New Jersey Pinelands Electric-transmission Right-of-way Vegetation-management Plan

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NEW JERSEY PINELANDS
ELECTRIC-TRANSMISSION RIGHT-OF-WAY
VEGETATION-MANAGEMENT PLAN

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INTRODUCTION

In 2006, the Pinelands Commission contracted with the Rutgers University Center for Remote Sensing and Spatial Analysis (CRSSA) to develop a span-by-span vegetation-management plan for the bulk-electric-transmission rights-of-way (ROWs) in the Pinelands Area. Bulk-transmission lines have a 69 kV capacity or greater. This ROW plan contains specific vegetation-management prescriptions for each of the 3,041 spans that compose the 233 mi (2,695 ac) of Pinelands ROWs. These ROWs are managed by three utility companies, including Public Service Enterprise Group (PSEG), Jersey Central Power and Light (JCP&L), and Atlantic City Electric (ACE), which is a Pepco Holdings, Inc. (PHI) company. The utility companies, along with the New Jersey Board of Public Utilities, were important partners in this project.

The specific goal of this project was to develop a ROW vegetation-management plan to create and maintain relatively stable and sustainable, early successional habitats that:

1. Represent characteristic Pinelands-reference habitats, such as scrub-shrub vegetation, emergent wetlands, and intermittent ponds;
2. Provide habitat for native Pinelands plants and animals, including threatened and endangered species;
3. Reflect the size, shape, and spatial distribution of characteristic Pinelands-reference habitats;
4. Reflect local soils and hydrologic features;
5. Reflect within-patch heterogeneity similar to characteristic reference habitats;
6. Maximize natural re-vegetation and minimize planting;
7. Are compatible with surrounding landscapes (e.g., locate grasslands adjacent to farmland);
8. Ensure transmission reliability and safety;
9. Require minimal subsequent management; and
10. Minimize the need for individual Pinelands permit reviews.

To accomplish this goal, a work plan was developed to complete the following five major tasks:

1. Task 1. Create a geographic-information system (GIS) database of bulk-electric-transmission rights-of-way in the Pinelands.
2. Task 2. Map and describe managed right-of-way and Pinelands-reference habitats.
3. Task 3. Compare patch and landscape characteristics of managed right-of-way and Pinelands-reference habitats.
4. Task 4. Summarize right-of-way vegetation-management strategies used by utility companies inside and outside the Pinelands.
5. Task 5. Develop a dynamic span-by-span vegetation-management plan for Pinelands rights-of-way.

In separate sections of this report, we describe the methods and results for each of these five tasks and provide recommendations regarding the implementation of the plan. The GIS layer that contains span-specific vegetation-management prescriptions is available on the Commission's web site at www.state.nj.us/pinelands/.

Task 1. Create a geographic-information-system database of bulk-electric-transmission rights-of-way in the Pinelands

The objective of this first task was to create a geographic-information-system (GIS) database that included a span-by-span GIS layer for Pinelands ROWs (ROW span layer), data from each utility company on historical vegetation-management activities, land-use/land-cover and soils data, and recent aerial photography. We used these data to complete various portions of the other tasks in this report. For this Task, we explain the collection of transmission-line data, describe the creation of the ROW span layer, and list the other data that was assembled in the database.

GIS Data Collection and Assembly

Transmission-line Data

In early 2006, we obtained geographic data for the bulk-electric-transmission lines for the Pinelands Area from each utility company. PSEG provided GIS polygon data, PHI supplied GIS line data for ACE, and JCP&L supplied geographic coordinates for each tower location in spreadsheet format. The data were imported, extracted, and re-formatted into a single GIS layer in ArcGIS (Environmental Systems Research Institute, Redlands CA., USA, 1999-2006) software (Figure 1.1).

ROW Span Layer

To create the ROW span layer, we used the re-formatted GIS layer and mapped the transmission lines between substations to identify individual circuits and confirm geographic coverage. Using aerial photographs from 2002 and 2006, utility towers were located and a standard ROW buffer width for that particular circuit was applied to create a polygonal coverage (Figure 1.2). The buffer widths varied by utility company and roughly corresponded to the boundaries of the existing managed ROW corridor visible from the aerial photographs.

For each tower that was visible on the aerial photographs, boundaries were generated to separate the circuits into individual polygons or spans (Figure 1.2). A span is the portion of a ROW between two adjacent towers. We assigned a unique alpha-numeric identifier to each span that included information on the utility company, circuit, and span number.

There were situations in which multiple lines and/or circuits shared the same ROW corridor. Up to seven circuits shared the same corridor in some locations. For most cases with multiple circuits, the spans in that corridor were subdivided into parallel sets of spans (Figure 1.3). The resulting ROW span layer included 233 miles of Pinelands ROWs, contained 3,041 individual spans, and covered 2,695 acres. The ROW span layer served as the foundation for the project because it represented the boundary for mapping vegetation within Pinelands ROWs and allowed for linking span-by-span vegetation-management prescriptions to specific geographic areas of the Pinelands.

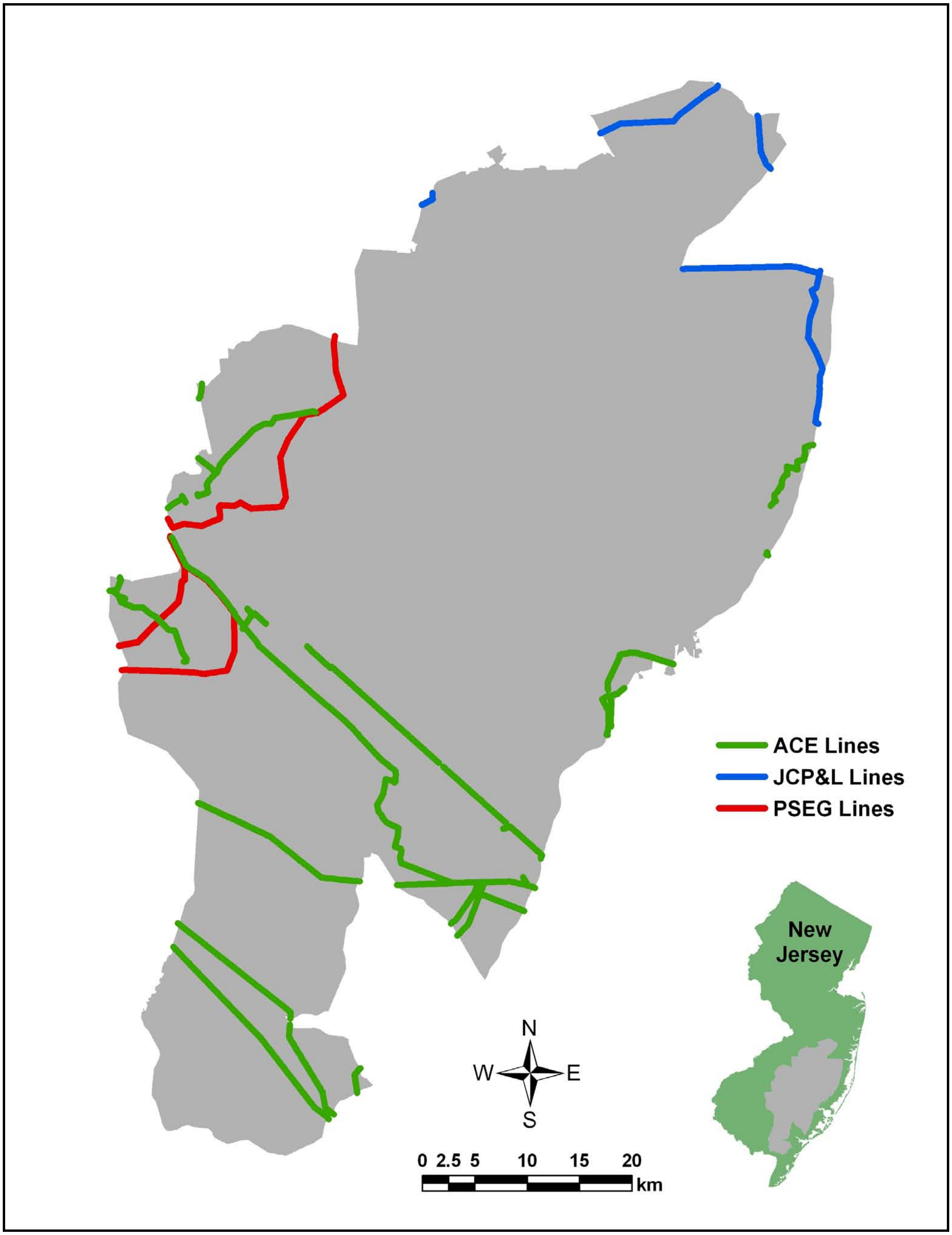

Figure 1.1. The GIS layer of bulk-electric transmission-line rights-of-way in the Pinelands Area managed by Atlantic City Electric (ACE), Jersey Central Power and Light (JCP&L), and Public Service Enterprise Group (PSEG). The Pinelands Area is shown in gray.

Other Data Collected for the Database

We obtained information from utility company representatives on both vegetation-management techniques that they currently use in the Pinelands and also historical vegetation-management data. The geographic extent and detail of the historical data received from each utility company varied. PSEG provided span-by-span records of past management in GIS format (Figure 1.4), JCP&L supplied span-specific information only on recommended management activities, and ACE offered a report that provided general recommendations for all of their ROWs (PHI 2006).

Other GIS data and digital-image data were compiled and added to the project database. These data included:

1. NJDEP 1995/1997 land-use/land cover (LU/LC): New Jersey Department of Environmental Protection (NJDEP), Office of Information Resources Management (OIRM), Bureau of Geographic Information Systems (BGIS). *NJDEP 1995/1997 Land use/Land cover Update.* Edition 1.3 (FINAL). Trenton, New Jersey. http://www.state.nj.us/dep/gis/lulc95shp.html

2. NJDEP 2002 land-use/land cover (LU/LC): New Jersey Department of Environmental Protection (NJDEP), Office of Information Resources Management (OIRM), Bureau of Geographic Information Systems (BGIS). *NJDEP 2002 Land use/Land cover Update.* Edition 20080304. Trenton, New Jersey. http://www.state.nj.us/dep/gis/lulc02shp.html

3. NRCS SSURGO soils data: United States Department of Agriculture, Natural Resources Conservation Service. *Soil Survey Geographic (SSURGO) Database*. Published 20061207. Fort Worth, Texas. http://soils.usda.gov/survey/geography/ssurgo/

4. 2002 digital aerial photography: State of New Jersey Office of Information Technology, Office of Geographic Information Systems. Color infrared, acquired February/March, 2002. *New Jersey 2002 High Resolution Orthophotography*. Published 20030731. Trenton, New Jersey. http://njgin.state.nj.us/

5. 2006 digital aerial photography: United States Department of Agriculture (USDA)-Farm Service Agency (FSA) Aerial Photography Field Office (APFO). Source scale 1:40,000, Natural color, acquired August 2006. *USDA-FSA APFO NAIP MrSID Mosaics, 2006*. Published 2006. Salt Lake City, Utah. http://www.fsa.usda.gov/

