New Jersey Pinelands Electric-transmission Right-of-way Vegetation Monitoring

September 2021

Cover Photo: White fringed orchid (*Platanthera blephariglottis*) blooming in a New Jersey Pinelands transmission-line right-of-way. Photo/Kim J. Laidig

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Executive Summary

In 2006, Pinelands Commission and Rutgers University scientists prepared a vegetation management plan for bulk-electric transmission-line rights-of-way in the Pinelands Area. Bulk-transmission lines have a 69 kV capacity or greater. The goal of the Right-of-Way Plan was to develop management prescriptions to create and maintain relatively stable and sustainable, early successional habitats that reflect characteristic Pinelands habitats, support native Pinelands species, maximize natural re-vegetation, minimize planting, require minimal subsequent management, ensure transmission reliability and safety, and minimize the need for individual Pinelands permit reviews. The Right-of-Way Plan includes specific vegetation-management prescriptions for various upland and wetland plant communities in each of the 3,041 spans that compose the 233 mi (2,695 ac) of Pinelands Area rights-of-way.

A pilot program was initiated in 2009 to assess the Right-of-Way Plan, with one of the assessment criteria being to evaluate whether or not "the vegetation-management prescriptions have resulted in relatively stable and sustainable early successional habitats that are characteristic of the Pinelands and which provide habitat for native-Pinelands plants and animals, including threatened and endangered species." To address this specific criterion of the pilot program, Commission scientists, over a seven-year period from 2011 to 2017, monitored vegetation plots in 24 managed right-of-way spans. These vegetation plots represented six vegetation types (6 vegetation types x 4 spans of each type = 24 managed study spans). Commission scientists also established and surveyed other vegetation plots along access roads and at towers, and in the adjacent forest to compare the plant species found in these areas to those present in the managed rights-of-way. The goals of the vegetation monitoring were to determine: 1) if the right-of-way plant communities were stable, 2) how often vegetation management occurred in the 24 managed right-of-way spans (study spans) and in all Pinelands right-of-way spans, and 3) if plant species found in the managed rights-of-way were characteristic Pinelands species and similar to the adjacent Pinelands forest.

To evaluate plant community stability of the 24 managed study spans, year-to-year changes in dominant plants and in individual species were assessed. Dominant shrubs and dominant herbaceous plant species were largely consistent over the seven-year period. The occasional change in dominant shrub and herbaceous species did not appear related to vegetation management. There were relatively few, year-to-year, additions or losses in individual plant species in the managed right-of-way vegetation plots. The consistent dominant species and the low change in individual species from year-to-year indicate a high degree of plant community stability in the 24 managed study spans.

Based on 2010-2018 data provided by Atlantic City Electric, Jersey Central Power and Light, and Public Service Electric and Gas Company for the 24 study spans, vegetation management occurred three times at four spans, twice at nine spans, and once at eleven spans. Of the 3,041 Pinelands rights-of-way that were managed more than once between 2010 and 2018, the number of years elapsed between management events (return interval) was calculated. Despite some variability among the utility companies and the type of vegetation management prescription, 3- to 4-year return intervals were typically used to manage vegetation in Pinelands rights-of-way.

To determine if managed right-of-way vegetation in the 24 spans had the same number and types of species as the surrounding Pinelands forest, vegetative communities within the managed right-of-way vegetation plots and adjacent Pinelands forest plots were compared for each of the six vegetation types. In general, plant communities within the managed right-of-way vegetation plots and adjacent-forest plots were similar with respect to woody species, but differed in the composition and number of herbaceous species. Differences in herbaceous vegetation may be related to conditions surrounding the removal of tree canopy in the managed rights-of-way.

Managed right-of-way vegetation plots differed from access road and tower plots. Managed right-of-way plots had a higher percentage of native Pinelands species than both tower and access road plots. Tower and access road plots supported a higher percentage of introduced species, which are species not native to the United States. Because native Pinelands species were low and introduced species were high in the more disturbed tower and access road plots, minimizing the width and number of access roads and the amount of disturbance at the towers may reduce the prevalence of non-Pinelands and introduced plant species.

Introduction

In 2006, Pinelands Commission and Rutgers University scientists collaborated to develop a vegetation management plan for approximately 233 miles of bulk-electric transmission-line rights-of-way in the Pinelands Area. Bulk-transmission lines have a 69 kV capacity or greater. The resulting New Jersey Pinelands Electric-Transmission Right-of-Way Vegetation-Management Plan (Right-of-Way Plan; Lathrop and Bunnell 2009) was completed in March 2009. The specific goal of the Right-of-Way Plan was to develop vegetation management prescriptions to create and maintain relatively stable and sustainable, early successional habitats that reflect characteristic Pinelands habitats, support native Pinelands species, maximize natural re-vegetation, minimize planting, require minimal subsequent management, ensure transmission reliability and safety, and minimize the need for individual Pinelands development application reviews. The Right-of-Way Plan includes specific vegetation-management prescriptions for various upland and wetland plant communities in each of the 3,041 spans that compose the 233 mi (2,695 ac) of Pinelands Area rights-of-way. The Right-of-Way Plan was developed in cooperation with representatives from the New Jersey Board of Public Utilities and the three utility companies including Public Service Electric and Gas Company (PSE&G), Atlantic City Electric (ACE), and Jersey Central Power and Light (JCP&L).

In December 2009, the Pinelands Commission initiated the Electric Transmission Right-of-Way Maintenance Pilot Program to implement and evaluate the Right-of-Way Plan (N.J.A.C. 7:50-10.31 through 10.35). To determine if the Pilot Program is successful, the regulations establish four criteria to be assessed at its end. One of these criteria is whether or not "the vegetation-management prescriptions have resulted in relatively stable and sustainable early successional habitats that are characteristic of the Pinelands and which provide habitat for native-Pinelands plants and animals, including threatened and endangered species." To address this specific criterion, Commission scientists established vegetation plots and sampled vegetation in the center, along access roads and towers, and in the adjacent forest in 24 study spans. A span is the area between adjacent transmission-line towers. The goals of the vegetation monitoring were to determine: 1) if the right-of-way plant communities were stable, 2) how often vegetation management occurred in the 24 managed right-of-way spans (study spans) and in all Pinelands right-of-way spans, and 3) if plant species found in the managed rights-of-way were characteristic Pinelands species and similar to the adjacent Pinelands forest. In this report, we describe the methods and results of these vegetation surveys.

Methods and Results

Site Selection. From the complete Pinelands Area inventory of 3,041 right-of-way spans characterized by Lathrop and Bunnell (2009), we selected 24 study spans that represent all three utility companies and a wide geographic distribution in the Pinelands (Figure 1). The 24 study spans also represent six commonly occurring vegetation type and vegetation-management prescription combinations (Table 1; Figure 2). Although the vegetation in all 24 study spans contained a mix of trees, shrubs, and herbs, we categorized each span into one of the six vegetation types based on whether it was an upland or wetland and whether trees, shrubs, or herbs dominated the vegetation in the span. Vegetation management prescriptions in these study spans consisted of manual tree removal in the two wetland types and mowing in the four upland types (Figure 3). Vegetation management frequency was conducted at the discretion of the three utility companies and the management activities performed during a given year were reported to the Commission by the utility companies annually. Based on a review of aerial photography, each of the 24 study spans were originally cleared at least 16 to 55 years prior to the beginning of the study in 2011.

