IMPACT OF BRUSH CONTROL ON WILDLIFE FOOD AND COVER

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INTRODUCTION

In the spring of 1953, an investigation of commonly-used chemicals and spray techniques was initiated on a 3-mile section of a new power line right-of-way in central Pennsylvania (Bramble and Byrnes, 1972). It was located on the eastern edge of the Allegheny escarpment at an elevation of about 2,000 feet in a forest cover dominated by oaks, commonly referred to as the oak-hickory forest type. The right-of-way had been cleared in the winter of 1951-52.

Concern had been expressed by sportsmen and others regarding the effect of brush control with herbicides on wildlife, so the major objective was to determine the effects of herbicide sprays on nontarget game food and cover plants. Other objectives were to observe: (1) use of the sprayed areas by major game species, (2) development of a stable low plant cover, (3) establishment of shrubby edges, and (4) control of tall-growing trees by the various sprays. Overall, the study area was used to observe ecological changes in the habitat represented by the sprayed right-of-way as compared with unsprayed control portions and the adjacent forest.

METHODS

Chemicals and Spray Techniques

Initial treatments were applied in 1953 as follows:

Treatment A—Unsprayed, woody brush cut as needed for control.

Treatment B—Broadcast foliage spray (D+T) of 2,4 dichloro-

phenoxy 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 in June 1953 to all vegetation on the right-of-way at an average rate of 460 gallons per acre.

Treatment C—Semibasal spray of emulsifiable acids of 2,4-D plus 2,4,5-T, half and half; at a concentration of 6 pounds aehg in an oil-water carrier consisting of 10 gallons of fuel oil in 87 gallons of water. Spray was applied to the stumps plus lower 2/3 of the stems and foliage of tall-growing woody brush to be controlled. Applied June 1953 at an average rate of 345 gallons per acre.

Treatment 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 fuel oil. The spray was applied under low pressure to the basal 12 inches of stems using enough volume to cause rundown to the root collar. Only tall-growing shrubs and trees were sprayed. Applied June 1953 at an average rate of 140 gallons per acre.

Treatment E—Selective winter basal of 2,4,5-T butoxy ethanol esters at a concentration of 12 pounds aehg in fuel oil. Only tall-growing shrubs and trees were sprayed, using the same technique as in "D" above. In addition, witchhazel (*Hamamelis virginiana*) and bear oak (*Quercus ilicifolia*) were not sprayed on 33-foot strips on each side of the right-of-way to encourage development of shrubby edges. Applied February 1954 at an average rate of 137 gallons per acre.

Treatment F—Broadcast foliage spray of ammonium sulfamate (AMS) at a concentration of 3/4 pound per gallon of water. Four ounces of DuPont sticker-spreader were added per 100 gallons of spray. Applied to all vegetation on the right-of-way in June 1953 at an average rate of 415 gallons per acre.

Follow-up basals applied in 1954:

Treatments B-D, C-D, D-D, E-D, F-D—a follow-up basal spray technique (D) was 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 was a summer basal spray containing 2 pounds of 2,4-D plus 2 pounds of 2,4,5-T per gallon, at a concentration of 16 pounds aehg in fuel

oil and applied at the average rate of 32 gallons per acre.

Retreatments applied in 1966:

Treatment G—Selective basal and stump spray of 2,4-D plus 2,4,5-T butoxy ethanol esters, half and half; at a concentration of 16 pounds aehg in fuel oil. A standard basal and stump spray was applied to thoroughly wet all exposed roots, stumps and stems to a height of about 10 inches. Applied in June and July 1966 at an average rate of 25 gallons per acre.

Treatment H—Stem-foliage spray of 2,4-D plus 2,4,5-T amine, half and half; at a concentration of 4 pounds active ingredient per hundred gallons in water. Spray was applied to thoroughly wet all foliage and stems at an average rate of 206 gallons per acre in June and July 1966.

Design of Tests

Each treatment was replicated four times in a randomized complete block design. While each block included a uniform site, the four blocks represented the range of upland sites on the 3-mile section of right-of-way. Individual treatment areas covered from 460 to 940 feet of the 180-foot-wide right-of-way.

Within each treatment area, a sample plot was located at random for detailed analysis; each plot being 33 feet wide by 165 feet long extending across the right-of-way. These plots were used to evaluate control attained on target woody brush species, and development of ground layer (under 5 feet) vegetation.

Data were taken on all ground layer plants using the combined estimate of abundance and sociability according to Braun-Blanquet (1932). Data were collected in August, annually for the first 5 years (1953-1957), then at intervals of 2 to 3 years in 1965, 1968, 1970 and 1973.

