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Plant Species Richness on a Transmission Right-of-Way in Southeastern Pennsylvania, U.S. Using Integrated Vegetation Management

Richard H. Yahner, Richard T. Yahner, and Bradley D. Ross

Abstract. The Green Lane Research and Demonstration Area, Montgomery County, Pennsylvania, U.S., has been studied each year since 1987, making this 21-year-old project extremely valuable as a source of information on the effects of mechanical and herbicidal maintenance on flora and fauna along an electric transmission right-of-way (ROW). In this article, our objective was to document plant species richness among treatment units and in relation to wire and border zones on the ROW. We noted the presence of plant species from late May through mid-August in 2005 and 2006 and observed 114 vascular plant species in the ten treatment units; 35 (31%) of these species were exotic. Twenty-seven (24%) species were widespread on the ROW and seven of these (26%) were exotic. The total number of species per unit ranged from 46 (40%) species in handcut units to 57 (50%) in stem–foliage spray units. Of the total number of species, 103 (90%) and 81 (71%) occurred in wire and border zones, respectively. The number of exotic species was higher in wire zones (33 [29%]) than in border zones (22 [19%]).

Key Words. Exotic species; herbicides; integrated vegetation management; rights-of-way; southeastern Pennsylvania; species richness; tree control; vegetation.

A major goal of the Green Lane 33 Research and Demonstration Project in southeastern Pennsylvania, U.S. since its establishment in 1987 has been to determine the use of Integrated Vegetation Management (IVM) for maintenance of an electric utility transmission right-of-way (ROW) (Bramble and Byrnes 1996; Yahner and Hutnik 2004a). The response of vegetation to IVM is important because plant communities can change within a relatively short time because of natural plant succession.

The IVM technique for vegetation involves two phases: 1) use of a herbicidal spray or mechanical treatment to initially control the density of target (undesirable) trees, i.e., those that have the potential of growing to a height that is not compatible with safe ROW maintenance; and 2) development of a tree-resistant plant cover type to reduce target tree invasion of the ROW (Bramble and Byrnes 1996; Yahner and Hutnik 2004a). The wire–border zone method was used on all treatment units of the Green Lane Research and Demonstration ROW to achieve this goal (Yahner and Hutnik 2004a, 2005; Ballard et al. 2007).

The Green Lane Research and Demonstration Area has been studied each year since 1987, making this 21-year-old project extremely valuable as a source of information on the effects of mechanical and herbicidal maintenance on flora and fauna along an electric transmission ROW (Yahner and Hutnik 2004a, 2004b). A desired objective of IVM on the Green Lane Research and Demonstration Area is to create a diversity of plant species, which in turn provides a diverse wildlife habitat (Yahner and Hutnik 2004a). On a broad scale, habitat diversity on the ROW is achieved by herbicidal and mechanical maintenance of treatment units through the wire–border zone method. However, on a smaller scale, plant species diversity also is achieved by the presence of different combinations of shrub, forb, and grass cover types.

In this article, our objective was to document plant species richness among treatment units and in relation to wire and border zones on the Green Lane Research and Demonstration ROW. Species richness is a simple, yet important, measurement of species diversity and is the total number of different species in a given area (Yahner 2000).

STUDY AREA AND METHODS

The study area consists of 10 units with two replicates of each of five treatments (mowing, mowing plus herbicide, stem–foliage spray, foliage spray, and handcutting) (Table 1) (see Yahner 2006 for details of treatments). The total area of the ROW is 5.43 ha. Each treatment unit is rectangular in shape, ranges from 0.38 to 2.47 ac (0.15 to 1.00 ha), and spans the width of the ROW. The western border zone (7 m wide) of the ROW is immediately adjacent to a ROW of Pennsylvania Power & Light Company (PP&L); thus, vegetation was measured only along eastern border zones (11.5 m [37.95 ft] wide). As part of the vegetation assessment of treatment units of plant species from late May through mid-August in both 2005 and 2006, presence of each plant species was noted relative to wire versus border zone in each treatment unit. We used correlation analyses to determine if either the total number of species or the number of exotic species was correlated with size of units (Sokal and Rohlf 1995).

