DEVELOPMENT OF A STABLE, LOW PLANT COVER ON A UTILITY RIGHT-OF-WAY

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Abstract.--An analysis of invasion of components of a plant community by trees was made on a transmission right-of-way in central Pennsylvania on which woody brush had been controlled by herbicide sprays. A stable, low plant cover, composed of a mosaic of single and mixed species, existed on all treatment areas in 1975. Community components most resistant to tree invasion were pure patches of meadow fescue, rough goldenrod, bear oak, blueberry, and meadow fescue mixtures. Species within the life forms of shrubs, herbs, and grasses appeared to be more important to resisting invasion than the particular life form itself.

INTRODUCTION

A project was initiated in 1953 on a utility right-of-way (ROW) in central Pennsylvania with one of its major objectives being "to follow ecological changes in the plant community present on the ROW as a result of spraying with a view towards comparison of the types of stable coverd developed" (Bramble and Byrnes, 1955).

Over the ensuing 22 years, a definite plant community has developed on the ROW and has been studied to determine its resistance to invasion by tall-growing tree species, such as red maple, referred to in this paper simply as "trees", in contrast to low trees and shrubs, such as bear oak and witchhazel, which are not likely to interfere with transmission lines. This community has been relatively stable and resistant to invasion, but there appeared to be considerable difference in resistance to tree invasion by its various components (Bramble and Byrnes, 1974).

BACKGROUND

Right-of-Way Treatments

Design of Herbicide Spray 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 ROW. Individual treatment areas were large enough for commercial spray application and covered from 460 to 940 feet of the 180-foot-wide ROW.

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 ROW. Data were taken on all plants of the ground layer (under 5 feet) using a combined esitmate of abundance and sociability according to Braun-Blanquet (1932). These plots also were used to evaluate control attained on target woody brush species.

Data were collected annually in August, for the first 5 years (1953-1957), then at intervals of 2 to 3 years in 1965, 1968, 1970, and 1973.

Spray Treatments

Initial Treatments, 1953.--Treatment A--Unsprayed, woody brush cut as needed for control.

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Treatment B--Broadcast foliage spray (D+T) 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 in June 1953 to all vegetation on the ROW 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 stem using enough volume to cause rundown to the root collar. Only tall-growing shrub and tree species 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 shrub and tree species were sprayed, using the same technique as in "D" above. In addition, witchhazel and bear oak of low-growth form were not sprayed on 33-foot strips on each side of the ROW 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 ROW in June 1953 at an average rate of 415 gallons per acre.

Follow-up Basals, 1954.

Treatments B-D, C-D, D-D, E-D, F-D--A follow-up basal spray (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.

Treatments, 1966 (Bramble and Byrnes, 1972).

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 to plots with scattered brush and larger trees.

Treatment H--Stem-foliage spray of 2,4-D plus 2,4,5-T amine, half and half; at a concentration of 4 pounds aihg (active ingredient per 100 gallons) in water. Spray was applied to thoroughly wet all foliage and stems on plots with brush thickets at an average rate of 206 gallons per acre in June and July 1966.

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 ROW 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. 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 and suckers developing on previously topkilled plants and on missed or invading tree seedlings. The combination of "initial plus follow-up basal" spray resulted in virtual elimination of the woody brush, a condition which persisted on the ROW for 20 years.

The first treatments since initial and follow-up sprays in 1953-54 were applied to developing brush in June and July 1966 on 12 of the 20 plots. These treatments included "selective basal sprays" on scattered brush clumps of all tall-growing species, "cut and stump sprays" on larger trees such as red maple and upland oaks, and "stem-foliage sprays" on thickets of sassafras. Resprays were applied to all woody plants, except ground cover species, growing in the center of the ROW; 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 plants--under 3 feet in height--provides desirable game food and cover, contributes to improved aesthetics, and does not interfere with power line operation.

Evaluation in August 1968, 2 years after

the respray, revealed that the 1966 treatments 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". These resprays reduced the number of plants in the shrub layer on "initial spray" areas by 43 to 97 percent and on "initial plus follow-up basal spray" areas by 80 to 97 percent. However, there remained a considerable number of small sprouts and seedlings under 3 feet in height which represented a reservoir of resurging brush on all treatment areas.

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

Development of Wildlife Food and Cover and Wildlife Use

A diversity of food plants useful to wildlife developed on the ROW 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 ROW and its edges were 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 ROW showed a consistent and heavy use in all seasons indicating that attractive food and cover had been developed (Bramble and Byrnes, 1972).

