RESPONSE OF AMPHIBIAN AND REPTILE POPULATIONS TO VEGETATION MAINTENANCE OF AN ELECTRIC TRANSMISSION LINE RIGHT-OF-WAY

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Abstract: A 2-year study of amphibian and reptile populations was conducted on a 500-kV transmission line right-of-way (ROW) of PECO Energy in the Piedmont Physiographic Province, Montgomery County, Pennsylvania, U.S., from June through July 1999, September through October 1999, and March through October 2000. The objectives were to compare the diversity and relative abundance of amphibians and reptiles between the ROW and the adjacent forest, among five treatment units on the ROW, and between wire and borders zones on treatments on the ROW. Eight species were observed during the study, and the two most common species were Jefferson salamanders (*Ambystoma jeffersonianum)* and redback salamanders *(Plethodon cinereus).* All eight species were noted on the ROW, but only Jefferson and redback salamanders occurred in the adjacent forest. The number of species ranged from six species in the mowing plus herbicide unit to three each in the stem–foliage spray and foliage spray units. All species were found in the wire zones compared to only five species in the border zones. The ROW contained a greater diversity of amphibian and reptile species than the adjacent forest. Because forest-management practices can have negative impacts on populations of amphibians and reptiles, this study provides valuable information on forest-management practices required for the conservation of amphibians and reptiles.

Key Words. Amphibians; herbicides; reptiles; right-of-way; salamanders; snakes; tree control; turtles.

Forest-management practices can have negative effects on amphibian and reptile populations (e.g., Ash 1997; deMaynadier and Hunter 1998; Rodewald and Yahner 1999). Vegetation maintenance, based on the use of the wire zone–border zone method, on an electric transmission line right-of-way (ROW) in central Pennsylvania, U.S., has been shown to support a diverse community of amphibians and reptiles (Yahner et al. 2001). From an ecological perspective, woodland salamanders comprise a major portion of the total vertebrate biomass in a terrestrial ecosystem and are important components of the ecosystem (Burton and Likens 1975). Amphibians (e.g., woodland salamanders) feed on a variety of invertebrates, whereas reptiles (e.g., snakes) feed on both invertebrate and small mammals (Shaffer 1991). Furthermore, there is considerable regional and global concern for the decline of amphibian populations (Blaustein and Wake 1990; Fisher and Shaffer 1996; Yahner 2000).

Vegetation management along a 4.8-km (10-mi) portion of the right-of-way (ROW) in Montgomery County, Pennsylvania, has been studied since 1987 (Yahner et al. 1999a). The ROW consists of a 500-kV transmission line of PECO Energy, which is located in the Piedmont Physiographic Province. The long-term objectives of this project have been to 1) compare the effectiveness of commonly used herbicide and mechanical maintenance treatments on control of target trees and development of tree-resistant plant cover, and 2) determine the effect of these maintenance treatments on selected wildlife species of special interest to the public.

The objectives of this 2-year (1999 through 2000) study were to compare the diversity and relative abundance of amphibians and reptiles between the ROW and the adjacent forest, among five treatment units on the ROW, and between

wire and border zones on treatments on the ROW. Because forest-management practices can have negative impacts on populations of amphibians and reptiles, this study is relevant from ecological and public-relations perspectives.

METHODS

Five treatment units were selected for study: handcutting, mowing, mowing plus herbicide, stem–foliage spray, and foliage spray. Beginning in 1987, each unit was treated using the wire zone–border zone method (Figure 1) (Yahner et al. 2001). The intent of this method is to produce a tree-resistant, low shrub–forb–grass cover type on the wire zone and a tall shrub–forb cover type on the border zone. Each of the units was treated by herbicides and/or mechanically in 1987, 1993, and 1999. Details of these treatments can be obtained in Yahner et al. (1999a, 2000).