6. 2007 digital aerial photography: State of New Jersey Office of Information Technology, Office of Geographic Information Systems. Color infrared, acquired March, 2007. *New Jersey 2007 High Resolution Orthophotography*. Published 20081001. Trenton, New Jersey. http://njgin.state.nj.us/

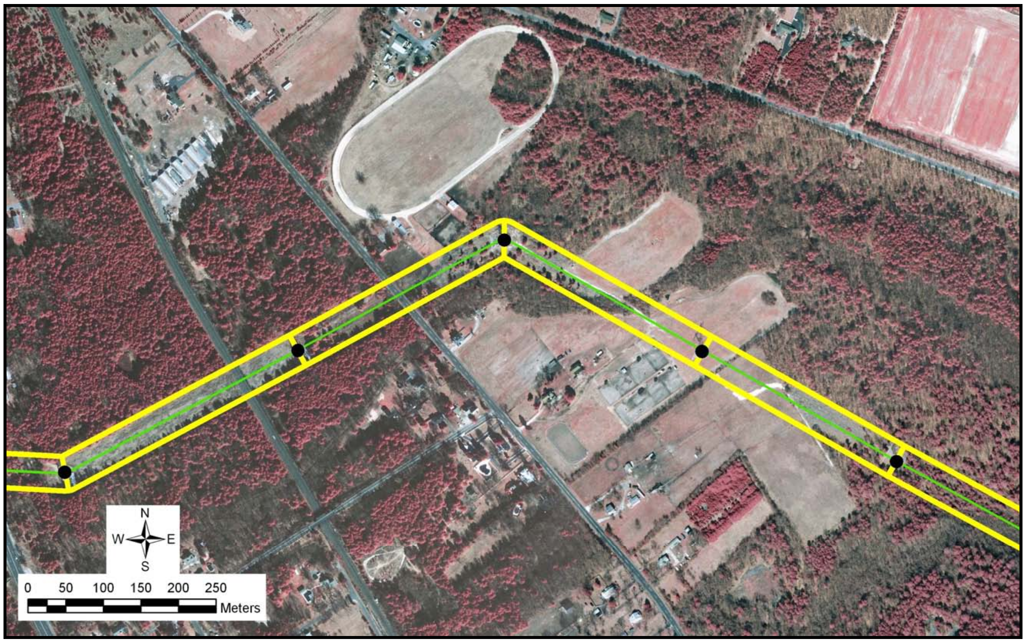

Figure 1.2. An example of a single ROW corridor with individual spans in yellow, the circuit path in green, and tower locations as black dots on a 2002 aerial photograph.

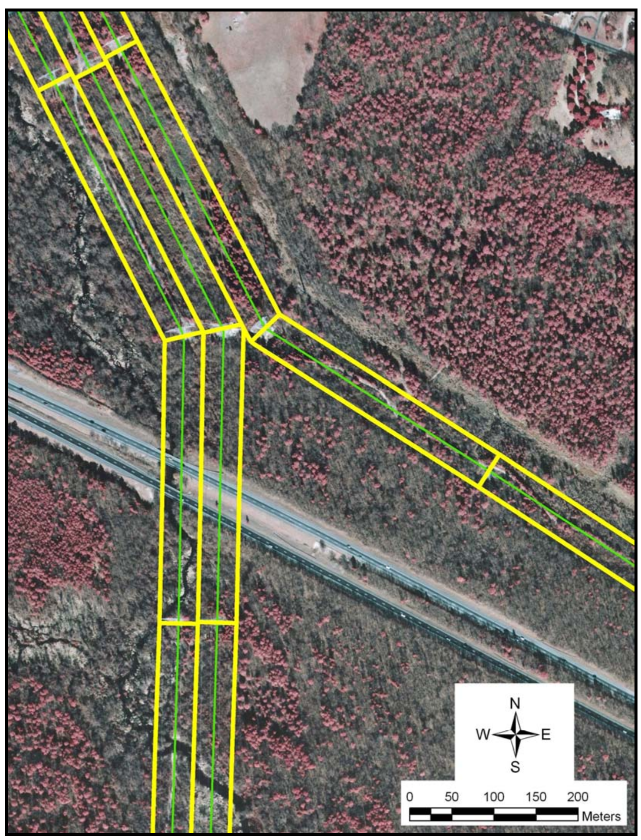

Figure 1.3. An example of parallel ROW corridors with spans in yellow and circuit paths in green on a 2002 aerial photograph.

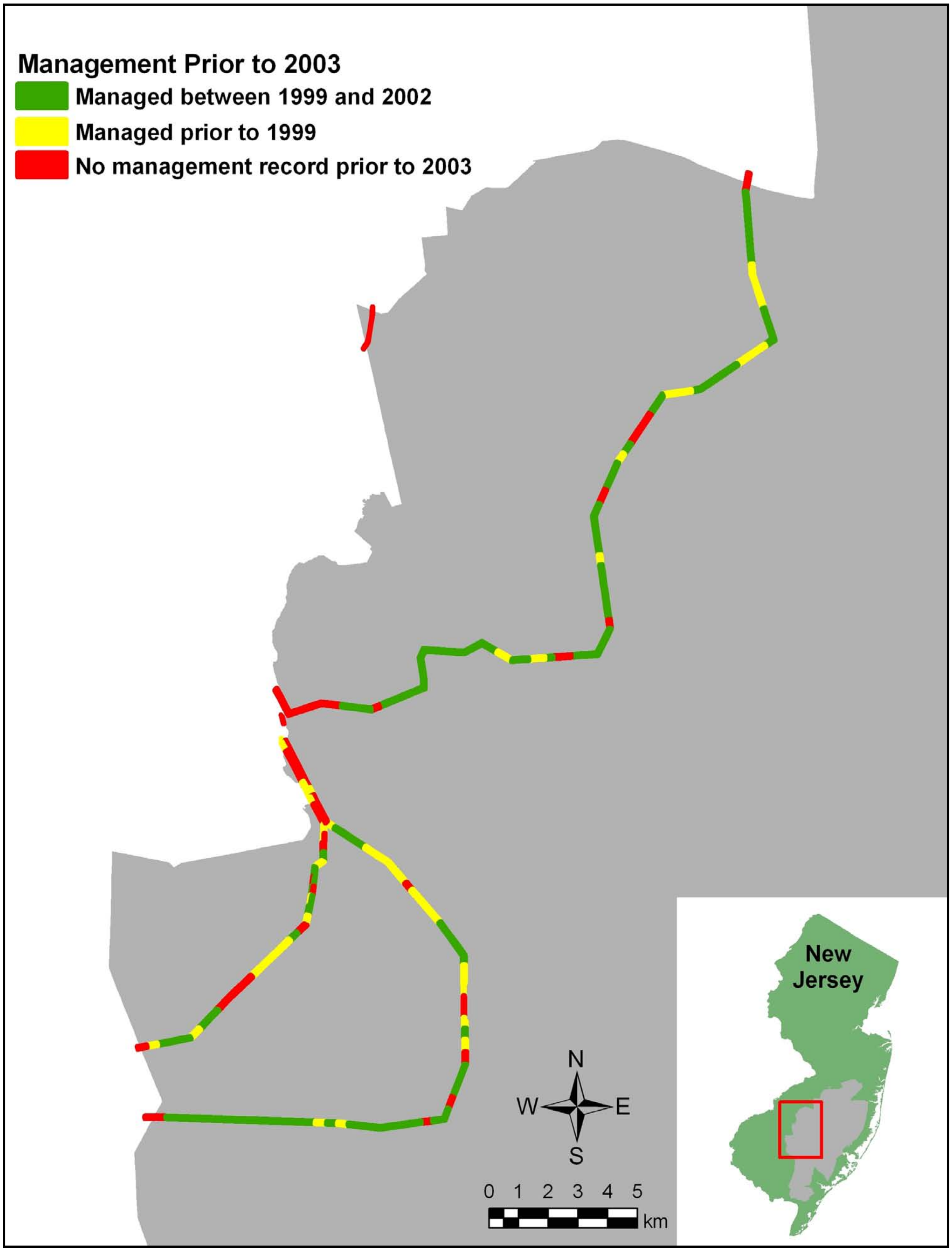

Figure 1.4. Vegetation-management history for a selected portion of bulk-electric transmission-line rights-of-way in the Pinelands Area. The Pinelands Area is shown in gray.

TASK 2. MAP AND DESCRIBE MANAGED RIGHT-OF-WAY AND PINELANDS-REFERENCE HABITATS

As mentioned in the Introduction, one of the goals of this project was to develop a ROW vegetation-management plan to create and maintain relatively stable and sustainable, early successional habitats that reflect the size, shape, and spatial distribution of characteristic Pinelands-reference habitats. To address this goal, the first step was to identify the structural attributes of vegetation associated with both the managed-ROW and Pinelands-reference habitats. To accomplish this, we mapped land cover in the managed-ROW habitats and in a randomly selected sample of Pinelands-reference habitats. We used data collected from field sampling in both ROW and reference habitats to assess the accuracy of the created maps. For this Task, we describe the random sampling of reference habitats and the mapping process and accuracy assessment results for ROW and reference habitats. The maps were then used in Task 3 of the report to compare various patch and landscape characteristics of ROW and reference habitats.

METHODS

Random Sample of Pinelands-reference-habitat Patches

We selected a sample of Pinelands-reference-habitat patches from outside the managed-ROW corridors to typify 'early successional' vegetation types characteristic of the broader Pinelands ecosystem. The reference-habitat data were created by extracting the early successional patch types from the NJDEP 1995/97 land-use/land-cover (LU/LC) data. The source for these data is listed at the end of Task 1. Early successional patch types included a variety of scrub/shrub, emergent marsh, and old-field cover types (Table 2.1).

Table 2.1. The number of patches, quartile patch-size values, and area values for all Pinelands-reference-habitat patches and the random sample of reference-habitat patches. These patch types represent the early successional patch types from in the NJDEP 1995/97 land-use/land-cover data. Refer to Table 2.2 for explanation of land-use/land-cover codes.

	All Reference-patch Types					Random Sample of Reference-patch Types						
	# of	Patch-size Quartiles			Total	# of	Patch-size Quartiles			Sample	% of	% of Total
NJDEP LU/LC Patch Type	Patches	25th	50th	75th	Area	Patches	25th	50th	75th	Area	Total Area	# of Patches
Upland-patch Types												
Coniferous brush/shrubland	1,906	1.6	2.9	5.9	22,268	110	1.6	3.1	5.8	1,121	5.0	5.8
Deciduous brush/shrubland	1,493	1.6	2.9	6.2	13,731	85	1.8	2.7	5.8	726	5.3	5.7
Mixed brush/shrubland	1,793	1.9	3.4	7.2	17,477	99	2.1	3.6	8.5	1,005	5.7	5.5
Old field	1,972	1.6	2.6	5.1	10,609	107	1.5	2.6	4.9	662	6.2	5.4
Wetland-patch Types												
PEM	1,381	1.2	2.4	5.4	9,603	74	1.1	2.2	6.4	495	5.2	5.4
PEM/PSS	349	3.3	7.1	15.8	5,388	21	3.5	5.4	15.8	270	5.0	6.0
PSS/PFO	285	3.2	8.0	15.5	3,864	18	1.3	8.8	17.0	196	5.0	6.3
PSS1	2,904	1.4	2.9	6.5	17,510	152	1.0	2.2	6.7	888	5.1	5.2
PSS1/3, PSS1/8	342	2.9	5.3	9.8	2,725	18	2.7	4.8	11.7	172	6.3	5.3
PSS1/4	612	2.3	4.9	10.1	5,913	35	2.1	3.7	8.4	321	5.4	5.7
PSS3	172	2.3	4.4	10.3	1,719	12	1.9	3.9	14.0	103	6.0	7.0
PSS4/1	434	2.6	5.5	13.9	6,412	24	2.6	4.4	11.9	332	5.2	5.5
PSS4	471	1.7	3.5	8.0	3,961	27	2.4	4.3	9.1	209	5.3	5.7
PSS8	428	1.8	4.2	9.1	3,952	26	1.6	4.2	6.8	207	5.2	6.0

We selected a random sample of each early successional patch types from the LU/LC data that was equivalent to about 5% of the total area of each patch type, which also represented about 5% of the total number of patches of each patch type. The number of patches and quartile patch-size and total-area values were generated for the entire population of reference-patch types and for the sample of reference-patch types. Qualitatively, the summary statistics for the sample were similar to those for the entire population of reference-habitat patches (Table 2.1).

