafras and red maple existed in the groundcover. Because of their small size and number, an effort was made to spray this small woody growth only where the groundcover was not sufficient to hide it.

Control plots (Treatment A) scheduled for recutting were cut in January and February of 1967 (Figure 11). They had previously been recut in 1958.

Table 3. Chemical treatment applied in June and July, 1966.

1966 Retreatment	Replications ¹				Total	Acres Treated	Per Acre Treated
	I	II	III	IV			
Treatment B (8.43A. Tot.) Spray Technique			Cut and Stump Spray	Selective Basal		3.29	
Man Hours	18	13.5	31.5		9.57
Gallons Spray	20	43	63.0		19.24
Treatment C (10.08A. Tot.) Spray Technique		Selective Basal		Selective Basal		4.63	
Man Hours	...	18	...	9	27.0		5.83
Gallons Spray	...	35	...	45	80.0		17.28
Treatment D (9.82A. Tot.) Spray Technique		Selective Basal	Selective Basal	Selective Basal		6.90	
Man Hours	...	39	10.5	18	67.5		9.78
Gallons Spray	...	130	38	325	493.0		71.45
Treatment E (10.05A. Tot.) Spray Technique	Stem- Foliage		Stem- Foliage	Selective Basal		7.05	
Man Hours	24	...	12	15	51		7.23
Gallons Spray	825	...	375	42	1242		176.17
Treatment F (12.65A. Tot.) Spray Technique		Cut and Stump Spray	Cut and Stump Spray			7.04	
Man Hours	...	120	33	...	153		21.73
Gallons Spray	...	160	37	...	197		27.98

¹ Single initial spray subplots and initial spray with follow-up basal subplots were sprayed as one for each treatment, except for IV CD which was treated separately from IV C.



Figure 11. Unsprayed control in June 1965, which had been recut in 1958. Red maple, white oak, and chestnut oak brush have resprouted and grown to a height of about 15 feet.

Development of a Stable Ground Cover

One of the major objectives of the study was to observe development of the ground cover towards a stable condition which would reduce the need for repeated sprays.

The selective basals were highly successful in maintaining the original ground cover (Figures 12 and 13) which has been designated as a Bracken-Sedge-Herb-Blueberry plant community after its dominant species (Table 4). Plant composition of both the summer and winter basals has



Figure 12. Summer basal area, sprayed in 1953, in June 1965. A bracken, sedge, herb, blueberry ground cover has remained since 1953 as a low, tight cover (Treatment I D).

Table 4. Plant composition of a typical Bracken-Sedge-Herb-Blueberry plant community on the right-of-way in 1965.

Characteristic and dominant species:	A-S ¹
Bracken (<i>Pteridium aquilinum</i>)	2-4
Sedge (<i>Carex pensylvanica</i>)	2-3
Panic Grass (<i>Panicum latifolium</i> and <i>Panicum commutatum</i>)	1-2
Upland Rice Grass (<i>Oryzopsis asperifolia</i>)	1-2
Loosestrife (<i>Lysimachia quadrifolia</i>)	+1
Sarsaparilla (<i>Aralia nudicaulis</i>)	+1
Goldenrod (<i>Solidago</i> spp.)	+2
Fireweed (<i>Erechtites hieracifolia</i>)	-
Blueberry (<i>Vaccinium</i> spp. and <i>Gaylussacia</i>)	3-3
Sweetfern (<i>Comptonia peregrina</i>)	1-3
Witchhazel (<i>Hamamelis virginiana</i>)	1-1
Teaberry (<i>Gaultheria procumbens</i>)	1-1
Blackberry (<i>Rubus allegheniensis</i>)	+1
Arbutus (<i>Epigaea repens</i>)	+1
Laurel (<i>Kalmia latifolia</i>)	+2
Azalea (<i>Rhododendron nudiflorum</i>)	+1

A = Abundance and cover expressed in symbols: + = Sparse, cover very small; 1 = Plentiful, but of small cover value; 2 = Covering 1/20 to 1/4 of the area; 3 = Covering 1/4 to 1/2 of the area; 4 = Covering 1/2 to 3/4 of the area; 5 = Covering more than 3/4 of the area.

