Arboriculture & Urban Forestry 2020. 46(6):395–401

The Effects of Integrated Vegetation Management on Richness of Native Compatible Flowering Plants and Abundance of Noncompatible Tree Species on a Right-of-Way in Central Pennsylvania, USA

By Carolyn G. Mahan, Bradley D. Ross, and Richard T. Yahner

Abstract. We examined the effects of integrated vegetation management (IVM) and nonselective mechanical removal techniques (hand cutting and mowing) on the richness and abundance of native compatible flowering plants and noncompatible trees on an electric transmission line right-of-way in central Pennsylvania, USA. Our study focused on native flowering plants to help determine how different vegetation management techniques may affect native wildlife communities. We found no correlation between amount of herbicide applied and native flowering plant species richness or tree abundance. We found that the richness of native flowering plants did not differ between plots treated with an IVM herbicide approach and those that were mechanically treated ($t = 1.06$, df = 1, $p = 0.31$). However, mechanically treated plots had significantly higher abundance of trees than IVM plots ($t = 3.10$, df = 1, $p = 0.009$). We found that plots that were treated with herbicide mixtures that contained glyphosate in 2012 had lower native flowering plant species richness in 2016 than those treated with herbicide mixtures that did not contain glyphosate ($t = -2.44$, df = 1, $p = 0.04$). Our study indicates that long-term IVM approaches support native flowering plant species richness while limiting tree abundance under electric transmission line right-of-way. However, further study is needed to determine if the herbicide type and method (selective versus broadcast) of application affects species richness of native flowering plant communities.

Keywords. Early Successional Habitat; Forest Vegetation; Herbicide; Plant Species Richness.

INTRODUCTION

Electrical rights-of-way (ROW) vegetation management methods aim to keep vegetation away from transmission wires and, therefore, may promote early successional habitat that is compatible with a variety of native species and resistant to tree invasion (e.g., Mercier et al. 2001; Yahner et al. 2007; Komonen et al. 2013; Wagner et al. 2014). One way to develop this compatible vegetation cover is through integrated vegetation management (IVM). IVM utilizes a variety of management approaches to achieve a desired vegetation community type. These approaches may include chemical (herbicide), manual, and mechanical techniques (e.g., McLoughlin 2002; Nowak and Ballard 2005; Lowe et al. 2007). The response of forest vegetation to IVM is important, because vegetation communities can change within 2 to 5 years due to natural plant succession processes. In general, the 2 phases of IVM along electrical ROW are: (1) use of an herbicidal spray and/or mechanical treatment to initially control the density of noncompatible trees (i.e., those that have the potential of growing to a height that is not compatible with safe ROW maintenance and electricity transmission); and (2) development of a tree-resistant plant cover type to reduce tree invasion of the ROW (Nowak and Ballard 2005). This vegetation management approach ideally produces a long-term reduction in treatment costs and herbicide use (Nowak and Ballard 2005; Turk 2015).

Previous studies—including many at this study site—have demonstrated that a taxonomically diverse array of early successional wildlife species is found using habitat under electric transmission lines managed by IVM. These wildlife include pollinators (bees, butterflies, moths, beetles, flies), reptiles, grassland and shrub land birds, and small mammals

©2020 International Society of Arboriculture

(Bramble et al. 1997; Litvaitis et al. 1999; Yahner et al. 2004, 2007; Komonen et al. 2013; Wagner et al. 2014; Berg et al. 2016; Wagner et al. 2019). In the northeastern United States and elsewhere, where early successional landscapes are disappearing (Litvaitis et al. 1999; DeGraaf and Yamasaki 2003), electrical transmission ROW may support numerous species of conservation concern that rely on this habitat type (e.g., DeGraaf and Yamasaki 2003; Ballard et al. 2007; Wagner et al. 2014). Furthermore, flowering plants are critical for pollinator populations and the species richness of this native plant community type, which provides the basis of food webs for native bees—wildlife in dramatic decline (Wagner et al. 2019).