DEVELOPMENT OF A LOW, STABLE PLANT COVER

The Original Forest Cover

The forest tree layer before ROW clearance in 1951-52 was a typical upland oak-hickory forest dominated by white oak, red oak, black oak, and chestnut oak, with red maple and sassafras. Some black cherry also were present.

There was a thin shrub layer containing witchhazel, bear oak, and mountain laurel. Sweetfern was present in openings.

The sparse ground layer was composed of blueberries, huckleberry, and teaberry. Blackberry and dewberry were occasional plants. Bracken, sedge, wild sarsaparilla, loosestrife, and various grasses; including upland rice grass, panic grasses, and meadow fescue, were typical. Occasional patches of hayscented fern also were present.

Effect of Sprays on Plant Cover

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 (fig. 1). On Treatment B (Broadcast D+T) areas, after an 80 to 100 percent topkill of the ground layer, a SEDGE-GRASS-HERB community dominated by vernal sedge, panic grasses, meadow fescue, upland rice grass and upland bent 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.

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 topkill of the lesser vegetation in 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 topkill 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 (Treatments D and E), however, there was relatively little disturbance of the original BRACKEN-SEDGE-HERB-BLUEBERRY community, and the total ground area 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 1/20 to 1/4 of the ground surface on basal spray areas. 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.

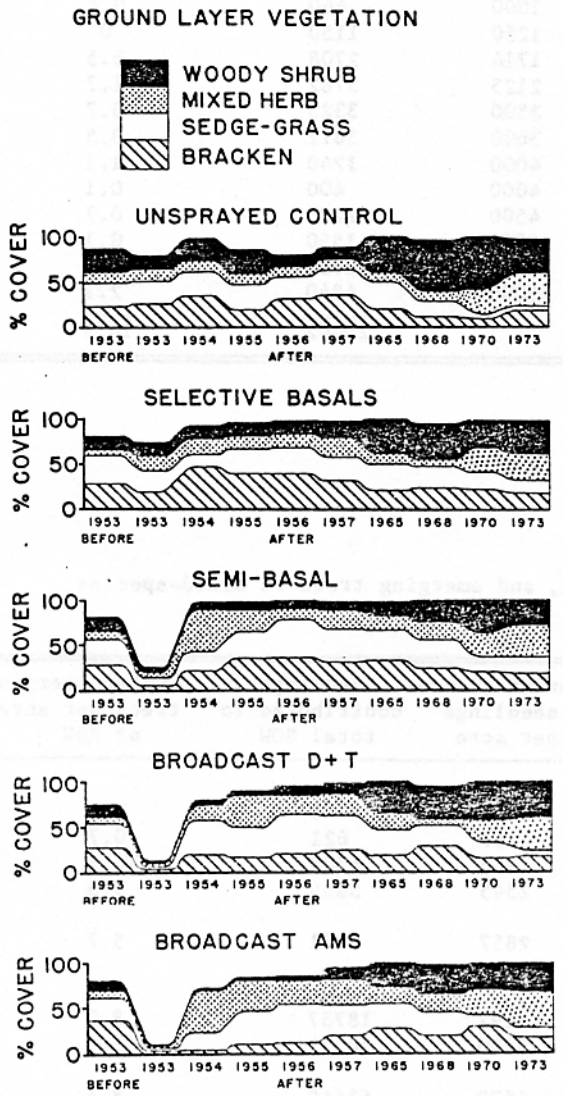

Figure 1.--Histogram showing changes in percent of ground area covered and in major forms of vegetation in the ground layer before spraying in 1953 and after spraying from 1953 to 1973. Selective basals include both summer and winter basal treatments.

Important plant invaders have become established in all treatment areas in recent years, namely, two species of goldenrod 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 had even grown up through sweetfern which was 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.

TREE INVASION AND EMERGENCE ON THE RIGHT-OF-WAY

The Dominant Plant Community

The dominant plant community of the right-of-way on all treatments in 1974 was made up of a mosaic of single and mixed species in patches which are referred to in this paper as community components. As a distinct plant community it was named Bracken-Blueberry (Pteridium-Vaccinium) after two of its common and characteristic species.

Although several significantly different plant communities developed after spraying in 1953-54, the various treatment areas all gradually developed the same plant cover prior to respraying in 1966 (See section on "Effect of Sprays"). This community was made up of typical components varying from pure patches of single species (Table 1) to complex mixtures (Table 2). In most cases, the dominant species of the mixtures could be named.

Data Collection Procedures

It was apparent that various components of the general plant community on the ROW differed in the amount of tree invasion (Table 3). Therefore, data on tree invasion was collected separately for each component.