S = Grouping (sociability) expressed in symbols: 1 = Growing singly; 2 = Grouped or tufted; 3 = Small patches (less than 1 milacre); 4 = Extensive patches or carpets; 5 = Pure population.

For example, 2-3 indicates that a plant covers 1/20 to 1/4 of the ground area and occurs in small patches.

remained essentially stable from 1953 through 1965 (Table 5). The greatest change has been an increase in blueberry.

The oil-water, semi-basal caused a marked decrease in blueberry but maintained bracken and sedge (Figure 14). By 1965 the original plant composition had been regained (Table 5).

Although the broadcast sprays caused a marked change in plant composition in the years immediately following spraying, those areas, too, returned to essentially the original plant composition.

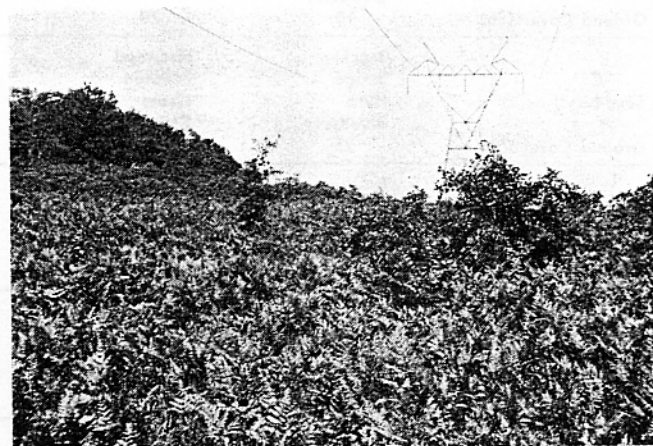


Figure 13. Winter basal area, sprayed in February 1954, in June 1965. A bracken, sedge, herb, blueberry community has been maintained as a tight cover (Treatment IE).



Figure 14. Oil-water, semi-basal area, sprayed in 1953, in June 1965. Bracken, sedge, herb, blueberry cover (Treatment IC).



Figure 15. Broadcast D + T area, sprayed in 1953, in June 1965. Sweetfern has become the common low shrub replacing blueberry (Treatment IB).

tion in about 5 years (Figure 15 and 16). Sweetfern, however, replaced blueberry as the dominant low shrub (Table 5).

Table 5. Changes in dominant species and in area covered by ground vegetation, under 3 feet in height, as a result of chemical spraying.

Dominant Plants in Late Summer, Aug.-Sept.						
Treatment June 1953	1953	1954	1955	1956	1957	1965
A Unsprayed	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry
Ground Cover (%)	79	96	84	80	89	100
B Broadcast D + T	Bracken Sedge Herb Blueberry	Sedge Grass Herb	Sedge Grass	Sedge Grass	Bracken Sedge Herb Sweetfern	Bracken Sedge Herb Sweetfern
Ground Cover (%)	10	79	88	96	98	100
C Semi-basal	Bracken Sedge Herb Blueberry	Fireweed Bracken Grass Sedge	Bracken Sedge Herb	Bracken Sedge Herb	Bracken Sedge Herb	Bracken Sedge Herb Blueberry
Ground Cover (%)	25	79	91	95	98	100
D Summer Basal	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry
Ground Cover (%)	75	95	96	98	98	100
E Winter Basal Feb. 1954	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry
Ground Cover (%)	75	95	95	97	90	100
F Broadcast Ammate	Bracken Sedge Herb Blueberry	Fireweed Sedge Grass	Fireweed Sedge	Sedge Fireweed Bracken	Sedge Bracken Herb Sweetfern	Bracken Sedge Herb Sweetfern
Ground Cover (%)	10	71	84	85	95	100

