

EFFECT OF HERBICIDES ON BUTTERFLY POPULATIONS OF AN ELECTRIC TRANSMISSION RIGHT-OF-WAY

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Abstract. A study was made in 1995 and 1996 of the butterfly populations on a 500 kV transmission line of PECO Energy in the Piedmont Region of eastern Pennsylvania. The objective was to compare the long-term effect of 3 herbicide sprays with 2 mechanical methods of right-of-way (ROW) maintenance on the number of butterfly species and their abundance. The wire zone/border zone technique was used on all units to maintain shrubs on border zones. Butterfly counts were made at 5 times over the growing season to coincide with flowering of common plant species. There was no discernible adverse effect of herbicide spray maintenance in comparison with mechanical methods on either the number of species, or individuals, of the ROW butterfly population. Twenty butterfly species were present on the handcutting unit and 19 to 21 on the 3 herbicide units. The number of individual butterflies present on the 3 herbicide units ranged between 122 to 154 in contrast to 116 on the handcut control unit.

Introduction

Although butterflies are important components of the ROW ecosystem, they are often overlooked owing to their somewhat obscure presence. However, they are highly valuable as food for wildlife, particularly in their caterpillar stage, as pollinators of wildflowers on which they feed, and for their natural beauty. Butterflies are also important indicators of environmental change and barometers of a healthy and diverse ecosystem (5). Recent butterfly population declines are presumably caused by habitat fragmentation, loss of host and nectar plants, and pesticide use (4, 2, 7).

In 1995, we initiated a study of butterflies on a PECO Energy transmission line ROW in response to the interest of our cooperators (1). The objective was to compare the effect of herbicide maintenance on ROW butterfly populations with mechanical methods of handcutting and mowing. Specifically, we were interested in: (1) distribution of butterfly species on herbicide-sprayed and mechanically-treated segments of the ROW, (2) the relative number of butterfly individuals of those species on treatment

units, and (3) the presence of flowering plant species that were used by butterflies on treatment units.

Background

Interest in butterflies on electric utility rights-of-way has centered in recent years on rare or endangered species. In New England, the rare Karner Blue (*Lycæides melissa*) was reported as occurring only on a ROW. This led to a long-term study of the Karner Blue and its relationship to blue lupine (*Lupinus perennis*) on rights-of-way in pine barrens in New York (6).

The importance of old fields, dominated by forbs and grasses, was described in a recent study of the declining Regal Fritillary (*Speyeria nokomis*) (3). Although the caterpillar stage of the Regal requires presence of violets as host plants, the adults also used herbs such as milkweeds, thistles, and some goldenrods that commonly grow on ROW as preferred food plants.

A recent study was begun in 3 different landscapes in central Pennsylvania that relates to ROW research (8). The ultimate objective of this study was to develop management recommendations for the conservation of butterflies and skippers.

Methods

A randomized complete block design consisting of 5 ROW maintenance treatments in 3 replications was located in 1987 on the ROW of a 500 kV line of PECO Energy on the Piedmont Plateau in eastern Pennsylvania. The wire zone/border zone method was used for all treatments (Figure 1).

Each treatment unit was 152 M (500 ft) long and extended across the ROW to cover approximately .8 ha (2.1 acres) so that treatments could be applied by a commercial operator with

standard spray equipment. For vegetation data collection, 3 circular plots, each 5 M (16.5 ft) in diameter, were placed at equal distances apart in the center of the wire zone and 3 similar plots on one border zone.

To simplify presentation of data, we have followed the Audubon Field Guide to North American Butterflies, and considered true butterflies and skippers as superfamilies combined under butterflies.

ROW Maintenance

ROW maintenance included the following treatments that were applied in 1987 and 1993. These treatments provided the setting for the butterfly study carried out in 1995 and 1996. As the wire zone/border zone method (Figure 1) was used for all treatments, they have been divided into applications on the wire zone and those applied on border zones. All herbicides used are commercially available.