Mapping ROW and Reference Habitats

We mapped land cover for the entire inventory of managed-ROW habitats and the random sample of Pinelands-reference habitats (Figures 2.1 and 2.2). The NJDEP 1995/97 LU/LC boundaries were used as a starting point because the 2002 LU/LC data were not available when this work was completed. For the ROW patches and the sample of reference patches, the LU/LC data were modified as needed with additional photointerpretation using the 2002 aerial photographs. Mapping was conducted at a backdrop photo scale of approximately 1:2,500. Boundaries of distinct homogeneous-vegetation patches were delineated based on a 0.25 acre (1,000 m^2) minimum-mapping unit. For the ROW habitats, distinct access roads were mapped as separate polygons. All mapping was completed in the state-plane coordinate system.

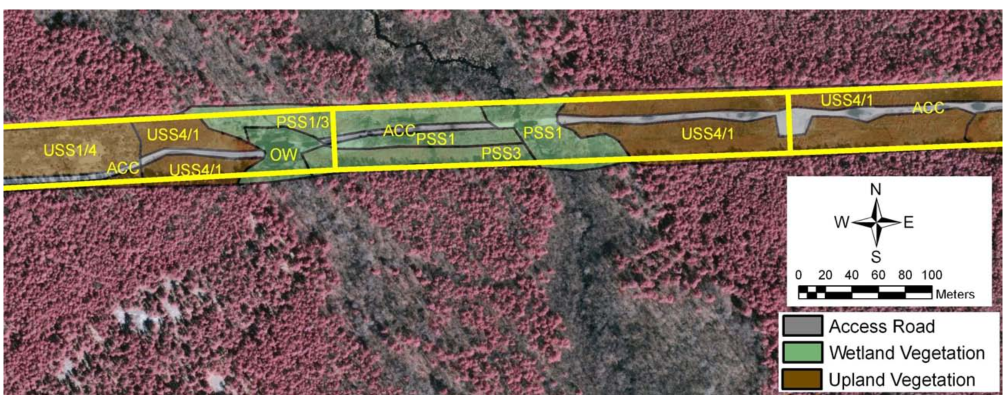

Figure 2.1. Example of land-cover mapping completed for managed-ROW habitats. See Table 2.2 for explanation of land-cover codes.

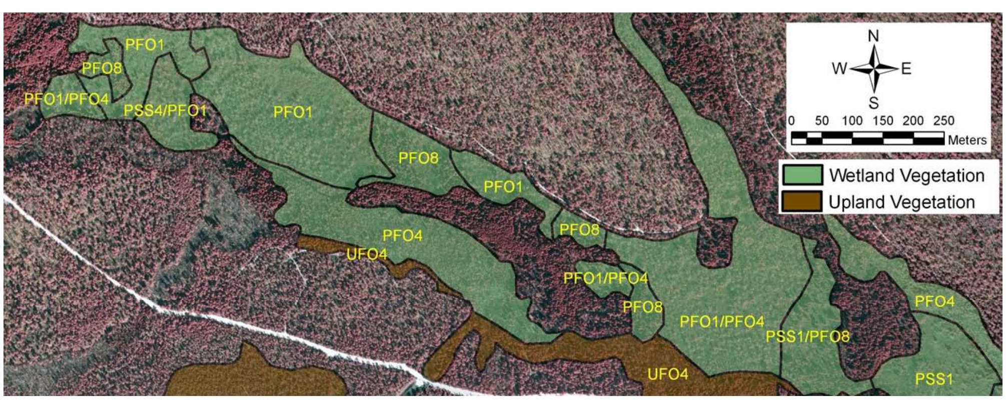

Figure 2.2. Example of land-cover mapping completed for Pinelands-reference habitats. See Table 2.2 for explanation of land-cover codes.

We classified the resulting ROW and reference-habitat patches into upland and wetland cover types (Table 2.2). The upland classification applied was a modified Anderson scheme, the same as that used in the NJDEP 1995/97 LU/LC data. The wetlands mapping used the U. S. Fish and Wildlife Service National Wetland Inventory classification scheme (Cowardin 1979). Dominant and subordinate vegetation components were included in the classification as needed. For example, palustrine scrub/shrub with deciduous shrubs (PSS1) as the dominant component and needle-leaved evergreen shrubs (PSS4) as the subordinate component was denoted as PSS1/4. The percentage cover for the dominant-vegetation-layer components (i.e., tree, shrub, herb, bare ground) was estimated separately using a ranked scale of 1 to 5 (low to high). This ranking was based on the Braun-Blanquet cover scale, where 1 = <5%, 2 = 5-25%, 3 = 25-50%, 4 = 50-75%, and 5 = >75% cover (Mueller-Dombois and Ellenberg 1974).

Field Sampling of ROW and Reference Habitats

To assess the accuracy of the photo-interpretation and mapping described above and to characterize the vegetation structure and composition of the managed-ROW and Pinelands-reference habitat patches, we field surveyed selected patches during the leaf-on period of May through October in 2006. We selected patches for field surveys of ROW and reference habitats using two criteria. First, the proportion of wetland to upland patches in the selected field-survey patches matched that for the ROW and reference habitats. Secondly, to facilitate access and minimize travel time, reference patches were selected from areas within 100 m of a paved road (based on New Jersey Department of Transportation series 600 roads or above) and managed-ROW patches were selected from areas within 800 m (0.5 mi) of a paved road. ROW patches were not selected from the first span along the paved road.

The selected patches were then visited. For reference-habitat patches, we used a global-positioning system (GPS) to navigate to the patches. For ROW patches, we used the ROW span layer as a guide. The entire length of the selected ROW patch was walked along the access road. For all of the ROW and reference patches surveyed, we classified the LU/LC of each patch noting both dominant and subordinate cover types. To characterize the structural composition of the patches, we ranked the percentage cover of the tree, shrub, herb and ground layers and deciduous versus coniferous cover using the 1 to 5 ranks from the Braun-Blanquet scale. Trees were defined as single-stem woody plants >6 m in height. Scrub/shrub was defined as woody plants <6 m tall.

For ROW and reference habitats, the height of the majority of the scrub/shrub layer was estimated for patches with scrub/shrub >1.5 m. We estimated the species dominance of the tree, shrub, and herb layer using the following scheme: dominant (>50%), co-dominant (25-50%), present (<25%), and rare (<5%). We also noted the composition of the ground layer as woody debris, leaf litter, or bare soil. We took two digital color photographs of each ROW patch shooting from the center of the patch looking toward the opposite towers. We also photographed reference patches. The type of past vegetation-management activity (e.g., mowing, trimming, topping, etc.) and the time since that activity occurred was estimated for ROW patches.

Table 2.2. Level I and II land-use/land-cover classification for managed-ROW and Pinelands-reference habitats. Patches were originally mapped and classified to level III, but levels I and II are shown because only these two levels were included in the analyses. Various level III combinations of deciduous (1), broad-leaved evergreen (3), needle-leaved evergreen (4), or Atlantic white cedar (8) are classified as mixed in the level II classification (e.g., PFO_MIX). Combinations of two different classes (e.g., PFO_PSS) were also mixed.

Level I Class	Level II Class	Description of Level II Class
PFO		Palustrine Forest
	PFO1	Palustrine Forest, Deciduous
	PFO4	Palustrine Forest, Needle-leaved Evergreen
	PFO8	Palustrine Forest, Atlantic White Cedar
	PFO_MIX	Palustrine Forest, Mixed
	PFO_PSS	Palustrine Forest/Palustrine Scrub/shrub, Mixed
PSS		Palustrine Scrub/shrub
	PSS1	Palustrine Scrub/shrub, Deciduous
	PSS3	Palustrine Scrub/shrub, Broad-leaved Evergreen
	PSS4	Palustrine Scrub/shrub, Needle-leaved Evergreen
	PSS8	Palustrine Scrub/shrub, Atlantic White Cedar
	PSS_MIX	Palustrine Scrub/shrub, Mixed
	PSS_PEM	Palustrine Scrub/shrub/Palustrine Emergent Marsh, Mixed
EM		Emergent Marsh
	PEM	Palustrine Emergent Marsh
	PSS_PEM	Palustrine Scrub/shrub/Palustrine Emergent Marsh, Mixed
	EEM	Estuarine Emergent Marsh
USS		Upland Scrub/shrub
	USS1	Upland Scrub/shrub, Deciduous
	USS3	Upland Scrub/shrub, Broad-leaved Evergreen
	USS4	Upland Scrub/shrub, Needle-leaved Evergreen
	USS_MIX	Upland Scrub/shrub, Mixed
	USS_UFO	Upland Scrub/shrub/Upland Forest, Mixed
UFO		Upland Forest
	UFO1	Upland Forest, Oak
	UFO4	Upland Forest, Pine
	UFO_MIX	Upland Forest, Mixed
	UFO_USS	Upland Forest/Upland Scrub/shrub, Mixed
OLDF	OLDF	Old Field
OTHER		Other: Bare Land, Beach, Open Water
	BARE	Bare Land, Beach
	OW	Open Water
ALT		Altered Land
	ACC	ROW Access Road
	DEV	Urban/developed
	EXT	Extractive Mining
	AG	Agriculture

Accuracy Assessment of ROW and Reference Habitats

To assess the accuracy of the photo-interpretation and mapping described above for the ROW and reference patches, we compared the LU/LC class designated for the aerial-photo-interpreted patches to the class assigned to the patches in the field. A total of 275 ROW and 89 reference patches were available for the comparison of the mapped and the field-surveyed dominant LU/LC class. The patches in which the mapped and field classifications did not match were flagged for further inspection to determine if there was a consistent bias in the aerial photo-interpretation and mapping. As part of this further examination, we evaluated other patch-attribute data, such as co-dominant class, dominant species list, field observations on recent vegetation-management actions, and available ground photographs. We also referred to the 2002 color-infrared leaf-off aerial photography and the leaf-on summer of 2006 USDA FSA APFO color imagery (see Task 1 for imagery sources and Figure 2.3 for an example of each).