The handcutting unit was characterized by a forb–shrub–tree cover type in wire and border zones; the mowing unit was a forb–grass–shrub cover type in wire zones and shrub–forb cover type in border zones; the mowing plus herbicide unit was grass–forb cover type in wire zones but forb–shrub in border zones; the stem–foliage spray unit was primarily forb–grass in wire zones and shrubs in border zones; and the foliage spray unit was primarily grass–forb cover type in wire zones and shrub–forb–grass in border zones. The dominant forb in all units was goldenrod (*Solidago* spp.). Species of grasses were not differentiated. The principal shrubs and trees were Japanese honeysuckle *(Lonicera japonica)*, black haw *(Viburnum prunifolium)*, multiflora rose *(Rosa multiflora)*, gray dogwood *(Cornus racemosa)*, and white ash *(Fraxinus americana)*.

Three sampling points were established in the wire zone and in the border zone of each treatment unit, giving six sampling points per unit (n = 30 points in the ROW) (Yahner et al. 2001). In addition, if forested habitat was adjacent to the ROW, sampling points were placed 30 to 35 m (33 to 38 yd) into the forest opposite a point in the border zone (n = 10 points in the forest). This distance from an edge was used for placement of forest sampling points because woodland salamanders reportedly are uncommon within 25 m (27 yd) of edges (deMaynadier and Hunter 1998, but see Yahner et al. 2001). At each sampling point, one large coverboard [waferboard, approximately 30 x 120 x 1.5 cm (12 x 48 x 0.6 in.)] and three small coverboards [untreated pine, approximately 15 x 90 x 2(6 x 36 x 0.8 in.)] were placed flush with the soil surface (DeGraaf and Yamasaki 1992; Rodewald and Yahner 1999; Yahner et al. 1999b; Yahner et al. 2001) (Figure 2).

Coverboards were checked at each sampling point two or three times per season (spring, summer, and autumn) for the presence of amphibians and reptiles beneath them (Rodewald and Yahner 1999; Yahner et al. 1999b; Yahner et al. 2001). Coverboards provide potential refugia and resting sites for amphibians and reptiles. During each sampling period, at least 1 hour also was spent searching for amphibians and reptiles on the soil surface in wire

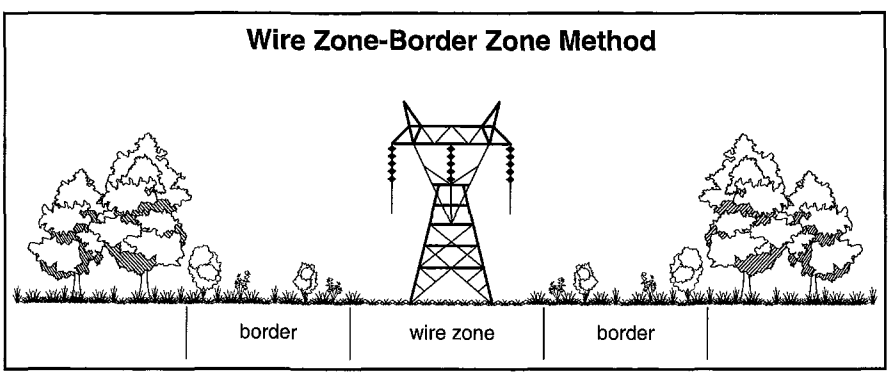

Figure 1. Diagram of a 500-kV line and ROW showing wire and border zones. A low shrub–forb–grass cover type is found in the wire zone, and a tall shrub–forb cover type is present in the border zone.

Figure 2. A large coverboard at a sampling point in a foliage-spray unit (photo taken by RHY in June 1999).

zones, border zones, and adjacent forest. In 1999, rocks and logs were overturned to check for amphibians and reptiles for comparison to data collected beneath coverboards. However, rocks and logs were very scarce along the ROW and adjacent forest, and no amphibians or reptiles were found under rocks or logs (Yahner et al. 1999a).

RESULTS AND DISCUSSION

Diversity and Relative Abundance on ROW Versus Adjacent Forest

Eight species of amphibians and reptiles were observed during the study (Table 1). All eight species were found on the ROW, whereas only two species occurred in the adjacent forest. These included 123 observations of one toad species, three salamander species, three snake species, and one turtle species. Because animals observed were not permanently marked for individual recognition, the same individual may have been observed more than once, but sampling periods were spaced at least 2 to 3 weeks to minimize recounting the same individual.