Despite these wildlife studies in powerline rights-of-way, Wagner et al. (2014) and Richardson et al. (2017) indicate that vegetation studies have primarily focused on rare or endangered plants (e.g., Tompkins 2013) and the maintenance of early successional vegetation that is resistant to tree invasion (Bramble et al. 1991; Bramble et al. 1996; De Blois et al. 2004; Yahner and Hutnik 2005). Surprisingly, the number of studies that focus on native flowering plant communities (in terms of native species richness) under transmission lines is small (see Wagner et al. 2014). However, recent work has begun to focus on the effects of specific herbicide mixtures and IVM on non-target plants and overall species richness under transmission lines (Clarke et al. 2006; Wagner et al. 2014; Isbister 2016; Wagner et al. 2019).

This research is a continuation of a project that began in 1953 when researchers at The Pennsylvania State University designed an initial electric transmission ROW study to test the effects of selective herbicide use and other vegetation management approaches on native plant and wildlife communities (e.g., Bramble and Byrnes 1979) in an electric transmission ROW. The project was initiated on State Game Lands (SGL) 33 in Centre County, Pennsylvania, with several partners, including Pennsylvania Electric Company (now First Energy Corp.), the Pennsylvania Game Commission, DuPont, AmChem (now Corteva), and Asplundh Tree Expert Co. The year 2018 marked the 65th year of the original study—making SGL 33 the site of the longest continuous study measuring the effects of herbicides and mechanical vegetation management practices on vegetation structure, wildlife habitat, and wildlife use within a ROW. Due to the continuous nature of the project, pre-treatment condition (pre-1953) was mixed-deciduous forest, and current plant and wildlife communities persist in response to decades of vegetation management. The objective of this study was to determine how herbicide or mechanical vegetation management approaches affect the number of trees and native compatible flowering plant species present on the ROW. This study focuses solely on native plant species that occur on the ROW.

MATERIALS AND METHODS

During July to August 2012, 14 sections (20 m × 200 m) of the ROW at SGL 33 located directly under a 230-kV electric transmission line (area defined as the wire zone) were managed with either IVM, chemical (herbicide), or mechanical treatments (mowing or hand cutting) to remove or limit tree growth (Table 1). Four of these sections were managed with nonselective mechanical treatments (e.g., all vegetation was cut to a height of 1 m with mowers or chain saws), and ten were treated with herbicide applications that were either applied broadly or selectively depending on site conditions and IVM prescriptions (see Table 1 for specific commercial/chemical herbicides used). In 2016, we sampled native flowering plant vegetation in late July to correspond to maximum plant emergence at our study sites, realizing the plants with short growing and/or blooming seasons (e.g., spring ephemerals, fall asters) may be missed. We used sampling techniques developed for the research project (see Bramble et al. 1991) that were modified from vegetation sampling techniques developed by Braun and Blanquet (Moore 1962; Wagner et al. 2014). All trees at least 0.3 m in height were recorded within 3 permanent transects (each 20 m long × 2 m wide) in wire zones of each section. Only trees rooted in a transect were counted (i.e., trees rooted outside the transect with foliage extending into the transect were not counted). We then calculated the total number of trees in each treatment section and presented trees as a per hectare (ha) figure. Additionally, we determined the species richness of native flowering plants under 2 m in height that were compatible with ROW maintenance (e.g., forbs or plants with shrubby-growth form). These plant species were counted within a 5-m radius plot placed in the center of each transect. We also determined the dominant (> 50% of area) cover type along each transect. For species richness, native grasses (sedges *Carex* sp.) were included as one species. All other grasses were non-native and listed only as cover type. We calculated a Pearson

©2020 International Society of Arboriculture

Table 1. Liters of herbicide applied/hectare (ha) in 2012, native flowering plant species richness, and number of trees/ha (< 0.3 m in height) in wire zones of 14 treatment sections on State Game Lands 33 Rights-of-Way Research and Demonstration Area, Centre County, PA, USA in 2016. Dominant (> 50% of area) cover type (forb, grass, or shrub) for wire zone is also presented.