Vegetation Sampling. Commission scientists established two 100-m² circular plots in each of the 24 study

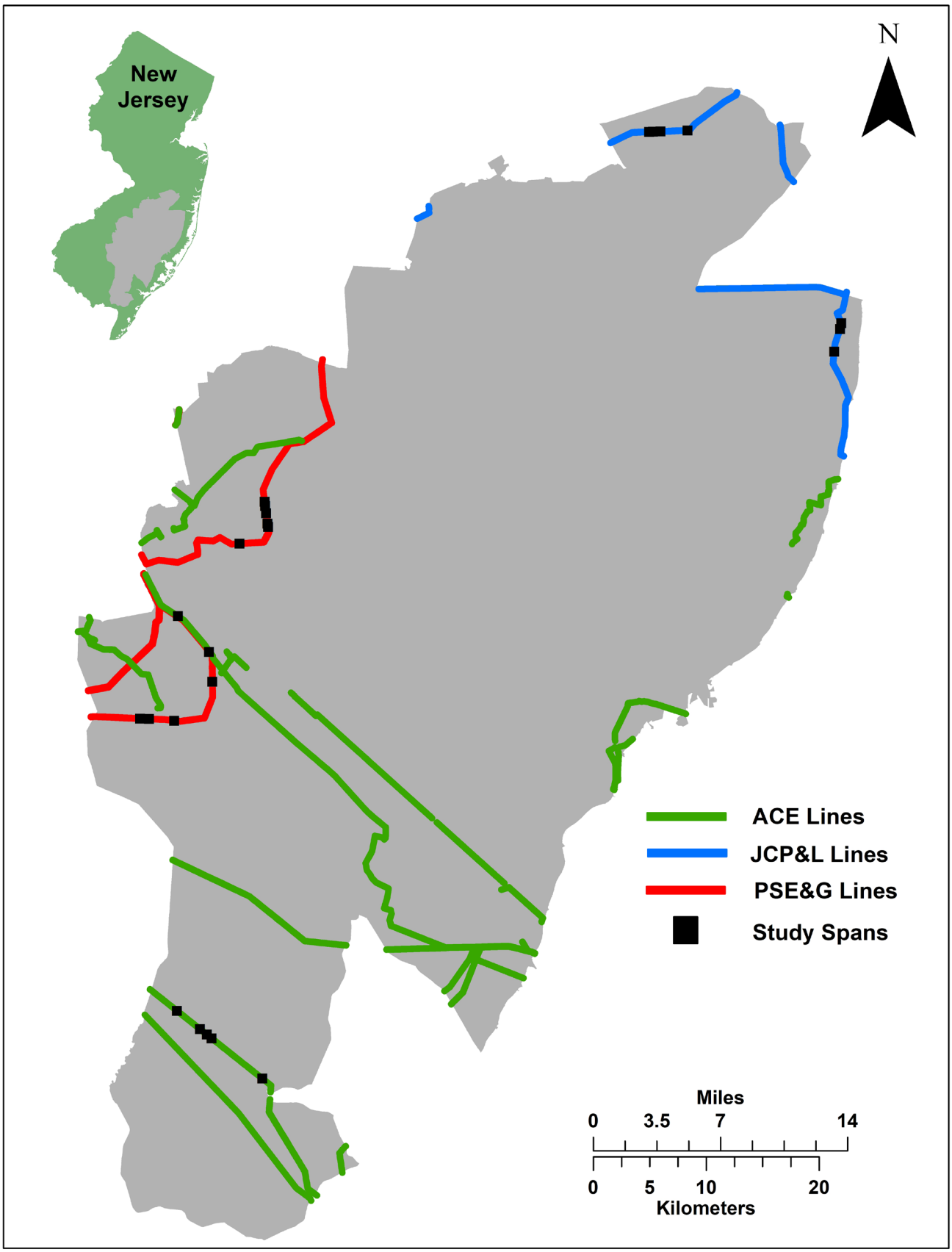

Figure 1. The location of 24 study spans and bulk-electric transmission-line rights-of-way in the Pinelands Area (shown in gray) managed by Atlantic City Electric (ACE), Jersey Central Power and Light (JCP&L), and Public Service Electric and Gas Company (PSE&G).

Table 1. Vegetation type and management prescriptions for 24 study spans

Vegetation Type	Management Prescription	# of Spans
Upland Herb	Mow trees, shrubs and herbs	4
Upland Scrub	Mow trees, shrubs and herbs	4
Upland Shrub	Mow trees, shrubs and herbs	4
Upland Tree	Mow trees, shrubs and herbs	4
Wetland Cedar	Manual tree removal	4
Wetland Shrub	Manual tree removal	4

spans to monitor vegetation in the center of managed rights-of-way (Figure 4). We selected plot locations to best characterize the representative plant communities in the managed areas and to avoid right-of-way and forest edges, more heavily accessed areas near towers, and access roads. The distance between the circular plots varied depending on the size and configuration of the representative plant communities found within the span. Five 1-m² subplots were nested within the circular plots, with four plots located on the perimeter in each of the cardinal directions and one plot located in the center (Figure 4). For each subplot, we recorded all plant species present and identified the dominant shrub and herbaceous species based on leaf cover. We surveyed vegetation in the managed right-of-way vegetation plots in June and July annually from 2011 through 2017. Plant names follow nomenclature provided by the United States Department of Agriculture, Natural Resources Conservation Service (USDA, NRCS 2021).

Vegetation Inventory. Managed right-of-way vegetation plots at the 24 study spans supported a total of 63 woody species and 131 herbaceous species (Table 2). Three plant species of conservation concern in New Jersey (NJDEP 2016) were found in the managed right-of-way plots. Two of these species, Pine Barren boneset (*Eupatorium resinosum*) and New Jersey rush (*Juncus caesariensis*), are listed as endangered, and one, humped bladderwort (*Utricularia gibba*), is listed as a species of concern.

1) Plant Community Stability. We evaluated the stability of the right-of-way plant communities over time by examining year-to-year changes in the most dominant plants and in individual species in the 24 study spans. We also assessed the potential association of vegetation management on these two measures of stability.

To evaluate changes in the most dominant plants over time, we compared the dominant shrubs and herbs identified each year in the managed right-of-way plots of the 24 study spans. Vegetation was considered to exhibit stability if the dominant species for a span remained the same during all or most years of the study. Dominant shrubs present in the 24 study spans were typically consistent from year to year (Table 3). For 18 of the 24 study spans, a single shrub species

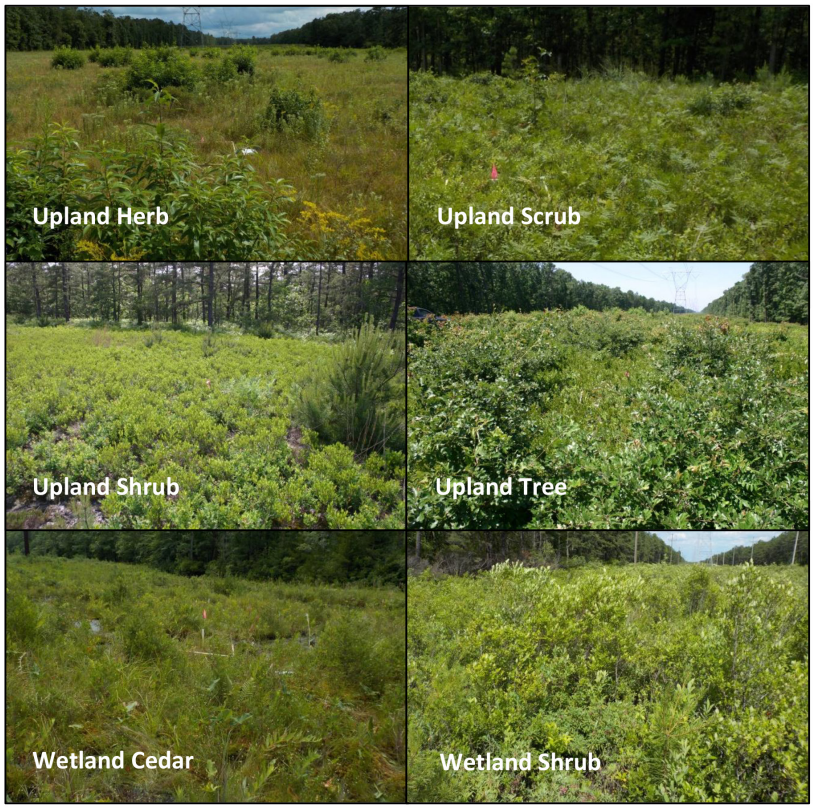

Figure 2. Six vegetation community types represented by the 24 study spans selected for vegetation monitoring. Four spans of each vegetation community type were monitored.

was dominant in every year surveyed. For the six spans where we observed a change, a single shrub species was dominant in the majority of years surveyed. Dominant herbaceous species were also fairly consistent from year to year (Table 4). A single herbaceous species was dominant every year in 13 of the 24 study spans. For the eleven spans where we observed a change, a single herbaceous species was dominant in the majority of years surveyed. The occasional change in dominant shrub and herbaceous species did not appear to be related to vegetation management. For example, of the 40 management events that occurred at the study spans from 2011 to 2017, there were changes in dominant shrubs and dominant herbs in the first growing season after vegetation management on only two and five occasions, respectively (Tables 3 and 4). The consistent occurrence of the same dominant shrub and herbaceous species over the years indicates a relatively high degree of vegetation stability in the study spans during the monitoring period.