A chart transect, 3 feet wide by 165 feet long, was laid out across the ROW along the edge of permanent, randomly located sample plots. Each community component was mapped on the transect and tree seedlings under 3 feet in height plotted.

For trees emerging above the ground layer, which varied from 3 to 6 feet in height, a strip transect 99 feet wide by 165 feet long was used at the same location as the chart transect described above. This larger transect was needed to get an adequate sample of emerging trees and the components in which they were found. All emerging trees were tallied by species, height, and community component, without mapping.

Table 1. Invading tree seedlings, under 3-feet height, and emerging trees in single-species community components on the ROW, 1975.

Community component single-species patches	Percent of ROW occupied	Acres of ROW occupied	Invading tree seedlings per acre	Seedlings contributed to total ROW	Number emerging trees per acre of ROW
Meadow Fescue (MF)	2.7	1.38	0	0	0
Rough Goldenrod (RG)	0.9	0.46	500	230	2.9
Bear Oak (BO)	0.9	0.46	1000	460	0.4
Low Early Blueberry (LEB)	1.8	0.92	1250	1150	0
Blackberry (Bl)	3.1	1.58	1714	2708	6.5
Hayscented Fern (HF)	3.5	1.78	2125	3782	1.7
Poverty Grass (PG)	2.6	1.33	2500	3325	0.7
Narrow-leaved Goldenrod (NG)	2.0	1.02	3600	3672	0.5
Sweetfern (SF)	0.6	0.31	4000	1240	1.1
Mountain Laurel (ML)	0.2	0.10	4000	400	0.1
Witchhazel (Wh)	1.0	0.51	4500	2295	0.7
Loosestrife (Lo)	0.6	0.31	5000	1550	0.1
Low Late Blueberry (LLB)	0.5	0.25	7000	1750	0.1
Huckleberry (Hu)	0.7	0.36	19000	6840	2.1
Total	21.1	10.77		29402	16.9

Table 2. Invading tree seedlings, under 3-feet height, and emerging trees in mixed-species community components on the ROW, 1975.

Community component mixed-species patches	Percent of ROW occupied	Acres of ROW occupied	Invading tree seedlings per acre	Seedlings contributed to total ROW	Number emerging trees per acre of ROW
Narrow-leaved Goldenrod Mixtures	0.4	.20	0	0	0.3
Fescue Mixtures	7.3	3.72	167	621	0.7
Blackberry Mixtures	12.8	6.53	966	6308	16.8
Dewberry Mixtures (De)	4.5	2.30	2545	5854	0.5
Hayscented Fern Mixtures	3.4	1.74	2857	4971	5.7
Huckleberry-Low Late Blueberry	1.0	0.51	3000	1530	0.1
Sweetfern Mixtures	11.5	5.87	3192	18737	8.0
Rough Goldenrod Mixtures	8.2	4.18	3400	14212	3.7
Bracken-Sedge-Loosestrife Blueberry Mixture (BSLB)	26.8	13.68	4639	63462	8.4
Low Early Blueberry Mixtures	1.7	0.87	6000	5220	0.1
Bear Oak Mixtures	1.3	0.66	9000	5940	-
Low Late Blueberry Mixtures	-	-	-	-	0.3
Mountain Laurel Mixtures	-	-	-	-	0.3
Total	78.9	40.26		126855	44.9

Table 3. Tree species emerging above the ground layer in 1975 on 20 transects, each 99 by 165 feet, representing 7.5 acres of ROW.

Community Component[1]	Number Trees Emerging: Red Maple	Black Cherry	Sassafras	White Oak	Red Oak	Black Oak	Chestnut Oak	Aspen	Total Number	Total Per A
Single-Species Patches										
MF									0	0
LEB									0	0
LLB						1			1	0.1
Lo		1							1	0.1
ML		1							1	0.1
BO			3						3	0.4
NG		2			1		1		4	0.5
PG		2			3				5	0.7
Wh	1	1	2		1				5	0.7
DB[2]	2	2	3						7	1.0
SF	4	1	2			1			8	1.1
HF	6	2			2	1	2		13	1.8
Hu	3		6	4	1	1	1		16	2.1
RG	4	10	1	3	2	1	1		22	2.9
Bl	26	11	2	1	4	2	2	1	49	6.5
Total	46	33	19	8	14	7	7	1	135	18.0
Mixed-Species Patches										
LLB mixtures						1			1	0.1
Hu "				1					1	0.1
LEB "	1				1				2	0.3
NG "		1				1			2	0.3
ML "			1	1					2	0.3
De "		1			1	2			4	0.5
MF "				3	1	1			5	0.7
RG "	3	16		1	4	3	1		28	3.7
HF "	9	14	9	2	3	3	2	1	43	5.7
SF "	17	19	3	6	7	4	4		60	8.0
BSLB "	8	8	25	3	3	6	10		63	8.4
Bl "	38	33	18	10	13	6	6	2	126	16.8
Total	76	92	56	27	33	27	23	3	337	44.9
Grand Total	122	125	75	35	47	34	30	4	472	62.9

[1] Community component symbols refer to the first letters of the plant species common name used in this report. See Tables 1 and 2.