Liters of herbicide applied/ha (2012 treatment cycle)	Number of stems of trees/ha[a]	Native species richness of compatible flowering plant species[b]	Integrated vegetation management herbicide (H) versus mechanical (M) treatment	Herbicide application (selective [backpack spray] or nonselective [broadcast spray])	Cover type
0	1482	7	M (Mowing)	N/A	Shrub
0	2718	9	M (Mowing)	N/A	Forb
0	11,613	11	M (Hand cutting)	N/A	Shrub
0	3459	25	M (Hand cutting)	N/A	Shrub
0.75	494	8	H (Glyphosate, Imazapyr)[c]	Selective	Grass
0.75	741	8	H (Glyphosate, Imazapyr)	Selective	Forb
0.75	494	6	H (Glyphosate, Imazapyr)	Selective	Forb
6.27	247	7	H (Aminopyralid, Imazapyr, Triclopyr)[d]	Selective	Forb
29.93	1729	15	H (Aminopyralid, Imazapyr, Triclopyr)	Broadcast	Forb
31.99	741	10	H (Aminopyralid, Imazapyr, Triclopyr)	Broadcast	Shrub
168.37	0	19	H (Aminopyralid, Imazapyr)[e]	Broadcast	Forb
241.33	494	10	H (Aminopyralid, Imazapyr)	Selective	Shrub
436.82	200	5	H (Aminopyralid, Glyphosate, Imazapyr, Picloram, Triclopyr)[f]	Broadcast	Grass
436.82	100	7	H (Aminopyralid, Glyphosate, Imazapyr, Picloram, Triclopyr)	Broadcast	Forb

[a]Mechanical treatments versus herbicide treatments differed significantly ($t = 3.10$, df = 1, $p = 0.009$); mechanical treatments versus glyphosate herbicide treatments differed slightly ($t = 2.18$, df = 1, $p = 0.06$); mechanical treatments versus non-glyphosate herbicide treatments differed slightly ($t = 2.03$, df =1, $p = 0.08$); glyphosate versus non-glyphosate herbicide treatments did not differ ($t = -0.74$, df =1, $p = 0.481$).

[b]Mechanical treatments versus herbicide treatments did not differ ($t = 1.06$, df = 1, $p = 0.31$); mechanical treatments versus glyphosate herbicide treatments differed slightly ($t = 1.81$, df = 1, $p = 0.09$); mechanical treatments versus non-glyphosate treatments did not differ ($t = 0.19$, df = 1, $p = 0.86$); glyphosate versus non-glyphosate herbicide treatments differed significantly ($t = -2.44$, df = 1, $p = 0.04$).

[c]Accord concentrate (glyphosate) 7% + Arsenal (imazapyr) 1%

[d]Garlon 3A (triclopyr) 5 pints/100 gal (2 L/380 L) + Milestone (aminopyralid) 7 oz/100 gal (210 mL/380 L) + Arsenal (imazapyr) 1%

[e]Milestone (aminopyralid) 5 oz/100 gal (150 mL/380 L) + Arsenal (imazapyr) 4 oz/100 gal (120 mL/380 L)

[f]Milestone (aminopyralid) 7 oz/100 gal (210 mL/380 L) + Rodeo (glyphosate) 1% + Arsenal (imazapyr) 1% + Tordon K (picloram) 4% + Garlon 3A (triclopyr) 5 pints/100 gal (2 L/380 L)

correlation coefficient (r) to determine if there was a relationship between herbicide application rate in 2012 and stems of tree species and/or compatible native flowering plant species richness measured in 2016. We also used a two-tailed t-test ($\alpha = 0.05$) for unequal sample sizes (and unequal variances) to determine if mechanical or chemical treatment influenced tree species abundance or the species richness of compatible native flowering plants at our plots. We also compared the effects of herbicide type on plant response; in particular, we examined the effects of herbicide mixes that contained glyphosate with those that did not. All statistical analyses were performed using Minitab® 17 (2010).

RESULTS

We documented a total of 29 compatible native flowering plant species on our plots (Table 2). Not all species were present in each section. We also documented 7 different species of trees within our vegetation plots (Table 2). There was no correlation between herbicide application rate (liters of herbicide applied) and the number of both trees ($r = -0.30$, $n = 14$, $p = 0.29$) and native flowering plant species richness ($r = 0.21$, $n = 14$, $p = 0.46$). There also was no difference in compatible native flowering plant species richness between mechanically treated plots and herbicide-treated plots ($t = 1.06$, df = 1, $p = 0.31$; Table 1). However, when we compared herbicide treatments that contained

©2020 International Society of Arboriculture

glyphosate versus those that did not, we found that glysophate-treated plots had significantly lower native flowering plant species richness than those treated with herbicide mixtures that did not contain glyphosate ($t = -2.44$, df = 1, $p = 0.04$; Table 1). Regardless of type of herbicide used, mechanically treated plots had significantly higher numbers of tree species than chemically treated plots ($t = 3.10$, df = 1, $p = 0.009$; Table 1).

