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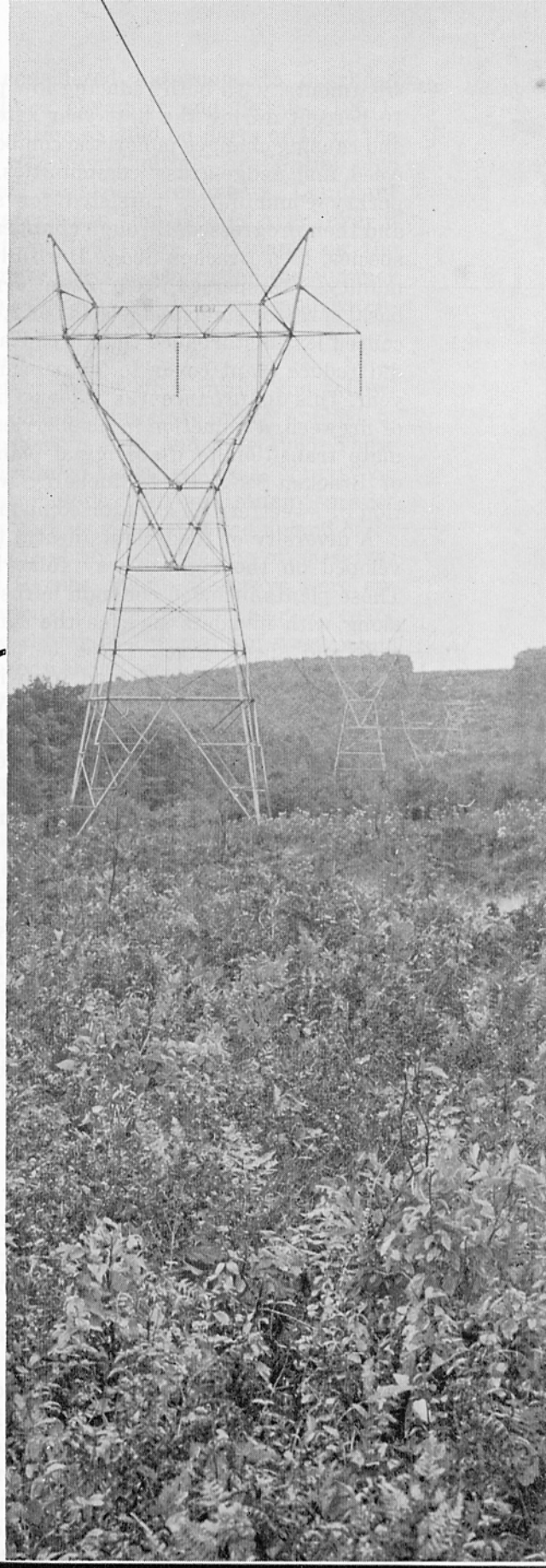
A Long-term Ecological Study Of Game Food and Cover On a Sprayed Utility Right-of-Way



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SUMMARY

Herbicide treatments applied in 1953, consisting of selective summer and winter basals, a semi-basal, and two broadcast sprays, were highly effective in controlling woody brush of mixed upland oak species on a utility right-of-way. Distinct variations in disturbance and subsequent development of ground layer vegetation occurred in response to the different spray techniques applied.

A stable low plant cover designated a Bracken-Sedge-Herb-Blueberry community persisted on unsprayed control areas and on selective summer and winter basal areas throughout the 19-year study period. Species such as bracken, sedge, loosestrife, and blueberry were continuously present. The woody shrub, sweetfern, which was very sparse in the early years, increased and now occurs in patches intermingled in a mosaic pattern with the Bracken-Sedge-Herb-Blueberry community.

In contrast, broadcast sprays of ammonium sulfamate and 2,4-D + 2,4,5-T esters were drastic

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treatments, with both reducing low plant cover to 10 percent during the first year after application and causing changes in floristic composition to fireweed and sedge-grass communities. These temporary communities persisted for several years and then progressed, through changes in dominant species, to a Bracken-Sedge-Herb-Blueberry community interspersed with sweetfern. The semi-basal spray of emulsifiable acids of 2,4-D + 2,4,5-T caused less disturbance than broadcast sprays but did reduce plant cover to 25 percent in the first year. This disturbance was followed by an invasion of fireweed, a reduction in blueberries, and an ultimate transition to the original plant community of Bracken-Sedge-Herb-Blueberry with the addition of sweetfern as a major component.

A diversity of food plants useful to wildlife developed on the right-of-way following spraying. These plants included common herbs of the forest along with invaders such as the common goldenrods and sheep-sorrel. These herbs were highly nutritious and provided food for wildlife both in the summer and winter seasons. Woody plants were interspersed throughout this plant community and included the common blueberries, huckleberry, and teaberry as low shrubs along with sweetfern and bear oak as tall shrubs or small trees. The taller woody plants supply food throughout the year and are particularly valuable as an emergency food when deep snow covers the ground in the winter. The right-of-way was heavily used by common wildlife species such as white-tailed deer, rabbit, grouse and wild turkey. A special study made of the white-tailed deer on the right-of-way showed a consistent and heavy use in all seasons indicating that attractive food and cover had been developed.

INTRODUCTION

In the Spring of 1953, a study of the effects of herbicide sprays on game food and cover was begun on a Pennsylvania Electric Co. power line right-of-way in central Pennsylvania. An initial right-of-way clearance had been made in the winter of 1951-52 through a typical upland oak forest (Figure 1). As a controversy had arisen at the time concerning effects of herbicides on game populations, the primary objective of the research was to determine the effect of chemical brush control on game food and cover. Other objectives were to study game use of treatment areas; to determine effectiveness of the various sprays in controlling undesirable woody plants; and to develop a low, stable plant cover on the right-of-way that would resist invasion by tree species.

Figure 1A. Upland oak forest adjacent to the right-of-way in winter with little game food and cover.

TREATMENT OF THE RIGHT-OF-WAY

Herbicides and application techniques used on four replications of each treatment for woody plant control were:

A—Unsprayed, cut as needed for control.

B—Broadcast foliage spray of 2,4-dichlorophenoxy acetic acid (2,4-D) plus 2,4,5-trichlorophenoxy acetic acid (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

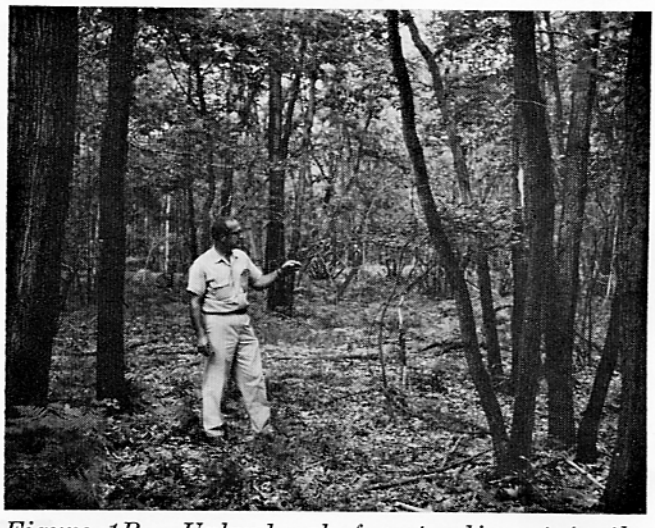

Figure 1B. Upland oak forest adjacent to the right-of-way in summer with sparse game and food and cover.

10 gallons of No. 2 fuel oil in 87 gallons of water. Applied June 1953.

D—Selective 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.

F—Broadcast foliage spray of ammonium sulfamate (Ammate or AMS) at a concentration of ¾ 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 that used 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.

WOODY BRUSH CONTROL

One of the original objectives of this investigation was to study the effectiveness of herbicide treatments on the control of "tall-growing" woody plants which may constitute a hazard to transmission line operation and maintenance. An undesirable woody brush layer, consisting mainly of tree sprout clumps, had developed by 1953 following creation of the right-of-way in 1951-52. The five initial spray treatments were highly effective in the control of this woody brush, resulting in 94 to 99 percent topkill at the end of the second season after treatment (Bramble, Byrnes and Worley, 1956). The follow-up summer basal spray on one-half of each replication of initial herbicide treatment areas was very efficient in the control of sprouts developing on previously topkilled plants and on missed or invading tree seedlings (Bramble and Byrnes, 1967). The combination of "initial plus follow-up basal" spray resulted in virtual elimination of the woody shrub layer, a condition which persisted on the right-of-way for many years.