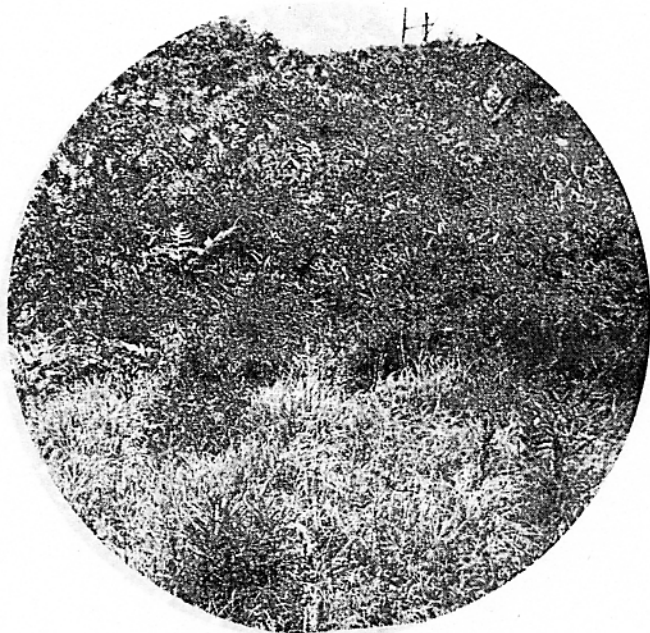


Figure 16. Broadcast ammate area, sprayed in 1953, in June 1965. A bracken, sedge, herb, sweetfern community has developed (Treatment IF).

Completeness of ground cover was maintained by the selective basal sprays; while disturbance was much greater, as might be expected, with semi-basal and broadcast sprays. All sprayed areas recovered quickly, however, so that by 1955 low vegetation covered 84 to 96 percent of the ground area.

While small tree seedlings remained numerous in the ground layer, the resurge of brush was very sparse where a summer basal followed the original sprays. Perhaps the best evidence of resistance to resurge by woody brush was the light treatments needed in 1966 (Table 3).

Game Usage

Direct observations in this study included both the animals themselves and definite signs of their having been on the right-of-way as shown by pellets (Figure 17), tracks, and evidence of feeding (Tables 6 and 7).

Table 6. Number of times common wildlife species or signs were observed on treatment areas from October 1, 1953 through October 1957.

Treatment	Deer	Grouse	Rabbit	Squirrel	Turkey
A Unsprayed	83	12	51	6	0
B Broadcast D + T	45	8	8	2	31
C Semi-basal	62	7	3	6	1
D Summer Basal	53	5	12	8	1
E Winter Basal	59	8	25	11	1
F Broadcast Ammate	69	8	7	18	15
Total	371	48	106	51	49

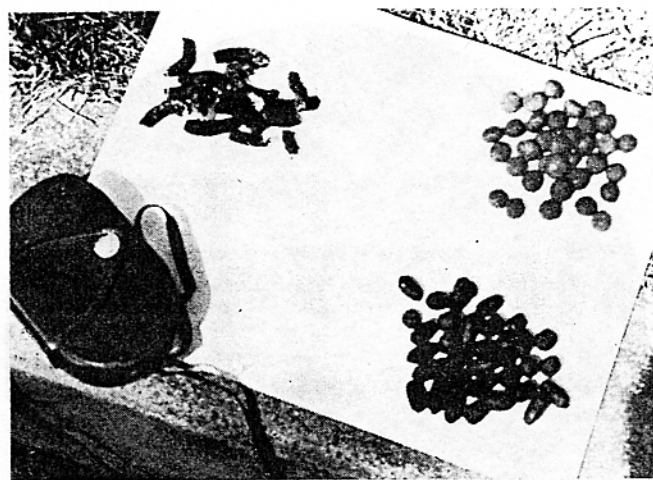


Figure 17. Pellet groups used in following game usage of the treatment areas. Grouse, upper left; rabbit, upper right; and deer, lower right.