EFFECT OF SPRAYS ON PLANT COVER

Comparison of the Effect on Major Plant Species

The forest cover before right-of-way clearance was a typical upland oak-hickory forest dominated by white oak (*Quercus alba*), red oak (*Quercus rubra*), black oak (*Quercus velutina*), and chestnut oak (*Quercus Prinus*). Red maple (*Acer rubrum*) and sassafras (*Sassafras albidum*) were abundant. Hickory (*Carya* spp.), black gum (*Nyssa sylvatica*), black cherry (*Prunus serotina*), Juneberry (*Amelanchier*

arborea), flowering dogwood (*Cornus florida*), aspen (*Populus tremuloides* and *P. grandidentata*), and scarlet oak (*Quercus coccinea*) were sparse. The thin shrub layer, over 5 feet high, was dominated by witch-hazel and sassafras, while bear oak, mountain laurel (*Kalmia latifolia*), maple-leaved virburnum (*Viburnum acerifolium*), and chestnut (*Castanea dentata*) sprouts were commonly present.

A sparse ground layer, under 5 feet high, in the forest contained as the common shrubs blueberries (*Vaccinum angustifolium* and *V. vacillans*), huckleberry (*Gaylussacia baccata*), deerberry (*Vaccinium stamineum*), and teaberry (*Gaultheria procumbens*). Blackberry (*Rubus allegheniensis*), dewberry (*Rubus hispidus*), and azalea (*Rhododendron nudiflorum*) were present, but sparse, along with seedlings of trees and shrubs. Bracken (*Pteridium aquilinum*), vernal sedge (*Carex pensylvanica*), wild sarsaparilla (*Aralia nudicalis*), loosestrife (*Lysimachia quadrifolia*), and panic grasses (*Panicum latifolium* and *P. commutatum*) were typical of the ground layer. Occasionally present were false Solomon's-seal (*Polygonatum biflorum*), Indian cucumber (*Medeola virginiana*), lady's slipper (*Cypripedium acaule*), upland rice grass (*Oryzopsis asperifolia*) and meadow fescue (*Festuca elatior*).

After the right-of-way was cleared and before spraying, it supported the same species as the uncut forest plus a few new plants of forest openings such as sweetfern (*Comptonia peregrina*) and fireweed (*Erechtites hieracifolia*) appearing particularly where brush had been piled and burned after clearing. Tree species were present as sprouts and seedlings. The plant community forming the ground layer in 1953 before spraying was named BRACKEN-SEDGE-HERB-BLUEBERRY after its dominant species.

Within 2 years after spraying, the broadcast and semibasal spray areas developed distinctly different plant communities as compared with unsprayed controls and selective basal spray areas (Figure 1). On Treatment B (Broadcast D+T) areas, after an 80 to 100 percent top-kill of the ground layer, a SEDGE-GRASS-HERB community dominated by vernal sedge, panic grasses, meadow fescue, upland rice grass and upland bent (*Agrostis perennans*) developed and persisted for 4 years. Fireweed was present as an abundant herb during this time. Most striking was the marked decrease of blueberries, which did not reappear in abundance until 1968, 15 years after spraying.