Redevelopment and Retreatment of Woody Brush

Evaluation of woody brush status on the right-of-way in June 1965 revealed that certain tree and shrub species had become reestablished and grown to a height considered hazardous to overhead transmission lines (Bramble and Byrnes, 1967). This brush condition existed on parts of 12 of the 20 replicates receiving "initial" or "initial plus follow-up basal" herbicide treatments. Dominant woody brush species in the Shrub Layer, over 3 feet in height, in 1965 were red maple on the broadcast ammate areas, sassafras on the summer and winter basal areas, and bear oak and witch-hazel on the semi-basal and broadcast 2,4-D + 2,4,5-T treatments.

The first retreatments since initial and follow-up sprays in 1953-54 therefore, were applied to redeveloping brush in June and July 1966. These retreatments included "selective basal sprays" on scattered brush clumps, "cut and stump sprays" on larger trees such as red maple and upland oaks, and "stem-foliage spray" on thickets of sassafras (Bramble and Byrnes, 1969). Resprays were applied to all woody plants, except ground cover species, on the center of the right-of-way; while low-growing woody shrub species such as bear oak, witchhazel, hawthorn and mountain laurel were left untreated along each edge. The "shrub edge" interspersed with ground layer—under 3 feet in height—plants provide desirable game food and cover, contribute to improved aesthetics, and do not interfere with power line operation.

Evaluation in August 1968, 2 years after the respray, revealed that retreatments produced topkill of the sprayed plants with no resprouting ranging from 66 percent for the "stem-foliage spray," 86 percent after "selective basal," and 94 percent following the "cut and stump spray" (Figure 2). These resprays reduced number of plants in the shrub layer on "initial spray" areas by 43 to 97 percent and on "initial plus follow-up basal

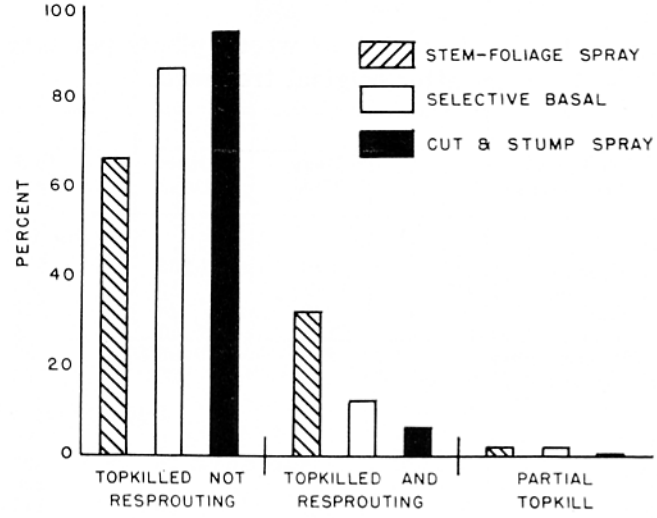

Figure 2. Topkill of woody brush in August 1968 from retreatment in July 1966.

Table 1. Total number of woody plants per acre in the shrub layer, over 3 feet in height, in August 1968, 15 years after original treatment

Original Treatment	Bear Oak	Other Oaks	Red Maple	Sassa-fras	Witch-hazel	Cherry	Misc. Hard-woods	Total	Reduc-tion* %
Single Initial Spray									
A Unsprayed	10	108	30	0	20	2	0	170	82
B Broadcast D+T	37	2	0	0	6	0	0	45	60
C Semi-basal	30	2	0	0	2	0	0	34	43
D Summer Basal	2	0	0	2	4	2	4	14	97
E Winter Basal	0	2	0	0	53	0	0	55	95
F Broadcast Ammate	8	0	0	6	7	2	2	25	90
Initial Spray with Follow-up Basal									
B-D	0	0	0	0	6	0	0	6	86
C-D	6	0	0	0	0	12	0	18	80
D-D	0	2	0	0	5	0	0	7	97
E-D	7	4	0	0	0	2	0	13	87
F-D	2	0	0	0	10	0	0	12	83

* Percent reduction in total number of woody plants in the Shrub Layer following 1966 retreatments.

spray" areas by 80 to 97 percent (Table 1). However, there remained a considerable number of small sprouts and seedlings under 3 feet in height which represent a reservoir of resurging brush (Table 2).

Woody brush on the untreated control plots developed rapidly following creation of the right-of-way and required recutting to prevent interference with overhead transmission lines in 1958 and again in 1967.

Woody Brush Status in 1969

The most recent evaluation of woody plants in the shrub layer was made in August 1969 on original treatment areas (Table 3). The unsprayed control (Treatment A) had 506 plants per acre, consisting predominately of sprouts resurging from stumps of brush cut in 1967. Woody plant species on the control areas have remained relatively constant and include mixed upland oaks (red, black, white and chestnut oak), bear oak, red maple, witchhazel and sassafras, all of which are common in the adjacent forest.

In contrast to the unsprayed controls, the shrub layer on chemically treated areas (Treatments B, C, D, E and F) was very sparse in 1969 (Table 3). Total number of woody plants over 3 feet in height on the five chemical treatments was only 42 to 54 per acre. Herbicide treatments have eliminated most "tall-growing" tree species and have retained bear oak and witchhazel, woody species of "low-growth" form (Figure 3). These latter species represent 87 to 100 percent of the total woody plants comprising the Shrub Layer in 1969 and

Table 2. Total number of woody plants per acre in the ground layer, under 3 feet in height, in August 1968, 15 years after original treatment

Original Treatment	Bear Oak	Other Oaks	Red Maple	Sassa-fras	Witch-hazel	Cherry	Misc. Hard-woods	Total
Single Initial Spray								
A Unsprayed	680	1,232	552	5,208	640	16	72	8,400
B Broadcast D+T	92	12	200	240	20	7	18	579
C Semi-basal	48	48	232	124	8	60	52	572
D Summer Basal	132	60	8	732	124	8	4	1,068
E Winter Basal	259	96	92	6,750	73	4	20	7,294
F Broadcast Ammate	36	28	120	412	0	12	28	636
Initial Spray with Follow-up Basal								
B-D	44	0	80	236	24	4	0	388
C-D	8	28	256	8	8	120	8	436
D-D	46	28	200	132	100	8	4	518
E-D	107	80	112	244	26	12	36	617
F-D	80	48	84	284	0	0	32	528

Table 3. Total number of woody plants per acre in the shrub layer, over 3 feet in height, in August 1969, 16 years after original treatment

Original Treatment	Bear Oaks	Other Oaks	Red Maple	Sassafras	Witch-hazel	Cherry	Misc. Hardwoods	Total
A Unsprayed	116	276	74	2	36	0	2	506
B Broadcast D+T	36	2	0	0	6	0	0	44
C Semi-basal	40	2	4	0	0	0	0	46
D Summer Basal	22	2	0	2	26	2	0	54
E Winter Basal	14	0	0	0	30	0	0	44
F Broadcast Ammate	12	2	0	0	26	2	0	42

are distributed mostly along the edges of the right-of-way (Figure 13).

There were still numerous small tree seedlings in the ground layer in 1968 (Table 2). However, very few of these plants have been able to emerge into the shrub layer because of severe competition of the dense groundcover, browsing by deer, or dieback caused by frost injury.

CHANGES IN THE LOW PLANT COVER FOLLOWING HERBICIDE SPRAYING

Development of a Stable Plant Community

A low plant cover under 3 feet in height, herein referred to as the "ground layer," was produced on the right-of-way after the tree sprouts were removed by chemical sprays and cutting. Several widely differing plant communities developed immediately after spraying to form this layer. These communities lasted for varying periods during which time they slowly developed into one common community on all treatment areas by 1968 (Figure 4B). The scientific names of the common and characteristic species of this community are listed in Table 4.