RESULTS AND DISCUSSION

We observed 114 vascular plant species in 10 treatment units on the Green Lane Research and Demonstration ROW during 2005 to 2006 (Table 1; Appendix). This total number of species at Green Lane was less than the 125 species noted along a transmission ROW in central Pennsylvania (State Game Lands [SGL]

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Table 1. Total number of plant species in wire zones, in border zones, and in either zone of ten treatment units at the Green Lane Research and Demonstration Area from late May through mid-August 2005 to 2006.[z]

Treatment	Replicate unit	Zone		
		Wire	Border	Either
Mowing	M-1	52 (18, 0.36)	35 (10, 0.24)	56 (19, 0.60)
	M-2[y]	35 (10, 0.23)	26 (7, 0.15)	41 (12, 0.38)
	Average	44 (14, 0.30)	31 (9, 0.20)	49 (16, 0.49)
Mowing plus herbicide	MH-1	33 (14, 0.19)	36 (6, 0.13)	52 (17, 0.32)
	MH-2	34 (10, 0.60)	28 (9, 0.40)	48 (15, 1.00)
	Average	34 (12, 0.40)	32 (8, 0.27)	50 (16, 0.66)
Stem–foliage spray	SF-1[y]	39 (10, 0.37)	30 (6, 0.25)	47 (11, 0.62)
	SF-2	60 (20, 0.41)	34 (9, 0.28)	66 (22, 0.69)
	Average	50 (15, 0.39)	32 (8, 0.27)	57 (17, 0.66)
Foliage spray	F-1	48 (15, 0.23)	43 (10, 0.16)	59 (16, 0.39)
	F-2	34 (5, 0.35)	28 (5, 0.24)	41 (7, 0.59)
	Average	41 (10, 0.29)	36 (8, 0.20)	50 (12, 0.49)
Handcut	HC-1	36 (12, 0.09)	24 (7, 0.06)	43 (13, 0.15)
	HC-2	43 (9, 0.41)	28 (4, 0.28)	48 (9, 0.69)
	Average	40 (11, 0.25)	26 (6, 0.17)	46 (11, 0.42)
Total area sampled (ha)		3.24	2.19	5.43

[z]Number of exotic species and total area (ha) are given in parentheses.
[y]Unit adjacent to a secondary road (Upper Ridge Road).

33), but the SGL 33 ROW consisted of 15 units (Yahner and Hutnik 2005).

Total number of species per unit at the Green Lane Research and Demonstration ROW ranged from 46 (40%) in handcut units to 57 (50%) in stem–foliage units (Table 1; Appendix). Only 27 (24%) of the total number of species were considered widespread (e.g., those found in 80% or more of the units), and seven of these (26%) were exotic. In comparison, 35 (31%) of the total number of species were exotic. This percentage of exotic species is considerably higher than that noted on the SGL 33 ROW (23%), which traverses a relatively pristine forested landscape (Yahner and Hutnik 2005), or that found in unfragmented forest stands in Wisconsin (20%) (Rooney et al. 2004). The Green Lane ROW traverses residential areas that have been human-impacted for decades; thus, the number of exotic species was expected to be high on the Green Lane ROW, like in a sector of Valley Forge National Historical Park (34%) in southeastern Pennsylvania (Cypher et al. 1986; see also Lundgren et al. 2004).

Of the total number of species, 103 (90%) and 81 (71%) were in wire and border zones, respectively (Appendix). In wire zones, number of species ranged from 34 (30%) in mowing plus herbicide units to 50 (44%) in stem–foliage units (Table 1). In border zones, number of species varied from 26 (23%) in handcut units to 36 (32%) in foliage–stem units. The number of exotic species ranged from 33 (29%) in wire zones to 22 (19%) in border zones (Appendix). The total number of species or number of exotic species were not correlated with size of units ($r = 0.19$ and 0.08, respectively; $P > 0.90$). Also, because exotic species were found throughout the ROW, the proximity to a road was not a factor in determining the current distribution of exotic species (Brothers and Spingarn 1992; Watkins et al. 2003; Yahner and Hutnik 2005).