Certain important trends appear in the number of times wildlife species, or signs of them were observed on treatment areas following spraying. (Tables 6 and 7). For example, deer were not only observed on all treatment areas, but the total usage of these areas increased. The control area, Treatment A, was used heavily in winter for bedding-down and for feeding on

Table 7. Average numbers of animal pellets per treatment obtained from 20, 3-by-100-foot transects, for each treatment.

Treatment	March 1954	April 1955	April 1956	April 1957	April 1962
DEER					
A Unsprayed	349	52	1177	1115	1905
B Broadcast D + T	112	113	260	426	1086
C Semi-basal	216	95	316	432	380
D Summer Basal	391	218	433	632	566
E Winter Basal	532	277	868	830	668
F Broadcast Ammate	165	124	610	668	490
RABBIT					
A Unsprayed	101	296	482	150	903
B Broadcast D + T	95	467	248	124	491
C Semi-basal	3	167	30	35	111
D Summer Basal	132	106	99	28	225
E Winter Basal	102	211	335	116	1620
F Broadcast Ammate	2	85	26	30	494
GROUSE					
A Unsprayed	2	0	6	0	1
B Broadcast D + T	0	0	0	¼	6
C Semi-basal	0	¼	¼	0	3
D Summer Basal	0	0	½	0	3
E Winter Basal	0	0	13	0	3
F Broadcast Ammate	1	0	¼	¼	1

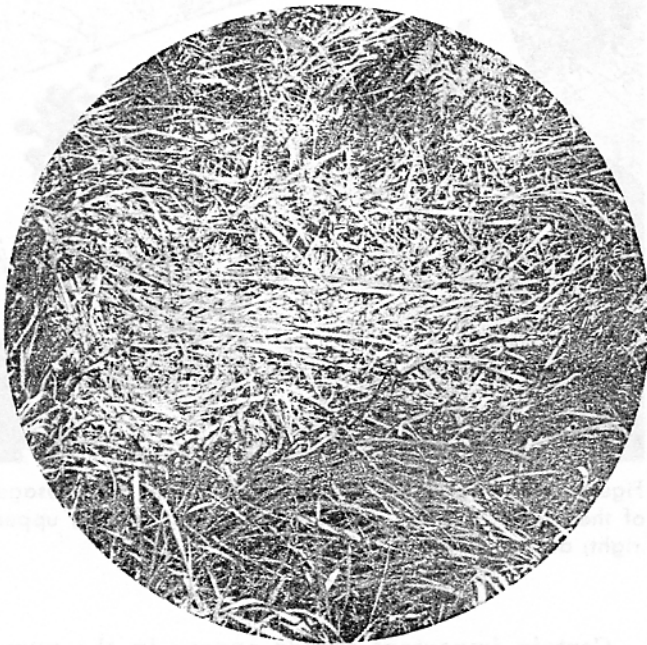


Figure 18. Deer bed in grass area (Treatment IV D) in June 1965.

woody browse. During this season the adjacent woods, which are seriously over-browsed, were nearly bare of low cover and food. In the other treatment areas, deer fed heavily in spring and early summer on young shoots of bracken and on the common herb, wild loosestrife. Deer commonly bedded down in the summer in treatment areas where grass and sedge were common (Figures 18 and 19).



Figure 19. A young fawn concealed in a dense bracken-blueberry cover on the right-of-way.

Grouse were observed in all treatment areas; and in addition, they were often found on the edges within 150 to 200 feet of the right-of-way. Use of the right-of-way by turkeys was observed on treatments B and F, broadcast spray areas, on which a grass-herb cover became dominant (Figure 20). Flocks of young turkeys use such openings in the summer when they are feeding on insects.