Treatments applied to the wire zone in 1987 were: on the handcutting treatment unit, trees and tall shrubs were cut to a height of 10 cm (4 in). The mowing unit was mowed to a height of 15 cm (6 in). For the unit treated with mowing plus herbicide spray, the wire zone was mowed and a spray applied immediately to the cut stubble. The spray consisted of a mix of Tordon K herbicide (2.8L) plus Garlon 3A herbicide (2.8L) in water to make 378.5L. A blue dye (Bullseye, 0.6L) was added to identify the coverage.

For the foliage spray unit, trees and tall shrubs were sprayed with Tordon 101 herbicide (1.9L) plus Garlon 3A herbicide (1.9L) in 374.7L of water plus clean cut surfactant (0.9L) and 38F drift retardant (0.1L). For the unit treated with a foliage spray, trees and tall shrubs were sprayed with Accord herbicide (3.8L) in 374.7L of water, plus LI 700 aquatic surfactant (0.9L)

and 38F drift retardant (0.1L). Trees over 4.5 M (15 ft) high were cut to remove the hazard of dead trees.

Treatments that were applied to the border zones in 1987 were: a low volume basal spray on all border zones of herbicide treatment units to tall-growing tree species only, using a mixture of Access herbicide (1.8L) and Garlon herbicide (2.7L) in Arborchem oil (14.2L). Trees on the border zones of handcutting units were selectively cut.

Retreatments applied in 1993 to the wire zone included: on the handcutting unit, the wire zone was cut to a height of 10 cm (4 in). On the mowing unit, the wire zone was mowed to 15 cm (6 in). Retreatments of the mowing plus herbicide was not needed in 1993.

On the stem-foliage spray unit, a selective foliage spray was applied to trees, tall shrubs, and blackberry with a mixture of Garlon 3A (2.7L) and Escort (0.03L) plus aquatic surfactant (1.8L) and 41A drift retardant (0.2L) in water (378.5L). For the foliage spray unit, a selective foliage spray was applied to trees, tall shrubs, and blackberry with Accord herbicide (4.5L) plus aquatic surfactant (1.8L) in water to make 378.5L, or with Krenite S herbicide (11.4L) in water (367.2L).

Retreatments applied to the border zones in 1993 were: the handcutting unit borders were cut selectively to remove tall trees. The herbicide-treated unit borders were selectively treated with

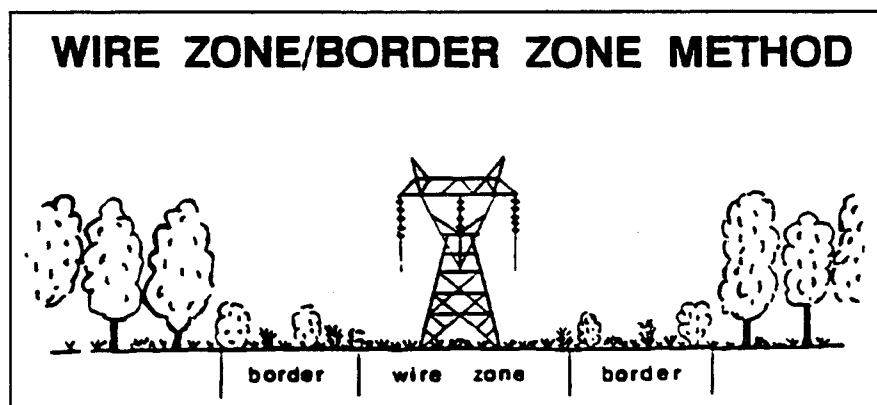


Figure 1. Diagram of a 230 kV line and ROW showing wire and border zones. A low shrub-forb-grass cover type is shown on the wire zone; a tall shrub-forb-grass cover type is on the border zones.

a low volume basal spray of Garlon 4 (0.25%) plus Arsenal herbicide (0.31%) in basal oil (0.44%).