Figure 3. Right-of-way span vegetation before and after manual tree removal in the wetland cedar vegetation (top) and mowing in the upland herb vegetation type (bottom).

To evaluate changes in individual species over time in the managed right-of-way vegetation plots, we compared year-to-year species turnover values (Hallett et al. 2016). Species turnover is defined as the sum of species gained and species lost from one year to the next, divided by the total number of species observed in both years. Species turnover values can range from 0 to 1, where 0 represents no turnover (i.e., high stability) and 1 represents maximum turnover. Using species turnover values that were calculated for each subplot separately, we compared year-to-year species turnover for the six vegetation types. Most subplot turnover values were between 0 and 0.5, and average turnover values were also low (Figure 5). There were no significant differences in annual turnover for any of the vegetation types. The species turnover results indicate that the presence of individual plant species in the managed right-of-way plots was relatively stable over time, regardless of the vegetation type present in the study span.

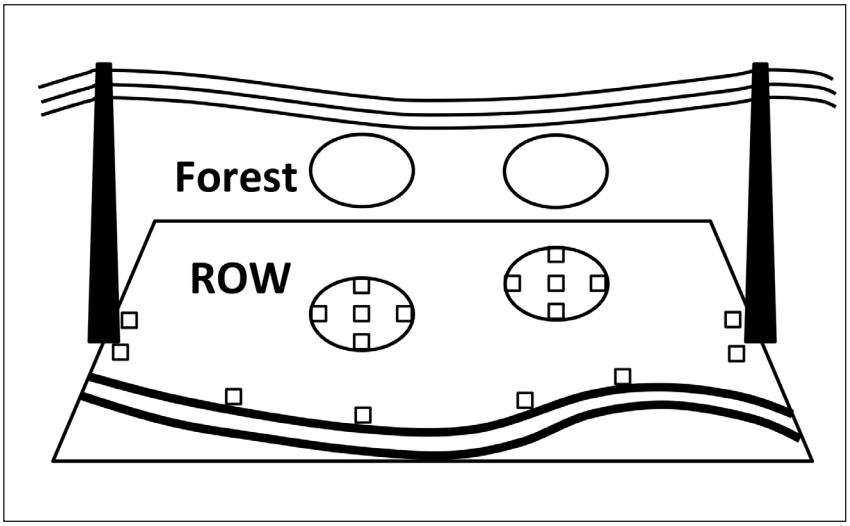

Figure 4. Layout of vegetation monitoring plots within the managed right-of-way, along the access road, at the base of the transmission towers, and in the adjacent forest.

Table 2. Frequency of occurrence of plant species classified as native Pinelands, non-native, and introduced species (Stone 1911, USDA, NRCS 2021) at 24 right-of-way spans in managed right-of-way (MR; 2011-2017 data), adjacent forest (F; 2012 data), access road (A; 2017 data), and tower (T; 2017 data) plots. Species that could not be definitively placed in a biogeographic category were considered unclassified species. Endangered species (**) and species of concern (*) are based on NJDEP (2016); invasive species (‡) are based on Snyder and Kaufman (2004).

Biogeographic Group Scientific Name	MR	F	A	T	Scientific Name	MR	F	A	T
Native Pinelands Species									
Acer rubrum	9	10	-	6	*Dichanthelium lucidum*	1	-	-	1
Agalinis setacea	1	-	-	-	*Dichanthelium meridionale*	4	-	9	2
Agrostis hyemalis	-	-	1	1	*Dichanthelium scoparium*	1	-	7	3
Amelanchier canadensis	4	2	1	2	*Dichanthelium sphaerocarpon*	-	-	2	4
Andropogon glomeratus	9	-	-	1	*Diodia teres*	1	-	15	1
Andropogon virginicus	17	-	16	13	*Drosera filiformis*	-	-	1	-
Arctostaphylos uva-ursi	2	-	1	-	*Drosera intermedia*	3	-	1	-
Aristida longespica	1	-	-	-	*Drosera rotundifolia*	4	2	-	1
Aronia arbutifolia	6	3	1	2	*Eleocharis tuberculosa*	3	-	-	-
Asclepias amplexicaulis	1	-	1	-	*Epigaea repens*	2	-	-	1
Aster nemoralis	5	-	-	-	*Eriophorum virginicum*	3	-	-	-
Aster novi-belgii	3	-	-	-	*Eubotrys racemosa*	6	8	3	1
Baptisia tinctoria	5	-	4	1	*Eupatorium album*	1	-	-	3
Bartonia paniculata	3	-	-	-	*Eupatorium hyssopifolium*	4	-	5	3
Bartonia virginica	1	-	-	-	*Eupatorium pilosum*	2	-	1	-
Betula populifolia	3	1	-	-	***Eupatorium resinosum*	1	-	-	-
Calamovilfa brevipilis	1	-	-	-	*Eupatorium rotundifolium v. ovatum*	-	-	3	1
Carex atlantica	2	1	-	-	*Eurybia spectabilis*	1	-	-	-
Carex atlantica v. capillacea	-	4	-	-	*Euthamia caroliniana*	11	-	12	5
Carex bullata	1	-	-	-	*Gamochaeta purpurea*	1	-	-	-
Carex collinsii	1	1	-	-	*Gaultheria procumbens*	10	14	2	1
Carex exilis	2	-	-	-	*Gaylussacia baccata*	19	14	11	8
Carex folliculata	-	2	-	-	*Gaylussacia dumosa*	8	8	-	-
Carex pensylvanica	18	7	13	9	*Gaylussacia frondosa*	18	19	2	3
Carex striata	4	-	1	-	*Helianthemum canadense*	15	-	7	-
Cephalanthus occidentalis	3	1	-	-	*Hieracium venosum*	-	1	-	-
Chamaecyparis thyoides	6	4	-	1	*Hudsonia ericoides*	5	2	7	-
Chamaedaphne calyculata	6	1	2	4	*Hudsonia tomentosa*	1	-	2	-
Cladium mariscoides	1	-	-	-	*Hypericum canadense*	3	-	-	-
Clethra alnifolia	9	7	2	1	*Hypericum densiflorum*	1	-	-	1
Comptonia peregrina	12	2	7	9	*Hypericum gentianoides*	2	-	3	-
Crataegus uniflora	4	-	-	-	*Hypericum hypericoides*	6	-	2	-
Croton michauxii v. ellipticus	-	-	2	-	*Ilex glabra*	10	6	2	-
Cyperus dentatus	-	-	1	-	*Ilex laevigata*	1	1	-	-
Cyperus grayi	1	-	-	-	***Juncus caesariensis*	2	-	-	-
Cyperus lupulinus ssp. macilentus	2	-	-	-	*Juncus canadensis*	4	-	-	-
Cyperus retrorsus	2	-	1	-	*Juncus dichotomus*	2	-	6	3
Cypripedium acaule	1	1	-	-	*Juncus effusus*	-	2	1	-
Danthonia sericea	2	-	11	11	*Juncus pelocarpus*	4	-	-	-
Danthonia spicata	3	-	-	-	*Kalmia angustifolia*	9	4	2	6
Decodon verticillatus	3	4	-	-	*Kalmia latifolia*	5	8	1	-
Dichanthelium commut. v. ashei	8	-	3	3	*Krigia virginica*	2	-	2	-

Table 2. Continued.