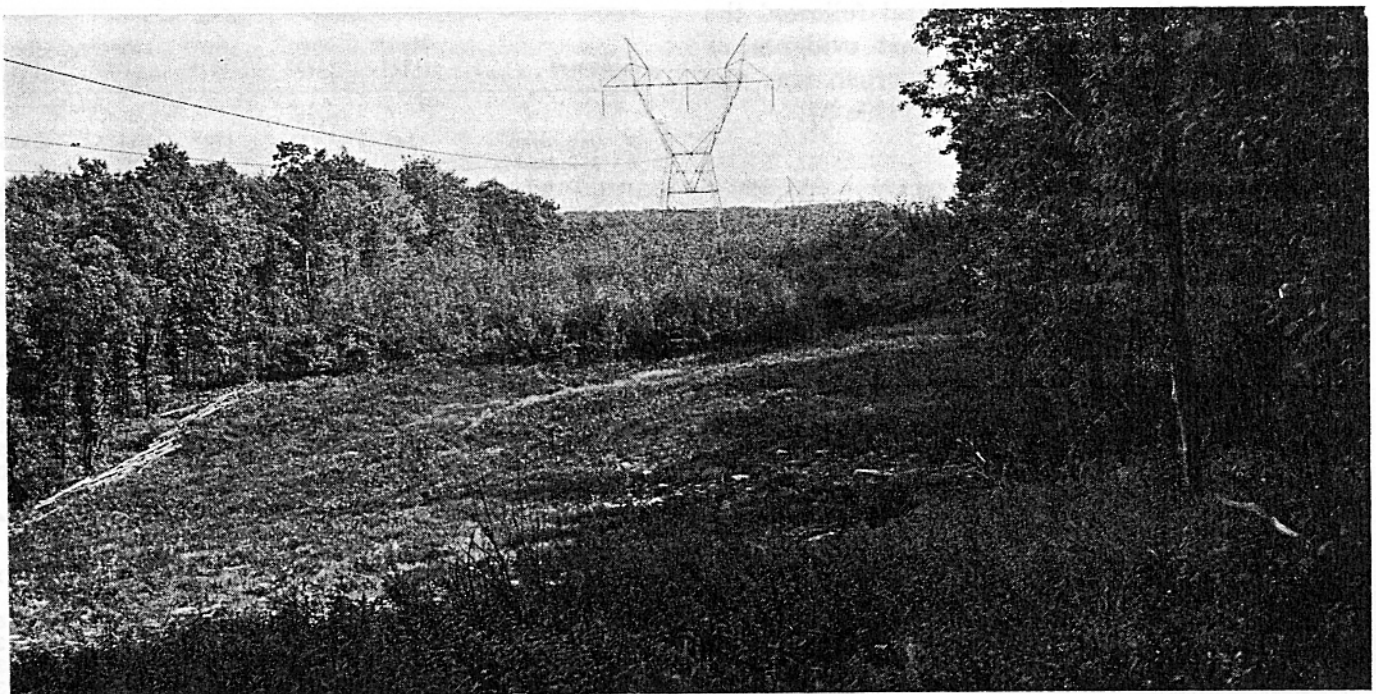


Figure 20. A low cover on the right-of-way, Treatment B in 1958, which young turkey poults used in feeding. Un-

sprayed control area (III A) is in the background at the tower site.

Table 8. Utilization by game of common plant species that occur on the right-of-way as observed and recorded.