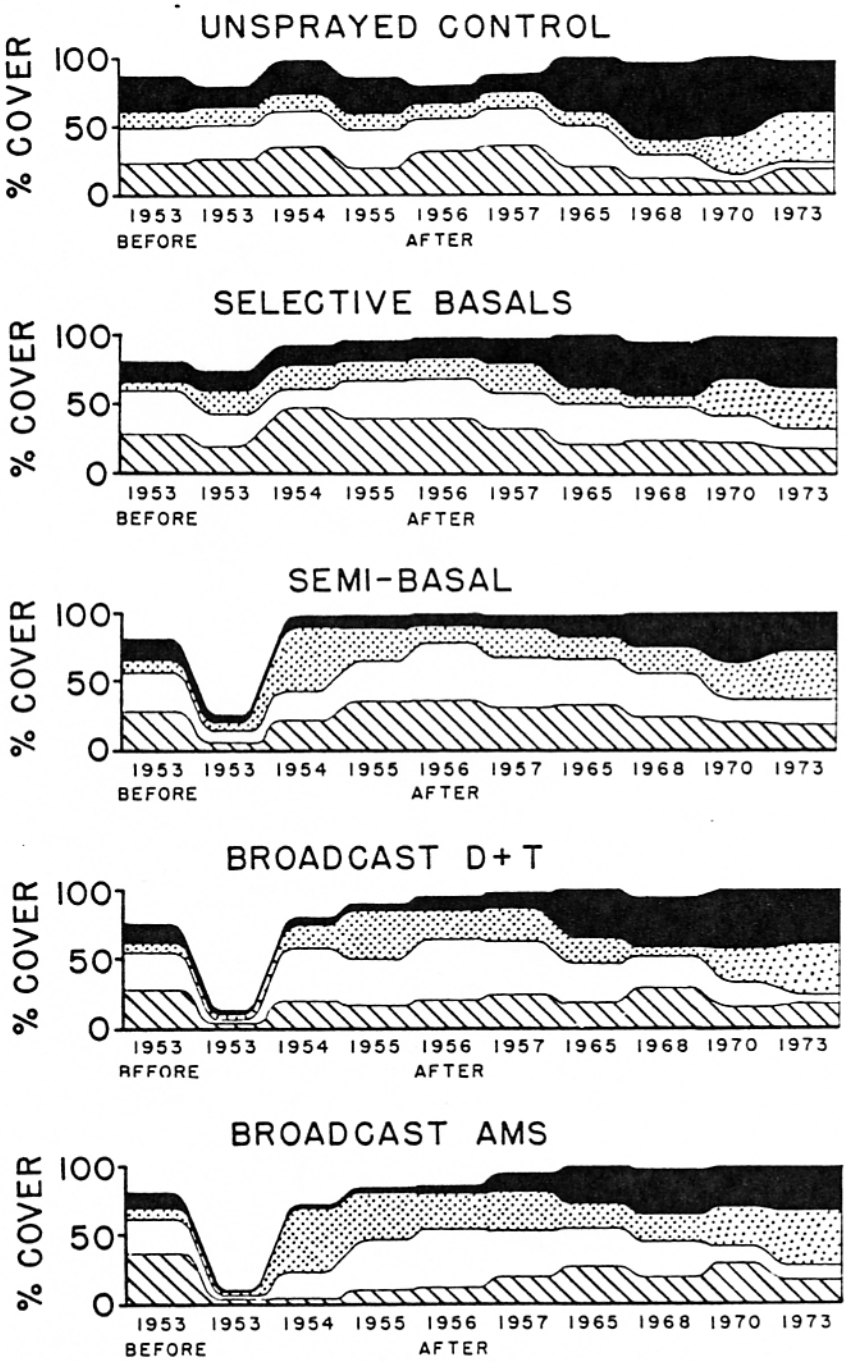

Figure 1. Histogram showing changes in percent of ground area covered and in major forms of vegetation in the ground layer before spraying in 1953 and after spraying from 1953 to 1973. Selective basals includes both summer and winter basal treatments.

By 1968 the BRACKEN-SEDGE-HERB-BLUEBERRY community with the addition of sweetfern again was the dominant ground cover. Treatment F (Broadcast AMS) areas also underwent a marked change to fireweed that grew up to 6 feet in height and completely dominated through 1956. It was not until 1968 that the AMS-sprayed areas regained enough blueberry to return to a BRACKEN-SEDGE-HERB-BLUEBERRY community as the dominant cover. Sweetfern had also developed into small patches on the AMS areas by 1965. The semibasal spray areas, after a 75 percent top-kill of the ground layer, developed a dominant fireweed community that lasted until 1954 and by 1965 was again dominated by the BRACKEN-SEDGE-HERB-BLUEBERRY community with sweetfern.

In general, therefore, on the broadcast spray areas there was first a nearly complete top-kill of the ground layer followed by development of a temporary plant community dominated by sedge-grass or fireweed. The vegetation then slowly returned to the original BRACKEN-SEDGE-HERB-BLUEBERRY community over the ensuing 15 years.

On the selective basal spray areas, however, there was relatively little disturbance of the original BRACKEN-SEDGE-HERB-BLUEBERRY community, and the total ground covered by vegetation after spraying in 1953 was 75 percent, as compared to 79 percent on the unsprayed controls. Sweetfern invaded basal spray areas more slowly than the broadcast areas and was still sparse in 1957; by 1965 sweetfern had developed into small patches and covered over one-fourth of the ground area. The original plant community, therefore, has been the dominant ground layer for 20 years with the addition of sweetfern as an important tall shrub after 10 years.

Important plant invaders have become established in all treatment areas in recent years, namely, two species of goldenrod (*Solidago graminifolia* and S. *rugosa*) and blackberry. The goldenrods have been particularly aggressive; and, from a sparse population in 1953, developed to cover more than one-fourth of the ground area in small to large patches in 1973. They have even grown up through sweetfern which now appears to be deteriorating in older patches. Blackberry also was sparse in 1953; but by 1965 it was plentiful, although growing singly. By 1973, blackberry had increased to form small groups and patches.

Development of a Stable Low Plant Cover

One of the objectives of this research was to encourage the development of a stable plant cover on the right-of-way that would resist invasion by tall-growing trees. The BRACKEN-SEDGE-HERB-BLUEBERRY as a low cover under 3 feet, with the addition of sweetfern as a tall shrub (up to 5-feet high) in recent years, has provided such a stable plant community for 20 years on selective basal spray areas; it also had developed by 1968 on the broadcast areas. It is comprised of a consistent group of plants that form a mosaic pattern, including both groups and patches of single species as well as complex mixtures of more than one species.

While there are no components of the mosaic that are entirely free of invasion by tree seedlings, some resist invasion more than others and have been free of emerging tree seedlings for 20 years.