Biogeographic Group					Biogeographic Group				
Scientific Name	MR	F	A	T	Scientific Name	MR	F	A	T
Native Pinelands Species (cont'd)									
Lechea pulchella	6	-	5	1	*Quercus montana*	1	6	1	-
Leiophyllum buxifolium	1	-	-	-	*Quercus prinoides*	4	2	1	2
Lespedeza hirta	1	-	-	-	*Quercus stellata*	12	11	-	2
Lespedeza repens	3	-	-	-	*Quercus velutina*	18	18	4	4
Linum medium	-	-	1	-	*Rhexia mariana*	-	-	-	1
Lycopodiella appressa	2	-	-	-	*Rhexia virginica*	4	-	1	-
Lyonia ligustrina	4	1	-	1	*Rhododendron viscosum*	6	4	-	1
Lyonia mariana	9	8	4	2	*Rhynchospora alba*	5	-	-	-
Lysimachia terrestris	2	1	-	-	*Rhynchospora chalarocephala*	1	-	-	-
Magnolia virginiana	2	3	-	-	*Sabatia difformis*	2	-	-	-
Melampyrum lineare	13	7	-	-	*Sagittaria engelmanniana*	3	2	-	-
Minuartia caroliniana	2	-	4	-	*Sarracenia purpurea*	2	1	-	-
Morella pensylvanica	6	5	-	1	*Sassafras albidum*	9	13	1	8
Nuttallanthus canadensis	5	-	10	4	*Schizachyrium scoparium*	17	-	-	-
Nymphaea odorata	3	2	-	-	*Scleria triglomerata*	9	1	2	-
Nyssa sylvatica	1	6	1	4	*Sericocarpus asteroides*	2	-	-	-
Orontium aquaticum	1	-	-	-	*Sericocarpus linifolius*	-	-	2	-
Osmunda cinnamomea	4	1	-	1	*Smilax glauca*	19	16	11	14
Osmunda regalis	2	1	-	-	*Smilax rotundifolia*	3	5	2	6
Panicum rigidulum v. pubescens	1	-	-	-	*Solidago odora*	8	2	10	5
Panicum verrucosum	3	-	-	-	*Sparganium americanum*	2	2	-	-
Panicum virgatum	6	1	15	17	*Tephrosia virginiana*	6	1	2	2
Paspalum setaceum	-	-	3	-	*Thelypteris simulata*	2	1	-	-
Pinus rigida	23	20	12	21	*Toxicodendron vernix*	-	1	-	-
Platanthera blephariglottis	1	-	-	-	*Triadenum virginicum*	4	-	-	-
Pogonia ophioglossoides	3	-	-	-	*Trichostema dichotomum*	1	-	-	-
Polygala brevifolia	4	-	-	-	*Utricularia cornuta*	3	-	-	-
Polygala cruciata	1	-	-	-	*Utricularia fibrosa*	4	-	-	-
Polygala lutea	3	-	-	-	**Utricularia gibba*	1	-	-	-
Polygala nuttallii	-	-	2	-	*Utricularia subulata*	2	-	1	-
Polygonella articulata	4	-	4	-	*Vaccinium corymbosum*	17	10	4	6
Pontederia cordata	-	1	-	-	*Vaccinium macrocarpon*	4	-	1	1
Pseudognaphalium obtusifolium	2	-	-	-	*Vaccinium pallidum*	18	17	15	14
Pteridium aquilinum	15	11	11	6	*Viburnum nudum*	2	-	-	-
Pyxidanthera barbulata	3	-	-	-	*Vulpia octoflora*	1	-	7	3
Quercus alba	13	10	4	3	*Woodwardia areolata*	-	2	-	1
Quercus coccinea	6	2	1	1	*Woodwardia virginica*	3	2	-	-
Quercus ilicifolia	19	7	14	10	*Xerophyllum asphodeloides*	3	-	-	-
Quercus marilandica	9	-	4	1	*Xyris difformis*	4	-	1	-
Non-native Species									
Aristida tuberculosa	1	-	-	-	*Chamaesyce maculata*	-	-	2	-
Asclepias syriaca	-	-	1	-	*Chasmanthium laxum*	2	-	2	2
Asclepias tuberosa	1	-	-	-	*Comandra umbellata*	-	-	1	-
Carex intumescens	-	1	-	-	*Dichanthelium clandestinum*	-	-	3	4
Carex swanii	1	-	1	1	*Dichanthelium depauperatum*	5	1	-	1

Table 2. Continued.

Biogeographic Group Scientific Name	MR	F	A	T	Biogeographic Group Scientific Name	MR	F	A	T
Non-native Species (cont'd)									
Dioscorea villosa	1	-	-	-	*Peltandra virginica*	3	2	-	-
Diospyros virginiana	-	1	-	-	*Phragmites australis*	1	-	1	2
Dulichium arundinaceum	3	2	-	-	*Pinus strobus*	1	-	-	-
Eragrostis spectabilis	1	-	-	-	*Piptochaetium avenaceum*	4	-	-	-
Erechtites hieracifolia	1	-	-	-	*Plantago aristata*	-	-	3	-
Galium pilosum	1	-	-	-	*Polygala sanguinea*	-	-	1	-
Ilex opaca	4	6	-	-	*Potentilla simplex*	-	-	3	1
Iris versicolor	-	1	-	-	*Prunus serotina*	9	-	8	14
Juncus scirpoides	-	-	1	-	*Quercus falcata*	5	3	1	1
Juniperus virginiana	2	-	3	7	*Rhus copallinum*	7	-	8	5
Leersia oryzoides	-	2	-	-	*Sisyrinchium fuscatum*	-	-	1	1
Lepidium virginicum	-	-	3	-	*Solanum carolinense*	1	-	-	-
Lespedeza capitata	-	-	2	1	*Sorghastrum nutans*	2	-	-	-
Lespedeza virginica	-	-	2	-	*Spiraea tomentosa*	-	-	-	1
Liquidambar styraciflua	1	-	-	-	*Spiranthes lacera v. gracilis*	1	-	-	-
Lycopus uniflorus	1	-	-	-	*Thelypteris palustris*	-	1	-	-
Lysimachia quadrifolia	4	-	1	2	*Toxicodendron radicans*	1	-	1	1
Mitchella repens	2	2	-	1	*Triodanis perfoliata*	1	-	2	1
Oenothera biennis	1	-	-	-	*Viburnum dentatum*	-	1	-	-
Oxalis dillenii	-	-	1	-	*Viola pedata*	1	-	-	-
Oxalis stricta	-	-	1	-	*Vitis labrusca*	3	-	3	3
Parthenocissus quinquefolia	2	-	3	7					
Introduced Species									
Achillea millefolium	-	-	-	1	‡*Lespedeza cuneata*	-	-	8	3
Albizia julibrissin	-	-	-	1	‡*Microstegium vimineum*	-	-	2	-
Allium vineale	1	-	-	-	*Plantago lanceolata*	-	-	3	1
Anthoxanthum odoratum	-	-	3	2	*Poa compressa*	-	-	-	1
Bromus arvensis	-	-	2	1	*Poa pratensis*	-	-	1	-
‡*Celastrus orbiculatus*	-	-	-	1	*Rumex acetosella*	1	-	3	-
Centaurea stoebe	-	-	2	1	*Schedonorus arundinaceus*	-	-	2	1
Cirsium vulgare	-	-	-	1	*Setaria viridis*	-	-	2	-
Daucus carota	-	-	1	-	*Spergula pentandra*	1	-	-	-
‡*Elaeagnus umbellata*	1	-	-	3	*Tragopogon pratensis*	1	-	-	-
Hieracium caespitosum	-	-	1	1	*Trifolium arvense*	-	-	1	-
Hieracium piloselloides	1	-	-	-	*Vicia tetrasperma*	-	-	1	-
Hypochaeris radicata	-	-	2	-	*Vulpia bromoides*	-	-	3	-
Kummerowia striata	-	-	5	-					
Unclassified Species									
Apocynum cannabinum	4	1	2	1	*Dichanthelium mattamuskeetense*	1	-	-	-
Carex longii	-	-	-	2	*Dichanthelium ovale v. addisonii*	7	-	1	-
Carya sp.	2	3	-	-	*Digitaria cognata*	1	-	-	1
Croton glandulosus	1	-	-	-	*Eupatorium serotinum*	4	-	3	3
Cuscuta sp.	3	-	-	-	*Rosa sp.*	2	-	1	-
Dichanthelium accum. v. lindheimeri	1	-	-	-	*Rubus sp.*	13	3	13	9
Dichanthelium dichotomum	7	-	2	2	*Vaccinium angustifolium*	-	-	-	1
Dichanthelium longiligulatum	-	-	1	3					