[2] DB = Deerberry

Invasion and Emergence

Tree seedling invasion and emergence was summarized for single-species community components (Table 1) and mixed-species components (Table 2). Single species in patches occupy 21.1 percent of the ROW while patches of mixed-species contribute 78.9 percent of the ROW plant cover.

The result of this marked difference in cover value is that the mixed-species components contribute more tree seedlings to ROW tree invasion than do single-species components. This occurs even though the average number of tree seedlings per acre for mixed-species is 2751 as compared to 4013 per acre for single-species components.

Components that Resist Tree Invasion

Single-Species Patches--Meadow fescue, rough goldenrod, bear oak, and low early blueberry were the four components most resistant to seedling invasion when growing in pure patches. Of these, meadow fescue, bear oak, and low early blueberry also showed low tree emergence of less than 0.5 trees per acre (Table 1).

Meadow fescue in pure patches was most outstanding as it had no seedlings and no emerging trees. This tall grass forms a thick turf with a dense mat of roots in the upper topsoil.

Low early blueberry also was a good resistant cover when growing in pure patches as it had low, 1250 per acre, seedling invasion and had no emerging trees. This low shrub forms dense mats with its tangle of stems and leaves.

Two species, loosestrife and low late blueberry, had low tree emergence of less than 0.1 trees per acre, although both were invaded by large numbers of tree seedlings, 5000 and 7000 per acre, respectively. Both plant competition and deer browsing appear to be important factors in eliminating or suppressing such seedlings before they can emerge.

Mixed-Species Patches--In the case of mixtures, as with pure patches, meadow fescue mixtures also were resistant to seedling invasion and tree emergence (Table 2).

Low early blueberry, bear oak, and narrow-leaved goldenrod mixtures were all low in tree emergence, although low early blueberry and bear oak mixtures were heavily invaded by tree seedlings.

Of all the mixed-species patches, the narrow-leaved goldenrod mixtures were both lowest in seedling invasion and very low, 0.3 trees per acre, in tree emergence.

Components Heavily Invaded

Single-Species Patches--Huckleberry showed the highest invasion by tree seedlings with 19,000 per acre and high emergence with 2.1 trees per acre (Table 1).

Blackberry while not high in number of invading seedlings, 1714 per acre, had the highest number of emerging trees, 6.5 per acre (fig. 2).

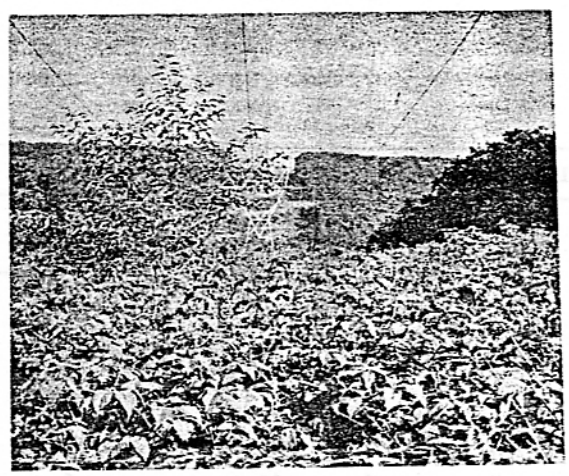

Figure 2.--Black cherry emerging from pure patch of blackberry.

Sweetfern was both heavily invaded by tree seedlings, 4000 per acre, and showed high emergence of 1.1 trees per acre.

The aggressive hayscented fern had moderate invasion, 2125 seedlings per acre, and had 1.7 emerging trees per acre.

Mixed-Species Patches--Sweetfern, blackberry, and hayscented fern mixtures were similar to their single species patches in having high tree emergence (Table 2). Both sweetfern and hayscented fern mixtures had a high number of invading seedlings per acre, 3192 and 2857 per acre; while, blackberry mixtures had a low number of seedlings, 966 per acre, but the

highest by far of all components in tree emergence, 16.8 trees per acre.

The most common mixture on the ROW, bracken-sedge-loosestrife-blueberry, was heavily invaded by seedlings, 4639 per acre, and had 8.4 emerging trees per acre (fig. 3).