Table 5 indicates major changes in the ground layer during 18 years following spraying. Of most interest to this study is the persistence of a stable plant community on control areas (Figure 5) and on selective summer (Figure 6) and winter (Figure 7) basal areas for 18 years. The dominant plants in 1953, bracken, sedge, loosestrife, and blueberry, were continuously present. Sweetfern invaded early in burned spots and bare areas, and gradually increased to become an important shrub by 1968. Goldenrod also became an important plant by 1968. The persistent low community has been called Bracken-Sedge-Herb-Blueberry. Sweetfern, a stoloniferous shrub, added a new dimension in 1968 by forming small to large patches 3 to 5½

Table 4. Species composition of a typical Bracken-Sedge-Herb-Blueberry plant community on the right-of-way in 1970

Characteristic and dominant species:

Bracken *(Pteridium aquilinum)*
Sedge *(Carex pensylvanica)*
Panic Grass *(Panicum latifolium* and *P. commutatum)*
Upland Rice Grass *(Oryzopsis asperifolia)*
Poverty Grass *(Danthonia spicata)*
Loosestrife *(Lysimachia quadrifolia)*
Sarsaparilla *(Aralia nudicaulis)*
Goldenrod *(Solidago graminifolia* and *S. rugosa)*
Fireweed *(Erechtites hieracifolia)*
Blueberry *(Vaccinium vacillans* and *V. angustifolium)*
Sweetfern *(Comptonia peregrina)*
Witchhazel *(Hamamelis virginiana)*
Teaberry *(Gaultheria procumbens)*
Blackberry *(Rubus allegheniensis)*
Bear Oak *(Quercus ilicifolia)*

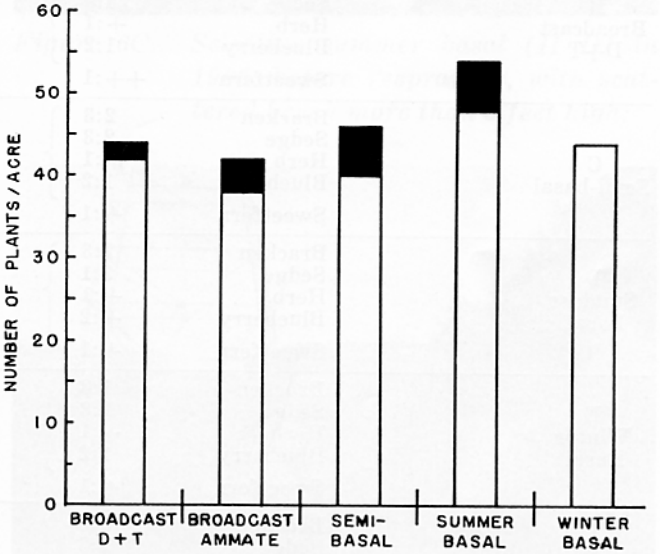

Figure 3. Total number of woody plants per acre in the shrub layer (total bar) and proportionate number of bear oak and witchhazel (white portion) in August 1969.

Figure 4A. Forest cover adjacent to the right-of-way offers sparse food and cover.

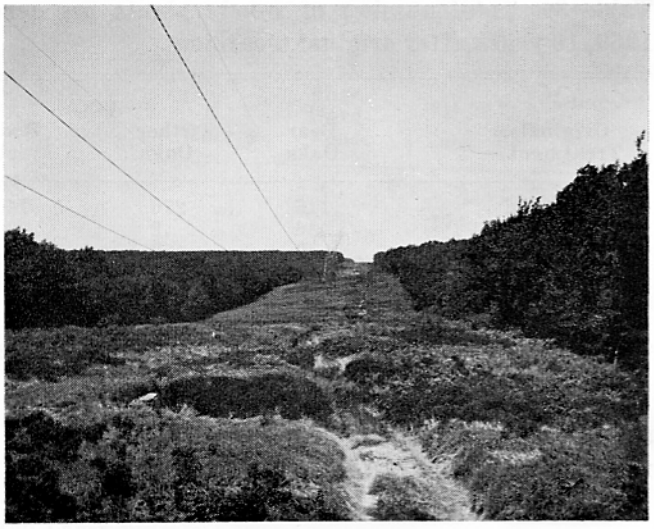

Figure 4B. The sprayed right-of-way in 1971 had a low cover of Bracken-Sedge-Herb-Blueberry with scattered dark patches of sweetfern that offers excellent game food and cover.

Table 5. Long-term development of low vegetation on treatment areas following spraying in 1953-54

Treatment June 1953	Status in 1953	A:S*	Development from 1954 through 1965	Status in 1970	A:S*
A Unsprayed Control	Bracken	2:3	A stable plant community persisted	Bracken	1:2
	Sedge	2:3		Sedge	+:2
	Herb	+:1		Herb	2:3
	Blueberry	2:2		Blueberry	3:3
	Sweetfern	++:1	Gradual increase	Sweetfern	3:4
B Broadcast D+T	Bracken	2:3	After spraying, passed through a sedge-grass stage and back to the original community	Bracken	2:3
	Sedge	2:3		Sedge	2:3
	Herb	+:1		Herb	2:3
	Blueberry	1:2		Blueberry	2:3
	Sweetfern	++:1	Gradual increase	Sweetfern	3:4
C Semi-basal	Bracken	2:3	After spraying, passed through a fireweed stage and back to the original community	Bracken	3:3
	Sedge	2:3		Sedge	2:3
	Herb	+:1		Herb	3:3
	Blueberry	1:2		Blueberry	2:3
	Sweetfern	+:1	Gradual increase	Sweetfern	3:2
D Summer Basal	Bracken	2:3	A stable plant community persisted	Bracken	2:2
	Sedge	2:1		Sedge	1:3
	Herb	+:1		Herb	3:3
	Blueberry	+:2		Blueberry	2:3
	Sweetfern	+:1	Gradual increase	Sweetfern	2:3
E Winter Basal	Bracken	1:3	A stable plant community persisted	Bracken	4:4
	Sedge	2:3		Sedge	2:3
	Herb	+:1		Herb	2:3
	Blueberry	1:2		Blueberry	2:3
	Sweetfern	+:1	Gradual increase	Sweetfern	2:2
F Broadcast Ammate	Bracken	3:3	After spraying, passed through a fireweed stage and back to the original community	Bracken	3:4
	Sedge	2:3		Sedge	1:2
	Herb	+:1		Herb	2:3
	Blueberry	1:2		Blueberry	1:2
	Sweetfern	++:1	Gradual increase	Sweetfern	2:3

* A = Abundance and cover expressed in symbols: ++ = Occasional; + = Sparse, cover very small; 1 = Plentiful, but of small cover value; 2 = Covering 1/20 to ¼ of the area; 3 = Covering ¼ to ½ of the area; 4 = Covering ½ to ¾ of the area; 5 = Covering more than ¾ 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 ¼ of the ground area and occurs in small patches (Braun-Blanquet, 1932).

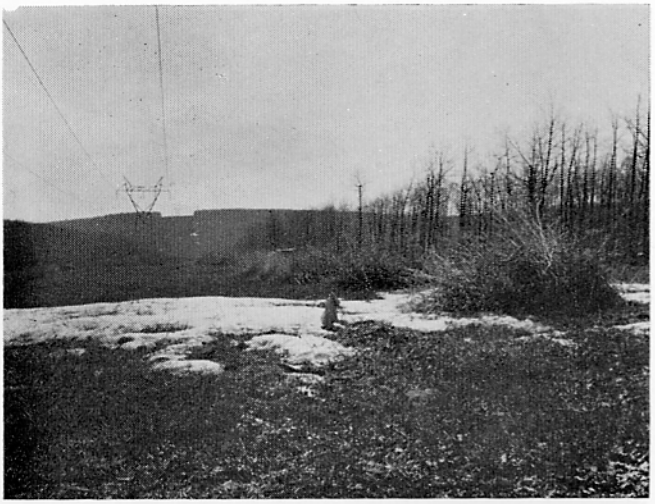

Figure 5A. Control area (IA) after recut in 1958.

Figure 5B. Control area (IA) in 1971 after second recut in 1967.

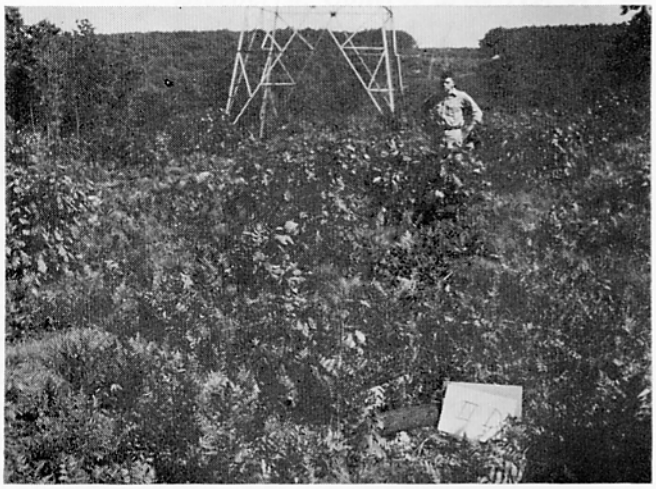

Figure 6A. Selective summer basal (II D) in 1953 before spraying.

Figure 6C. Selective summer basal (II D) in 1965, before respraying, with scattered brush more than 3 feet high.