	Deer				Grouse				Turkey				Rabbit			
Herbs and Grasses	Sp	Su	F	W	Sp	Su	F	W	Sp	Su	F	W	Sp	Su	F	W
Bracken	H	H	—	—	—	—	H	—	—	—	—	—	—	—	—	—
Sedge	H	L	L	H	—	—	L	L	L	H	L	L	—	—	—	—
Loosestrife	H	H	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Panic Grass	L	L	L	L	—	—	L	—	—	H	H	H	H	H	H	H
Goldenrod	L	L	—	—	—	L	—	—	—	—	—	—	—	H	H	—
Fireweed	L	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Shrubs																
Blueberry	H	L	L	H	—	H	H	H	—	H	—	L	L	L	L	H
Teaberry	L	L	L	L	H	H	H	H	—	L	L	L	—	—	—	—
Blackberry	L	L	L	L	L	H	H	H	—	H	L	L	H	H	H	H
Sweetfern	H	—	H	H	—	—	L	L	—	—	—	—	—	—	—	L
Witchhazel	L	L	L	H	—	—	H	H	—	—	H	L	—	—	—	L

H = eaten commonly or heavily utilized

L = eaten rarely or sparsely utilized

Season = Sp, spring; Su, summer; F, fall; W, winter

Use of the right-of-way by squirrels was mostly along the edges where oaks and most other mast-producing trees and shrubs supplied food. Squirrels were observed to cross the right-of-way from one side to the other during their winter activities and buried acorns which occasionally produced young oak seedlings some distance from the edges.

Rabbits increased on the treatment areas over the observation period. They are not a common game animal in the forests of the plateau but increased under right-of-way conditions where woodchuck holes appeared to provide refuges (Figure 21). The abundant low cover on the right-of-way not found in the woods made food available to them.



Figure 21. Woodchuck activity on the right-of-way increased after the spraying and provided rabbit escape cover in open areas.

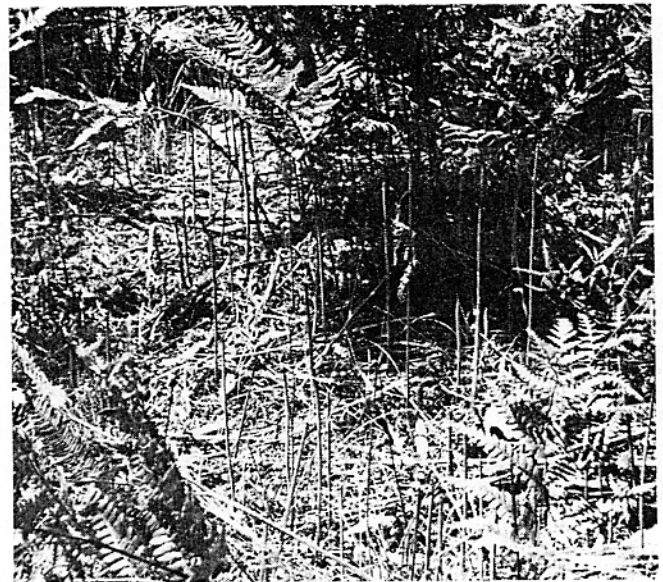


Figure 22. Bracken fern heavily browsed by deer in June 1965 (Treatment IC).

All of the common species of plants composing the dominant plant cover on the right-of-way were used by major game species of the area (Table 8). All plants except fireweed were used heavily in at least one season by at least one species of game. This gave further indication of the value of plants produced in large quantities on the right-of-way following chemical brush control.

In June of 1965, there was a striking use by deer of bracken fern and of some of the common herbs including loosestrife and goldenrod (Figure 22). Also heavily used were the shrubs blackberry, witchhazel, and sweetfern. As bracken was

Table 9. Composition of bracken fern (*Pteridium aquilinum*) at three stages of development (oven-dry basis).¹

Composition	Stage of Development		
	Immature ²	Intermediate ³	Mature
	%	%	%
Protein	37.70	35.70	16.50
Fat (ether extract)	0.92	2.70	2.50
Crude Fiber	10.40	13.30	21.90
Calcium	0.12	0.10	0.23
Magnesium	0.30	0.30	0.14
Phosphorus	0.92	0.83	0.30
Potassium	3.00	3.20	2.10

¹ Analysis of composite samples collected on June 29, 1965.