Butterfly counts were taken on warm, sunny days in the morning after 9 a.m., ending at about 12:30 p.m. The average time for a count was 3-1/4 hours. A different starting point was selected for each day. Butterfly counts were made on the 5 units of Replication 2. Each unit was surveyed on 2 days at each of 5 census periods that were distributed so as to coincide with flowering periods from May through August. For uniform coverage, each unit was divided into 3 sections with 15 minutes spent on each section. Butterfly species were identified, their behavior noted, and their location on the ROW recorded.

Results

Control of target trees. Effective control of target trees was provided by the herbicide sprays applied in 1987 and 1993 (Figure 2). The average

number of trees over .3 M (1 ft.) height on the 3 replications was reduced from over 2000 per acre in 1987 to 100-700 per acre in 1995. Thorough applications of herbicides were used to provide a realistic appraisal of their effect on butterfly habitat.

In contrast to herbicide maintenance, the number of trees per acre over .3 M (1 ft.) height in 1995 was 2300 for handcutting and 1400 for mowing. While this is not satisfactory tree control, it is typical of mechanical maintenance and provided a realistic perspective for comparison with the effect of herbicide maintenance on butterflies.

Cover types produced by maintenance: The herbicide applications in 1987 and 1993 resulted in a forb-grass cover type dominated by goldenrods and fall panic grass on the wire zones; and a shrub-forb cover type dominated by blackberry and goldenrods on the wire zones (1). This resulted in a diverse ROW plant cover of