DISCUSSION

Our research supports past results from this study area (e.g., Yahner and Hutnik 2005) and from other ROW (De Blois et al. 2004; Yahner et al. 2008; Wagner et al. 2014) that demonstrate selective herbicide use as part of an IVM plan is an effective approach to limiting tree species on ROW while maintaining native plant species richness (Clarke et al. 2006; Wagner et al. 2014). Although our study took place under transmission lines within an eastern forest landscape, studies from a variety of forest areas indicate that selective use of herbicides does not significantly reduce native plant diversity and may cause less disturbance to native ecosystems than mechanical removal approaches. Menges and Gordon (2010) found that mechanical-only vegetation management treatments increased soil compaction and disturbance, while treatments that used mechanical vegetation removal in conjunction with targeted herbicide application were best at reducing hardwood abundance and maintaining native species in Florida upland habitats. Furthermore, Fortier and Messier (2006) found that manual brush cutting (similar to hand cutting) was the least effective vegetation management approach at reducing competing deciduous trees and shrubs in forests in Canada. However, they also found that non-selective (broadcast) application of herbicides can decrease plant species richness and abundance over time. In boreal forests, native plant species abundance was reduced following severe mechanical site preparation but was maintained with targeted herbicide application to competing non-native plants (Swift and Bell 2011).

Our research indicates that the type of herbicide mixture applied (as well as application method) may affect species richness of native flowering plants—a topic that is receiving more attention. For example, Isbister (2016) found that herbicide mixtures that contained imazapyr caused more damage to non-target plant species than triclopyr in boreal forests. However, Lowe et al. (2007) found that herbicide mixtures that contained both imazapyr and triclopyr effectively controlled non-native invasive plants and permitted restoration of native plant communities in central Indiana. Glyphosate has been an important tool in the removal of invasive, non-native vegetation in forest communities, and a systemic review of the use of glyphosate in forest environments indicates no significant risk to wildlife and plant communities (Rolando et al. 2017). Furthermore, recent research in central Pennsylvania demonstrated the resilience and recovery of native plant communities when invasive, non-native plants were controlled through selective and careful application of glyphosate (Maynard-Bean and Kaye 2019). However, the potential negative effects of glyphosate on forest soil microbial and earthworm communities indicate caution for long-term application, especially in northern ecosystems (see Helander et al. 2012 for review; Gaupp-Berghausen et al. 2015; Aristilde et al. 2017). Therefore, we urge further study into the effects of specific herbicide mixtures on native and non-native plant and soil communities, especially in forest (versus agricultural) settings (Kettenring and Adams 2011).

Our research is unique due to the long-term nature of IVM management at the study site. However, our research is hampered by this feature as well. Over the 50+ years of treatment, herbicide mixtures, amounts, and application approaches have changed, but the basic research objective of understanding IVM as compared to mechanical approaches to ROW management have remained consistent. Our research focuses on measuring response of wildlife and plants to the treatments and, in general, our study supports the findings of other researchers that non-selective mechanical treatments (e.g., mowing, hand cutting) facilitated the invasion and abundance of trees in transmission line ROW (Mercier et al. 2001; De Blois et al. 2004). Integrated vegetation management on ROW, which includes selective herbicide treatment, provides opportunities for maintaining native plant species richness while limiting the invasion of tree species. We note that our vegetation sampling in mid-summer may miss the effects of IVM on plants with short emergence (e.g., spring ephemerals), but we do note the presence of native plant communities dominated by Ericaceae and Asteraceae that dominate ROW in other northeastern studies (Wagner et al. 2019). Other common native plant species found along the ROW corridor in our study, such as *Rubus* and *Solidago*, have

©2020 International Society of Arboriculture

Table 2. Compatible, native flowering plant species and noncompatible native tree species documented on 14 treatment sections of State Game Lands 33 Rights-of-Way Research and Demonstration Area, Centre County, PA, USA in 2016.