Figure 6B. Selective summer basal (II D) in 1954, after spraying, with clumps of fireweed invading where woody brush was killed.

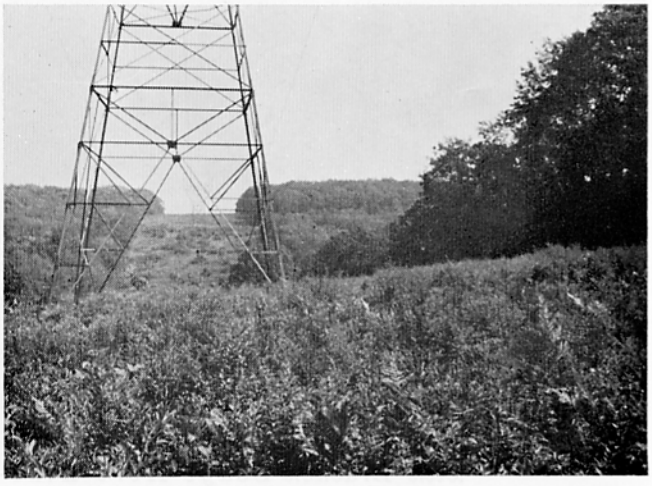

Figure 6D. Selective summer basal (II D) in 1971 with Bracken-Sedge-Herb-Blueberry and Sweetfern.

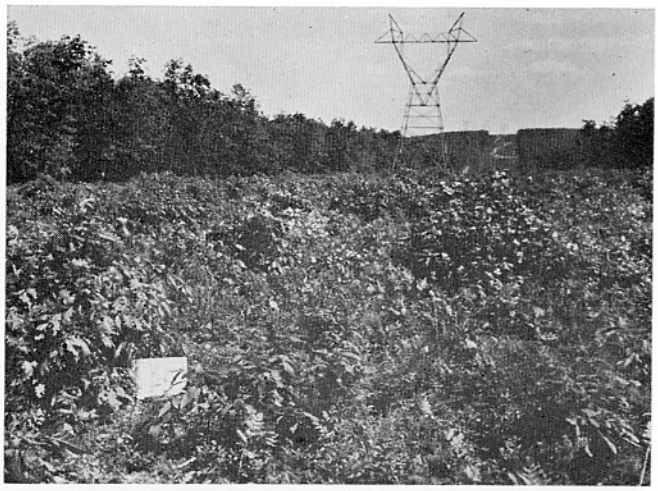

Figure 7A. Selective winter basal (IE) in 1953 before spraying.

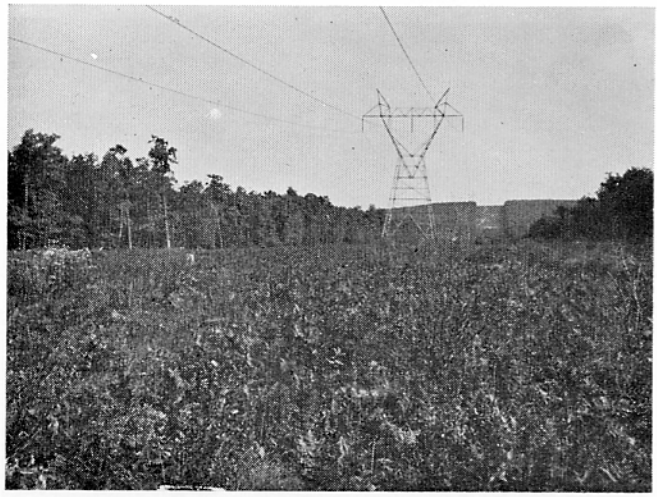

Figure 7B. Selective winter basal (IE) in 1954 with dead brush hardly visible.

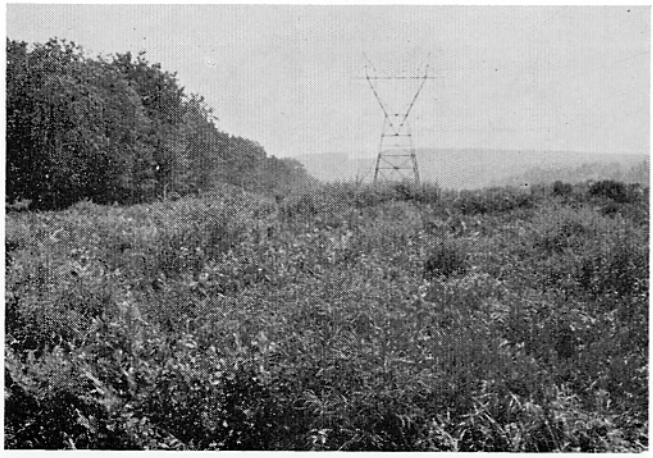

Figure 7C. Selective winter basal (IE) in 1971 with Bracken-Sedge-Herb-Blueberry and Sweetfern. The herb component was dominated by tall clumps of goldenrod species.

Figure 8A. Broadcast D + T area (III B) in 1954 with sedge-grass and fireweed.

feet in height. The result was a mosaic pattern of sweetfern patches intermingled with the Bracken-Sedge-Herb-Blueberry community.

In contrast to the above, temporary plant communities developed immediately following the 1953 broadcast spray treatments (Figures 8 and 9) and the oil-water, semi-basal spray (Figure 10). A sedge-grass community lasted through 1956 following the 2,4-D + 2,4,5-T broadcast spray, a fireweed community followed the ammate broadast spray which lasted through 1956, and a fireweed community followed the semi-basal and lasted through 1954. Blueberries were reduced to a sparse component by the broadcast and semi-basal sprays

Figure 9A. Broadcast Ammate spray area (III F) in 1953 before spraying.

Figure 8B. Broadcast D + T area (III B) in 1958 with Bracken-Sedge-Herb-Blueberry. Control area (III A) is in the background.

Figure 8C. Broadcast D + T area (III B) in April 1971 when dark patches of sweetfern were visible on the left.

and did not recover their former abundance until 1968.

By 1965, the ground layer of all spray areas except Ammate had returned to the original plant community of 1953 (Figure 11). Blueberry was the missing species on Ammate areas and by 1968 it had recovered its former abundance. The stoloniferous shrub, sweetfern, developed more rapidly on broadcast than on basal spray areas and became an important species on Ammate broadcast areas by 1956, several years earlier than on the other spray areas (Figure 12).

Individual Species Changes in the Ground Layer

When changes in individual species were studied following spraying of the right-of-way (Figure 12), distinct groups could be recognized. Most attention has been focused on the effect of broadcast sprays, since selective basals, owing to limited disturbance, differed very little from the unsprayed control. These groups are:

(1) *Plants of high ground cover value which have been constantly present on selective spray and control areas for at least 18 years.* These plants are typical of the local forest which thrived

Figure 9B. Broadcast Ammate spray area (III F) in 1954, after spraying, covered with a solid stand of fireweed.

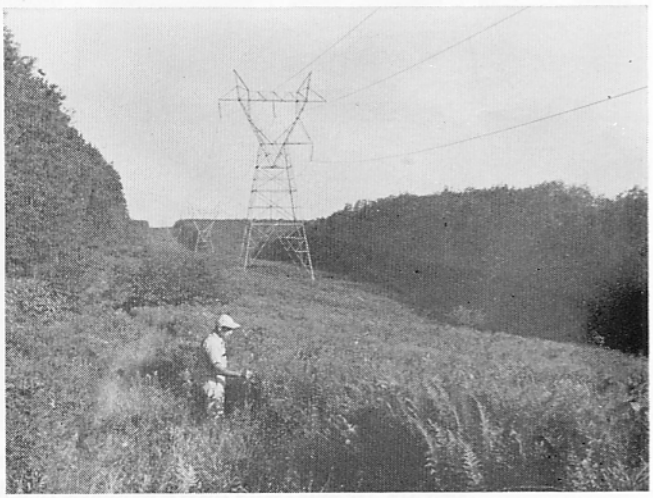

Figure 9C. Broadcast Ammate area in 1971 with a Bracken-Sedge-Herb-Blueberry community and sweetfern.