Table 3. Stability of dominant shrub species at 24 right-of-way spans grouped by six vegetation types from 2011 to 2017. Open circles indicate years when the species was the dominant shrub at a span. Closed black circles indicate when another species was dominant. Vegetation management (shaded cells) occurred prior to vegetation sampling for that year. With the exception of span N115, no spans were managed in 2010.

Group	Span	Dominant species*	2011	2012	2013	2014	2015	2016	2017
Upland herb	J25	golden heather	○	○	○	○	○	○	○
	J28	highbush blueberry	○	○	○	○	○	●	○
	N103	lowbush blueberry	○	○	○	○	○	○	○
	S423	blackberry	○	○	○	○	○	○	○
Upland scrub	A33	bear oak	○	○	○	○	○	○	○
	A36	bear oak	○	○	○	○	○	○	○
	N102	bear oak	○	○	○	○	○	○	○
	N114	bear oak	○	○	○	○	○	○	○
Upland shrub	A29	lowbush blueberry	○	○	○	○	○	○	○
	J13	lowbush blueberry	●	●	○	○	○	○	○
	J18	black huckleberry	○	○	●	○	●	○	●
	S384	lowbush blueberry	○	○	○	○	○	○	○
Upland tree	N112	lowbush blueberry	○	○	○	○	●	○	○
	S364	bear oak	○	○	○	○	○	○	○
	S372	black huckleberry	○	○	○	○	●	○	○
	S442	lowbush blueberry	○	○	○	○	○	○	○
Wetland cedar	A16	highbush blueberry	○	○	○	○	○	○	○
	A65	bayberry	○	○	○	○	○	○	○
	J11	leatherleaf	○	○	○	○	○	○	○
	J20	sweet pepperbush	○	○	○	○	○	○	○
Wetland shrub	A147	dangleberry	○	○	○	○	○	○	○
	J27	sheep laurel	○	●	○	○	○	○	○
	N115	sheep laurel	○	○	○	○	○	○	○
	N81	dangleberry	○	○	○	○	○	○	○

* bayberry = *Morella pensylvanica*, bear oak = *Quercus illicifolia*, blackberry = *Rubus* sp., black huckleberry = *Gaylussacia baccata*, dangleberry = *Gaylussacia frondosa*, golden heather = *Hudsonia ericoides*, highbush blueberry = *Vaccinium corymbosum*, leatherleaf = *Chamaedaphne calyculata*, lowbush blueberry = *Vaccinium pallidum*, sheep laurel = *Kalmia angustifolia*, sweet pepperbush = *Clethra alnifolia*

Table 4. Stability of dominant herbaceous species at 24 right-of-way spans grouped by six vegetation types from 2011 to 2017. Open circles indicate years when the species was the dominant herb at a span. Closed black circles indicate when another species was dominant. Vegetation management (shaded cells) occurred prior to vegetation sampling for that year. With the exception of span N115, no spans were managed in 2010.

Group	Span	Dominant species*	2011	2012	2013	2014	2015	2016	2017
Upland herb	J25	switchgrass	○	○	○	○	●	○	●
	J28	switchgrass	○	○	○	○	●	○	○
	N103	Pennsylvania sedge	○	○	○	○	○	○	○
	S423	Pennsylvania sedge	○	○	○	○	○	○	○
Upland scrub	A33	little bluestem	○	○	○	○	○	○	●
	A36	little bluestem	○	○	○	○	○	○	○
	N102	Pennsylvania sedge	○	○	○	○	○	○	○
	N114	bracken	○	○	○	○	○	○	○
Upland shrub	A29	bracken	○	○	●	○	○	○	○
	J13	bracken	●	●	○	○	○	○	○
	J18	fragrant goldenrod	○	○	○	○	○	○	○
	S384	Pennsylvania sedge	○	○	○	○	○	○	○
Upland tree	N112	little bluestem	○	○	○	○	●	○	●
	S364	variable panicgrass	○	○	○	○	○	○	○
	S372	variable panicgrass	●	○	○	○	●	○	●
	S442	bracken	○	○	○	○	○	○	○
Wetland cedar	A16	white beaksedge	○	○	●	○	○	○	○
	A65	white beaksedge	●	○	○	○	○	○	○
	J11	coast sedge	○	○	○	○	○	○	○
	J20	Walter's sedge	○	○	○	○	○	○	○
Wetland shrub	A147	bracken	○	○	○	○	○	○	○
	J27	bushy beardgrass	○	●	○	○	○	○	●
	N115	turkeybeard	○	○	○	○	○	○	○
	N81	Addison's rosette grass	●	●	○	○	○	●	○

* Addison's rosette grass = *Dichanthelium ovale*, bracken = *Pteridium aquilinum*, bushy beardgrass = *Andropogon glomeratus*, coast sedge = *Carex exilis*, fragrant goldenrod = *Solidago odora*, little bluestem = *Schizachyrium scoparium*, Pennsylvania sedge = *Carex pensylvanica*, switchgrass = *Panicum virgatum*, turkeybeard = *Xerophyllum asphodeloides*, variable panicgrass = *Dichanthelium commutatum*, Walter's sedge = *Carex striata*, white beaksedge = *Rhynchospora alba*