The four most common species in decreasing order of relative abundance were Jefferson salamanders *(Ambystoma jeffersonianum)* (n = 77 observations, or 62.6% of total) (Figure 3), redback salamanders *(Plethodon cinereus)* (n = 33, 26.8%), northern ringneck snakes *(Diadophis punctatus edwardsii)* and eastern box turtles *(Terrapene carolina carolina)* (n = 3 each, 2.4%) (Table 1). In the study of amphibian and reptile populations on the State Game Lands 33 ROW in central Pennsylvania (Yahner et al. 2001) and in other studies of terrestrial salamander populations throughout the northeastern United States (e.g., DeGraaf and Yamasaki 1992; Rodewald and Yahner 1999), the redback salamander was the most abundant species. However, the Green Lane ROW was characterized by relatively flat terrain and had numerous standing pools of water, so it was a very suitable habitat for Jefferson salamanders.

A relatively similar number of salamanders were observed on the ROW (n = 58, 51.8%) and in the adjacent forest (n = 54, 48.2%) (Table 1). Based on the number of coverboards on the ROW versus in the forest (30 versus 10, respectively), only 28 individual salamanders would be expected in the forest. More salamanders occurred in the forest than on the ROW because they require moist microclimatic conditions for foraging and breeding (Shaffer 1991). In contrast, snakes were found exclusively on the ROW, which provided a combination of shrubby and grassy habitat for these species. Similarly, snakes were noted only on the State Game Lands 33 ROW and not in the adjacent forest in central Pennsylvania (Yahner et al. 2001).

In contrast to State Game Lands 33 ROW (Yahner et al. 2001), three species did not occur on the Green Lane ROW. These included the eastern smooth green snake *(Opheodrys vernalis vernalis)*, mountain earth snake *(Virginia valeriae pulchra)*, and northern redbelly snake *(Storeria occipitomaculata occipitomaculata)*. The mountain earth snake is restricted to the mountainous areas of Pennsylvania (Shaffer 1991) and, therefore, is not expected to be found on the Green Lane

Table 1. Diversity and relative abundance (number of observations) of amphibians and reptiles under coverboards or in miscellaneous locations (under rocks or logs or on the soil surface) on the Green Lane ROW and in the adjacent forest, 1999–2000.

	Coverboards		Miscellaneous		
Species	ROW	Forest	ROW	Forest	Total
Toads					
American toad *(Bufo americanus americanus)*	0	1	0	2	3
Salamanders					
Jefferson salamander *(Ambystoma jeffersonianum)*	38	39	0	0	77
Redback salamander *(Plethodon cinereus)*	19	14	0	0	33
Spotted salamander *(Ambystoma maculatum)*	1	1	0	0	2
Snakes					
Eastern garter snake *(Thamnopnis sirtalis sirtalis)*	2	0	0	0	2
Northern ringneck snake *(Diadophis punctatus edwardsii)*	3	0	0	0	3
Black rat snake *(Elaphe obsoleta obsoleta)*	1	0	0	0	1
Turtles					
Eastern box turtle *(Terrapene carolina carolina)*	0	0	3	0	3
Total observations	65	54	4	0	123

ROW. Moreover, eastern box turtles were absent from the mountainous areas of the state (Shaffer 1991) and, hence, did not occur on the State Game Lands 33 ROW.

Diversity and Relative Abundance per Treatment Unit

Sixty-nine observations of amphibians and reptiles were recorded in the five treatment units on the Green Lane ROW (Table 2). The most common species was the Jefferson salamander (n = 38 observations, 55.1% of total), followed by the redback salamander (n = 19, 27.5% of total) and the eastern box turtle and northern ringneck snake (n = 3 each, 4.3%). Of these 69 observations, only six were made prior to treatment in June 1999: one American toad *(Bufo americanus americanus)*, one eastern garter snake *(Thamnopnis sirtalis sirtalis)*, one ringneck snake, and three box turtles. Thus, the remaining 63 individuals were observed subsequent to the treatments.