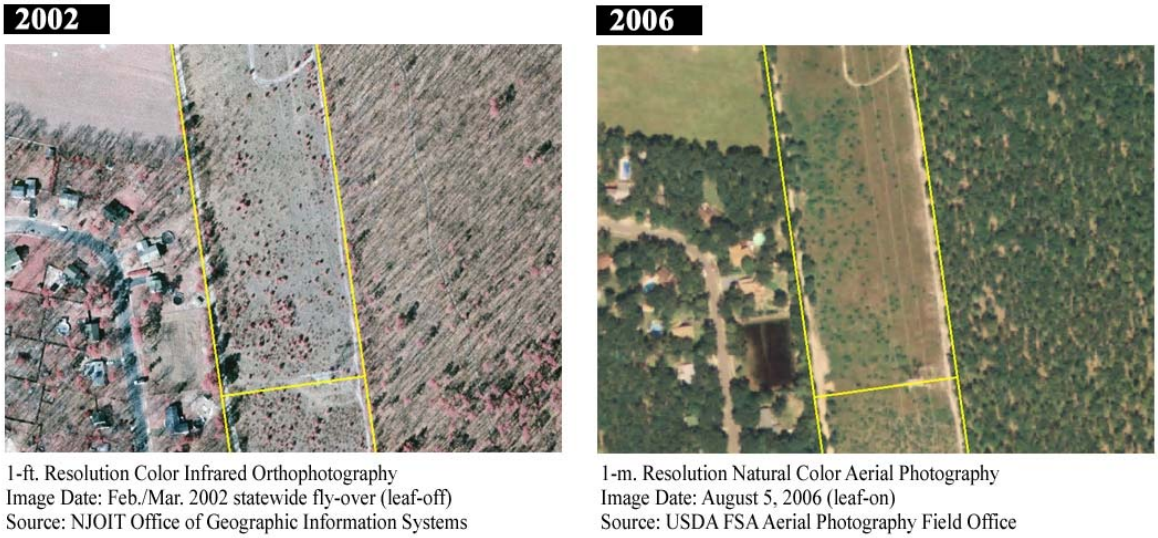

Figure 2.3. Comparison of 2002 color-infrared leaf-off aerial photography and 2006 color leaf-on photography for a selected portion of Pinelands ROW.

RESULTS

Accuracy Assessment for Managed-ROW Mapping

Of the 275 patches included in the accuracy assessment for the managed-ROW habitats, the dominant LU/LC class for 133 patches correctly matched between the aerial-photo-interpreted and the field classifications (Table 2.3). The other 142 patches did not match initially so additional data from these patches were evaluated to help explain the discrepancies between the interpreted and field classifications. Nineteen of the mismatched patches were a partial match because the dominant/co-dominant classifications shared at least one cover type. Eighteen of the 142 patches did not match because of incorrect aerial-photo-interpreted classifications. These 18 patches included eight patches where uplands and wetlands were confused and ten patches with other miscellaneous misclassifications.

Thirty-five of the mismatched patches did not match initially due to three types of incorrect field classifications (Table 2.3). The first type of incorrect field classification was a mismatch for 17 patches because of a discrepancy between the species list compiled in the field and the dominant/co-dominant classification originally given in the field. These 17 patches were considered a correct or partial match when the dominant/co-dominant classifications were corrected to match the species list and Braun-Blanquet ranks from the field data. The second type of incorrect field classification was a mismatch for six patches that occurred when the field data characterized only a portion of the larger patch. The third type of incorrect field classification was a mismatch for 12 patches in which there was an unaccountable difference between the dominant/co-dominant classification given in the field, the species data collected in the field, and the aerial photos (e.g., an old field classification for an area that is clearly heavily forested).

Seventy mismatched patches were a mismatch due to a temporal difference in land cover (Table 2.3). The aerial photographs used to classify the managed-ROW patches were from 2002 and the field work was completed in 2006. Vegetation in those patches was managed during that period resulting in a mismatch.

From the original 275 managed-ROW patches available for the assessment, we deleted the six patches in which the field data only characterized a portion of the larger patch, the 12 patches with an unaccountable difference, and the 70 patches with a temporal difference (Table 2.3). This resulted in a total of 187 possible patches to use in the assessment. We added the number of patches that correctly matched (133) to those with a partial match (36) for a total of 169 correct patches. The 169 correct patches out the possible 187 patches resulted in a 90% accuracy for the managed-ROW mapping.

Table 2.3. Results of the comparison of LU/LC classifications from aerial-photo-interpretations and field-survey data for 275 managed-ROW patches.

Results from Comparison of Mapped and Field Classification	Correct or Partial Match	Incorrect LU/LC Classification	Deleted From Analysis
Correct Match	133	-	-
Partial Match			
ROW and field patch shared at least one dominant or co-dominant cover type	19	-	-
Incorrect aerial-photo classification			
Confusion between uplands and wetlands	-	8	-
Other misclassification	-	10	-
Incorrect field classification			
Mismatch between field species list and LU/LC classification in the original field data			
Full or partial match when LU/LC classification is corrected to match species list and dominant/co-dominant scale from field	17	-	-
Field data characterized only a portion of the whole patch	-	-	6
Unaccountable difference between LU/LC classification given in the field and the species data from the field and the aerial-photo interpretation	-	-	12
Temporal difference due to vegetation-management activities between 2002 and 2006.	-	-	70
Total	169	18	88

Accuracy Assessment for Pinelands-reference Mapping

Of the 89 patches included in the accuracy assessment for Pinelands-reference habitats, the dominant LU/LC classification derived from the aerial-photo interpretations correctly matched the field classifications for 45 patches (Table 2.4). The other 44 patches did not match initially so additional data from these patches were evaluated to help explain the discrepancies between the interpreted and field classifications. Nine of the 44 patches were a partial match because the dominant/co-dominant classifications shared at least one cover type. Eleven of the 44 patches did not match because of incorrect aerial-photo-interpreted classifications. These 11 patches included three patches where PFO4 and PFO8 were confused, four patches where uplands and wetlands were confused, and four patches with other miscellaneous misclassifications.

Table 2.4. Results of the comparison of LU/LC classifications from aerial-photo-interpretations and field-survey data for 89 Pinelands-reference patches.

Results from Comparison of Mapped and Field Classification	Correct or Partial Match	Incorrect LU/LC Classification	Deleted From Analysis
Correct Match	45	-	-
Partial Match			
ROW and field patch shared at least one dominant or co-dominant cover type	9	-	-
Incorrect aerial-photo classification			
Confusion between PFO4/PFO8	-	3	-
Confusion between uplands and wetlands	-	4	-
Other misclassification	-	4	-
Incorrect field classification			
Mismatch between field species list and LU/LC classification in the original field data			
Full or partial match when LU/LC classification is corrected to match species list and dominant/Co-dominant scale from field	7	-	-
Difference unable to be resolved	-	-	1
Field data only characterized a portion of the whole patch	-	-	3
Unaccountable difference between LU/LC classification, species data from field, and aerial-photo interpretation	-	-	11
Altered-land covers not representative of reference habitats	-	-	2
Total	61	11	17

Twenty-two of the 44 patches did not match initially due to three types of incorrect field classifications (Table 2.4). The first type of incorrect field classification was a mismatch for eight patches because of a discrepancy between the species list compiled in the field and the dominant/co-dominant classification originally given in the field. Of these eight patches, seven were considered a correct or partial match when the dominant/co-dominant classifications were corrected to match the species list and Braun-Blanquet ranks from the field data. No reason for the other mismatched patch could be identified. The second type of incorrect field classification was a mismatch for three patches that occurred when the field data characterized only a portion of the larger patch. The third type of incorrect field classification was a mismatch for 11 patches in which there was an unaccountable difference between the dominant/co-dominant classification given in the field, the species data collected in the field, and the aerial photos (e.g., an old field classification for an area that is clearly heavily forested). Two patches were dominated by human-altered land-cover types (e.g., grass median), which are not representative of Pinelands-reference habitats.

From the original 89 reference patches available for the accuracy assessment, we deleted the patch in which the reason for the mismatch could not be identified, the three patches in which the field data only characterized a portion of the patch, the 11 patches with an unaccountable difference, and the two patches that were not representative of Pinelands-reference habitats (Table 2.4). This resulted in a total of 72 possible patches to use in the assessment. We added the number of patches that correctly matched (45) to those with a partial match (16) for a total of 61 correct patches. The 61 correct patches out the possible 72 patches resulted in an 85% accuracy for the reference mapping.

TASK 3. COMPARE PATCH AND LANDSCAPE CHARACTERISTICS OF MANAGED RIGHT-OF-WAY AND PINELANDS REFERENCE HABITAT TYPES

As mentioned in the Introduction, one of the goals of this project was to prepare a ROW vegetation-management plan to create and maintain relatively stable and sustainable, early successional habitats that reflect the size, shape, and spatial distribution of characteristic Pinelands-reference habitats. Using the spatial-analysis capabilities of GIS software, we measured a variety of landscape-pattern indices using the digitized mapped boundaries of the managed-ROW and the random sample of Pinelands-reference habitats. To determine if ROW habitats were similar to reference habitats, we compared patch structure, composition, size, shape, and diversity and the landscape setting between ROW and reference habitats. We also determined the spatial relationship between ROW patch types and patch types in the adjacent landscape to assess whether or not ROW patches were compatible with the surrounding landscape.

METHODS

ROW and Reference Land-cover Class Composition

For this analysis, we compared the overall LU/LC class composition of managed-ROW and the sample of Pinelands-reference habitats. We determined the number of patches, the area, and the percentage area for Level I classes (Table 2.2) and qualitatively compared these values between ROW and reference habitats.

ROW and Reference Patch Size, Shape, and Diversity

We compared the patch size, shape, and diversity for managed-ROW and the sample of reference habitats. For both ROW and reference habitats, patch size and patch shape metrics were generated for Level I classes, whereas the patch diversity measures were determined for Level II classes (Table 2.2).

Patch-shape Metrics. We used two different software programs to generate a full suite of landscape-pattern indices for each Level I class for ROW and the sample of reference habitats. The landscape-pattern indices included the size, edge, shape, area-weighted shape, perimeter to area ratio, and area-weighted fractal dimension for each patch. The two programs, V-Late 1.1 and Patch Analyst 3.1, consisted of ArcGIS plug-in/extensions and operated in polygon vector mode re-projected from state plane to a universal transverse mercator (UTM) map projection (UTM was required by the V-Late software). V-Late 1.1 (ArcMap 9 plug-in) was initially used as the primary plug-in with Patch Analyst 3.1 (ArcView 3.x extension) used to validate the V-Late results. The validation outputs from Patch Analyst were consistent with V-Late results. Patch Analyst provided additional landscape metrics not available in V-Late and vice-versa, therefore, both the V-Late and Patch Analyst output tables were included in the analysis.

A non-parametric Wilcoxon Rank Sum test (2-sided t approximation) was used to assess differences between the ROW and reference-patch metrics for each Level I class using the SAS statistical package (SAS Institute Inc., Cary, NC, USA, 2002-2003). Because we completed multiple tests, we employed the conservative standard Bonferonni correction to the *p*-value. The seven patch types for each landscape metric resulted in a corrected *p*-value of 0.007 (α level = 0.05/7).