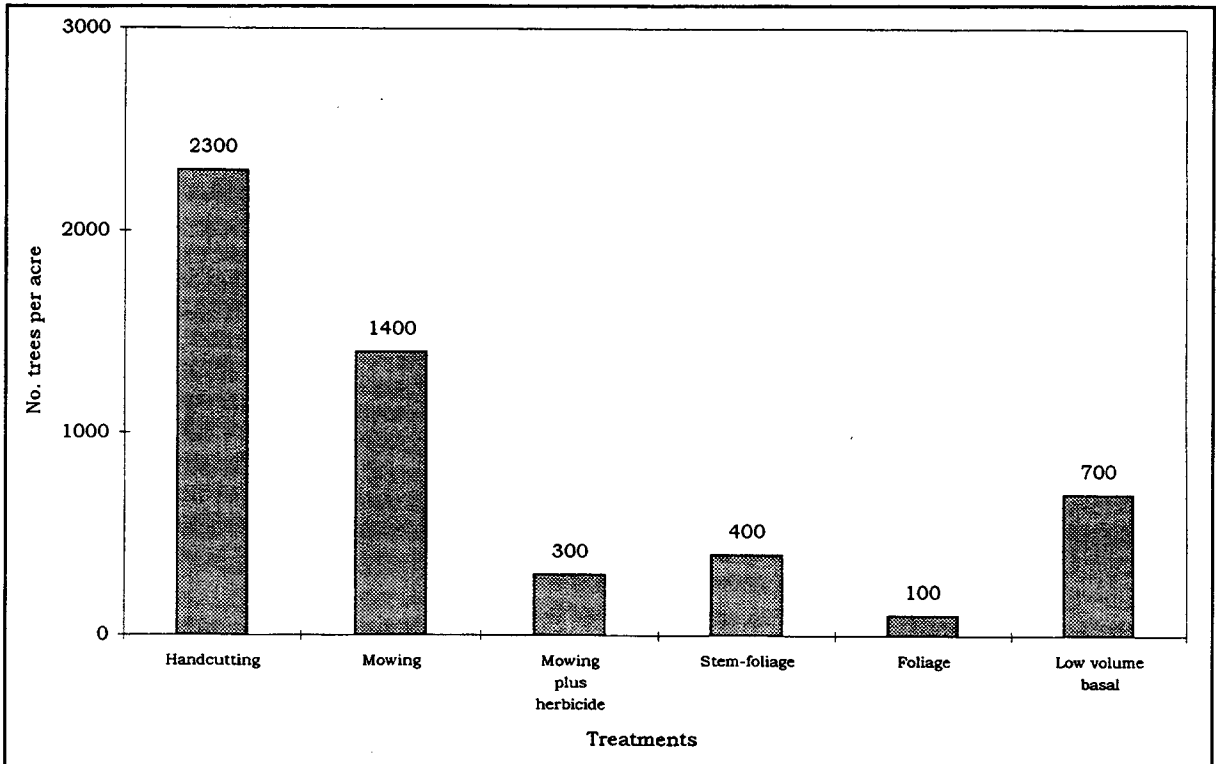


Figure 2. Density of target trees over .3 M (1 ft.) height in 1995 after maintenance treatments in 1987 and 1993.

Table 1. Total number of butterfly individuals and species counted on treatment units. Data are totals of 5 census counts.

Common Species	Treatment					Total
	Handcutting	Mowing	Mowing plus herbicide	Stem-Foliage	Foliage	
	Number of Individuals					
Cabbage White (<i>Pieris rapae</i>)	32	37	31	29	47	176
Little Wood-Satyr (<i>Megisto cymela</i>)	20	47	22	37	20	146
Great Spangled Fritillary (<i>Speyaria cybele</i>)	21	24	23	30	16	114
Eastern Tailed-Blue (<i>Everes comyntas</i>)	5	1	12	20	3	41
European Skipper (<i>Thymelicus lineola</i>)	4	4	7	0	9	24
Eastern Tiger Swallowtail (<i>Papilio glaucus</i>)	6	7	3	2	5	23
Meadow Fritillary (<i>Beloria bellona</i>)	4	3	6	2	4	19
Black Swallowtail (<i>Papilio polyxenes</i>)	4	2	3	4	3	16
Peck's Skipper (<i>Polites peckius</i>)	2	7	1	2	1	13
Dun Skipper (<i>Euphyes vestris</i>)	0	2	4	6	1	13
Pearl Crescent (<i>Phyciodes horos</i>)	1	6	1	1	2	11
Silver-spotted Skipper (<i>Epargyreus clarus</i>)	6	2	0	1	0	9
Spring Azure (<i>Celastrinus argiolus</i>)	1	1	0	3	3	8
Spicebush Swallowtail (<i>Papilio troilus</i>)	2	0	3	4	0	9
Clouded Sulphur (<i>Colias philodice</i>)	1	0	1	4	1	7
Number of common individuals	109	143	117	145	115	629
Number of common species	14	13	13	14	13	15

high value to butterflies. The mechanical treatments produced a tree-shrub-forb cover type on both wire and border zones. Blackberry and goldenrods were dominants on these units along with tree species.

Presence of butterfly species on ROW treatment units. A total of 32 butterfly species was counted on the 5 ROW treatment units (Table

1). Twenty species were present on the handcutting unit; 19 on the mowing, foliage spray, and the stem-foliage spray units; and 21 on the mowing plus herbicide unit. The 3 most common species (Cabbage White, Little Wood-Satyr, and Great Spangled Fritillary) were present in appreciable numbers on both herbicide-sprayed and mechanically-treated units.