Figure 3.--Chestnut oak emerging from mixed-species patch of sweetfern plus bracken-sedge-loosestrife-blueberry.

Emerging Tree Species

The most frequent trees emerging on the ROW were black cherry, red maple and sassafras in that order. Seeds of these species are transported either by birds and mammals or by wind and so readily spread onto the ROW from the adjacent forest.

The oaks, with acorns transported mostly by squirrels, were less frequent invaders of the ROW. Red oak was the most common oak species.

Invasion of the ROW was not uniform over the 3-mile research section. Invasion depended upon a number of variables of which presence of seed trees near the ROW appeared most important. Where black cherry seed trees were present on the edge of the ROW, for example, heavy invasion by that species usually took place.

DISCUSSION

There have been varied opinions expressed in recent years on the effectiveness of shrubs versus other life forms in repelling tree invasion of a ROW (Niering and Goodwin, 1974). Results from this study, however, indicate that while some shrubs are effective cover plants, others are not. Low early blueberry, for example, was an excellent plant cover and showed a low number of invading seedlings and emerging trees. Sweetfern, on the other hand, a tall aromatic shrub was invaded by a large number of seedlings with many emerging as trees above the ground layer.

The same is true of grasses; for while meadow fescue was the most effective cover of all in repelling invasion, poverty grass was heavily invaded.

It should be emphasized, therefore, that one cannot generalize. Species differences within the life forms of shrubs, herbs, and grasses are more important than the particular life form to which they belong.

PLANTS REFERRED TO IN THE REPORT

Aspen
- Large-toothed-------*Populus grandidentata*
- Trembling-----------*Populus tremuloides*

Blackberry-----------*Rubus allegheniensis*

Blueberry
- Low Early-----------*Vaccinium angustifolium*
- Low Late------------*Vaccinium vacillans*

Bracken--------------*Pteridium aquilinum*

Cherry
- Black---------------*Prunus serotina*
- Fire----------------*Prunus pensylvanica*

Cow-Wheat------------*Melampyrum lineare*

Deerberry------------*Vaccinium stamineum*

Dewberry-------------*Rubus villosus*

Dogwood, Flowering----*Cornus florida*

Fireweed-------------*Erechtites hieracifolia*

Goldenrod
- Narrow-leaved-------*Solidago graminifolia*
- Rough---------------*Solidago rugosa*

Hawthorn-------------*Crataegus spp.*

Hayscented Fern-------*Dennstaedtia punctilobula*

Huckleberry-----------*Gaylussacia baccata*

Juneberry------------*Amelanchier arborea*

Loosestrife----------*Lysimachia quadrifolia*

Maple, Red-----------*Acer rubrum*

Meadow Fescue---------*Festuca elatior*

Mountain Laurel-------*Kalmia latifolia*

Oak
- Bear----------------*Quercus ilicifolia*
- Black---------------*Quercus velutina*
- Chestnut------------*Quercus Prinus*
- Red-----------------*Quercus rubra*
- White---------------*Quercus alba*

Panic Grass----------*Panicum latifolium*

Poverty Grass---------*Danthonia spicata*

Sassafras------------*Sassafras albidum*

Sedge----------------*Carex pensylvanica*

Sorrel---------------*Rumex Acetosella*

Sweetfern----------Comptonia peregrina
Teaberry----------Gaultheria procumbens
Upland Bent----------Agrostis perennans
Upland Rice Grass------Oryzopsis asperifolia
Wild Sarsaparilla------Aralia nudicaulis
Witchhazel----------Hamamelis virginiana

LITERATURE CITATIONS

Bramble, W. C. and W. R. Byrnes.
1955. Effect of certain common brush control techniques and materials on game food and cover on a power line right-of-way. Penna. Agric. Exp. Stn., Progress Report No. 126, 4 p.

Bramble, W. C. and W. R. Byrnes.
1972. A long-term ecological study of game food and cover on a sprayed utility right-of-way. Purdue Univ., Agric. Exp. Stn., Research Bull. No. 885, 20 p.

Bramble, W. C. and W. R. Byrnes.
1974. Impact of herbicides upon game food and cover on a utility right-of-way. Purdue Univ., Agric. Exp. Stn., Research Bull. No. 918, 16 p.

Braun-Blanquet, J.
1932. Plant sociology. McGraw-Hill, N.Y., 439 p.

Niering, W. A. and R. H. Goodwin.
1974. Creation of relatively stable shrublands with herbicides: arresting succession on rights-of-way and pastureland. Ecology 55:784-795.