The most resistant pure patches are meadow-fescue which has formed a heavy sod free of tree seedlings. Witchhazel has appeared in some fescue patches but is growing singly and is sparse. Sweetfern has also invaded fescue patches (Figure 2).

Blueberries also occur in patches free of tree seedlings particularly on dry sandy loam sites. A few oak seedlings have invaded some blueberry patches, indicating that nothing is entirely free of invasion, where squirrels are actively burying nuts. Where blueberries occur

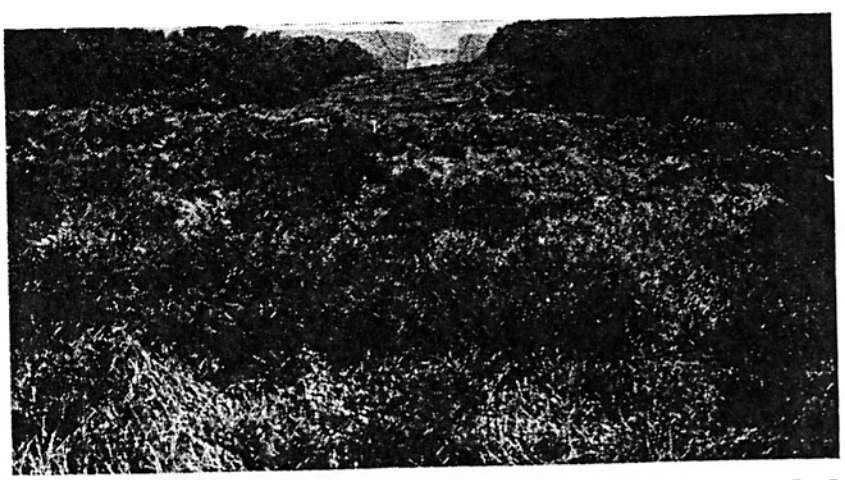

Figure 2. Meadow fescue in a large patch invaded by sweetfern but not by trees over a 20-year period. On a broadcast D+T treatment area, I B, 1973.

in association with goldenrod or other shrubs or herbs, the association has been invaded by red maple seedlings.

Goldenrod in pure patches and mixed with other vegetation has been invaded by cherry, red maple and oaks. Patches of sweetfern are commonly invaded by red maple which then emerges through the shrub canopy.

In general, although the common plant community of BRACKEN-SEDGE-HERB-BLUEBERRY of sprayed areas has been invaded by small tree seedlings, few have emerged above the ground layer to become large enough to be a problem in line maintenance. For example in 1957, 5 years after original spraying, numerous small seedlings or sprouts were present in the ground layer on all treatment areas (Figure 3). These ranged from a low of 886 per acre in the broadcast D+T (Treatment B) areas to 16,878 in winter basal (Treatment E) areas and were dominated by sassafras. Seedling numbers in the ground layer increased further by 1961, except for a slight decrease on the winter basal (Treatment E); then declined drastically by 1968, 2 years after resprays were applied.

When the number of tree seedlings and sprouts in the ground layer in 1957 and 1961 (Figure 3) are compared with those in the shrub layer in 1957 and 1965 (Figure 4); relatively few emerged above the ground layer. For instance in fall 1965, woody plants in the shrub layer on original herbicide-treated areas ranged from a low of 60 per acre on semi-basal (Treatment C) to a high of 1136 on winter basal (Treatment E) plots; few of these were more than 5 feet in height.

In 1966, when woody brush on the right-of-way was resprayed for the first time, 8 of the original 20 herbicide treatment areas did not require spraying to control emergent trees. On the other 12 areas, light selective basal sprays were applied to control scattered trees, stump sprays on large red maple trees emerging on two AMS (Treatment F) plots, and stem-foliage sprays to control sassafras thickets on three winter basal (Treatment E) plots. Woody brush on unsprayed control (Treatment A) areas was recut in winters of 1958 and 1967.

Very few woody plants were present in the shrub layer on all herbicide treatments in 1968, 2 years after respraying (Figure 4). Total numbers had increased some by 1973, but were composed pre-

dominantly of bear oak and witchhazel (Table 1), which are species of low growth form that are desirable for wildlife food and cover, that were left unsprayed in the 1966 treatments.

The portion of each treatment area which had received the original herbicide treatments in 1953 plus a quick follow-up basal spray in 1954 (Treatments B-D, C-D, D-D, E-D, and F-D) had relatively few tree seedlings and sprouts, generally less than 2,000 per acre, in the ground layer through 1968. An extremely small proportion of these seedlings subsequently emerged into the shrub layer.