Species common name (Latin name)	Compatible flowering plants	Noncompatible trees
Arrowwood (*Viburnum dentatum*)	X	
Bear oak (*Quercus ilicifolia*)	X	
Black cherry (*Prunus serotine*)		X
Black huckleberry (*Gaylussacia baccata*)	X	
Blackberry (*Rubus allegheniensis*)	X	
Canada mayflower (*Maianthemum canadense*)	X	
Chestnut oak (*Quercus montana*)		X
Choke cherry (*Prunus virginiana*)	X	
Common milkweed (*Asclepias syriaca*)	X	
Dogbane (*Apocynum cannabinum*)	X	
Goldenrod (*Solidago* sp.)	X	
Hawthorn (*Crataegus* sp.)		X
Hillside blueberry (*Vaccinium pallidum*)	X	
Indian cucumber (*Medeola virginiana*)	X	
Lowbush blueberry (*Vaccinium angustifolium*)	X	
Mayapple (*Podophyllum peltatum*)	X	
Moccasin flower (*Cypripedium acaule*)	X	
Mountain azalea (*Rhododendron canescens*)	X	
Mountain laurel (*Kalmia latifolia*)	X	
Mountain mint (*Pycnanthemum virginianum*)	X	
Painted trillium (*Trillium undulatum*)	X	
Pennsylvania smartweed (*Polygonum pensylvanicum*)	X	
Red maple (*Acer rubrum*)		X
Red oak (*Quercus rubra*)		X
Sedge (*Carex* sp.)	X	
Spicebush (*Lindera benzoin*)	X	
Spiraea (*Spiraea tomentosa*)	X	
Stinging nettle (*Urtica dioica*)	X	
Teaberry (*Gaultheria procumbens*)	X	
Tulip tree (*Liriodendron tulipifera*)		X
Virginia creeper (*Parthenocissus quinquefolia*)	X	
White oak (*Quercus alba*)		X
Wild sarsaparilla (*Aralia nudicaulis*)	X	
Witch hazel (*Hamamelis virginian*)	X	
Wood lily (*Lilium philadelphicum*)	X	
Yellow whorled loosestrife (*Lysimachia quadrifolia*)	X	

ecological importance in terms of ecosystem function in food webs. *Solidago* (goldenrods) play a central role in supplying late-season nectar and pollen for flower visitors (Wagner et al. 2014). In addition, the vegetation structure and native plant species richness maintained under transmission lines, in part, determines what subsets of vertebrates will forage, nest, or shelter along a right-of-way.

LITERATURE CITED

Aristilde L, Reed ML, Wilkes RA, Youngster T, Kukurugya MA, Katz V, Sasaki CRS. 2017. Glyphosate-induced specific and widespread perturbations in the metabolome of soil *Pseudomonas* species. *Frontiers in Environmental Science*. 5(34):1-13.

Ballard BD, McLoughlin KT, Nowak CA. 2007. New diagrams and application of the wire zone-border zone approach to vegetation management on electric transmission line rights-of-way. *Arboriculture & Urban Forestry*. 33:435-439.

Berg A, Bergman KO, Wissman J, Zimhorski M, Ockinger E. 2016. Power-line corridors as source habitat for butterflies in forest landscapes. *Biological Conservation*. 201:320-326.

Bramble WC, Byrnes WR. 1979. Evaluation of the wildlife habitat values of rights-of-way. *Journal of Wildlife Management*. 43:643-649.

Bramble WC, Byrnes WR, Hutnik RJ, Liscinsky SA. 1991. Prediction of cover type on rights-of-way after maintenance treatments. *Journal of Arboriculture*. 17:38-43.