² Fiddle-head stage.

³ Expanding frond stage.

most abundant and most heavily eaten, it became of special interest. By sample clipping and later drying and weighing, it was estimated that there was about 424 pounds of bracken (air-dry weight) per acre on the right-of-way. It was generally green with numerous fresh sprouts even in late June as compared to the sparse, wiry-

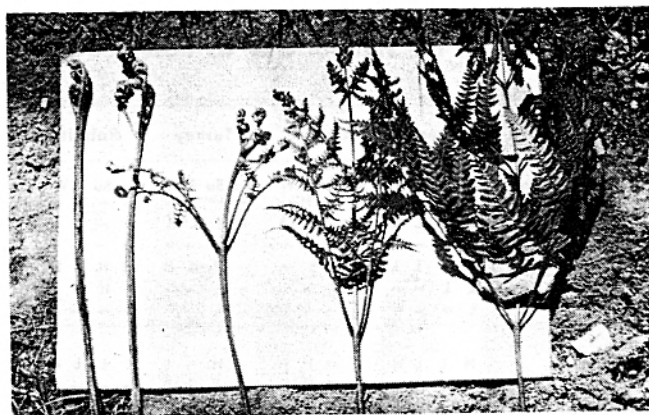


Figure 23. Growth stages of bracken fern collected in June 1965. Fiddle-heads on the left are the young stages preferred by deer and as bracken becomes mature (right) it is rarely eaten in normal years.

stemmed bracken in the adjacent forest. The food value of the bracken based on a standard feed analysis is fairly high. The younger stages which seem to be preferred by deer are particularly high in protein, phosphorus, and potassium as compared with the mature stage (Table 9 and Figure 23).

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Appendix

Common and Scientific Names of Plants Referred to in the Report
From Gray's Manual of Botany, 8th Edition, 1950

Aspen	<i>Populus grandidentata</i>
	<i>Populus tremuloides</i>
Blackberry	<i>Rubus allegheniensis</i>
Blueberries	<i>Vaccinium angustifolium</i>
	<i>Vaccinium vacillans</i>
Bracken	<i>Pteridium aquilinum</i>
Cherry, Black	<i>Prunus serotina</i>
Fire	<i>Prunus pensylvanica</i>
Chestnut	<i>Castanea dentata</i>
Dogwood, Flowering	<i>Cornus florida</i>
False Solomon's-seal	<i>Smilacina racemosa</i>
Fireweed	<i>Erechtites hieracifolia</i>
Gum, Black	<i>Nyssa sylvatica</i>
Hawthorn	<i>Crataegus spp.</i>
Hickory	<i>Carya spp.</i>
Holly, Large-leaved	<i>Ilex montana</i>
Huckleberry	<i>Gaylussacia baccata</i>
Indian Cucumber-root	<i>Medeola virginiana</i>
Juneberry	<i>Amelanchier arborea</i>
Lady's Slipper	<i>Cypripedium acaule</i>
Loosestrife	<i>Lysimachia quadrifolia</i>
Maple, Red	<i>Acer rubrum</i>
Mountain-Laurel	<i>Kalmia latifolia</i>
Oak, Bear	<i>Quercus ilicifolia</i>
Black	<i>Quercus velutina</i>
Chestnut	<i>Quercus Prinus</i>
Red	<i>Quercus rubra</i>
White	<i>Quercus alba</i>
Panic grasses	<i>Panicum latifolium</i>
	<i>Panicum commutatum</i>
Sassafras	<i>Sassafras albidum</i>
Sedge	<i>Carex pensylvanica</i>
Sweetfern	<i>Comptonia peregrina</i>
Teaberry	<i>Gaultheria procumbens</i>
Upland Bent	<i>Agrostis perennans</i>
Wild Sarsaparilla	<i>Aralia nudicaulis</i>
Witchhazel	<i>Hamamelis virginiana</i>