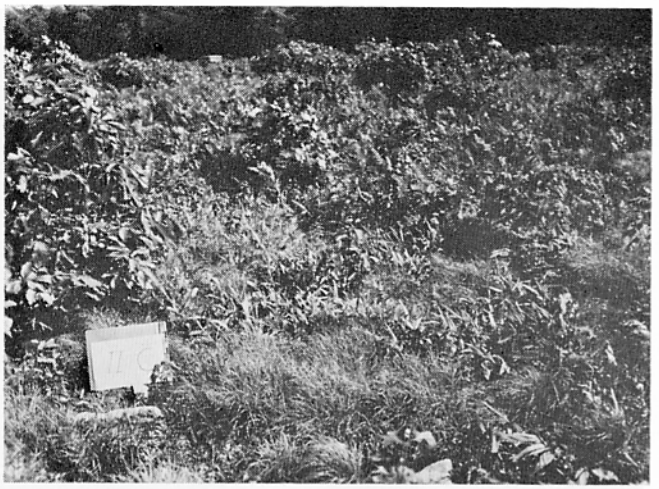

Figure 10A. Oil-water semi-basal area (II C) in 1953 before spraying.

Figure 10B. Oil-water semi-basal area (II C) in 1954 with fireweed stage.

Figure 10C. Oil-water semi-basal area (II C) in 1971 with a ground cover of Bracken - Sedge - Herb - Blueberry and bear oak which was left unsprayed for game food and cover.

on the unsprayed right-of-way after it has been cleared and include bracken fern, sedge, and blueberries.

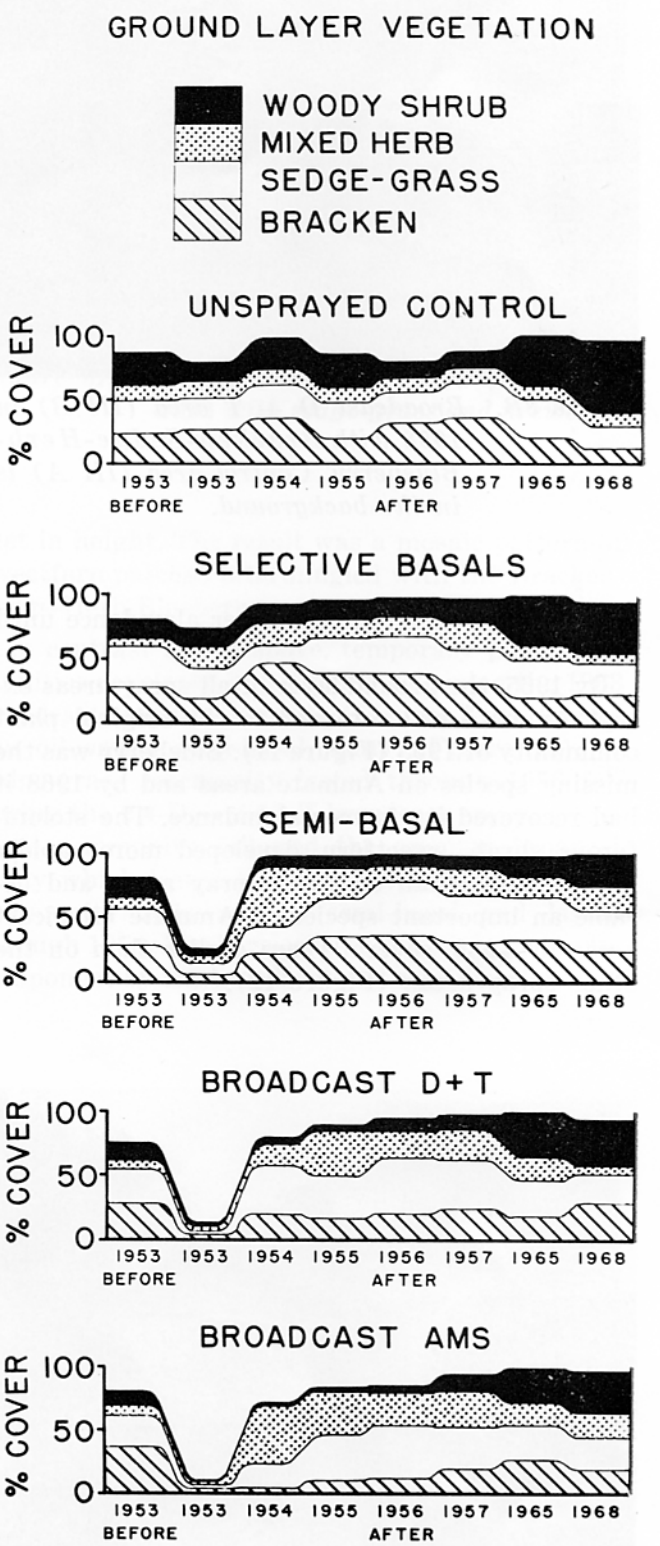

Figure 11. Histogram to show changes in percent of ground area covered and in major forms of vegetation after spraying in 1953.

The species most severely affected by broadcast sprays were the blueberries which became very sparse after broadcast and semi-basal treatments. By 1968-70, however, blueberries in broadcast spray areas had recovered but were not equal in abundance to selective spray areas.

Bracken fern was reduced by broadcast sprays but only for a few years (1954 to 1956), and came back strongly to become a dominant species on all areas by 1957.

Sedge was a third consistently abundant species for 18 years on both spray and control areas.

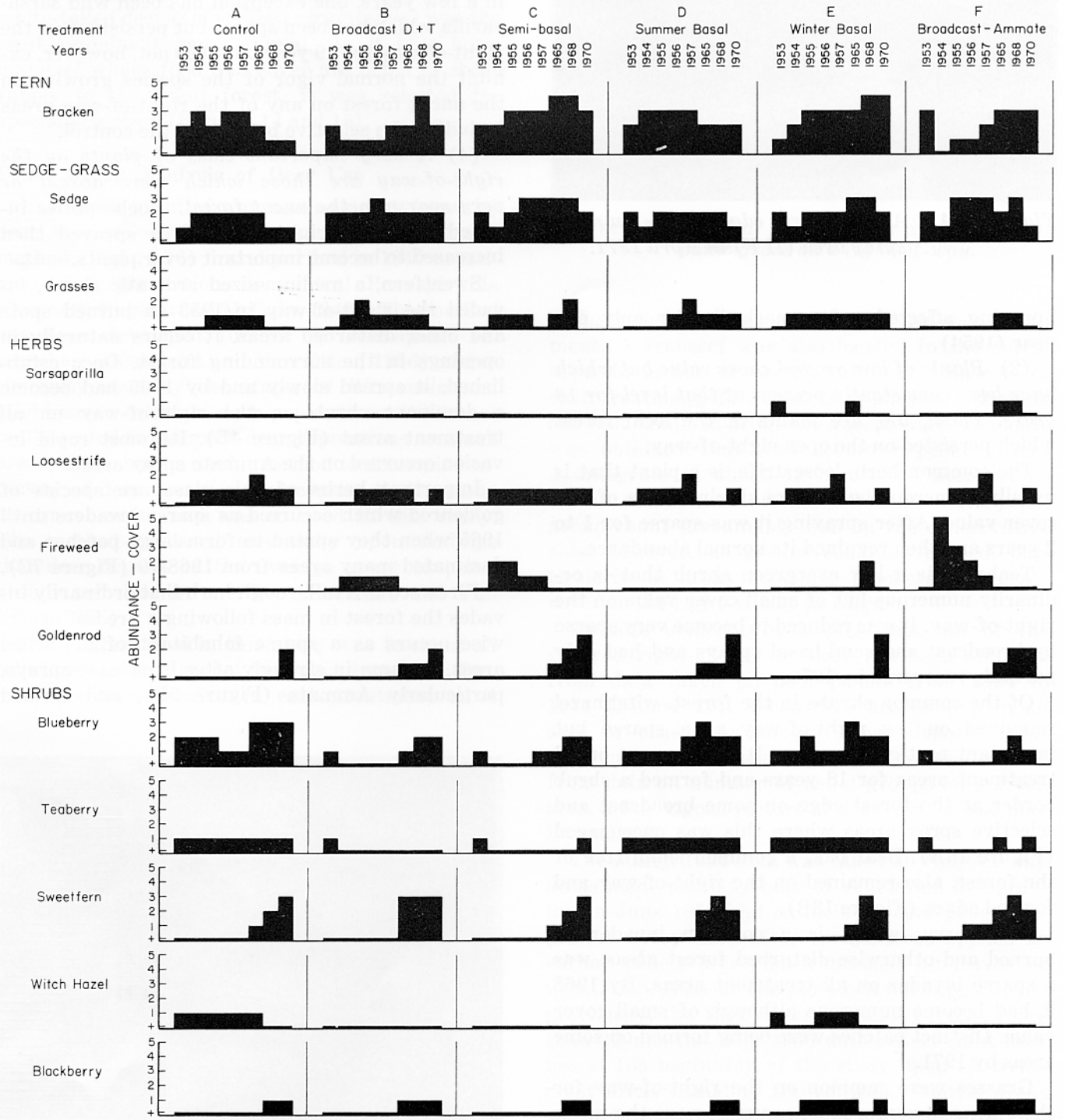

Figure 12. Histograms of individual plant species from the time of spraying in 1953 through 1970. Abundance and cover figures are explained in Table 5, and follow the combined estimates of Braun-Blanquet (1932).