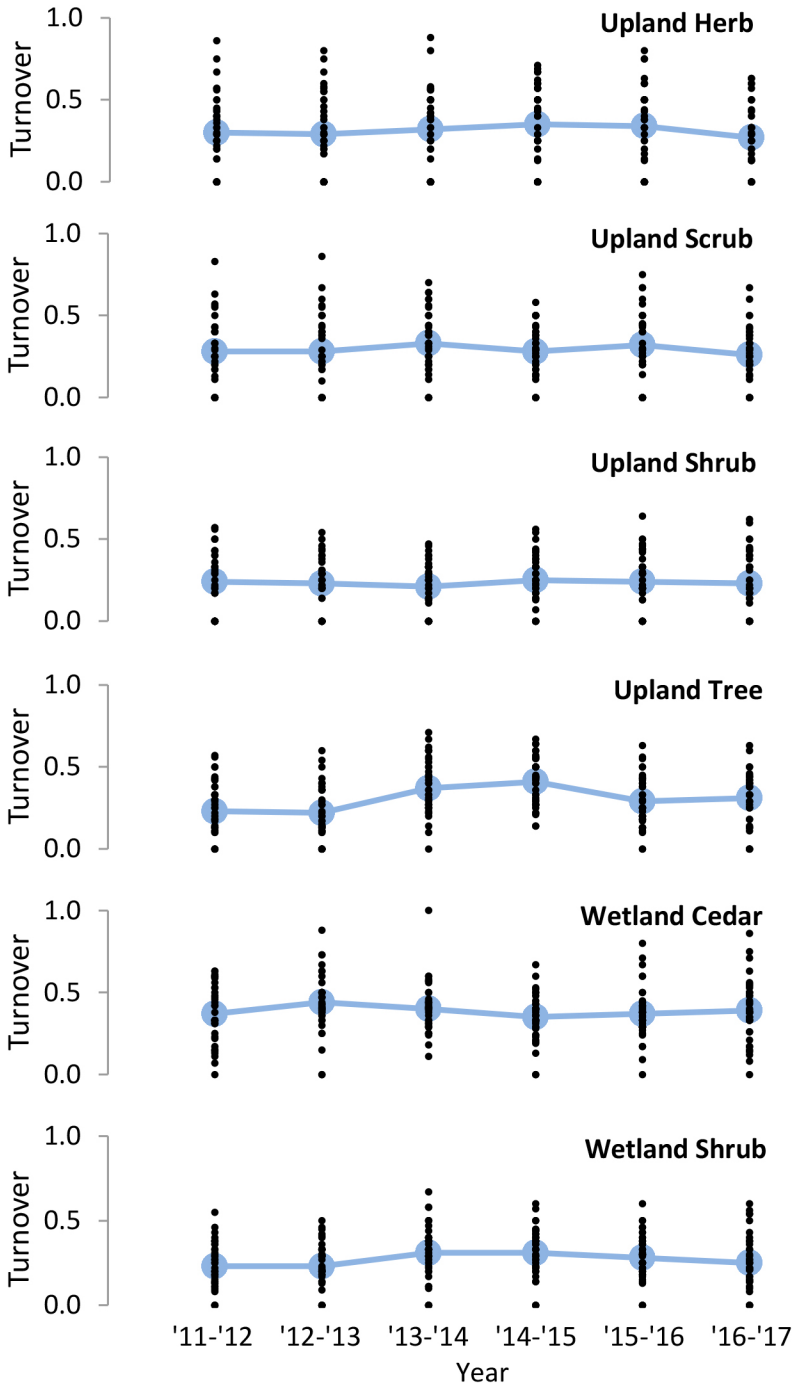

Figure 5. Annual plant species turnover in 40 subplots (black circles; average values are in blue) for six vegetation types from 2011 to 2017. Linear mixed models indicated no significant differences in annual turnover during the monitoring period for any of the vegetation types (p = 0.291).

To assess the potential effect of vegetation management on changes in species turnover, we used individual subplot values from the above analysis to calculate average annual turnover values for each study span, ordered them from smallest to largest, highlighted values that occurred immediately after management, and visually examined the ordered and highlighted values for any apparent patterns (Figure 6). If high turnover values were associated with vegetation management, then the highest values would be shaded. We did not see this pattern (Figure 6), which indicated there was no clear relationship between vegetation management and species turnover. The species turnover analyses indicate right-of-way vegetation as a whole was stable over the monitoring period and that vegetation management did not appear to be associated with major changes in the presence of plant species.

Upland herb	J25	0.08	0.14	0.14	0.21	0.23	0.26
	J28	0.25	0.31	0.32	0.33	0.37	0.45
	N103	0.23	0.28	0.29	0.39	0.40	0.44
	S423	0.36	0.41	0.42	0.44	0.51	0.54
Upland scrub	A33	0.20	0.21	0.24	0.29	0.31	0.32
	A36	0.23	0.24	0.27	0.31	0.39	0.43
	N102	0.22	0.22	0.26	0.35	0.35	0.35
	N114	0.19	0.19	0.24	0.25	0.27	0.34
Upland shrub	A29	0.08	0.09	0.13	0.19	0.21	0.24
	J13	0.00	0.11	0.11	0.11	0.12	0.16
	J18	0.24	0.29	0.31	0.34	0.35	0.37
	S384	0.09	0.13	0.17	0.24	0.33	0.40
Upland tree	N112	0.10	0.13	0.15	0.15	0.20	0.24
	S364	0.14	0.27	0.32	0.33	0.36	0.38
	S372	0.11	0.15	0.15	0.20	0.23	0.28
	S442	0.11	0.23	0.27	0.30	0.33	0.38
Wetland cedar	A16	0.14	0.14	0.25	0.29	0.34	0.37
	A65	0.19	0.25	0.26	0.27	0.31	0.34
	J11	0.23	0.29	0.32	0.35	0.41	0.62
	J20	0.22	0.24	0.25	0.28	0.28	0.28
Wetland shrub	A147	0.17	0.21	0.22	0.25	0.26	0.32
	J27	0.11	0.14	0.15	0.15	0.18	0.23
	N115	0.17	0.20	0.21	0.23	0.24	0.27
	N81	0.20	0.23	0.24	0.25	0.32	0.47

Species Turnover

Min → Max

Figure 6. Plant species turnover in 24 right-of-way spans for six vegetation types. The annual turnover values for each span represent the average of ten subplots, and are ordered from minimum turnover (left) to maximum turnover (right). Shaded cells indicate turnover values that are associated with vegetation management events.

2) Plant Community Sustainability. For plant community sustainability, we tallied the number of vegetation management events used by the utility companies to maintain low-growth vegetation communities in the 24 study spans. To determine if management effort varied by vegetation type, we compared the number of management events among the six different habitat types. Based on 2010 – 2018 data provided by the utility companies for the 24 study spans, vegetation management occurred three times at four spans, twice at nine spans, and once at eleven spans (Figure 7). There was no significant difference in the number of management events between the six vegetation types (Figure 7).

To determine vegetation management return intervals in rights-of-way throughout the Pinelands, we calculated return intervals for Pinelands spans that were managed more than once based on data provided by the utility companies. A return interval, also known as a management cycle, is defined as the number of years elapsed between vegetation management events. Because only thirteen of the 24 study spans were managed more than once, we used the larger pool of 3,041 Pinelands spans for this analysis. To compare return intervals by the utility company and the type of prescription, we calculated the mean return interval for each utility company and for the two most common prescriptions, which are some variation of “cut trees manually” and “mow.” Not including the 24 study spans, a total of 1,745 spans were managed more than once and 1,272 spans were managed once or not at all. The return interval for 1,745 Pinelands spans that were managed more than once was 3-4 years (Figure 8). Return intervals were 2-3 years for PSE&G spans and 3-4 years for JCP&L and ACE spans (Figure 8). The return interval for “cut trees manually” spans was four years and for “mow” spans was 3-4 years. Despite some variability among the utility companies

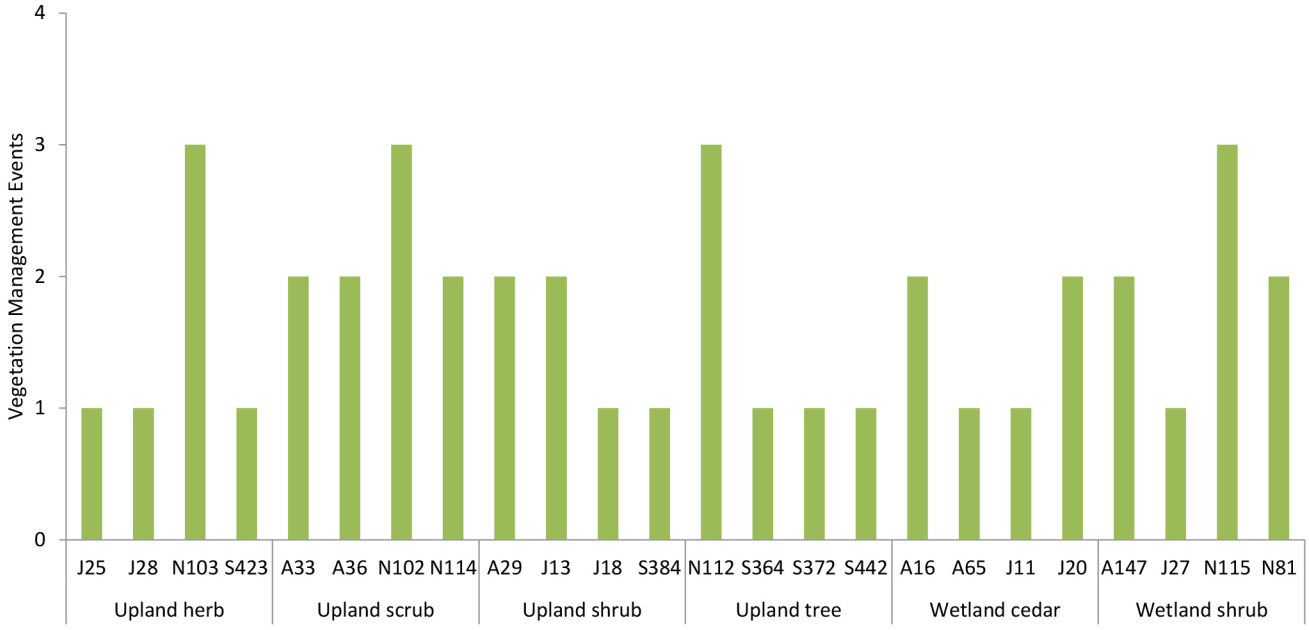

Figure 7. The number of vegetation management events for 24 right-of-way spans in six vegetation types from 2010-2018. There was no significant difference in the number of management events between the six vegetation types (One-way analysis of variance, $p = 0.634$).