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APPENDIX

Plant species (in phylogenetic order) noted in wire zones (W), in border zones (B), in both zones (WB), or absent (–) in ten treatment units on the Green Lane Research and Demonstration Area from late May through mid-August 2005 to 2006.[z]

Species	M-1	M-2	MH-1	MH-2	SF-1	SF-2	F-1	F-2	HC-1	HC-2
Hayscented fern										
Dennstaedtia punctilobula	—	—	B	—	—	WB	—	—	—	WB
Sensitive fern										
Onoclea sensibilus	WB	W	WB	—	WB	WB	W	—	B	WB
Pitch pine										
Pinus rigida	—	—	—	—	—	—	—	W	—	—
Redcedar										
Juniperus virginiana	B	—	B	—	WB	WB	WB	WB	B	W
Virginia pine										
Pinus virginiana	—	—	—	—	B	W	—	—	—	—
Sassafras										
Sassafras albidum	WB	—	B	B	WB	W	—	B	WB	W
Columine										
Aquilegia vulgaris[y]	—	—	—	—	—	W	—	—	—	—
Japanese barberry										
Berberis thunbergii[y]	—	WB	—	—	—	B	W	WB	—	WB
May-apple										
Podophyllum peltatum	—	—	B	—	—	—	—	—	—	W
Bloodroot										
Sanginaria canadensis	—	—	—	—	—	W	B	—	—	—
Witchhazel										
Hamamelis virginiana	W	—	—	—	—	—	—	B	—	W
American elm										
Ulmus americana	—	—	—	—	—	—	B	W	—	—
Hickory										
Carya spp.	WB	WB	WB	—	B	—	B	WB	—	—
Black walnut										
Juglans nigra	—	—	—	—	B	—	—	—	—	B
Northern red oak										
Quercus rubra	W	WB	B	W	W	WB	WB	WB	—	W
Black oak										
Quercus velutina	—	—	—	—	—	—	—	W	—	—
Hornbean										
Carpinus caroliniana	—	—	B	—	—	—	WB	—	W	—
Pokeweed										
Phytolacca americana	—	—	—	—	B	—	—	—	—	—
Deptford pink										
Dianthus armeria[y]	—	—	—	B	—	B	—	—	—	—
Smartweed (Pennsylvania)										
Polygonum pensylvanicum	—	—	—	W	—	—	—	—	—	—
Mile-a-minute										
Polygonum perfoliatum[y]	—	—	—	WB	W	W	—	—	—	W
Climbing false-buckwheat										
Polygonum scandens[y]	—	—	—	—	B	—	—	—	—	—
Bouncing bet										
Saporaria officinalis[y]	WB	—	WB	W	—	W	W	—	—	—
St. John's wort										
Hypericum perforatum[y]	—	—	—	—	—	W	—	—	—	—
Autumn olive										
Elaeagnus umbellata[y]	W	WB	W	W	W	WB	W	—	WB	W
Prickly cucumber										
Echinocystis lobata	—	—	—	—	B	—	—	—	—	—
Violet										
Viola spp.	B	—	B	—	B	—	B	—	—	—
Garlic-mustard										
Alliaria petiolata[y]	W	—	W	WB	WB	WB	WB	B	WB	—
Horseradish										
Armoracia rusticana[y]	—	—	W	—	—	—	—	—	—	—

(*continued*)