It appears, therefore, that plant competition along with animal browsing and dieback from frost have been effective in reducing

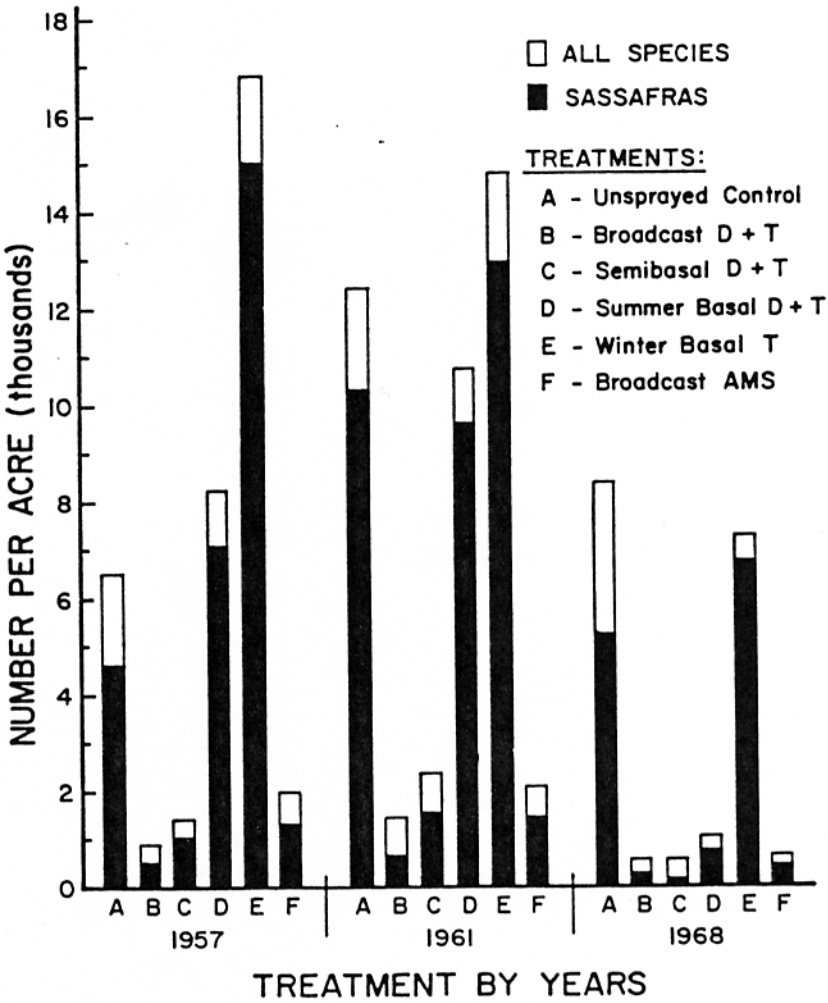

Figure 3. Mean number of woody plants per acre under three feet in height for initial treatments.

emergence of the numerous tree seedlings and sprouts that occurred in the ground layer. A right-of-way with a low dense ground cover and free of woody brush has been the result.

WILDLIFE USE OF SPRAYED AREAS

Random direct observations were made of use of sprayed and unsprayed treatment areas by major game species immediately following spraying in 1953 (Table 2). From June to October, white-tailed deer (*Odocoileus virginianus*) browsed heavily on new shoots of bracken