Patch-diversity Metrics. We calculated land-cover class richness and the Shannon-Weiner index to compare land-cover diversity between the managed-ROW and the sample of Pinelands-reference habitats. Class richness was the number of class types for ROW and reference habitats. The Shannon-Weiner index reflects the abundance and evenness of patch types in ROW and reference habitats using the formula:

$$H' = -\sum_{i=1}^{S} (p_i)(\ln p_i)$$

where:

H' = Shannon-Weiner index of diversity,
S = number of patches or patch size,
i = land-use/land-cover type, and
p_i = proportion of measurements in class i.

We calculated the Shannon-Weiner diversity index for ROW and reference habitats using both the number of patches and patch size. Diversity and class richness values were determined using the Level II classification (Table 2.2).

Vegetation Adjacent to ROW Habitats

We completed a linear-adjacency analysis to summarize which land-cover types most frequently shared a boundary with managed-ROW patches. We placed a 100-ft buffer on all ROW corridors and clipped the NJDEP 1995/97 LU/LC data to the buffer. The NJDEP 1995/97 patches in the buffer and the ROW patches mapped from the interpretation of 2002 aerial photography were converted from polygons to lines. We determined adjacency by intersecting the two line datasets using the GIS. Line-segment lengths were calculated and the length of the adjacency was tabulated for each ROW patch type.

We only determined adjacency for the ROW patches in contact with the adjacent landscape, i.e. along the interface of the ROW boundary and the adjacent landscape. We did not determine the adjacency of ROW patches to other ROW patches because the goal was to assess whether or not the ROW patches were compatible with the surrounding landscape. The adjacency process is illustrated in Figure 3.1.

The Edaphic-landscape Setting of ROW and Reference Habitats

The objective of this analysis was to compare the edaphic-landscape setting of managed-ROW and Pinelands-reference habitats using soil characteristics from the STATSGO and SSURGO database. We extracted three soil variables, including the soil associations from the STATSGO data and the soil series and drainage rating from the SSURGO data. These three variables were compared qualitatively between the managed-ROW and the sample of Pinelands-reference habitats.

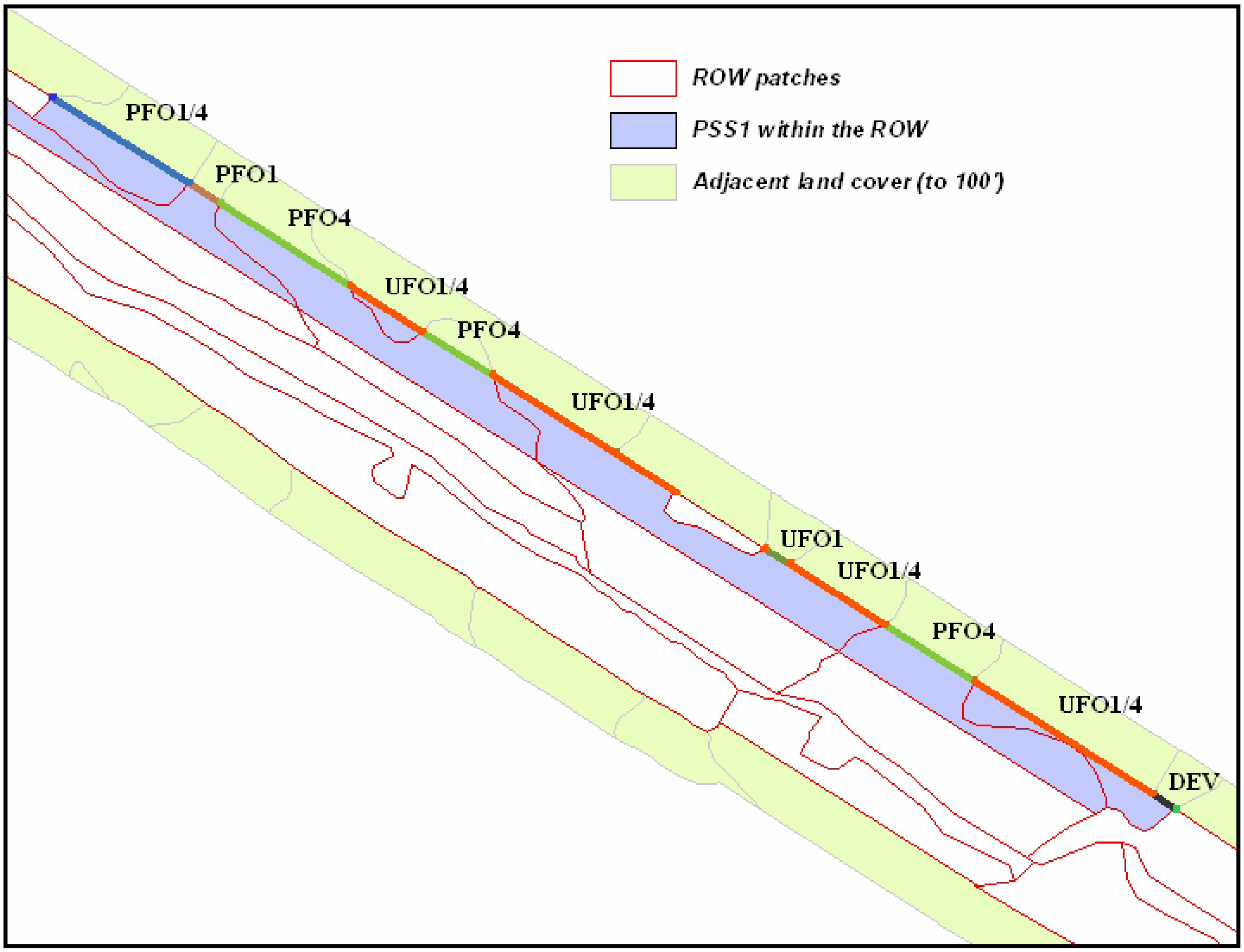

Figure 3.1. An example of the adjacency analysis for palustrine scrub/shrub (PSS1) in managed-ROW habitats. Thick colored lines indicate contact between PSS1 patches in the ROW and various land-cover patches in the adjacent landscape. Land-cover classes are shown for patches in the adjacent landscape.

RESULTS

ROW and Reference LU/LC Class Composition

As previously explained we extracted the sample of Pinelands-reference habitats from 1995/97 LU/LC data and then re-mapped the sample using 2002 aerial photography. In many cases, the smaller minimum-mapping unit (0.25 acre or 1000 m^2) used in the re-mapping process resulted in a vegetation-patch structure that was more finely mapped because the original polygons were subdivided (Figure 3.2). Although the Pinelands-reference sample was originally selected from 1995/97 early successional scrub/shrub, emergent-wetland, and old-field classes, the re-mapped reference patches contained a large number of patches and total area of upland forest (UFO) and palustrine forest (PFO). A total of 2,799 UFO patches covered 42% of the total reference-habitat area and a 1,778 PFO patches covered 26% of the total reference-habitat area. The large number of forest patches is most likely due to a combination of the finer-scale mapping, the higher quality spatial resolution and spectral response of the imagery from 2002 compared to 1995, and natural successional processes with scrub/shrub communities growing up into forest in the absence of disturbance.

UFO and PFO represented 8% and 4% of the ROW habitats, respectively. To compare the early successional patch types among ROW and reference habitats, we removed the forest patches and the human-altered patches from both ROW and reference habitats. Upland (USS) and palustrine (PSS) scrub/shrub together represented 80% of the early successional reference habitats and 76% of the early successional ROW habitats (Tables 3.2 and 3.3). PSS dominated reference habitats and USS dominated ROW habitats. Old Field (OLDF) patches represented a similar total area of the early successional ROW and reference habitats. Although much of the OLDF area in ROW habitats was associated with developed and agricultural landscapes, some was due to New Jersey Department of Environmental Protection Division of Fish and Wildlife food plots located on Wildlife Management Areas. Emergent-wetland (EM) cover was slightly higher for the early successional reference habitats compared to the early successional ROW habitats. Open water (Other) was relatively rare in both types of habitats. Access road (ACC) patches were present only in ROW habitats.

Table 3.2. Level I land-cover summary statistics for early successional Pinelands-reference patch types. See Table 2.2 for explanation of Level I classifications.

Reference-class Type	Number of Patches	Patch-size Statistics (ac)				% of Total Area
		Mean	Standard Deviation	Variance	Total Area	
PSS	188	4.8	8.5	71.6	906	56
USS	90	4.4	6.1	37.2	395	24
EM	55	2.9	5.2	26.6	158	10
OLDF	52	2.8	6.2	37.9	148	9
Other	21	0.6	0.7	0.4	12	<1
Total	406				1,619	100

Table 3.3. Level I land-cover summary statistics for early successional managed-ROW patch types. See Table 2.2 for explanation of Level I classifications. Access roads (ACC) are shown because this patch type was only mapped in ROW habitats.

ROW-Class Type	Number of Patches	Patch-size Statistics (ac)				% of Total Area
		Mean	Standard Deviation	Variance	Total Area	
USS	514	2.6	3.9	15.3	1,359	52
PSS	351	1.8	3.1	9.4	630	24
ACC	170	1.4	2.1	4.4	238	9
OLDF	150	1.9	3.4	11.6	289	11
EM	57	1.3	2.9	8.4	74	3
Other	30	1.1	1.9	3.5	33	1
Total	1,422				3,011	100

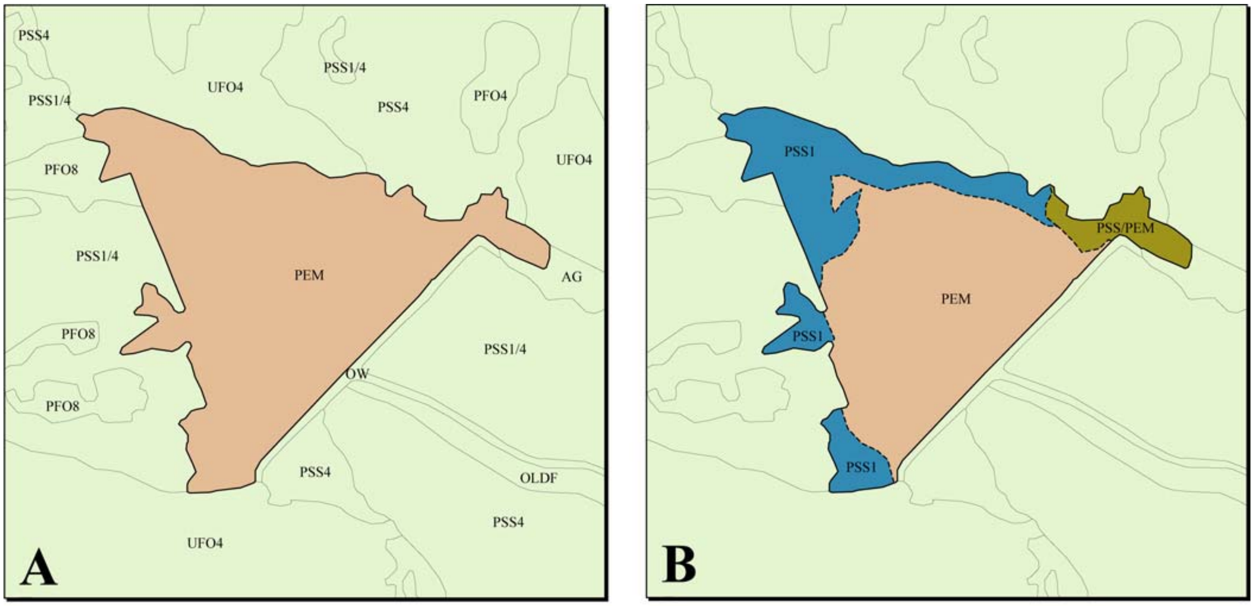

Figure 3.2. An example of subdividing a Pinelands-reference patch into several patch types. Panel (A) shows the original patch from 1995/97 data and panel (B) shows the patch subdivided and re-classified using the 2002 imagery.