©2020 International Society of Arboriculture

Bramble WC, Byrnes WR, Hutnik RJ, Liscinsky SA. 1996. Interference factors responsible for resistance of forb-grass cover types to tree invasion on an electric utility right-of-way. *Journal of Arboriculture*. 22:99-105.
Bramble WC, Yahner RH, Byrnes WR. 1997. Effects of herbicides on butterfly populations of an electric transmission right-of-way. *Journal of Arboriculture*. 23:196-206.
Clarke DJ, Pearce KA, White JG. 2006. Powerline corridors: degraded ecosystems or wildlife havens? *Wildlife Research*. 33:615-626.
De Blois S, Brisson J, Bouchard A. 2004. Herbaceous covers to control tree invasion in rights-of-way: ecological concepts and applications. *Environmental Management*. 33:606-619.
DeGraaf RM, Yamasaki M. 2003. Options for managing early-successional forest and shrubland bird habitats in the northeastern United States. *Forest Ecology and Management*. 185:179-191.
Fortier J, Messier C. 2006. Are chemical treatments more sustainable for forest vegetation in the context of the TRIAD? *Forestry Chronicle*. 82:806-818.
Gaupp-Berghausen M, Hofer M, Rewald B, Zaller JG. 2015. Glyphosate-based herbicides reduce the activity and reproduction of earthworms and lead to increased soil nutrient concentrations. *Scientific Reports*. 5:12886.
Helander M, Saloniemi I, Saikkonen K. 2012. Glyphosate in northern ecosystems. *Trends in Plant Science*. 17:569-574.
Isbister K. 2016. Early responses of northern boreal vegetation to power line right-of-way management techniques including the acute toxicity of imazapyr and triclopyr to non-target plants [master's thesis]. Saskatoon (Saskatchewan, Canada): University of Saskatchewan. 138 p.
Kettenring KM, Adams CR. 2011. Lessons learned from invasive plant control experiments: a systematic review and meta-analysis. *Journal of Applied Ecology*. 48:970-979.
Komonen A, Lensus T, Kotiaho JS. 2013. Optimal timing of powerline rights-of-ways management for the conservation of butterflies. *Insect Conservation and Diversity*. 6:522-529.
Litvaitis JA, Wagner DL, Confer JL, Tarr MD, Snyder EJ. 1999. Early successional forest and shrub-dominated habitats: land-use artifact or critical community in the northeastern United States? *Northeast Wildlife*. 54:101-118.
Lowe ZE, Weeks Jr. HP, Holt HA, Parker GR. 2007. Techniques to control woody invasive plants in Indiana hardwood forests. *Native Plants Journal*. 8:107-113.
Maynard-Bean E, Kaye M. 2019. Invasive shrub removal benefits native plants in an eastern deciduous forest of North America. *Invasive Plant Science and Management*. 12:3-10.
McLoughlin KT. 2002. Integrated vegetation management: the exploration of concept to application. In: Goodrich-Mahoney JW, Mutrie DF, Guild A, editors. *Proceedings of the 7th International Symposium on Environmental Concerns in Rights-of-Way Management*. 9–13 September 2000; Calgary, Alberta, Canada. New York (NY, USA): Elsevier Science. p. 29-35.
Menges ES, Gordon DR. 2010. Should mechanical treatments and herbicides be used as fire surrogates to manage Florida's uplands? A review. *Florida Scientist*. 73:147-174.
Mercier C, Brison J, Bouchard A. 2001. Demographic analysis of tree colonization in a 20-year-old right-of-way. *Environmental Management*. 28:777-787.
Minitab 17 Statistical Software. 2010. State College (PA, USA): Minitab, Inc. www.minitab.com
Moore J. 1962. The Braun-Blanquet system: a reassessment. *Journal of Ecology*. 50:761-769.
Nowak CA, Ballard BD. 2005. A framework for applying integrated vegetation management on rights-of-way. *Journal of Arboriculture*. 31:28-37.
Richardson ML, Wilson BA, Aiuto DAS, Crosby JE, Alonso A, Dallmeier F, Golinski GK. 2017. A review of the impact of pipelines and power lines on biodiversity and strategies for mitigation. *Biodiversity and Conservation*. 26:1801-1815.
Rolando CA, Baillie BR, Thompson DG, Little KM. 2017. The risks associated with glyphosate-based herbicide use in planted forests. *Forests*. 8(6):208.
Swift KI, Bell FW. 2011. What are the environmental consequences of using silviculturally effective forest vegetation management treatments? *Forestry Chronicle*. 87:201-216.
Tompkins RD. 2013. Prairie-relict communities of a piedmont monadnock. *Castanea*. 78:185-197.
Turk JR. 2015. Assessing the costs and benefits of a native plant species for electric transmission line right-of-way revegetation within the Tennessee Valley Authority power service area [master's thesis]. Chattanooga (TN, USA): University of Tennessee. 95 p.
Wagner DL, Metzler KJ, Frye H. 2019. Importance of transmission line corridors for conservation of native bees and other wildlife. *Biological Conservation*. 235:147-156.
Wagner DL, Metzler KJ, Leicht-Young SA, Motzkin G. 2014. Vegetation composition along a New England transmission line corridor and its implications for other trophic levels. *Forest Ecology and Management*. 327:231-239.
Yahner RH, Hutnik RJ. 2005. Integrated vegetation management on an electric transmission right-of-way in southeastern Pennsylvania, U.S. *Journal of Arboriculture*. 31:263-268.
Yahner RH, Ross BD, Yahner RT, Hutnik RJ, Lacinsky SA. 2004. Long-term effects of rights-of-way maintenance via the wire-border zone method on bird nesting ecology. *Journal of Arboriculture*. 30:288-293.
Yahner RH, Yahner RT, Hutnik RJ. 2007. Long term trends in small mammals on a right-of-way in Pennsylvania, U.S. *Arboriculture & Urban Forestry*. 33:147-152.
Yahner RH, Yahner RT, Ross BD. 2008. Plant species richness on a transmission right-of-way in southeastern Pennsylvania, U.S. using integrated vegetation management. *Arboriculture & Urban Forestry*. 34:238-244.