The number of species per treatment unit varied from six species in the mowing plus herbicide unit to three each in the stem–foliage and foliage spray units (Table 2). Eighteen and 17 observations of amphibians and reptiles were found in the handcutting and stem–foliage spray units, respectively; 11 to 12 observations were found in mowing, mowing plus herbicide, and foliage spray units. All units, including handcutting, were relatively heterogeneous in cover types, thereby providing a diversity of habitat for amphibian and reptile species. In contrast, the handcutting unit on the

Figure 3. Two Jefferson salamanders beneath a large coverboard in the wire zone of a foliage spray unit. The Jefferson salamander was the most common salamander found on the ROW and in the adjacent forest. This is a large salamander, which is usually at least 10 cm (4 in.) long. It typically prefers damp woods near water and feeds on a variety of insects, grubs, and earthworms (photo taken by RHY in March 2000).

Table 2. Diversity and relative abundance (number of observations) of amphibians and reptiles in five treatment units on the Green Lane ROW, 1999–2000.

Species	Handcutting	Mowing	Mowing plus herbicide	Stem–foliage spray	Foliage spray	Total
Toad						
American toad	1	1	0	0	0	2
Salamanders						
Jefferson salamander	12	5	4	9	8	38
Redback salamander	4	3	3	7	2	19
Spotted salamander	0	0	1	0	0	1
Snakes						
Eastern garter snake	1	0	0	0	1	2
Northern ringneck snake	0	1	11	0	3	
Black rat snake	0	0	1	0	0	1
Turtles						
Eastern box turtle	0	2	1	0	0	3
Total species	4	5	6	3	3	8
Total observations	18	12	11	17	11	69

State Game Lands ROW was relatively homogeneous (tree cover type), which was similar to young, even-aged stands that are of little value to amphibian and reptiles as habitat (Rodewald and Yahner 1999;Yahner et al. 2001).

Diversity and Relative Abundance in Wire Versus Border Zones

Eight and five species of amphibians and reptiles, respectively, were recorded in wire and border zones on the ROW (Table 3). These include 38 (55.1%) observations in wire zones and 31 (44.9%) in border zones. Furthermore, a slightly greater number of salamander observations was noted in wire zones (n = 31, 53.4%) than in border zones (n = 27, 46.6%). This may be attributed in part to relatively wet conditions created throughout wire zones of the ROW after rains. In contrast, salamanders were less common in wire zones compared to border zones on the State Game Lands 33 ROW (Yahner et al. 2001).

CONCLUSIONS

The ROW in this study contained a more diverse community of amphibians and reptiles compared to the adjacent forest. All treatment units provided suitable habitat for these vertebrates. The border zones of the ROW ensured moist microenvironments for salamanders, and the wire zones provided suitable habitat for all species. Utility companies are encouraged to adopt the wire zone–border zone method, as it provides acceptable habitat for a variety of amphibian and reptile populations noted in this study.

Table 3. Diversity and relative abundance (number of observations) of amphibians and reptiles in wire versus border zones on the Green Lane ROW, 1999-2000.

Species	Wire zone	Border zone	Total
Toads			
American toad	1	1	2
Salamanders			
Jefferson salamander	21	17	38
Redback salamander	9	10	19
Spotted salamander	1	0	1
Snakes			
Eastern garter snake	1	1	2
Northern ringneck snake	1	2	3
Black rat snake	1	0	1
Turtles			
Eastern box turtle	3	0	3
Total species	8	5	8
Total observations	38	31	69