(Table 1 continued) Infrequent Species	Treatment					Total
	Handcutting	Mowing	Mowing plus herbicide	Stem- Foliage	Foliage	
	Number of Individuals					
Painted Lady (<i>Vanessa virginiensis</i>)	0	1	0	3	0	4
American Copper (<i>Lycaena phlaeas</i>)	0	0	1	0	1	2
Common Wood Nymph (<i>Cercyonis pegala</i>)	1	0	0	0	0	1
Coral Hairstreak (<i>Satyrium titus</i>)	0	2	1	0	0	3
Common Sootywing (<i>Pholisora catullus</i>)	0	0	0	1	0	1
Eastern Comma (<i>Polygonia comma</i>)	0	0	1	0	1	2
Gray Hairstreak (<i>Stryon melinus</i>)	0	1	0	0	0	1
Hoary Edge (<i>Achalarus lyciades</i>)	0	0	1	0	0	1
Hobomok Skipper (<i>Poanes hobomok</i>)	0	0	3	1	1	5
Juvenal's Duskywing (<i>Erynnis juvnealis</i>)	2	0	0	0	0	2
Least Skipper (<i>Ancyloxypha numitor</i>)	0	1	0	0	2	3
Little Glassywing (<i>Pompeius verna</i>)	1	0	2	3	0	6
Monarch (<i>Danaus plexippus</i>)	1	0	0	0	0	1
Mulberry Wing (<i>Poanes massasoit</i>)	0	0	0	0	1	1
Orange Sulphur (<i>Colias eurytheme</i>)	1	2	0	0	1	4
Southern Cloudywing (<i>Thorybes pathyllus</i>)	0	0	1	0	0	1
Viceroy (<i>Limenitis archippus</i>)	1	1	2	1	0	5
						43
Number of infrequent individuals	7	8	12	9	7	
Number of infrequent species	6	6	8	5	6	17
Total number of individuals	116	151	129	154	122	672
Total number of all species	20	19	21	19	19	32

A diverse butterfly population was present on the ROW that was well-distributed among the 5 treatment units (Table 1). This was illustrated by a high Sorensen index of similarity between the handcut control unit and the herbicide units. The index ranged from 86% on the handcutting unit versus the stem-foliage herbicide spray unit to 89% on the handcutting versus the foliage spray unit for the 15 common butterfly species.

Presence of individual butterflies on ROW treatment units. A total of 672 individual butterflies was recorded on the ROW for the 5 counts combined (Table 1). The number of individuals on each of the 3 herbicide units all exceeded the number on the handcutting unit. Totals for the treatment units ranged from a low of 116 for handcutting to 122 to 154 for the herbicide units. When tested for significance of

Table 2. Occurrence of 15 common butterfly species on the ROW at 5 census counts distributed over the growing season.

Species	CENSUS DATES					Total
	5/31 - 6/2	6/19 - 6/20	7/5 - 7/6	7/22 - 7/23	8/13 - 8/14	
	1996	1995	1995	1995	1995	
Number of Individuals						
Cabbage White	1	102	24	47	2	176
Little Wood-Satyr	139	1	6			146
Great Spangled Fritillary		51	45	9	9	114
Eastern Tailed-Blue	32		1	2	6	41
European Skipper		19	5			24
Eastern Tiger Swallowtail	5	3		5	10	23
Meadow Fritillary		11	4	4		19
Black Swallowtail		2		3	11	16
Peck's Skipper	6		1	3	3	13
Dun Skipper			9	3	1	13
Pearl Crescent			9	2		11
Silver-spotted Skipper		4	3	2		9
Spring Azure		4	2	2		8
Spicebush Swallowtail	9					9
Clouded Sulphur		3	4			7
Total	192	200	113	82	42	629

differences between treatment means by the Wilcoxon two-sample test, the differences between handcutting and the 3 herbicide units were not significant at the 0.05 level.

Similar results were obtained recently from an unpublished study of butterfly populations on an electric transmission line ROW in central Pennsylvania. A total of 61 individual butterflies were counted on the handcutting unit in contrast to 76 to 182 on 3 herbicide spray units.

Distribution of butterfly species on the ROW over the growing season. Several important differences were observed in distribution of butterfly species over the growing season (Table 2). For example, Little Wood Satyr (Figure 3)

and Eastern Tailed-Blue (Figure 4) were numerous only in early June; Clouded Sulphur in late June and early July; and Pearl Crescent in July. The very common species, Cabbage White, was present in relatively large numbers over a period from late June through July, while the Great Spangled Fritillary was present from late June through early July.