ROW and Reference Patch Size, Shape, and Diversity

Patch-shape Metrics. With one exception, mean patch size was smaller for managed-ROW patch types compared to Pinelands-reference patch types (Tables 3.2 and 3.3). The exception of was the class Other, which includes open water (OW) patches. With one exception, the Wilcoxon Rank Sum test results indicated that ROW-patch types were significantly smaller with shorter patch-edge lengths compared to reference-patch types (Table 3.4). The exception was OW patches, which comprise a small percentage of the number of patches and area of ROW and reference habitats (Tables 3.2 and 3.3). The generally smaller size of the ROW patches is likely due to the patches being bound by the relatively narrow ROW corridor.

Most of the managed-ROW patch types exhibited a significantly higher shape index, area-weighted-shape index, perimeter-to-area ratio, and area-weighted-fractal dimension (Table 3.4). The exceptions were the shape index and area-weighted-shape index for OW and PEM patches, which displayed the same trend but were not significant, and the area-weighted-shape index for PSS, which showed a significant opposite trend. The greater values for the various patch-shape metrics for most managed-ROW patch types suggests that ROW patches have a complex, convoluted edge. However, visual inspection of the ROW patches indicated that they were not more convoluted, but were generally long and thin and therefore departed from a simple compact shape, such as a circle.

Patch-diversity Metrics. As mentioned in the Methods section, we used the Level II classifications when calculating the patch-diversity metrics. Therefore, the number of patches used in these calculations was 2,893 for ROW habitats and 1,611 for reference habitats (Table 3.5). ROW and references habitats displayed a similar diversity in the number and size of patches (Table 3.5).

Table 3.4. Comparison of patch metrics for managed-ROW and Pinelands-reference habitats using a Wicoxon Rank Sum 2-sided test. Comparisons followed by an asterisk are significant at a corrected *p*-value of 0.007. See Table 2.2 for class descriptions.

Class	Patch Size	Patch Edge	Shape Index	Area Weighted Shape Index	Perimeter: Area Ratio	Area-weighted Fractal Dimension
OLDF	ROW < REF*	ROW < REF*	ROW > REF*	ROW > REF*	ROW > REF*	ROW > REF*
OW	ROW < REF	ROW < REF	ROW > REF	ROW > REF	ROW > REF*	ROW > REF*
EM	ROW < REF*	ROW < REF*	ROW > REF	ROW > REF	ROW > REF*	ROW > REF*
PFO	ROW < REF*	ROW < REF*	ROW > REF*	ROW > REF*	ROW > REF*	ROW > REF*
PSS	ROW < REF*	ROW < REF*	ROW > REF*	ROW < REF*	ROW > REF*	ROW > REF*
UFO	ROW < REF*	ROW < REF*	ROW > REF*	ROW > REF*	ROW > REF*	ROW > REF*
USS	ROW < REF*	ROW < REF*	ROW > REF*	ROW > REF*	ROW > REF*	ROW > REF*

Table 3.5. Land-cover class richness and Shannon-Weiner diversity indices for managed-ROW and Pinelands-reference patches. Attributes were determined from the Level II classes in Table 2.2.

Attribute	Managed-ROW Patches	Pinelands-reference Patches
Number of Patches	2,893	1,611
Class Richness	27	25
Shannon-Weiner Index		
Using Number of Patches	2.50	2.66
Using Patch Size	2.49	2.49

Vegetation Adjacent to ROW Habitats

The total length of the boundary along the interface between the ROW habitats and the adjacent landscape outside the ROW was approximately 445 mi. For the ROW habitats, about 44% of the boundary was upland scrub/shrub (USS), 19% was palustrine scrub/shrub (PSS), 19% was altered land (ALT), 9% was old field (OLDF), 5% was upland forest (UFO), 2% was palustrine forest (PFO), and 2% was emergent marsh (EM). ALT in the ROW habitats included the access road (ACC), other human-altered-land covers, and bare land (OTHER).

For the adjacent land cover outside the ROW, about 50% of the boundary was UFO, 18% was PFO, 19% was ALT, and 13% was PSS and EM. The ALT in the adjacent habitats included transportation/utilities/communications, development, agriculture, and extractive mining. A significant proportion of this adjacent-altered land consisted of roadways and rail lines, most notably the Atlantic City Expressway and a parallel Conrail railway corridor to the north.

PSS patches in the ROW displayed the highest percentage adjacency to PFO (61.5%) patches in the adjacent landscape (Table 3.6). USS patches in the ROW displayed the highest percentage adjacency to UFO (71.1%) patches in the adjacent landscape OLDF patches in the ROW showed a relatively high percentage adjacency to ALT (27.5%) and UFO (54.4%). For the association with ALT, the utility companies usually managed ROWs in developed and agricultural landscapes more intensely resulting in herbaceous-dominated spans. Some of the association between ROW OLDF and adjacent UFO was due to NJDEP Division of Fish and Wildlife food plots, which are located in forest landscapes.

Table 3.6. Summary of linear-adjacency results for managed-ROW habitats. Values are the percentage of the ROW boundary for each patch type in the adjacent landscape.

	Adjacent Patch Types								
	ALT	OLDF	USS	UFO	EEM	PEM	PSS	PFO	Other
ROW Patch Types									
ALT	43.5	1.6	4.0	44.4	-	0.1	1.5	3.8	1.0
OLDF	27.5	9.7	5.0	54.5	-	-	0.7	2.1	0.5
USS	13.5	0.9	6.7	71.1	0.1	0.1	1.2	6.1	0.3
UFO	13.0	0.5	5.6	75.6	-	-	0.3	4.9	0.1
EM	2.8	0.8	-	2.0	72.6	9.9	1.3	7.8	2.7
PSS	10.2	0.4	1.1	9.6	-	1.3	15.3	61.5	0.4
PFO	1.8	-	0.7	6.3	0.6	0.2	5.7	84.5	0.2
OTHER	8.8	-	-	25.2	-	2.4	3.0	22.5	38.0

The Edaphic-landscape Setting of ROW and Reference Habitats

Comparison of the soil-association, soil-series, and soil-drainage class data indicated that the managed-ROW habitats and Pinelands-reference habitats were located in similar landscape settings. The Atsion-Manahawkin-Berryland, Downer-Sassafras-Hammonton, Lakehurst-Lakewood-Atsion, and Aura-Downer-Sassafras soil associations together comprise almost the entire area of ROW (94%) and reference habitats (87%) (Table 3.7). The individual percentages for each soil association were also similar between ROW and reference habitats. For the various soil series, Downer and Manahawkin soils dominated the ROW habitats and Lakehurst, Atsion, Manahawkin, and Downer soils dominated reference habitats (Table 3.7). The percentage composition of the various soil-drainage classes was also similar for ROW and reference habitats (Table 3.7). The two contrasting drainage classes, well-drained soils and very poorly drained soils, represented the greatest percentages of both ROW and reference habitats.

Table 3.7. Soil-association, soil-series, and drainage-class composition (%) of managed-ROW and Pinelands-reference habitats. A dash indicates an attribute covered <1% or was not associated with ROW or reference habitats.

Soil Attributes	ROW	Reference
STATSGO Soil Associations		
Atsion-Manahawkin-Berryland	37	44
Downer-Sassafras-Hammonton	25	14
Lakehurst-Lakewood-Atsion	16	19
Aura-Downer-Sassafras	16	10
Hammonton-Woodstown-Mullica	3	4
Sulfaquents-Udothends-Psamments	2	1
Woodmansie-Atsion-Downer	-	5
Westphalia-Freehold-Pasquotank	-	2
SSURGO Soil Series		
Downer	19	10
Manahawkin	10	11
Aura	8	6
Berryland	7	9
Lakehurst	7	13
Lakewood	7	8
Atsion	7	15
Evesboro	6	2
Woodstown	4	2
Sassafras	3	1
Mullica	3	4
Atsion-Berryland	3	3
Hammonton	3	3
Galloway	3	2
Pits	2	1
Aura-Downer	2	-
Transquacking	1	-
Fluvaquents	-	2
Ingleside	-	1
Woodsmansie	-	2
(Water)	-	1
SSURGO Natural Drainage-class		
Somewhat excessively drained	-	-
Excessively drained	13	10
Well drained	38	22
Moderately well drained	15	20
Somewhat poorly drained	2	2
Poorly drained	10	19
Very poorly drained	22	26
Unrated	-	1

TASK 4. SUMMARIZE RIGHT-OF-WAY VEGETATION-MANAGEMENT STRATEGIES USED BY UTILITY COMPANIES INSIDE AND OUTSIDE THE PINELANDS

To ensure electrical energy reliability, utility companies have an ongoing need to manage vegetation within the ROW corridor to minimize interference with the tower infrastructure and overhead transmission lines. The primary objective of ROW vegetation management is to reduce the height of trees and shrubs beneath the transmission lines and to remove trees or branches along the boundary of the ROW corridor that have the potential to fall into the wires. Vegetation management occurs on a fairly regular return cycle to keep pace with regenerating vegetation. For this Task, we describe the existing range of ROW vegetation-management strategies that are used by utility companies in the Pinelands, in areas adjacent to the Pinelands, and in other regions of the east coast.

BACKGROUND

The clearance needs of transmission lines are defined by New Jersey Board of Public Utilities (NJBPU), Occupational Safety and Health Administration (OSHA), National Energy Regulatory Commission (NERC), U.S. Department of Energy (DOE), and National Security Administration (NSA) rules. In May 2006, a memorandum of understanding (MOU) established that the Edison Electric Institute (EEI), which is an association of shareholder-owned electric companies, would work with federal land-management bureaus, Department of the Interior, the Forest Service, and the EPA to develop cooperative ROW integrated-vegetation-management (IVM) practices (EEI 2006). This MOU was included in the final report to the Federal Energy Regulatory Commission (FERC) on the Northeast U.S. blackout (C. N. Utility Consulting 2004). Recommendations from the FERC report (C. N. Utility Consulting 2004), the related U.S.-Canada Task Force (United States - Canada Power System Outage Task Force 2004), and the MOU (EEI 2006) are reflected in the current NJBPU standards (NJBPU 2006).

The MOU mentions the wire-zone border-zone design as a preferred configuration for electric-transmission ROWs, where low shrub-forb-grass cover is desired directly beneath the transmission lines (wire zone) and taller shrub-forb cover is preferred along the ROW border (border zone) (Figure 4.1). Although habitat diversity plays a secondary role, the primary objective of the wire-zone border-zone design is to remove undesirable species, including trees that have the potential to grow to a height that may interfere with the transmission lines and vines that grow up towers, poles or guy wires (Bramble and Byrnes 1996, PHI 2006).