ACKNOWLEDGMENTS

We thank Asplundh, Corteva Agriscience, FirstEnergy, PECO, TREE Fund, Pennsylvania Game Commission, and Penn State Altoona for providing financial and in-kind support. John Berger and Carl Engstrom assisted with data collection. Lisa Emili assisted with editing and manuscript preparation.

©2020 International Society of Arboriculture

Carolyn G. Mahan, PhD (corresponding author)
The Pennsylvania State University-Altoona College
Division of Mathematics and Natural Sciences
Altoona, PA, USA
814-949-5530
cgm2@psu.edu

Bradley D. Ross, MS
The Pennsylvania State University-Altoona College
Division of Mathematics and Natural Sciences
Altoona, PA, USA

Richard T. Yahner, BS
The Pennsylvania State University-Altoona College
Division of Mathematics and Natural Sciences
Altoona, PA, USA

Conflicts of Interest:
The authors reported no conflicts of interest.

Résumé. Nous avons examiné les effets de la gestion intégrée de la végétation (GIV) et les techniques d'enlèvement mécanique non sélectif (coupe et fauchage à la main) sur la richesse et l'abondance des plantes à fleurs indigènes compatibles et d'arbres non compatibles sur l'emprise d'une ligne de transmission électrique au centre de la Pennsylvanie, États-Unis. Notre étude a porté sur les plantes à fleurs indigènes afin de déterminer dans quelle mesure, les différentes techniques de gestion de la végétation peuvent affecter les communautés végétales indigènes. Nous n'avons trouvé aucune corrélation entre la quantité d'herbicide appliquée et la richesse des espèces de plantes florifères indigènes ou l'abondance des arbres. Nous avons constaté que la richesse des plantes à fleurs indigènes ne différait pas entre les parcelles traitées selon une approche GIV avec herbicide et celles qui étaient traitées avec l'enlèvement mécanique ($t = 1.06$, df = 1, $p = 0.31$). Cependant, les parcelles traitées mécaniquement montraient une abondance plus élevée d'arbres que les parcelles GIV ($t = 3.10$, df = 1, $p = 0.009$). Nous avons constaté que les parcelles traitées en 2012 avec des mélanges d'herbicides contenant du glyphosate montraient en 2016, une richesse de plantes florifères indigènes plus faible que celles traitées avec des mélanges d'herbicides sans glyphosate ($t = −2.44$, df = 1, $p = 0.04$). Notre recherche a démontrée qu'à long terme, une approche GIV permettait une richesse de plantes à fleurs indigènes tout en limitant l'abondance des arbres dans l'emprise des lignes de transmission électrique. Toutefois, une étude plus approfondie est nécessaire afin de déterminer si le type d'herbicide et la méthode d'application (sélective ou à la volée) affectent la richesse en espèces des communautés de plantes à fleurs indigènes.