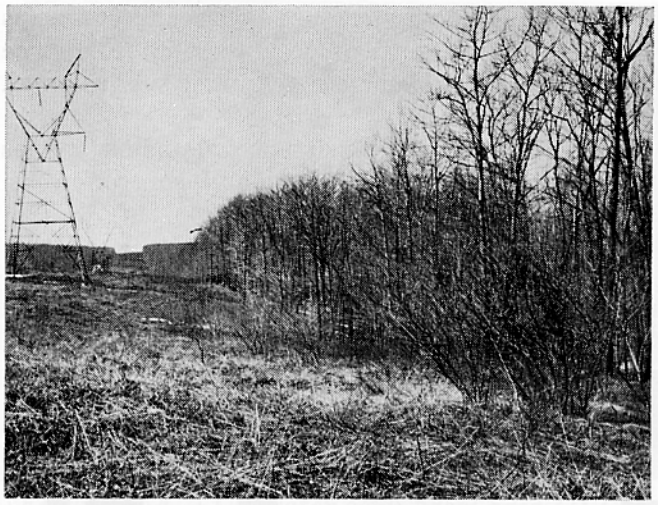

Figure 13A. A witchhazel edge on an Ammate spray area (II F) in April 1971.

Spraying affected sedge markedly for only one year (1954).

(2) *Plants of low ground cover value but which have been consistently present at that level for 18 years.* These, too, are plants of the local forest which persisted on the open right-of-way.

The common herb, loosestrife, is a plant that is usually numerous but occurs singly and is of low cover value. After spraying it was sparse for 1 to 2 years and then regained its normal abundance.

Teaberry is a low evergreen shrub that is ordinarily numerous but of small cover value on the right-of-way. It was reduced to become very sparse by broadcast and semi-basal sprays and had only partially recovered by 1970.

Of the common shrubs in the forest, witchhazel remained on the right-of-way as a sparse but important part of the cover. It was present on all treatment areas for 18 years and formed a shrub border at the forest edge on some broadcast and selective spray areas where this was encouraged (Figure 13A). Bear oak, a common small tree of the forest, also remained on the right-of-way and formed edges (Figure 13B).

Blackberry, which is a common invader of burned and otherwise disturbed forest areas, was a sparse invader on all treatment areas. By 1968 it had become numerous although of small cover value. Distinct patches were being formed on some areas by 1971.

Grasses were common on the right-of-way for the entire 18 years. Most common were the panic grasses and upland rice grass which was particularly abundant on the D + T broadcast spray areas but sparse on the Ammate areas. Grasses were constantly present on the control and selective spray areas mostly in clumps or small patches of low cover value. Poverty grass was a prominent invader on access roads on the right-of-way.

(3) *A third class of plants are those that are best suited for growth in forest shade and tend to turn yellow and become unthrifty in the open sunlight.* While most of these plants disappeared in a few years, one exception has been wild sarsaparilla which has been sparse but persistent on the right-of-way for 19 years. It does not, however, exhibit the normal vigor of the species growing in the uncut forest on any of the right-of-way areas including the selective basals and the control.

(4) *A very important class of plants on the right-of-way are those which were absent or very sparse in the uncut forest.* Such species invaded after the right-of-way was sprayed then increased to become important cover plants.

Sweetfern, a medium-sized aromatic shrub, invaded the right-of-way in 1953 on burned spots and other disturbed areas. It occurs naturally in openings in the surrounding forest. Once established, it spread slowly and by 1965 had become a dominant shrub on the right-of-way on all treatment areas (Figure 4B). Its most rapid invasion occurred on the Ammate spray areas.

Important herbs of this class are species of goldenrod which occurred as sparse invaders until 1965 when they spread to form large patches and dominated many areas from 1968-70 (Figure 7C).

Fireweed is a tall, rough herb that ordinarily invades the forest in mass following a fire but otherwise occurs as a sparse inhabitant of disturbed areas. It came in strongly after broadcast sprays, particularly Ammate (Figure 9B), and formed

Figure 13B. A bear oak edge on a selective winter basal spray area (IV E) in August 1969.

pure populations for a few years. In about 4 years it became very sparse on the right-of-way.

DEER USE OF THE RIGHT-OF-WAY

Of the common wildlife species using the right-of-way following spraying with herbicides, the white-tailed deer *(Odocoileus virginianus)* was the most prominent game animal. As it is a large mammal whose food and cover are often in short supply in the uncut forest, it was selected for special attention (Figures 14 and 15).

Pellet Group Analysis of Deer Use

Use of the right-of-way and adjacent forest by deer was followed by means of a pellet group method (Figure 16) first described in 1940 to estimate deer populations in central Pennsylvania (Bennett, English and McCain, 1940). This method has been developed further by subsequent researchers (Eberhart and Van Etten, 1956) and is currently used by the states of Wisconsin and Michigan to estimate deer populations. While not really suited to estimate deer populations on small areas, it has been a useful method to determine intensity of deer use on a comparative basis among treatment areas and was so used in this study. The method is based essentially upon findings that deer deposit on the average about 13 pellet groups per deer in one day (Eberhart and Van Etten, 1956).

The method used in this study was to count all pellet groups on 100-foot by 3-foot transects. Two transects were located in each treatment on 4 replications, totalling 8 transects for each treatment. A transect was also located in the forest opposite to one of the right-of-way transects of each treatment, 24 transects in all, and beginning one-half chain in from the forest edge. Evidence was obtained that while summer pellet groups disintegrate in about 12 months, winter pellets remain visible for more than 12 months. The pellet group count presumably was on the conservative side, however, as groups could be missed, particularly in areas of dense blueberry or grass cover on the right-of-way in August.

Figure 14. Deer bed of matted grass under a witchhazel bush on a winter basal spray area (II E) in 1971.

Figure 15. Spotted fawn hiding in a cover of panic grass on a right-of-way.

Definite evidence of a consistent use of the sprayed right-of-way by deer has been obtained from data taken on deer pellets from 1954 to 1971 (Figure 17). When deer are feeding in an area or otherwise using it, they deposit about 13 groups of fecal pellets per deer per day so that from data on number of pellet groups on a given area, a fairly good picture of deer days of use may be obtained.

The March 1954 data was taken on right-of-way areas made partially bare of vegetation by spraying in June 1953 and so includes deer pellets deposited before and after sprays were applied as earlier pellets were not concealed by leaves or vegetation. Also, as the plots had not been cleared previously, the 1954 count no doubt covered more than 12 months. The 1955 data reflect light deer use at the beginning of the study upon all treatment areas including the controls. Control areas showed the highest continuous deer use from 1956 to 1969 when use of controls was equalled by use of selective basal areas. By 1969, the vegetation on both treatment and control areas had developed into a similar Bracken-Sedge-Herb-Blueberry-

Figure 16A. Winter deer pellet group used to estimate use.

Figure 16B. Summer deer pellet group used to estimate use.

Sweetfern community and all but one of the four control areas had lost their tree sprouts through heavy deer browsing. There was a light use of broadcast and semi-basal 2,4-D+2,4,5-T spray areas in the early years, 1955 and 1956, when they were dominated by fireweed and grass-sedge cover (Figures 8A and 9B). Fireweed was not browsed by deer during the summer months, although other investigators report it being eaten occasionally in a dry state in the winter.

When statistically tested, there was no significant difference in number of pellet groups per acre between the various treatments or replications (blocks) on the right-of-way in 1970 (Table 6). In other words, deer use was not affected at that time by differences in treatments applied in 1953. Variations observed appeared to be caused by such natural factors as topography, location of deer trails, and vegetative cover variations, all affecting normal deer movement on the plateau.

Deer move about during the year from one habitat to another feeding, escaping from enemies, playing, and mating. It has been reported that a major dispersal takes place in fall and winter when yearling deer seek new ranges. Also, in severe winters with heavy snowfall deer tend to move to sheltered locations, or to areas where woody browse is available above the snow cover. When chased by dogs, they often move in a large circle of a mile or more.

A special study made of deer use in 1969, 1970, and 1971 indicated that the right-of-way was heavily used by deer on all treatment areas (Table 6). The forest edge was used less than the adjacent

Figure 16C. Grouse pellet group used to estimate use.