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Species	M-1	M-2	MH-1	MH-2	SF-1	SF-2	F-1	F-2	HC-1	HC-2
Early winter-cress										
Barberea verna[y]	WB	W	WB	W	WB	WB	WB	—	W	W
Field (cow) cress										
Lepidium campestre[y]	WB	—	—	—	—	—	—	W	W	—
Poor-man's pepper										
Lepidium virginicum	—	—	W	—	—	—	W	—	—	—
Deerberry										
Vaccinium stamineum	—	—	—	—	—	W	—	—	—	W
Whorled loosestrife										
Lysimachia quadrifolia	—	—	W	—	W	W	W	—	—	—
Serviceberry										
Amelanchier arborea	—	W	—	—	—	—	—	—	—	—
Chokeberry										
Aronia spp.	—	B	—	—	—	—	—	—	W	W
Hawthorn										
Crataegus spp.	—	—	—	—	—	W	B	—	W	—
Wild strawberry										
Fragaria virginiana	W	WB	—	—	—	WB	WB	W	WB	WB
Old-field (common) cinquefoil										
Potentilla simplex	W	WB	WB	B	WB	WB	WB	W	W	WB
Wild black cherry										
Prunus serotina	W	WB	B	WB	WB	WB	—	WB	WB	WB
Wild rose										
Rosa virginiana	—	—	—	B	—	—	—	—	—	—
Multiflora rose										
Rosa multiflora[y]	WB	WB	B	B	—	WB	WB	WB	WB	WB
Blackberry										
Rubus allegheniensis	WB	WB	WB	WB	WB	WB	WB	WB	WB	WB
Swamp dewberry										
Rubus hispidus	WB	WB	WB	W	WB	WB	WB	WB	W	WB
Crown-vetch										
Coronilla varia[y]	—	—	—	—	—	—	W	—	—	—
Maryland tick-clover (Tick-trefoil)										
Desmodium marilandicum	—	—	—	—	W	—	—	—	—	—
Tick-trefoil										
Desmodium paniculatum	—	—	—	—	—	B	WB	W	—	—
Virginia (slender) bush-clover										
Lespedeza virginica	—	—	—	—	—	W	—	—	—	—
Alfalfa (Lucerne alfalfa)										
Medicago sativa[y]	—	—	—	—	—	W	—	—	—	—
White sweet-clover										
Melilotus alba[y]	W	—	W	—	—	W	—	—	—	—
Wild bean										
Phaseolus polystachios	—	—	—	—	—	—	B	—	—	—
Red clover										
Trifolium pretense	—	—	—	—	—	—	W	—	—	—
White clover										
Trifolium repens[y]	W	—	W	—	—	—	W	—	—	—
Evening-primrose										
Oenothera biennis	WB	—	W	W	—	WB	W	—	—	—
Flowering dogwood										
Cornus florida	—	—	—	—	—	B	B	—	B	WB
Round-leaved (gray) dogwood										
Cornus rugusa	B	WB	B	B	—	W	W	WB	W	WB
Oriental (Asiatic) bittersweet										
Celastrus orbiculatus[y]	—	B	B	—	W	—	WB	—	B	—

(*continued*)

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Species	M-1	M-2	MH-1	MH-2	SF-1	SF-2	F-1	F-2	HC-1	HC-2
Virginia-creeper										
Parthenocissus quinquefolia	W	B	B	B	B	W	WB	WB	WB	WB
Grape										
Vitis spp.	WB	WB	—	W	WB	WB	WB	WB	WB	WB
Red maple										
Acer rubrum	—	—	B	W	W	W	W	W	—	WB
Sugar maple										
Acer saccharum	—	—	—	—	WB	—	WB	B	—	B
Staghorn Sumac										
Rhus typhina	—	—	—	—	—	—	B	—	—	—
Poison-ivy										
Toxicodendron radicans	WB	WB	B	WB	WB	W	WB	WB	WB	WB
Wood-shamrock (Wood sorrel)										
Oxalis dillenii	W	—	WB	WB	W	—	WB	—	W	—
Wild geranium										
Geranium carolinianum	WB	—	—	—	—	WB	—	—	—	—
Jewelweed										
Impatiens spp.	WB	—	WB	WB	—	—	—	—	W	W
Spreading dogbane										
Apocynum androsaemifolium	—	—	—	W	—	W	—	—	—	W
Purple milkweed										
Asclepias purpurascens	—	—	—	W	W	—	—	—	—	—
Common milkweed										
Asclepias syriaca	WB	W	WB	W	W	WB	W	W	WB	WB
Field bindweed										
Convolvulus arvensis[y]	WB	—	WB	W	W	WB	—	—	—	—
Phlox										
Phlox spp.	—	—	—	—	—	—	—	W	—	—
Fleabane										
Erigeron philadelphicus[y]	WB	—	—	—	—	—	—	—	W	—
Heal-all										
Prunella vulgaris	—	—	—	—	—	W	—	—	—	—
White ash										
Fraxinus americana	WB	WB	WB	WB	WB	WB	WB	WB	WB	WB
Beard-tongue										
Penstemon hirsutus	—	—	—	W	—	—	—	—	—	—
Mullein										
Verbascum thapsus[y]	W	W	W	WB	WB	W	WB	—	WB	W
Bedstraw										
Galium spp.	W	W	B	—	WB	WB	WB	WB	W	W
Japanese honeysuckle										
Lonicera japonica[y]	WB	B	B	B	WB	WB	B	WB	WB	WB
Tatarian honeysuckle										
Lonicera tatarica[y]	WB	WB	—	B	—	W	—	B	WB	—
Southern arrowwood (Viburnum)										
Viburnum dentatum	—	WB	B	B	WB	WB	—	WB	B	—
Black-haw										
Viburnum prunifolium	WB	WB	WB	B	WB	W	—	WB	B	W
Common yarrow										
Achillea millefolium[y]	W	WB	W	WB	W	WB	WB	WB	W	W
Common ragweed										
Ambrosia artemisiifolia	—	—	—	—	—	—	—	—	—	B
Dog-fennel (Mayweed)										
Anthenis colula[y]	WB	—	W	—	WB	—	WB	—	W	—
Tickseed-sunflower										
Bidens aristosa[y]	—	—	—	WB	—	W	—	—	—	—
Sheep sorrel										
Rumex acetosella[y]	—	—	—	W	—	W	—	—	—	—