Based on 2002 LU/LC data, about 75% of the Pinelands are forested habitats. Upland forests are composed of pine and/or oak species; lowland forests are pine dominated; and swamps support pine, Atlantic white cedar, red maple, and black gum. Based on the results in Task 3, about 72% of the vegetation in the ROW corridor was woody vegetation (60% scrub/shrub and 12% forest) and only 11% of the ROW vegetation was herbaceous (9% old-field uplands and 2% emergent wetlands). Controlling undesirable species in a forest-dominated region represents an ongoing challenge for utility companies in the Pinelands.

Although the Pinelands is largely forested, there are also several species of shrubs common to upland and wetland forests of the region. Shrub cover can be dense, exceeding 60% in upland and wetland forest plots (Zampella 1990). As mentioned in the Introduction, the primary goal of this ROW project was to develop a ROW vegetation-management plan to create and maintain relatively stable and sustainable, early successional habitats that represent characteristic Pinelands-reference habitats, such as scrub-shrub vegetation, emergent wetlands, and intermittent ponds.

Although a secondary, but no less important, objective was to ensure transmission reliability and safety, the ecological goal of this ROW plan differs from the shrub-forb-grass endpoint that is recommended in the MOU described above.

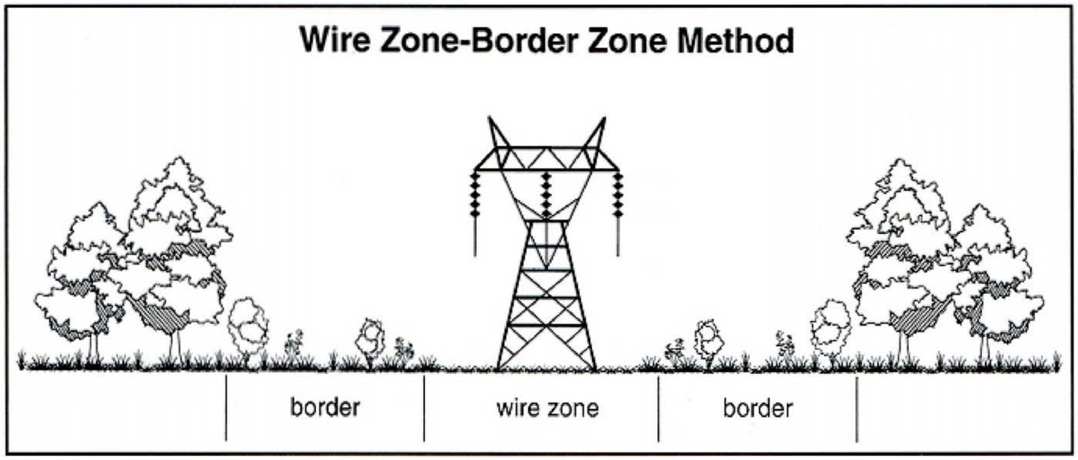

Figure 4.1. A cross section of a ROW corridor showing the transmission-line tower and vegetation in the wire zone, border zone, and adjacent landscape. The source of the figure is Yahner et al. (2001a).

VEGETATION-MANAGEMENT STRATEGIES USED IN THE PINELANDS

As mentioned in Task 1, we obtained information on vegetation-management techniques used in the Pinelands from the foresters and land managers of the three utility companies. Because current Pinelands Commission regulations do not permit the use of herbicides to control the growth of woody vegetation, vegetation management in Pinelands ROWs is limited to manual and mechanical control measures. The most commonly employed methods consisted of mowing, manually cutting individual woody stems to the ground, topping woody vegetation to a target height, or a combination of the three.

Manual Cutting of Vegetation

Manual cutting (i.e., hand cutting) involves cutting stems close to the ground that are too large to mow or topping trees or tall shrubs at some higher height using a chainsaw or similar hand tools (Figure 4.2). Manual cutting of taller vegetation can be accomplished using hydraulic platforms or bucket trucks to place the saw operator at the proper height. Chain or circular saws mounted on poles can also be used.

In the Pinelands, manual cutting was used in wetlands because equipment associated with mowing can cause excessive soil disturbance or risk equipment damage. Manual topping was also used in the Pinelands to reduce tree height where it was deemed that the trees or tall shrubs not be entirely removed (Figure 4.3). To reduce the amount of slash left in a ROW, logs and branches that result from manual-cutting activities should be chipped (Nickerson 1992).

Figure 4.2. Atlantic white cedar (*Chaemacyparis thyoides*) stumps from manual cutting.

Figure 4.3. Upland scrub/shrub-dominated community with 8 to 10 ft pitch pine (*Pinus rigida*) trees two years after being topped. Species are white oak (*Quercus alba*), pitch pine, highbush blueberry (*Vaccinium corymbosum*), black huckleberry (*Gaylussacia baccata*), and bracken fern (*Pteridium aquilinum*).

Mowing Vegetation

Types of Mowers. Mowing was reported to be the most commonly used vegetation-management practice in the Pinelands. Mowing can be done with large rotary, flail, or circular-saw mowers mounted on a boom, pushed, or pulled over the vegetation in the ROW using equipment on wheels or tracks. Rotary blades are similar to a standard gas-powered lawn mower, but in either single or multiple large-blade configurations within an industrial housing. Flail mowers are comprised of multiple blades rotating parallel to the direction of travel that shear off vegetation caught within the mowing box. Circular-saw mowers are single or multiple large saw blades within an open housing designed to pull or trap vegetation against the blade(s) for cutting. Most mower housings are mounted on hydraulic booms to control the height and angle of the mow. Mounted mowers can be used to trim the vertical walls of the ROW corridor. This practice does not result in clean pruning, but does control vegetation dimension (ANSI 2001).

In the Pinelands, the contracted vegetation-management company determined the type of equipment used for mowing, but utility company foresters assigned the vegetation-management prescription, suggested methods to be used, and occasionally provided specific management direction. Mowing was typically used in grass-forb-dominated habitats (Figure 4.4). PHI specifications call for mowing grass ROWs annually in sparsely populated areas and from four to six times per year in urban and suburban areas (PHI 2006). Mowing was also normally used for habitats dominated by small-diameter (<6 in) scrub/shrub or re-sprouting trees (Figure 4.5). PHI specifications call for woody vegetation to be mowed to a height of 4 in (PHI 2006).

Figure 4.4. A grass-forb-dominated community in an agricultural matrix the first year after a mow. Species are grass species and multiflora rose (*Rosa multiflora*).

Restrictions on Mowing. Mowing was usually limited to wetlands that were at the drier end of the upland-to-wetland gradient (Figure 4.6). These mineral-soil wetlands lacked a thick organic layer and well-developed hummock-hollow topography that would be more susceptible to disturbance by heavy equipment. Mowing was also restricted in other locations where equipment was unable to reach the target vegetation, such as on slopes or near transmission-line towers.

Figure 4.5. An upland-scrub/shrub-dominated community the second year after a mow. Species are white oak (*Quercus alba*), black cherry (*Prunus serotina*), high-bush blueberry (*Vaccinium corymbosum*), scrub oak (*Quercus ilicifolia*), winged sumac (*Rhus copallina*), and grass and forb species.

Coppice Growth

Unfortunately, both mowing and cutting trees and shrubs often results in stump sprouting, or coppice growth (Figure 4.7), which can increase the density of sprouts. Coppice growth converts a single woody stem into multiple stems that can grow several feet per year if connected to a viable root system (Bramble and Byrnes 1983, McLoughlin 1997). Sprouts may originate from lateral buds on residual-stem material or from the near-surface root mass (Johnstone 1990). Coppice growth has been reported for birch (Nowak et al. 2002) and dogwood (Boeken and Canham 1995) in New York, red maple in Massachusetts (ECI 1989), mixed hardwoods, oak, and red maple in Pennsylvania (Bramble and Byrnes 1983, Yahner and Hutnick 2004) and mixed pine and hardwoods in North Carolina (Porteck et al. 1994).

Figure 4.6. A wetland-scrub/shrub-dominated community the first year after a mow. Species are red maple (*Acer rubrum*), highbush blueberry (*Vaccinium corymbosum*), sweet pepperbush (*Clethra alnifolia*), and cinnamon fern (*Osmunda cinnamomea*).

Figure 4.7. Pine stump re-sprouting after being mowed.

Vegetation-management Return Intervals

As mentioned in Task 1, long-term vegetation-management data were not available from the three utility companies so we were unable to determine specific return intervals used for vegetation management. However, discussions with the utility foresters suggested that a three to four year return interval was common practice, with specific recommendations based on annual site evaluations. Our field observations during the summer of 2006 suggested that up to four-year intervals were the norm for all three utility companies (Figure 4.7). However, we also observed ROW areas with forest vegetation that did not appear to have ever been managed and other areas where trees were allowed to grow very tall since last managed.

As mentioned in Task 1, ACE follows the vegetation-management directives established by their parent corporation PHI (PHI 2006). ROWs managed by ACE are inspected each year to guide annual-work plans and associated budgets. Aerial surveys are conducted for each circuit twice each year, including one time during the dormant season and one time during the growing season. Aerial inspections are supplemented with ground inspections to evaluate safety sign integrity, tower maintenance, access-road maintenance, and vegetation compliance.

Figure 4.7. Upland pine-herbaceous area four to five years after the last management. Species are pitch pine (*Pinus rigida*) and Virginia pine (*Pinus virginiana*).

VEGETATION-MANAGEMENT STRATEGIES USED IN AREAS OUTSIDE THE PINELANDS

The most substantial difference between vegetation-management techniques used inside and outside the Pinelands is the use of herbicides outside the region. A survey of 81 utility companies throughout the United States and parts of Canada indicated that, of the total area of ROWs in which vegetation was actively managed in 1995, about 73% was managed by mowing and manual cutting and 27% was managed using various herbicide treatments (Sulak and Kielbaso 2004). In the 1980's, Delmarva Power, a subsidiary of PHI that manages ROWs in the coastal plain of Delaware, Maryland, and Virginia, changed its vegetation-management policy from one that relied primarily on mowing to one in which herbicides were preferred (Johnstone 1990). ACE, a PHI subsidiary in New Jersey, also uses herbicides as the primary method of vegetation control in areas adjacent to the Pinelands (PHI 2006). Herbicide treatments include foliar applications during the growing season, dormant-stem applications in the dormant season, and a cut-stubble/vine application throughout the year (PHI 2006). In areas adjacent to water where herbicides are prohibited, manual cutting is generally used and stumps are chemically treated to inhibit sprouting (PHI 2006).