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Résumé. Une étude sur deux ans (juin-juillet 1999, septembre-octobre 1999, mars-octobre 2000) des populations de reptiles et d'amphibiens a été menée au sein de l'emprise d'une ligne électrique de transport de 500 kV de la PECO Energy, emprise située dans la province physiographique de Piedmont, comté de Montgomery en Pennsylvanie. L'objectif était de comparer la diversité et l'abondance relative en amphibiens et en reptiles entre la portion d'emprise située sous les fils et celle limitrophe (latérale), et ce suite à diverses interventions. Huit espèces ont été étudiées lors de l'étude, les deux espèces les plus communes étant les salamandres de Jefferson (*Ambystoma jeffersonianum*) et les salamandres à dos rouge (*Plethodon cinereus*). Les huit espèces ont été observées au sein de l'emprise, mais seules les salamandres de Jefferson et à dos rouge étaient présentes dans la forêt limitrophe. Le nombre d'espèces variait de trois, dans le cas des unités traitées soit par vaporisation foliaire ou encore par vaporisation à la fois sur les feuilles et les tiges, à six espèces dans le cas de l'unité traitée par fauchage avec application d'herbicide. Toutes les espèces étaient présentes dans la portion sous les fils alors que cinq d'entre elles étaient présentes dans la zone latérale. L'emprise renfermait une plus grande diversité en espèces d'amphibiens et de reptiles que dans la forêt adjacente. Parce que les pratiques de gestion forestière peuvent avoir des impacts négatifs sur les populations d'amphibiens et de reptiles, cette étude apporte des informations précieuses sur les pratiques de gestion forestière requises pour la préservation des amphibiens et des reptiles.

Zusammenfassung. In der physiographischen Provinz von Piedmont in Montgomery County, Pennsylvania wurden im Juni/Juli 1999, Sept./Okt. 1999 und März-Okt. 2000 eine zweijährige Studie an der Amphibien- und Reptilienpopulation innerhalb eines 500 kV Überlandkorridors durchgeführt. Es sollte die Diversität und die relative Vielzahl der Amphibien und der Reptilien zwischen Kabel und Grenzzonen in dem Korridor verglichen werden. Während der Studie wurden 8 Spezies beobachtet, wobei die häufigsten Salamander der Jefferson- und der Rotrückensalamander waren. Alle 8 Spezies kamen in dem Korridor vor, aber nur die beiden obengenannten kamen auch in den benachbarten Wäldern vor. Die Anzahl der Spezies rangierte von 6 Spezies in den gemähten Bereichen plus Herbizideinsatz bis zu jeweils drei in den Bereichen mit Spritzen des Stammes und der Grünmassen und reinen Spritzungen der Grünmasse. Alle Spezies wurden in der Kabelzone gefunden, aber nur fünf in den Randbereichen. Der Korridor enthielt eine größere Diversität von Amphibien- und Reptilienarten als die benachbarten Forste. Diese Studie liefert wertvolle Informationen über Forstmanagementpraktiken, die erforderlich sind, um Amphibien und Reptilien zu erhalten, weil einige Praktiken negative Auswirkungen haben können.

Resumen. Se condujo un estudio de dos años en poblaciones de anfibios y reptiles, en el derecho de vía (ROW, por sus siglas en inglés) en líneas de transmisión de 500 kV, de la PECO Energy en la Provincia Fisiográfica de Piedemonte, condado Montgomery, Pennsylvania, en Junio-Julio 1999, Septiembre-Octubre de 1999, y Marzo-Octubre de 2000. Los objetivos fueron comparar la diversidad y abundancia relativa de anfibios y reptiles bajo los cables y las zonas de tratamiento de frontera en el ROW. Se observaron ocho especies durante el estudio, siendo las dos más comunes las salamandras Jefferson (*Ambystoma jeffersonianum*) y las salamandras de lomo rojo (*Plethodon cinereus*). Se observaron las ocho especies en el ROW, pero solamente las dos salamandras anteriores se encontraron en el bosque adyacente. El número de especies varió de seis en la unidad donde se empleó herbicida además de remoción, a tres en las unidades donde se empleo aspersión sobre el follaje. Todas las especies fueron encontradas en las zonas de cables, comparando con solamente cinco en las zonas de frontera. El ROW tuvo una mayor diversidad de anfibios y reptiles que el bosque adyacente. Debido a que el manejo del bosque pueden traer impactos negativos sobre las poblaciones de anfibios y reptiles, este estudio proporciona información valiosa sobre las prácticas requeridas para la conservación de tales poblaciones.