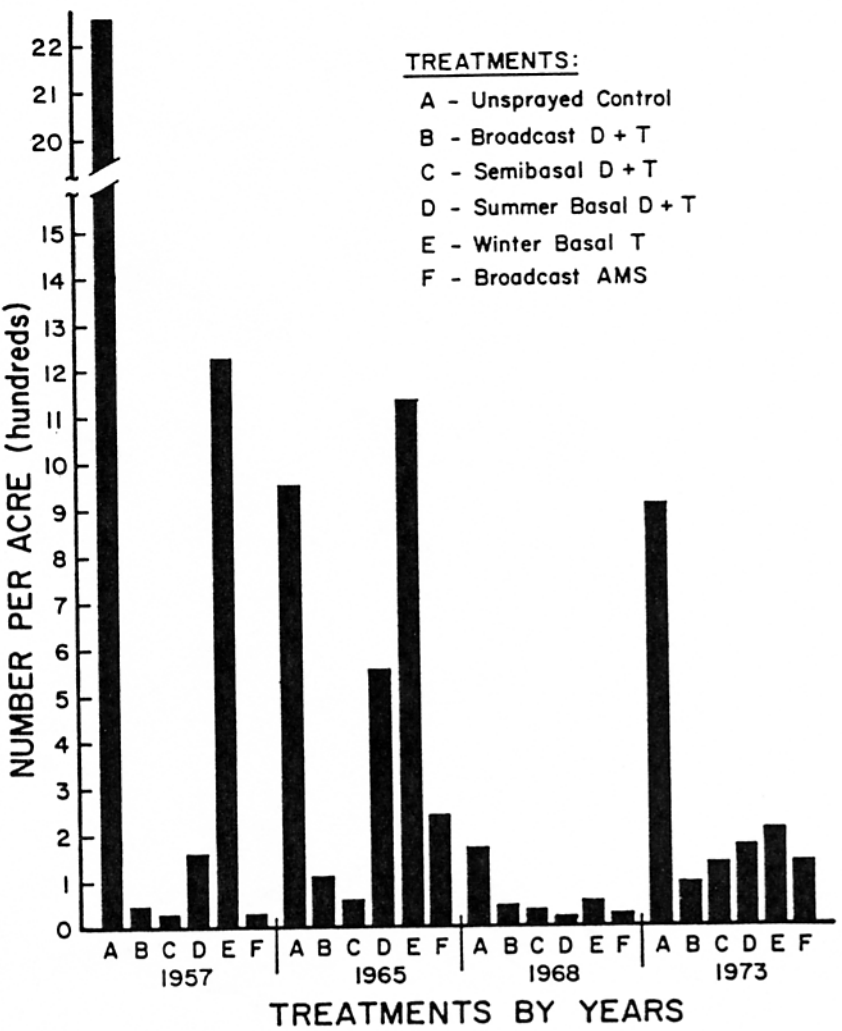

Figure 4. Mean number of woody plants per acre over 3 feet in height for initial treatments. Woody brush on herbicide treatments was resprayed in 1966 and on control plots recut in winter 1958 and 1967.

Table 1. Mean number of woody plants per acre in the shrub layer, over 3 feet in height in August, 1973, 20 years after original treatment

Original treatment	*Bear Oak*	*Other oaks**	*Red Maple*	*Sassafras*	*Witch-hazel*	*Cherry*	*Other hardwoods***	*Total*	*Percent Bear Oak + Witchhazel*
A Unsprayed	132	416	90	74	146	42	8	908	31
B Broadcast D+T	46	8	12	8	10	6	2	92	61
C Semi-basal	46	16	30	8	10	18	6	134	42
D Summer Basal	38	22	10	4	64	18	16	172	59
E Winter Basal	52	36	8	54	50	0	4	204	50
F Broadcast AMS	22	16	10	10	68	12	0	138	65

* Black, chestnut, red, and white oaks.
** Aspen, black gum, hawthorn (*Crataegus* spp.), large-leaved holly (*Ilex montana*), and Juneberry.

Table 2. Direct observations of animals and signs on sprayed areas taken from October through December 1953, shortly after spraying in June 1953

Game species observed	*Treatment*						
	A	*B*	*C*	*D*	*E*	*F*	*Total*
	Number times observed						
White-tailed deer	8	11	20	12	8	9	78
Cottontail rabbit	1	4	1	3	1	0	10
Ruffed grouse	5	7	3	1	6	2	24
Wild turkey	0	16	1	1	0	1	19
Gray squirrel	0	1	3	3	6	6	19
Red and grey fox	0	0	1	0	0	0	1
Opossum	0	0	1	0	0	0	1

and moderately on loosestrife and the two common panic grasses. Cottontail rabbit (*Sylvilagus floridanus*) and wild turkey (*Meleagris gallopavo*) signs were found on both unsprayed and sprayed treatment areas. From October through December 1953, frequent observations of deer, rabbit, grouse (*Bonasa umbellus*) and squirrel (*Sciurus carolinensis*) were made by a technician who was clipping and measuring deer browse on the right-of-way. No obviously abnormal or dead animals were found.

Further direct observations on both animals and signs were recorded by researchers working on the test area from October 1953, through October 1957, and showed use of all spray treatments by major game species for 5 years (Table 3).

As direct observations may often give an incorrect impression of the number of game animals present owing to differences in cover, a special technique of observation using animal pellet counts was begun in March 1954. This technique had been used for estimating deer populations in Pennsylvania by Bennett, English and McCain (1940) with some success and has been developed further by other wildlife specialists (Eberhardt and Van Etten, 1956). While not really suited to estimate deer or other game populations on small areas, it has been a useful method to determine intensity of use on a comparative basis among treatment areas and was so used in this study. This method as

Table 3. Direct observations of both wildlife species and signs on treatment areas taken from October 1, 1953, through October 1957

Treatment	*Wildlife species*				
	White-tailed deer	*Ruffed grouse*	*Cottontail rabbit*	*Grey squirrel*	*Wild turkey*
A Unsprayed control	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 AMS	69	8	7	18	15
Total	371	48	106	51	49

applied to deer is based essentially upon reports that deer deposit, on the average, 13 pellet groups per deer in one day (Eberhardt and Van Etten, 1956). Droppings of other species were taken to record their use of test areas.