Zusammenfassung. Wir untersuchten die Auswirkungen des integrierten Vegetationsmanagements (IVM) und nicht-selektiver mechanischer Entnahmetechniken (Handschnitt und Mähen) auf den Reichtum und die Fülle von einheimischen kompatiblen Blütenpflanzen und nicht-kompatiblen Bäumen an einer elektrischen Übertragungsleitung mit Vorfahrt im Zentrum von Pennsylvania, USA. Unsere Studie konzentrierte sich auf einheimische, blühende Pflanzen, um herauszufinden, wie sich verschiedene Techniken des Vegetationsmanagements auf einheimische Wildtiergemeinschaften auswirken können. Wir fanden keine Korrelation zwischen der Menge des eingesetzten Herbizids und dem Reichtum an einheimischen blühenden Pflanzenarten oder dem Baumreichtum. Wir stellten fest, dass sich der Reichtum an einheimischen Blütenpflanzen nicht zwischen den mit einem IVM-Herbizideinsatz behandelten Parzellen und den mechanisch behandelten Parzellen unterschied ($t = 1.06$, df = 1, $p = 0.31$). Mechanisch behandelte Parzellen wiesen jedoch eine signifikant höhere Baumdichte auf als IVM-Parzellen ($t = 3.10$, df = 1, $p = 0.009$). Wir fanden heraus, dass Parzellen, die 2012 mit Herbizidmischungen behandelt wurden, die Glyphosat enthielten, im Jahr 2016 einen geringeren Reichtum an einheimischen blühenden Pflanzenarten aufwiesen als Parzellen, die mit Herbizidmischungen behandelt wurden, die kein Glyphosat enthielten ($t = −2.44$, df = 1, $p = 0.04$). Unsere Studie deutet darauf hin, dass langfristige IVM-Ansätze den Reichtum an einheimischen blühenden Pflanzenarten unterstützen und gleichzeitig die Häufigkeit von Bäumen unter der elektrischen Übertragungsleitung begrenzen. Es sind jedoch weitere Studien erforderlich, um zu bestimmen, ob der Herbizidtyp und die Methode der Anwendung (selektiv versus gestreut) den Artenreichtum der einheimischen Blühpflanzengemeinschaften beeinflusst.

Resumen. Examinamos los efectos de la gestión integrada de la vegetación (IVM, por sus siglas en inglés) y las técnicas de eliminación mecánica no selectiva (corte a mano y siega) en la riqueza y abundancia de plantas con flores compatibles nativas y árboles no compatibles en una línea de transmisión eléctrica de derecho de paso en el centro de Pensilvania, EE. UU. Nuestro estudio se centró en las plantas nativas con flores para ayudar a determinar cómo las diferentes técnicas de manejo de la vegetación pueden afectar a las comunidades nativas de vida silvestre. No encontramos correlación entre la cantidad de herbicida aplicado y la riqueza de especies de plantas con floración nativa o la abundancia de árboles. Encontramos que la riqueza de las plantas con flores nativas no difería entre las parcelas tratadas con un enfoque de herbicidas IVM y las que fueron tratadas mecánicamente ($t = 1.06$, df = 1, $p = 0.31$). Sin embargo, las parcelas tratadas mecánicamente tenían una abundancia de árboles significativamente mayor que las parcelas de IVM ($t = 3.10$, df = 1, $p = 0.009$). Encontramos que las parcelas que fueron tratadas con mezclas de herbicidas que contenían glifosato en 2012 tenían menor riqueza de especies de plantas con floración nativa en 2016 que las tratadas con mezclas de herbicidas que no contenían glifosato ($t = −2.44$, df = 1, $p = 0.04$). Nuestro estudio indica que los enfoques de IVM a largo plazo apoyan la riqueza de las especies de plantas con flores nativas, al tiempo que limitan la abundancia de árboles bajo la línea de transmisión eléctrica de derecho de paso. Sin embargo, se necesitan más estudios para determinar si el tipo de herbicida y el método (selectivo versus no selectivo) de aplicación afecta la riqueza de las especies de las comunidades de plantas con flores nativas.

©2020 International Society of Arboriculture