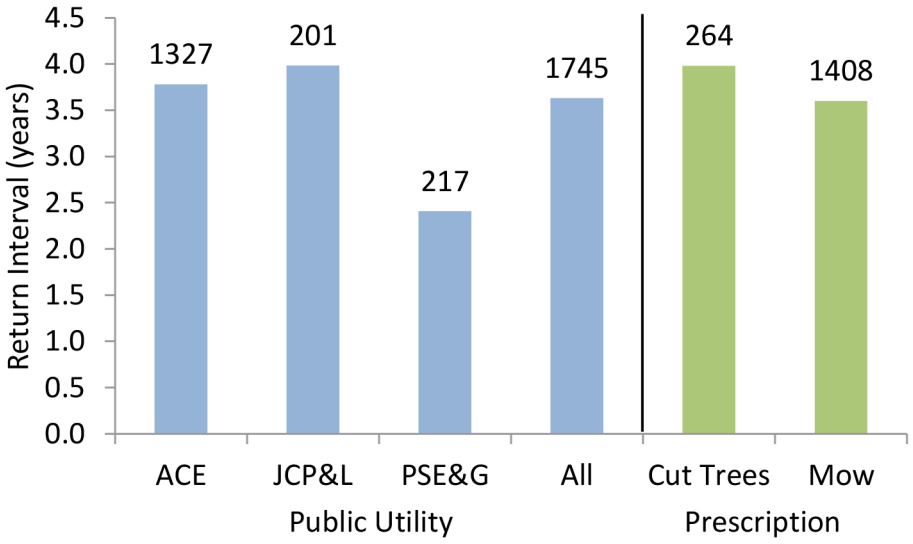

Figure 8. Average vegetation management return intervals for each utility company, for all spans combined, and for the two most common management prescriptions (i.e., "cut trees" and "mow"). Return intervals are based on data for 1,745 Pinelands rights-of-way that were managed more than once from 2010 through 2018. Numbers above the bars represent the number of spans used to calculate return intervals. Return intervals could not be calculated for 1,272 spans that were managed once or not at all during the same time period.

and the type of vegetation management prescription, 3- to 4-year return intervals were typically used to manage vegetation within Pinelands rights-of-way.

3) Characteristic Pinelands Plant Community. To determine if the managed right-of-way vegetation was similar to the surrounding Pinelands forest, we compared managed right-of-way and adjacent Pinelands forest plant communities for each of the six vegetation types. We established two 100-m² circular plots

in the forest adjacent to each of the 24 study spans and surveyed vegetation on a single occasion in June – July 2012 to identify all woody and herbaceous plant species and to determine the dominant shrub and herbaceous species based on plant leaf cover (Figure 4). We used species presence-absence data from the 2012 surveys of managed right-of-way vegetation plots and 2012 surveys of adjacent forest plots for this comparison. Because the overstory tree canopy is intact in the adjacent forest and removed in the managed rights-of-way, we made separate comparisons of woody and herbaceous plant communities. We also separately compared the number of woody and herbaceous species in managed right-of-way and adjacent forest plots for each of the vegetation types.

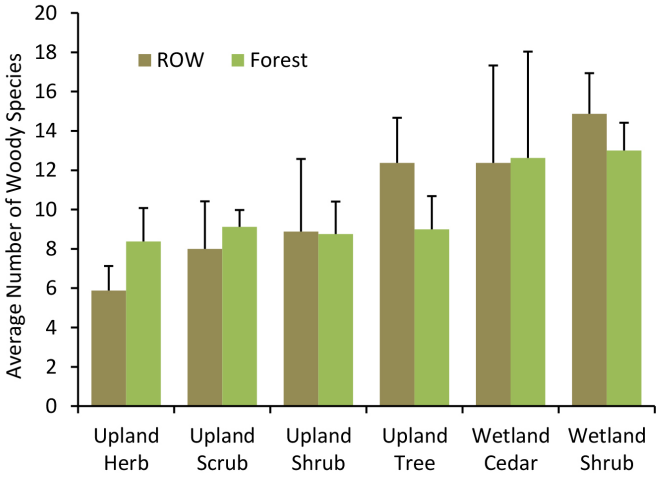

Figure 9. The average number (± one standard deviation) of woody species in managed right-of-way and adjacent-forest plots for six vegetation types. Managed right-of-way and adjacent-forest woody plant communities did not differ significantly for all vegetation types, with the exception of the upland herb type (Multi-response Permutation Procedure test, $p < 0.05$). For the upland herb type, the number of woody species was significantly higher in the adjacent forest (Mann-Whitney U test; $p < 0.05$).

Adjacent-forest plots at the study spans supported a total of 46 woody species and 35 herbaceous species (Table 2). Managed right-of-way and adjacent-forest woody plant communities did not differ significantly, with the exception of the upland herb type. For the upland herb spans, the number of woody species was higher in the adjacent forest (Figure 9). In contrast, herbaceous plant composition in managed right-of-way and adjacent forest communities differed for all vegetation types with the exception of the upland herb type. The number of herbaceous species found in the managed right-of-way plots was significantly greater than in the adjacent forest for all vegetation types except the upland herb type (Figure 10). These analyses indicate that woody vegetation of the managed right-of-way plots reflected the adjacent forest plots, but the managed and forest plots differed in the composition and number of herbaceous species. Differences in herbaceous vegetation may be related to conditions surrounding the removal of tree canopy in the managed rights-of-way.

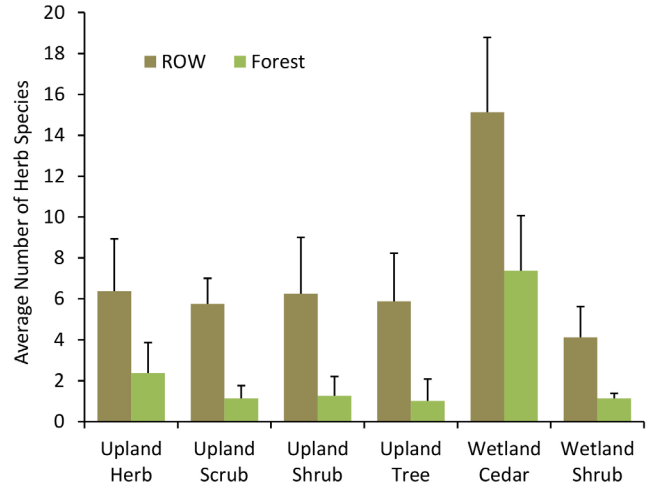

Figure 10. The average number (± one standard deviation) of herbaceous species in the managed right-of-way and adjacent-forest plots for six vegetation types. Managed right-of-way and adjacent-forest herbaceous plant communities were significantly different for all vegetation types (Multi-response Permutation Procedure test, $p < 0.05$), with the exception of upland herb ($p = 0.051$). The numbers of herbaceous species were significantly higher in the managed right-of-way for all vegetation types (Mann-Whitney U test; $p < 0.05$).