Figure 16D. Rabbit pellets used to estimate use.

Table 6. Deer use of sprayed areas on the right-of-way and in the forest edge as determined by pellet group counts made between August 1 and 15 of 1969, 1970, and 1971

Treatment	No. pellet groups per acre*			Deer days of use per acre** (12 mo.)		
	1969	1970	1971	1969	1970	1971
A Unsprayed	782	563	508	60	44	39
B Broadcast D+T	309	400	381	24	31	29
C Oil-water Semi-basal	345	491	600	27	38	46
D Selective Summer Basal	1000	563	963	77	44	74
E Selective Winter Basal	963	618	508	75	48	39
F Broadcast Ammate	545	563	927	42	44	71
Average of All Treatments	657	533	648	51	42	50
Forest Edge (133 feet)	631	224	175	49	17	13

* Pellet groups per acre = $\frac{\text{Number pellet groups on transects}}{\text{Acres in transects}}$

** Deer days of use per acre = $\frac{\text{Number pellet groups per acre}}{\text{Number pellet groups deposited by one deer in one day (average of 13)}}$

right-of-way in 1970 and 1971. Based on the number of pellet groups counted in 1970 as representing deposition over 12 months (plots were cleared of pellets in 1969), a population estimated to be one deer per 9 acres used the right-of-way and the edges. The actual number of deer using the 3-mile study section was estimated to be about 12 on 104 acres comprising the right-of-way plus the two forest edges. This indicates that the right-of-way is providing an important part of the habitat for use by a high deer population. In the 1930's when the deer population of central Pennsylvania was considered very high, the scrub oak-pitch pine Barrens had an estimated population of one deer to 15 acres while the oak-hickory ridges supported about one deer to 60 acres. Bennett, *et al* (1940) calculated that a population of one deer to 6 to 14 acres deposited 54 pellet groups per acre per month. In this study, a deer population of one deer to 9 acres deposited 45 pellet groups per acre per month in 1970 and 54 in 1971.

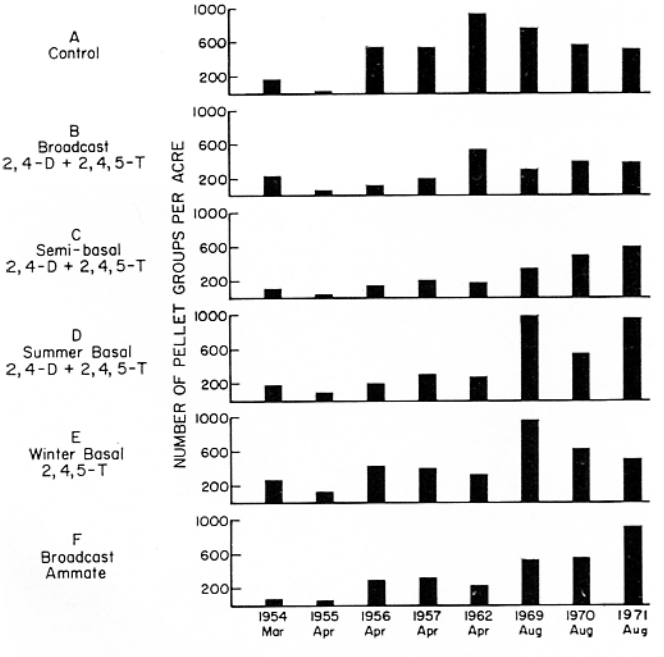

Figure 17. Deer pellet groups per acre on treatment areas counted from 1954 through 1971 as an indicator of deer use.

On April 5 to 6, 1971, a special count was made of deer pellet groups to get a picture of use in the dormant season on the right-of-way. It had been a winter of unusually heavy snowfall in central Pennsylvania, and a dense layer of snow was still present in the forest in early April. Most of the right-of-way and the northerly edge of the bordering forest, however, were bare of snow when the pellet group count was made (Figure 1A). Buds had not yet opened on normally dormant plants and only herbs that remain green over winter and evergreen plants were in leaf.

Evidently deer use the right-of-way in the dormant season as shown in Table 7. Woody shrubs such as blueberry and sweetfern on the right-of-way showed signs of heavy deer browsing of dormant stems that also indicated winter deer use on all areas.

USE OF VEGETATION ON THE RIGHT-OF-WAY BY DEER FOR FOOD AND COVER

As the white-tailed deer is a common and important game animal in the forests of central Pennsylvania, special attention was given in this

Table 7. Distribution of pellet groups counted on transects in treatment areas in four randomized replications in 1971, presented as they occur in sequence from I through IV on the test area along a 3-mile stretch of right-of-way

Replication I						
Treatments	A	E	B	D	C	F
April pellets	3	2	3	5	7	6
August pellets	7	6	1	4	3	4
Replication II						
Treatments	B	E	A	D	C	F
April pellets	5	3	1	1	0	0
August pellets	1	1	3	9	2	1
Replication III						
Treatments	E	A	B	F	D	C
April pellets	1	2	0	8	13	5
August pellets	1	0	1	1	6	4
Replication IV						
Treatments	F	A	E	B	D	C
April pellets	19	7	12	9	8	8
August pellets	12	5	2	1	7	4

study to plant use by that species. Two variants were used in analyzing use of plants as food by deer (Aldous, 1944). These were (1) the density of each plant species on the area studied taken as the per cent of ground area covered, and (2) the per cent each species was browsed. Four classes were used for both density and browsing: (1) 50% or more, using an average value of 70%; (2) 10 to 50%, using an average value of 30%; (3) trace to 10%, using an average value of 5%; and (4) none or 0%.

To calculate the density and browsing values given in Table 8, the "average density" was obtained by dividing the total of the densities on all plots of a treatment by the number of plots on which the species occurred. The "average degree of browsing" was obtained by dividing the total per cent browsed on all plots of a treatment by the number of plots on which the species occurred. The "utilization factor" was obtained by multiplying the average density by the average degree of browsing for each species. The utilization factor gives a single figure that combines density and browsing to indicate the relative importance of plant species as food for deer.

From Table 8 it may be seen that deer heavily utilized the common herbaceous plants; bracken, goldenrod and loosestrife as food on the sprayed right-of-way (Figure 18). Bracken was used mostly in the spring and early summer when it was tender and succulent; the other herbs were browsed throughout the growing season and, in addition, their basal leaves were eaten during the winter when not covered by deep snow.

Most of the common woody plants on the right-of-way were browsed both during the growing season and in the winter with the exception of sweetfern which was utilized only in winter and early spring. Deer commonly show seasonal preferences for most woody species when food is not in short supply, i.e. when the range is not overbrowsed (Bramble and Goddard, 1953). Of the woody species browsed on the sprayed right-of-

Figure 18A. Bracken and loosestrife on the right-of-way (Area III C) showing deer browsing.

Table 8. Comparison of utilization of plants by deer on the sprayed and cut right-of-way and in the forest as expressed by a utilization factor (average density x average browsing)

	Sprayed right-of-way			Cut right-of-way			Uncut forest		
	Average density %	Average browsing %	Utilization factor	Average density %	Average browsing %	Utilization factor	Average density %	Average browsing %	Utilization factor
Herbaceous Plants									
Bracken	39	44	1716	18	50	900	18	7	126
Goldenrod	11	57	627	3	70	210	0	0	0
Loosestrife	4	38	152	3	3	9	3	6	18
Aster	4	9	36	0	0	0	0	0	0
Cow Wheat	1	11	11	5	35	175	1	0	0
Sarsaparilla	2	12	24	0	0	0	8	5	40
Woody Plants									
Sweetfern	27	60	1620	18	70	1260	1	56	56
Bear Oak	4	53	212	5	70	350	3	24	72
Blueberry	9	10	90	50	5	250	18	6	108
Blackberry	4	47	188	3	35	105	0	0	0
Sassafras	4	61	244	5	70	350	11	51	561
Witchhazel	3	52	156	5	50	250	5	40	200
Red Maple	2	37	74	18	70	1260	5	51	255
White Oak	3	53	159	15	35	525	2	38	76
Black Cherry	1	38	38	0	0	0	0	0	0
Chestnut Oak	1	57	57	3	70	210	3	48	144
Red Oak	1	70	70	5	35	175	3	30	90
Laurel	1	70	70	0	0	0	1	43	43

way, sweetfern showed the highest utilization as it was both abundant and heavily utilized; sassafras, bear oak, witchhazel, and blackberry were in a group that was heavily used but occurred at a low density (Figure 19).