Presence of flowering plant species used by butterflies on ROW treatment units. Eight shrub species were used by butterflies on the ROW (Table 3). One of those species were present on all 5 treatment units and 2 on 4 units. Blackberry was of special value as it flowered in early June on the border zones of all treatment units at a

Table 3. Common plant species flowering on the ROW and the number of butterfly species using them at 5 census counts. Common plant species were those that occurred on at least 4 of the 5 treatment units.

Shrub Species	CENSUS COUNT					Total
	1 5/31 - 6/2	2 6/19 - 6/20	3 7/5 - 7/6	4 7/22 - 7/23	5 8/13 - 8/14	
	Number of butterfly species					
Blackberry (<i>Rubus allegheniensis</i>)	2					2
Deerberry (<i>Vaccinium stamineum</i>)	1					1
Dawberry (<i>Rubus hispidus</i>)	4					4
Elderberry (<i>Sambucus canadensis</i>)		2				2
Japanese honeysuckle (<i>Lonicera Japonica</i>)		4				4
Ninebark (<i>Physocarpus opulifolius</i>)	1					1
Purple flowering raspberry (<i>Rubus odoratus</i>)		1	1	1	1	4
Wild rose (<i>Rosa sp.</i>)		1				1
Total	8	8	1	1	1	19

time when other flowering food plants were scarce (Table 4). Japanese honeysuckle, an important species used by butterflies in late June, also was present on border zones both of handcutting and the 3 herbicide-sprayed units.



Figure 3. Little Wood Satyr perched on grass on the wire zone of a mowing plus herbicide spray unit, 5/30/96. Grasses and forbs of the wire zone were used commonly for both perching and hiding.

This indicated the value of the wire zone/border zone method in retaining shrubby borders (Figure 5).

Fifteen herbaceous species used by butterflies were present on the ROW (Table 3). These species flowered at specific time periods in the



Figure 4. Eastern Tailed-Blue perched on rough goldenrod on the wire zone of a mowing plus herbicide unit, 6/3/96. These forbs were also used for hiding.

(Table 3, continued)	CENSUS COUNT					Total
	1 5/31 - 6/2	2 6/19 - 6/20	3 7/5 - 7/6	4 7/22 - 7/23	5 8/13 - 8/14	
Herbaceous Species	Number of butterfly species					
Barrens strawberry (<i>Waldsteinia fragaroides</i>)					1	1
Bull thistle (<i>Cirsium vulgare</i>)				1	2	3
Canada thistle (<i>Cirsium arvense</i>)				2	3	5
Cinquefoil (<i>Potentilla canadensis</i>)	1					1
Common milkweed (<i>Asclepias syriaca</i>)			1		1	2
Daisy fleabane (<i>Erigeron annuus</i>)		1				1
Indian tobacco (<i>Lobelia inflata</i>)					1	1
Healall (<i>Prunella vulgaris</i>)			1		1	2
Joe Pye weed (<i>Eupatorium dubium</i>)					1	1
Mountain mint (<i>Pycnanthemum tenuifolium</i>)				8		8
Purple milkweed (<i>Asclepias purpurascens</i>)		1				1
Queen Anne's lace (<i>Daucus carota</i>)					1	1
Spreading dogbane (<i>Apocynum androsaemifolium</i>)		4	4			8
Spotted knapweed (<i>Centaurea maculosa</i>)			5	2		7
Yarrow (<i>Achillea millefolium</i>)		1	1	1		3
Total	1	7	13	13	11	45

growing season (Table 4). For example, spreading dogbane flowered on all treatment units in early July, while mountain mint flowered on all units in late July.

Figure 5. The mowing plus herbicide unit in June 1994. A forb-grass cover type on the right was on the wire zone where oxeye daisy was flowering. A shrub-forb cover type is on the border zone on the left where blackberry was in flower.