The technique used in this study was to count all deer pellet groups and other animal droppings on 100-foot by 3-foot transects; each transect was cleared of pellets after each count as deer pellet groups may remain visible for as long as 3 years on the right-of-way. In the forest, pellet groups are covered with leaves in the fall and so are usually not found after leaf-fall in October-November. Two transects were used for each of 4 replications, totalling 8 transects for each treatment. Also, a transect was located in the forest one-half chain from the edge, opposite to one of the right-of-way transects in each treatment replicate; resulting in 24 forest transects. The pellet group count was on the conservative side, as groups could be missed, particularly in areas of dense blueberry or grass cover on the right-of-way in August when most counts were made.

Both sprayed and unsprayed areas were used by deer, rabbit and grouse in the winter of 1954 following spraying in June 1953 (Table 4). Deer use was low in 1954 on broadcast D+T (Treatment B) areas and on broadcast AMS (Treatment F) areas as vegetation had been almost completely top-killed; while on the selective summer and winter basal areas covered with a BRACKEN-SEDGE-HERB-BLUEBERRY cover use was equal to the unsprayed controls.

Table 4. Average number of pellets or droppings (grouse) per treatment area on 3 by 100-foot strip transects on the right-of-way; 20 transects taken in each treatment in March 1954, after spraying in June 1953 and February 1954 (E)

Treatment	March 1954		
	Deer	*Rabbit*	*Grouse*
A Unsprayed control	349	101	2
B Broadcast D+T	112	95	0
C Semi-basal	216	3	0
D Summer basal	391	132	0
E Winter basal	532	102	0
F Broadcast AMS	165	2	1

Deer Use of Sprayed Areas

Use of treatment areas on the right-of-way and of the adjacent forest by white-tailed deer has been followed for 20 years. As deer are an important large game animal of the Allegheny plateau, special attention was given to them by means of the pellet group count technique described in the preceding section. Transects were cleared of pellets in March and May 1954 to begin counts in April 1955 for the long-term study that has followed deer use through 1973.

During the period from May 1954 to April 1955, there was low use of the right-of-way by deer, ranging from 2 deer days per acre in unsprayed control areas to 9 days on the winter basal treatment (Figure 5). There was increased deer use on all treatment areas through 1956, 1957, and 1962, with the brushy unsprayed controls showing the highest use. By 1969, coincident with the time when sweetfern became a dominant tall shrub forming patches on all treatment areas, there was higher deer use on the selective basal than on other spray areas. However, when tested statistically in 1970, there was no significant difference in number of pellet groups per acre among treatments or replications (blocks) at the .05 probability level. By 1970, all sprayed areas had developed the same general plant cover of BRACKEN-SEDGE-HERB-BLUEBERRY with sweetfern. There was an estimated population of 1 deer per 9 acres on the right-of-way at this time.

Evidently the right-of-way with its low dense plant cover has produced edges and type interspersion in contrast to the uncut forest with its sparse ground layer, and is providing an important improvement of the local habitat. As a further check on deer use in the uncut forest, ten 3 x 100-foot transects were established at 0.1-mile