(*continued*)

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Species	M-1	M-2	MH-1	MH-2	SF-1	SF-2	F-1	F-2	HC-1	HC-2
Curly (curled) dock										
Rumex crispus[y]	W	—	W	—	—	—	—	—	W	—
Thistle (several species)										
Circium spp.	WB	—	W	B	W	W	W	WB	W	W
Bird's-eye speedwell										
Veronica persica[y]	W	—	W	—	—	—	WB	—	—	—
American elder (elderberry)										
Sambucus canadensis	W	WB	—	—	—	—	WB	—	—	WB
Hysop-leaved thoroughwort										
Eupatorium hyssopifolium	—	—	—	W	—	W	—	—	—	W
Boneset										
Eupatorium perfoliatum	WB	W	W	—	—	B	WB	—	—	—
Joe-pie-weed										
Eupatorium purpureum	—	—	—	—	—	—	—	—	—	W
Orange hawkweed										
Hieracium aurantiacum[y]	—	W	—	—	—	—	—	—	—	—
King-devil (Smoothish hawkweed)										
Hieracium piloselloides[y]	—	W	—	—	—	W	W	—	—	—
Hawkweed										
Hieracium scabrum	W	W	—	—	—	—	WB	W	—	—
Wild lettuce										
Lactuca canadensis	W	—	—	—	—	—	—	—	W	—
Black-eyed-susan										
Rudbeckia hirta	—	—	—	—	—	B	—	—	—	—
Golden ragwort										
Senecio aureus	B	—	—	—	—	W	—	—	—	
Goldenrod (several species)										
Solidago spp.	WB	WB	WB	WB	WB	WB	WB	WB	WB	WB
Milk-thistle (Common sow-thistle)										
Sonchus oleraceus[y]	—	—	—	W	—	W	—	—	—	—
Yellow goat's-beard										
Tragopogon pratensis[y]	W	—	W	—	—	—	W	—	—	—
Jack-in-the-pulpit										
Arisaema triphyllum	WB	—	B	B	WB	WB	B	B	—	WB
Sedge										
Carex spp.	WB	W	WB	W	—	—	WB	—	WB	B
Wild oats										
Avena fatua[y]	WB	—	—	—	—	—	WB	—	—	—
Deer-tongued grass										
Panicum clandestinum	WB	—	B	W	—	—	WB	W	W	—
Fall panic grass										
Panicum spp.	WB	B	WB	WB	WB	WB	WB	B	B	WB
Common reed (Phragmites)										
Phagmites australis	W	W	WB	W	W	W	—	—	—	W
Field garlic										
Allium oleraceum[y]	—	W	—	—	—	W	—	—	—	WB
False Solomon's seal										
Smilacina trifolia	—	W	—	B	WB	WB	WB	WB	W	—
White twisted-stalk										
Streptopus amplexifolius	—	—	—	—	—	W	—	—	—	—
Blue-eyed grass										
Sisyrinchium angustifolium	—	W	—	WB	—	—	—	W	—	—
Carrion-flower										
Smilax herbaea	WB	—	—	—	W	—	—	—	—	—
Greenbriar										
Smilax rotundifolia	—	B	—	—	W	WB	B	—	—	B

[z]The replication of each treatment is given after each unit, where treatments are mowing (M), mowing plus herbicide (MH), stem–foliage spray (SF), foliage spray (F), and handcut (HC). Common and scientific names are taken from Rhoades and Klein (1993).
[y]Considered an exotic species (Rhoades and Klein 1993).