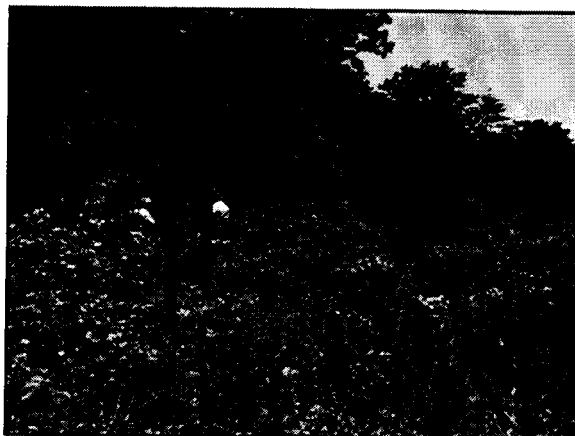


Table 4. Presence of flowering plant species used by butterflies on ROW treatment units at 5 census counts.

Census	TREATMENT				
	Handcutting	Mowing	Mowing plus herbicide	Stem-foliage	Foliage
1 5/31 - 6/2	Blackberry	Blackberry	Blackberry Dewberry Deerberry	Blackberry	Blackberry Common cinquefoil
2 6/19 - 6/20	Dogbane Japanese honeysuckle Yarrow		Japanese honeysuckle	Elderberry Japanese honeysuckle Purple milkweed Purple raspberry	Bull thistle Daisy fleabane Japanese honeysuckle Wild rose
3 7/5 - 7/6	Dogbane Common milkweed Yarrow	Dogbane Purple flowering raspberry Spotted knapweed	Dogbane Purple flowering raspberry Spotted knapweed Yarrow	Dogbane Spotted knapweed Yarrow	Dogbane spotted knapweed Yarrow
4 7/22 - 7/23	Mountain mint Purple flowering raspberry Yarrow	Mountain mint Spotted knapweed Yarrow	Mountain mint Spotted knapweed Yarrow	Mountain mint Spotted knapweed Canada thistle Yarrow	Mountain mint Canada thistle
5 8/13 - 8/14	Joe Pye weed Purple milkweed Purple flowering raspberry Queen Anne's Lace	Canada thistle Queen Anne's Lace	Canada thistle Purple milkweed Queen Anne's Lace	Canada thistle Joe Pye weed Purple milkweed Queen Anne's Lace	Canada thistle Bull thistle Indiana tobacco Joe Pye weed Queen Anne's Lace Wild strawberry

Conclusions

Herbicide maintenance of the ROW resulted in a diverse and abundant butterfly population that compared favorably with that produced by mechanical methods. This was due in large part to use of the wire zone/border zone technique to produce a forb-grass cover type on the wire zone and a shrub-forb-grass cover type on border zones. The result was a diverse cover of shrubs and herbaceous plants on the ROW that flowered in succession over the growing season.

The data clearly indicated clearly that: 1) the number of common butterfly species on the herbicide-sprayed units were similar to the mechanically-treated units (13 to 14 per unit); 2) more individual butterflies (122 to 154) were counted on each of the 3 herbicide-sprayed units than on the handcut control unit (116); 3) common species of flowering shrubs used by butterflies

were present both on all herbicide-sprayed units and on the handcut control unit; and 4) common herbaceous species used by butterflies were present on all treatment units during their flowering periods.