NUTRITIVE VALUE OF PLANTS EATEN BY DEER

To determine the feed value of common plants eaten by deer on the sprayed right-of-way, data were taken from samples collected in August and April. The importance of this has been emphasized by studies with penned deer which showed that the feed value of the diet upon which deer subsist markedly affected such important items as body growth and development of antlers (Long, *et al,* 1965). Standard feed analyses were made of species observed to be commonly eaten by deer on the sprayed right-of-way, and these were compared with the complete synthetic deer ration developed for comparative use in a study of penned deer (Long *et al,* 1965). This complete ration had been designed to give the penned deer the components of a diet that permitted normal body growth.

Figure 18B. Goldenrod browsed on the right-of-way (Area II FD).

Comparison of the complete ration with herbs which are utilized by deer on the right-of-way (Table 9) showed that the protein and fat content of the common herbs, bracken, goldenrod, loosestrife, and sorrel are relatively high. Also, while the calcium content of those herbs is relatively low compared to the synthetic ration, other minerals such as phosphorous, magnesium, and potassium are relatively high. Phosphorous has been observed in the pen studies to act in combination with calcium to make up for calcium deficiency.

Woody browse on the right-of-way generally provides important winter food for deer when snow covers the ground. Analyses showed that such browse was relatively low in protein as com-

Figure 19A. Sweetfern browsed by deer, April 1971.

Figure 19B. Bear oak browsed by deer, April 1971.

pared to the synthetic ration; however, all but two species contained more than the 7.3 per cent protein of a "deficient ration" used in penned deer studies (Tables 9 and 10). Stems of sweetfern and the leaves of blueberry (*Vaccinium angustifolium*) in particular showed high values of 9.2 per cent protein. In fat content, the woody plants rated considerably higher than the synthetic ration, 2.90 to 4.95 per cent as compared with 1.70 per cent in the ration. There was a higher per cent of calcium in woody browse than that found in herbaceous plants, and it was higher than the 0.24 per cent of low-calcium experimental rations (Magruder, *et al*).

Therefore, it seems safe to state that the common herbs and woody plants consumed by deer on the right-of-way were nutritious and should in total provide deer with a balanced diet.

OTHER GAME SPECIES

During the first 5 years of the study (1953-57), four other species of game were studied in addition to deer. These are ruffed grouse, cottontail rabbit, gray squirrel, and turkey.

Grouse were observed in all treatment areas (Tables 11 and 12); and in addition, they were often found on the edges within 150 to 200 feet of

Table 9. Feed value of species commonly eaten by deer on the right-of-way compared with a complete, synthetic deer ration.

Species	Plant part	Protein %	Fat %	Fiber %	Ca %	P %	Mg %	K %	Total minerals
Synthetic deer ration	----	14.4	1.70	14.7	1.27	0.18	----	----	----
Herbs:									
Bracken	Young fronds	37.7	0.92	10.4	0.12	0.30	0.92	3.00	4.34
Goldenrod									
S. graminifolia	Leaves	11.6	1.80	30.2	0.40	0.29	0.09	2.40	3.18
S. rugosa	Leaves	14.0	4.20	19.9	0.74	0.29	0.17	2.60	3.80
Loosestrife	Leaves	15.3	7.50	17.2	0.41	0.26	0.16	2.20	3.03
Sorrel	Leaves	20.4	2.68	18.4	0.37	0.28	0.24	1.99	2.88
Woody Plants:									
Sweetfern	Stems	9.2	3.80	20.9	0.93	0.11	0.11	0.30	1.45
Blueberry									
V. vacillans	Leaves	7.9	3.45	14.4	0.82	0.09	0.17	0.59	1.67
	Stems	4.4	3.70	37.3	0.67	0.10	0.09	0.46	0.96
V. angustifolium	Leaves	9.2	4.95	11.4	0.97	0.08	0.14	0.49	1.68
	Stems	5.3	4.00	38.7	0.52	0.08	0.05	0.31	0.96
Teaberry	Leaves	7.5	3.60	21.8	0.92	0.08	0.19	0.67	1.86
Bear Oak*	Stems	5.2	2.90	39.1	---	---	---	---	2.20
Red Maple*	Stems	5.7	3.70	37.0	---	---	---	---	2.40

* Hellmers, 1940.

Figure 19C. Low blueberry browsed by deer, April 1971.

Figure 19D. Witchhazel browsed by deer, April 1971.

Table 10. Feed analysis of sweetfern plant parts collected April 1971

Plant part	Composition—% oven-dry weight							
	Protein	Fat	Fiber	Water	Ca	P	Mg	K
Catkins	16.17	4.21	14.52	3.50	0.56	0.23	0.16	0.55
Leaves	9.59	1.76	12.32	4.50	1.02	0.03	0.01	0.30
Stems	9.23	3.80	20.98	3.14	0.93	0.11	0.11	0.30
Catkins + stems	14.13	4.09	16.62	3.50	0.78	0.20	0.15	0.50
Catkins + leaves + stems	12.62	3.40	16.21	3.98	0.78	0.13	0.10	0.35

the right-of-way. Use of the right-of-way by wild turkeys was difficult to determine as this bird has a wide daily and annual cruising radius. Most visual observations of turkeys were made on treatments B and F, broadcast spray areas, on which a grass-herb cover had become dominant. Flocks of young turkeys use such openings in the summer when they are feeding heavily on various insects.

Table 11. 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

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 to these animals. Squirrels were observed to cross the right-of-way from one side to the other during

Table 12. Average numbers of animal pellets per treatment obtained from twenty 3 x 100-foot transects, for each treatment

Treatment	March 1954	April 1955	April 1956	April 1957	Total
	Rabbit				
A Unsprayed	101	296	482	150	1029
B Broadcast D + T	95	467	248	124	934
C Semi-basal	3	167	30	35	235
D Summer basal	132	106	99	28	365
E Winter basal	102	211	335	116	764
F Broadcast Ammate	2	85	26	30	143
	Grouse				
A Unsprayed	2	0	6	0	8
B Broadcast D + T	0	0	0	¼	¼
C Semi-basal	0	¼	¼	0	½
D Summer basal	0	0	½	0	½
E Winter basal	0	0	13	0	13
F Broadcast Ammate	1	0	¼	¼	1½

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 (Table 12). Rabbits are not a common game animal in the forests of the plateau but appear to be building up under right-of-way conditions where woodchuck holes are increasing and providing refuges. Also the abundant low cover and food available on the right-of-way not found in the woods must be attractive to them.

APPENDIX

Common and Scientific Names of Plants and Animals Referred to in the Report

Plants:

Aspen	*Populus grandidentata*
	Populus tremuloides
Aster	*Aster* spp.
Blackberry	*Rubus allegheniensis*
Blueberry	*Vaccinium angustifolium*
	Vaccinium vacillans
Bracken	*Pteridium aquilinum*
Cherry, Black	*Prunus serotina*
Fire	*Prunus pensylvanica*
Chestnut	*Castanea dentata*
Cow-Wheat	*Melampyrum lineare*
Dogwood, Flowering	*Cornus florida*
Fireweed	*Erechtites hieracifolia*
Goldenrod	*Solidago graminifolia*
	Solidago rugosa
Gum, Black	*Nyssa sylvatica*
Hawthorn	*Crataegus* spp.
Hickory	*Carya* spp.
Huckleberry	*Gaylussacia baccata*
Juneberry	*Amelanchier arborea*
Loosestrife	*Lysimachia quadrifolia*
Maple, Red	*Acer rubrum*
Mountain Laurel	*Kalmia latifolia*
Oak, Bear	*Quercus ilicifolia*
Black	*Quercus velutina*
Chestnut	*Quercus Prinus*
Red	*Quercus rubra*
White	*Quercus alba*
Panic Grass	*Panicum latifolium*
	Panicum commutatum
Pitch Pine	*Pinus rigida*
Poverty Grass	*Danthonia spicata*
Sassafras	*Sassafras albidum*
Sedge	*Carex pensylvanica*
Sorrel	*Rumex Acetosella*
Sweetfern	*Comptonia peregrina*
Teaberry	*Gaultheria procumbens*
Upland Rice Grass	*Oryzopsis asperifolia*
Wild Sarsaparilla	*Aralia nudicaulis*
Witchhazel	*Hamamelis virginiana*

Birds and Mammals:

Cottontail Rabbit	*Sylvilagus floridanus*
Gray Squirrel	*Sciurus carolinensis*
Ruffed Grouse	*Bonasa umbellus*
White-tailed Deer	*Odocoileus virginianus*
Wild Turkey	*Meleagris gallopavo*

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