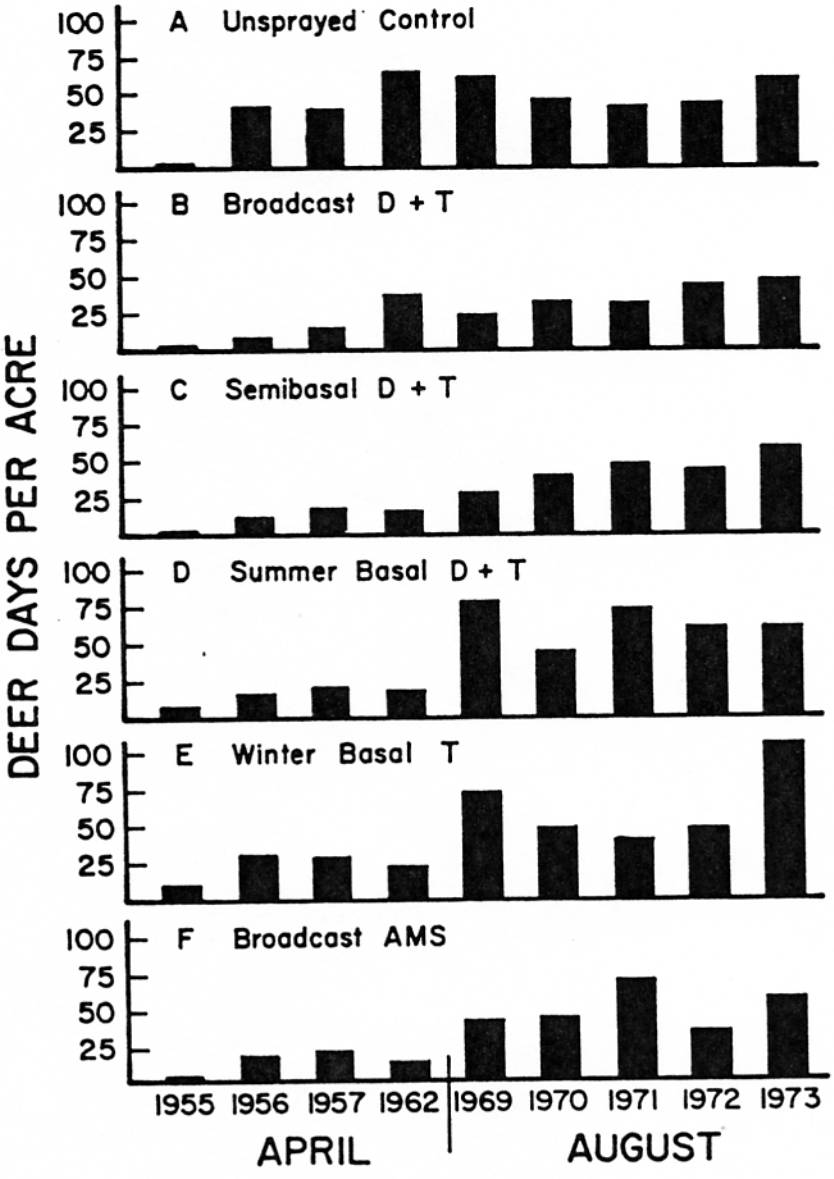

Figure 5. Deer days of use per acre from 1955 to 1973 on the right-of-way treatment areas. (Deer days per acre = Number pellet groups per acre ÷ 13 pellet groups per day, the average deposited by one deer in 1 day).

intervals on two lines at right angles to the right-of-way and covering 0.2 to 0.3 miles distance to a point where other open areas such as burns or cuttings occurred in the forest. Deer use in the forest averaged 22 deer days per acre in 1972 and 36 deer days per acre in 1973, as compared with 45 and 65 deer days per acre on the right-of-way for those same years.

Utilization of Vegetation on the Right-of-Way by Deer

A special study was made of plant use by deer on the right-of-way owing to the importance of that species. Two variants were used in analyzing use of plants as food by deer (Aldous, 1944). These were, (1), density of each plant species taken as a percent of ground area covered, and (2), percent of the plants of each species that 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 for each species given in Table 5, "average density" was obtained by dividing the total of density of a species on all plots by the number of plots on which that species occurred. "Average browsing" was obtained by dividing total percent of plant browsed on all plots by the number of plots on which the species occurred. The "utilization factor" was obtained by multiplying the average density by the average browsing for each species (Aldous, 1944). The utilization factor, therefore, is a single value that combines density and browsing to indicate the relative importance of plant species as food for deer.

Deer heavily utilized the common herbaceous plants; bracken, goldenrod and loosestrife as food on the sprayed right-of-way (Table 5). Bracken was used mostly in the spring and early summer when it was tender and succulent; 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

Table 5. Browsing of plants by deer in 1968 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		Percent			Percent			Percent	
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
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

is not overbrowsed (Bramble and Goddard, 1953). Of the woody species browsed on the sprayed right-of-way, sweetfern showed the highest utilization as it was both abundant and heavily browsed; sassafras, bear oak, witchhazel, and blackberry were in a group that was heavily used but occurred at a low density.

Nutritive Value of Plants Eaten by Deer

To determine the feed value of common plants eaten by deer, analyses were made on samples collected on the sprayed right-of-way. The importance of feed value has been emphasized by studies with penned deer which showed that 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 of plant species commonly eaten by deer on the sprayed right-of way, 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 was designed to give the penned deer components of a diet that permitted normal body growth.

Comparison of the complete ration with herbs which are utilized by deer on the right-of-way showed that protein and fat content of the common herbs, bracken, goldenrod, loosestrife, and sorrel (*Rumex acetosella*) are relatively high (Table 6). Although the calcium content of these herbs is relatively low compared with the synthetic ration, other minerals such as phosphorous, magnesium, and potassium are relatively high. Phosphorous has been observed in pen studies to act in combination with calcium to make up for calcium deficiency.

Recent studies (Liscinsky *et al.*, 1973) indicate that herbaceous plants are eaten throughout the year by deer and make up an average of about 30 percent of their diet.

Woody plants on the right-of-way generally provide summer food as well as important winter food for deer. Feed analysis showed that such browse was low in protein as compared to the synthetic ration; however, all but two species contained more than the 7.3 percent protein of the low-protein ration used in penned deer studies. Stems of sweetfern and the leaves of blueberry, contained the highest value of 9.2 percent protein. In fat content, the woody plants rated considerably higher than the synthetic ration; 2.90 to 4.95 percent

Table 6. 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. Gaminifolia	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

* Helmers, 1940.

as compared with 1.70 percent in the ration. There was higher calcium in woody browse than that found in herbaceous plants, and it was higher than the 0.24 percent of low-calcium experimental rations (Magruder, *et al.*, 1957).

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 combination provide deer with a suitable diet.

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