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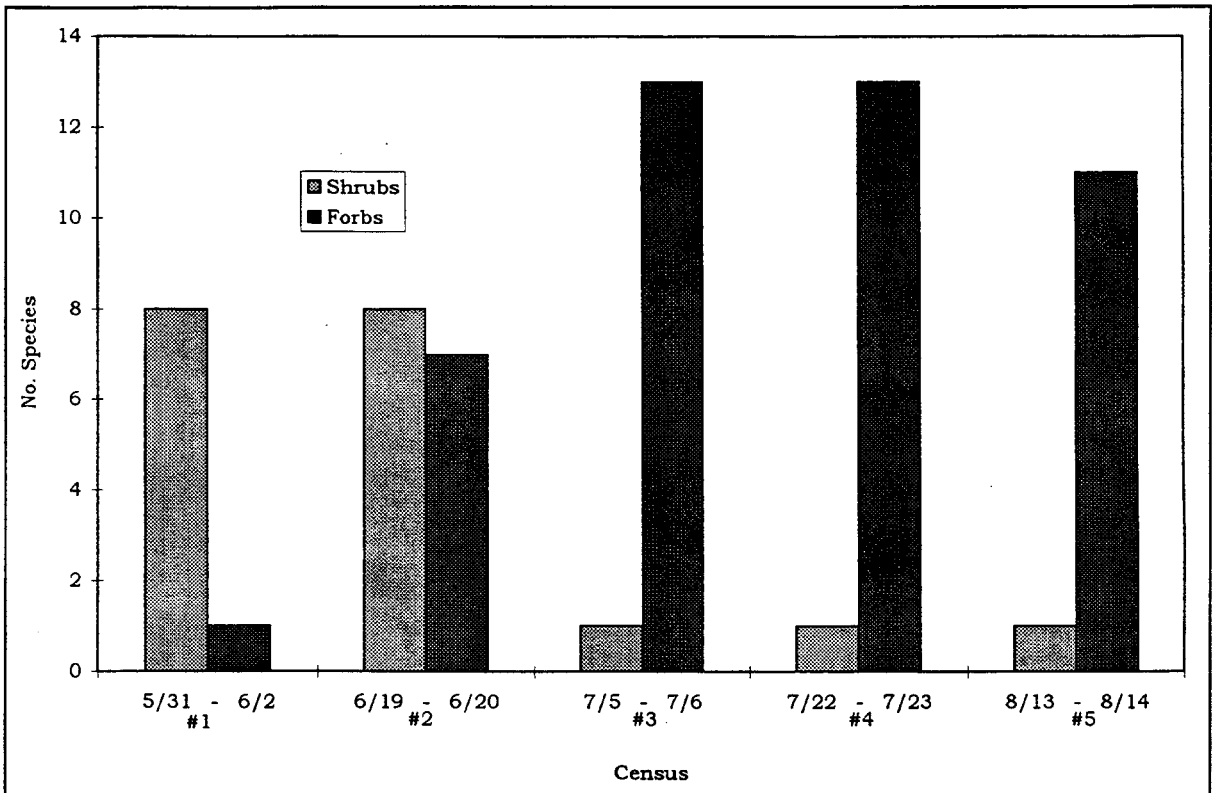


Figure 6. Number of flowering species of shrubs and forbs used by butterflies at 5 census counts.

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Résumé. L'effet à long terme sur les populations de papillons après trois épandages d'herbicide a été com-paré à deux types de travaux de coupe mécanique des arbres et des arbustes dans l'emprise d'une ligne électrique de transport. Aucun effet adverse visible causé par l'emploi d'herbicide n'a été observé en comparaison avec les méthodes mécaniques, tant en regard du nombre de papillons ou de la diversité en espèces. Une population diversifiée et abondante de papillons a été observée dans tous les tronçons d'emprise qui ont été traités d'une façon ou d'une autre.

Zusammenfassung. Im Bereich einer Überlandstromleitung wurden die Langzeitwirkungen von drei Herbiziden auf die Schmetterlingspopulationen mit zwei mechanischen Behandlungen der Bäume und Büsche verglichen. Es wurde kein wahrnehmbarer, nachteiliger Effekt der Herbizidbehandlung im Vergleich zu den mechanischen Methoden auf die Anzahl der Arten oder Individuen der Schmetterlinge festgestellt. Bei allen behandelten Bereichen wurde eine Artenvielzahl und große Individuenzahl festgestellt.