To determine whether vegetation in the managed right-of-way plots differed from areas associated with more physically altered and frequently accessed portions of the rights-of-way, we established four 1-m² plots near the base of towers and four 1-m² plots along the edge of access roads in each of the 24 study spans (Figure 4). These subplots were visited on a single occasion in June – July 2017 to identify all herbaceous and woody species present. We used species presence-absence data from the 2017 surveys of managed right-of-way plots and the 2017 surveys of tower and access road plots to compare managed right-of-way, tower, and access road plant communities. We also assessed the relative Pinelands character of the vegetation by comparing the percentage of native species and introduced species in managed right-of-way, tower, and access road plots. Native species are those species considered characteristic of the Pinelands based on a classification system adapted from Stone (1911; Bunnell and others 2018). Non-native species (Bunnell and others 2018) were not compared because the results would be the opposite of native species. Introduced species are those species originating outside the United States (USDA, NRCS 2021).

Table 5. Comparisons of plant communities located in managed right-of-way, access road, and tower plots for six span types using 2017 presence/absence data. Multi-response Permutation Procedure test *p* values < 0.05 (*) indicate a significant difference in the plant communities between the compared locations.

Span Type	Overall	ROW-Access	ROW-Tower	Access-Tower
Upland Herb	0.202	-	-	-
Upland Scrub	0.015*	0.005*	0.496	0.025*
Upland Shrub	0.153	-	-	-
Upland Tree	0.008*	0.006*	0.015*	0.230
Wetland Cedar	0.019*	0.008*	0.006*	0.771
Wetland Shrub	0.022*	0.006*	0.014*	0.576

Access-road plots at the study spans supported a total of 41 woody species and 84 herbaceous species (Table 2). Tower plots supported 45 woody species and 56 herbaceous species (Table 2). Managed right-of-way plant communities differed from tower plant communities for three of the six vegetation types, including wetland cedar, wetland shrub, and upland tree types (Table 5, Figure 11). Managed right-of-way vegetation also differed from access road communities for the same three vegetation types, along with the upland scrub type. Access road and tower plant communities were similar to each other, with the exception of the upland scrub vegetation type (Table 5).

Figure 11. Plant communities associated with access roads (top) and towers (bottom) generally differed from the interior of the right-of-way spans. A higher number of introduced species and a lower percentage of native Pinelands species were found near access roads and towers.

Managed right-of-way vegetation plots had a higher percentage of native Pinelands species than both

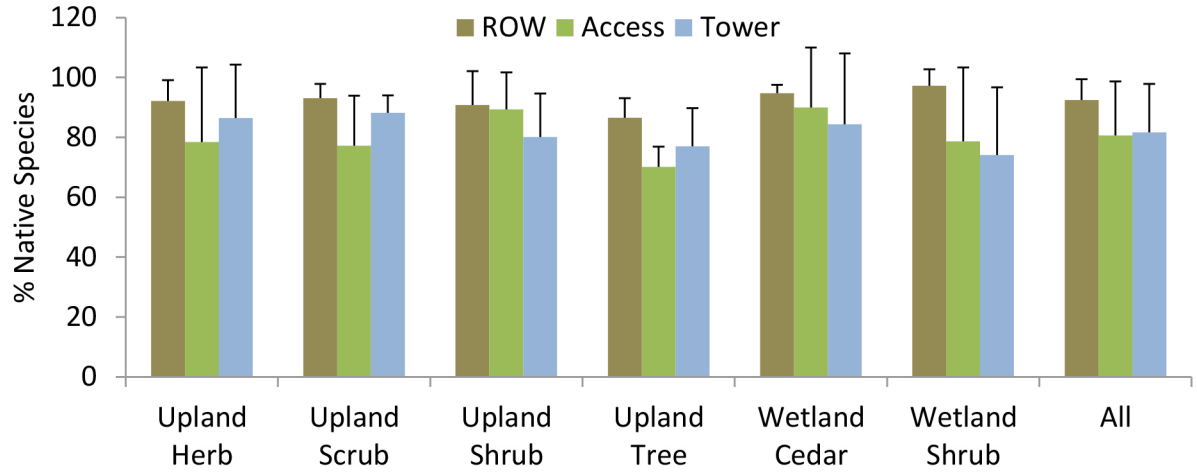

Figure 12. Pinelands native species (mean percentage ± one standard deviation) in managed right-of-way, access road, and tower plots for six vegetation types and for all spans combined. Managed right-of-way plots had a higher percentage of native Pinelands species than both tower and access road plots (Kruskal-Wallis H test, $p < 0.05$; "All" series). Differences in native Pinelands species did not reach statistical significance within vegetation types.

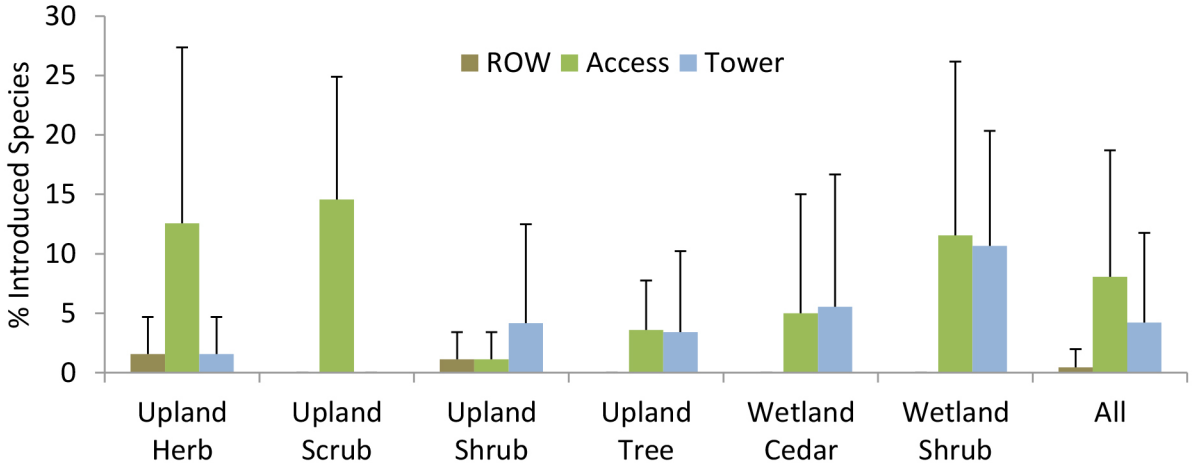

Figure 13. Introduced species (mean percentage ± one standard deviation) in managed right-of-way, access road, and tower plots for six vegetation types and for all spans combined. Managed right-of-way plots had a lower percentage of introduced species than both access road and tower plots (Kruskal-Wallis H test, $p < 0.05$; "All" series). Differences in introduced species did not reach statistical significance within vegetation types, with the exception of the upland scrub ($p < 0.05$).

tower and access road plots (Figure 12). Introduced species were primarily limited to access road and tower plots and nearly absent from managed right-of-way plots (Figure 13, Table 2). Four introduced species that were primarily found in access road and tower plots, including Asian bittersweet (*Celastrus orbiculatus*), autumn olive (*Elaeagnus umbellata*), Chinese bush-clover (*Lespedeza cuneata*), and Japanese stiltgrass (*Microstegium vimineum*), are considered invasive because these plants are known to displace native species in New Jersey plant communities (Snyder and Kaufman 2004).

These results indicate that, in general, managed right-of-way vegetation in the 24 study spans consisted of characteristic Pinelands plant species that reflected adjacent forest communities. Introduced species and a lower percentage of native Pinelands species were associated with transmission-line towers and access roads. Because native Pinelands species were low and introduced species were high in the more disturbed access road and tower plots, minimizing the width and number of access roads and the amount of disturbance at the towers may reduce the prevalence of non-Pinelands and introduced plant species in Pinelands rights-of-way.

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