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Résumé. L'*Aire de recherche et de démonstration de corridor vert* du comté de Montgomery en Pennsylvanie a été étudiée annuellement depuis 1987, ce qui fait de ce projet vieux de 21 ans une source précieuse d'information sur les effets des traitements mécaniques et chimiques d'entretien par rapport à la flore et la faune le long des emprises de lignes électriques de transport. Dans cet article, notre objectif était de documenter la richesse en espèces de plantes parmi les unités traités en relation avec la zone à l'intérieur de l'emprise et la zone limitrophe à l'emprise. Nous avons noté la présence d'espèces de plantes de la fin mai jusqu'à la mi-août en 2005 et 2006 et y avons observé la présence de 114 espèces de plantes vasculaires au sein des 10 unités de traitement; 35 (31%) de ces espèces étaient non indigènes. Vingt-sept (24%) espèces se retrouvaient au sein de toutes les unités dont 7 (26%) d'entre elles étaient non indigènes. Le nombre total d'espèces par unité était en moyenne de 46 (40%) au sein des unités traitées mécaniquement et de 57 (50%) au sein des unités traitées chimiquement. Du nombre total d'espèces, 103 (90%) étaient présentes à l'intérieur de l'emprise tandis que 81 (71%) étaient présentes dans la zone limitrophe à l'emprise. Le nombre d'espèces exotiques était plus élevé à l'intérieur de l'emprise (33 espèces ou 29%) qu'en bordure de l'emprise (22 espèces ou 19%).

Zusammenfassung. Die Green Lane Forschungs- und Demonstrationsfläche in Montgomery County, Pennsylvanien wird seit 1987 jährlich untersucht. Dadurch ist dieses 21jährige Experiment eine extrem wertvolle Informationsquelle für den Einfluss von mechanischer und chemischer Kontrolle von Flora und Fauna entlang einer Überlandleitung. In dieser Studie war unser Ziel, die Pflanzenartenvielfalt in den Behandlungseinheiten und in Relation zu Zentrum und Randzonen zu dokumentieren. Wir erfassten die gegenwärtigen Pflanzenarten von Ende Mai bis Mitte August 2005 und 2006 und beobachteten dabei 114 vaskuläre Pflanzenarten in 10 Behandlungseinheiten. 35 (31%) dieser Arten waren exotisch. 27 (24%) waren bei Überlandleitungen weit verbreitet und 7 von diesen (26%) waren exotisch. Die totale Anzahl von Arten pro Einheit betrug durchschnittlich 46 (40%) in handgeschnittenen Einheiten und 57 (50%) in Einheiten mit Spray-Herbizideinsatz. Von der totalen Artenanzahl tauchten 103 (90%) im Zentrum unter den Drähten auf und 81 (71%) in den Randbereichen. Die Anzahl der exotischen Arten war im Zentrum (33, 29%) höher als in den Randbereichen (22, 19%).

Resumen. El área de demostración de Green Lane Research, Montgomery County, Pennsylvania, U.S., ha sido estudiada anualmente desde 1987, logrando con esto 21 años de proyectos extremadamente valiosos como fuente de información sobre los efectos de las prácticas de mantenimiento de la flora y fauna, mecánicos y con herbicidas, a lo largo de la líneas de transmisión del derecho de vía (ROW, por sus siglas en inglés). En este reporte, nuestro objetivo fue documentar la riqueza de especies de plantas entre unidades de tratamiento y en relación a las zonas de frontera alambradas en el ROW. Se notó la presencia de especies de plantas desde Mayo y a lo largo de Agosto en 2005 y 2006, y se observaron 114 especies de plantas vasculares en las 10 unidades de tratamiento; 35 (31%) de estas especies fueron exóticas. Veintisiete (24%) estaban ampliamente distribuidas y siete de estas especies (26%) fueron exóticas. El número total de especies por unidad promedió de 46 (40%), en unidades cortadas manualmente, a 57 (50%) en unidades con aerosol. Del número total de especies, 103 (90%) y 81 (71%) se presentaron en zonas alambradas y de frontera, respectivamente. El número de especies exóticas fue más alto en zonas alambradas (33, 29%) que en zonas de frontera (22, 19%).

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