Several Pennsylvania studies have been completed where various vegetation-management techniques were compared, but the vegetation in these regions differs from that of the Pinelands. In a long-term study in the uplands of the Allegheny Mountain and Piedmont regions of Pennsylvania, six commonly used vegetation-management prescriptions were compared, including manual cutting, mowing, mowing plus herbicide, stem-foliage spray, foliage spray, and selective-basal spray (Bramble et al. 1991). Although many of the plant species differed between the two physiographic regions, the vegetation structure that resulted from each prescription was considered similar in both areas. Manual cutting resulted in tree sprout-shrub dominated cover with some forbs and grass; mowing and selective-basal spray resulted in cover dominated by shrubs, forbs, and grass; and mowing plus herbicide, stem-foliage spray, and foliage spray resulted in cover dominated by grass and forbs (Bramble et al. 1991). Similar results were found in a subsequent study of the Piedmont region (Bramble and Byrnes 1996) and in the Allegheny Mountain region of Pennsylvania (Yahner and Hutnik 2004), but in the mountain region shrub cover, mostly blueberry (*Vaccinium* spp.), had increased in relation to forb and grass cover overtime for the mowing plus herbicide, stem-foliage spray, and foliage spray prescriptions. In Massachusetts wetlands, Nickerson (1992) found a similar basic pattern in that manual-cutting and mowing prescriptions resulted in more tree and shrub cover and less herbaceous cover compared to various herbicide treatments.

Several wildlife studies have also been completed in Pennsylvania ROWs in which the same six vegetation-management prescriptions were compared. Bird-species richness and total abundance was much greater for mowing, mowing plus herbicide, foliar spray, basal spray, and stem-foliage spray compared to manual cutting, which supported the lowest bird richness and abundance similar to the adjacent Allegheny Mountain forest land (Yahner et al. 2002). Most of the increased bird richness and abundance for the other five prescriptions was due to the border zones, which were dominated by shrub-forb-grass cover, rather than the wire zone, which was largely forb-grass cover (Yahner et al. 2002). Only two bird species were abundant in the herbaceous wire zones.

Results of reptile and amphibian studies conducted in Pennsylvania ROWs varied. In the Allegheny Mountain region, Yahner et al. (2001b) studied the same vegetation-management prescriptions mentioned above, with the exception of mowing. Compared to the four herbicide prescriptions, manual cutting resulted in the lowest combined reptile and amphibian richness and number of observations. The higher richness and number of observations for the herbicide prescriptions was primarily due to the increased snake abundance in the more open herbaceous conditions. In the Piedmont region, Yahner et al. (2001a) studied the same vegetation-management prescriptions mentioned previously, except for basal spray. Manual cutting and mowing supported a similar species richness and number of observations of reptiles and amphibians compared to the three herbicide prescriptions.

CONCLUSIONS AND RECOMMENDATIONS

For this Task, we summarized the vegetation-management strategies used to maintain transmission-line ROW corridors inside and outside the Pinelands region. Due to restrictions on the application of herbicides in the Pinelands and because a comprehensive technical review of the potential impacts of herbicide use on plants and animals is beyond the scope of this ROW project, the span-specific vegetation-management prescriptions described in Task 5 were limited to variations on cutting and mowing.

Cutting and mowing are well-established methods in the Pinelands and elsewhere. Both are effective for controlling vegetation height and have fairly predictable return intervals that can be adjusted for regeneration or habitat expectations. Compared to mowing, manual cutting is relatively expensive and carries greater risk to personnel due to the reliance on chainsaws, but causes less disturbance to wetland vegetation and soils due to the lack of heavy equipment needed and can be useful in small or otherwise inaccessible areas where mowing is not feasible. Both mowing and manual cutting activities can result in environmental dosing of petroleum products, such as fuels, lubrication oils, or hydraulic fluids (Nickerson 1992).

Neither mowing nor manual cutting permanently removes trees from ROWs, but mowing can result in much lower tree density compared to manual cutting (Bramble and Byrnes 1996, Yahner and Hutnik 2004). Mowing can also result in more shrub and herbaceous cover compared to manual cutting (Bramble et al. 1991, Bramble and Byrnes 1996, Yahner and Hutnik 2004). Both mowing and manual cutting have been reported to maintain a similar species composition to that of adjacent wetland forest in Massachusetts (Nickerson 1992). In the Pinelands, the results presented in Task 3 indicated that patch diversity and edaphic-landscape characteristics were similar for ROW and Pinelands-reference habitats. Although the upland to wetland proportion of scrub-shrub differed, early successional patch types were also similar between ROW and reference habitats. Pinelands ROW habitats were created by mowing and manual cutting. The main difference between ROW and reference habitat types was that ROW patches were smaller and more linear compared to reference patches, which was likely due to the patches being managed in a narrow ROW.

The primary ecological goal of this ROW project was to create and maintain relatively stable and sustainable, early successional habitats that represent characteristic Pinelands-reference habitats, such as scrub-shrub vegetation, emergent wetlands, and intermittent ponds. Based on the results presented in Task 3, these end-point land-cover types comprised about 63% of the ROW habitats. Future conversion of the 12% of the ROW habitats that was upland and wetland forest to upland and wetland scrub/shrub would bring the percentage of ROW habitats that meets the goal to 75%. Since the remaining 25% of the ROW habitats was comprised of access-road, old-field, and human-altered land uses, the ROW project goal seems attainable through the use of various mowing and manual-cutting activities.

TASK 5. DEVELOP A DYNAMIC SPAN-BY-SPAN VEGETATION-MANAGEMENT PLAN FOR PINELANDS RIGHTS-OF-WAY

The objective of this task was to develop a GIS-based span-by-span vegetation-management plan for the bulk electric-transmission ROWs in the Pinelands. To accomplish this, we characterized the current vegetation along the approximately 233 miles of ROW and assigned a vegetation-management prescription to each of the 3,041 spans contained in the ROW span GIS layer (see Task 1). The vegetation-management prescriptions were variations on mowing and manual and mechanized cutting (see Task 4) and, for some spans, included timing restrictions due to the presence of wetlands or nearby records of threatened or endangered species.

METHODS

ROW Spans, Area, and Length

We used the ROW span layer to determine the number of spans and the amount of ROW area managed by each utility. We generated centerlines for each ROW corridor in the GIS layer and used these lines to calculate the length of ROW for each utility. We also calculated the percentage of the total number of spans, total area, and total length for each utility.

Characterizing Existing ROW Vegetation

As mentioned previously, the vegetation-management information obtained from the utility companies was not sufficient to allow the development of individual span-specific recommendations. Therefore, we chose to survey the existing vegetation along Pinelands ROWs using a combination of field and aerial photograph interpretation methods. We completed field surveys during the summer and fall of 2007 and visually interpreted vegetation cover from 2007 aerial photography. Because of on-going vegetation management on the ROWs, aerial photographs from 2002 and 2006 were also examined to more accurately characterize existing vegetation.

For the field and aerial photograph surveys, we estimated the percentage cover of forest, topped trees, tree sprouts, shrub oaks, shrubs, herbaceous, and bare ground in each span. Field surveys were conducted by slowly driving ROW access roads and periodically stopping to photograph and categorize the vegetation. When completing the aerial photograph interpretations, it was difficult to differentiate tree sprouts, shrubs, and shrub oak so these three cover types were often combined as scrub/shrub. The cover categories for all surveys included dominant (>50%), co-dominant (25-50%), subordinate (<25%), and present (<5%).

Vegetation-management Prescriptions

We assigned a vegetation-management prescription to each of the spans in the GIS layer using the terms *cut trees manually*, *cut trees mechanically*, or *mow*. Cut trees manually means to cut trees or topped trees at the base by hand with the use of chainsaws or similar hand tools. Cut trees mechanically means to cut trees or topped trees at the base with the use of machines.

Mowing refers to shearing off any woody and herbaceous vegetation with the use of a machine. The type of machine used for a mowing prescription can be determined by the utility company.

Each span was assigned a cutting and/or mowing prescription based on the vegetation characterized through the field and aerial-photograph surveys. If forest (Figure 5.1) or topped trees (Figure 5.2) were present in a span, we assigned a prescription to cut those trees. In spans where tree-sprout cover was low compared to shrub cover, we assigned a prescription to cut the tree sprouts manually when tree sprouts and shrubs were well mixed (Figure 5.3) or to mow only the tree sprouts and not the shrubs when the tree sprouts and shrubs were distributed in relatively distinct patches (Figure 5.4). For spans where tree-sprouts were present with little to no shrub cover, we prescribed mowing for that span (Figure 5.5). We also prescribed mowing for spans that were already well-groomed herbaceous areas in developed and agricultural landscapes and for spans that crossed herbaceous patches maintained as food plots by the New Jersey Department of Environmental Protection Division of Fish and Wildlife (Figure 5.6).

When assigning a prescription to a span, we also considered whether the span was upland or wetland. Compared to the field visits, we were more conservative when applying prescriptions to wetland spans using the aerial photographs. Some of the wetland spans that were field surveyed supported too many tree sprouts for manual tree cutting to be practical. In those cases, a mowing prescription was applied. For wetland spans interpreted from aerial photographs, if standing water, access road flooding, or significant soil disturbance was visible on the aerial photographs, we applied a manual tree cutting prescription to the span rather than a mowing prescription to avoid soil disturbances associated with mowing equipment. We also indicated how to dispose of branches and logs that result from cutting trees.

Timing Restrictions

Wetlands. Timing restrictions were incorporated into the vegetation-management prescriptions of some spans due to the presence of wetlands. If a prescription called for wetland forest to be cut, the work was prescribed to occur from July 1 through October 31, which is the period of low water-table levels in Pinelands wetlands (Zampella et al. 2001). This was done to minimize wetland-soil disturbance during vegetation-management activities.

Threatened and Endangered Species. Records for threatened and endangered (T&E) species were obtained from local botanists, the New Jersey Department of Environmental Protection Office of Natural Lands Management and Endangered and Nongame Species Program, the United States Fish and Wildlife Service, and the New Jersey Pinelands Commission. T&E data were composed of polygon and point data.

Timing restrictions were applied to some prescriptions because of known occurrences of T&E species. We placed a 1,000 foot buffer around each span and determined whether or not a T&E plant or animal record was found either on or within 1,000 feet of the span. For each span associated with one or more T&E records, we examined the vegetation-management prescription to determine if timing restrictions were necessary to minimize impact to the species. For example, if a barred owl (*Strix varia*) record was associated with a forested span, the prescription was modified to avoid cutting trees during the active period of mating, nesting, and fledging. If mowing was the prescription for a span that contained a population of T&E plant species, mowing was restricted to a window after the period of growth, flowering, and seed set. Activity times for animals were obtained from NJDEP (2004) and Beans and Niles (2003). Flowering and seed set times were obtained from Stone (1911) and Hough (1983) with the advice of a local botanist.

Figure 5.1. Example of a span dominated by forest. The vegetation-management prescription is to cut the trees manually.

Figure 5.2. Example of a span dominated by herbaceous vegetation and tree sprouts, but with individual topped trees. The vegetation-management prescription is to cut the topped trees manually and mow.

Figure 5.3. Example of a span dominated by shrubs with a few scattered tree sprouts. The vegetation-management prescription is to cut the trees manually.

Figure 5.4. Example of a span dominated by shrubs and trees. The vegetation-management prescription is to mow the trees and avoid mowing the shrubs.

Figure 5.5. Example of a span dominated by herbaceous vegetation and tree sprouts with few or no shrubs. The vegetation-management prescription is to mow.

Figure 5.6. Example of a span dominated by herbaceous vegetation. The span is a food plot on a New Jersey Department of Environmental Protection, Division of Fish and Wildlife, Wildlife Management Area. The vegetation-management prescription is to mow.

RESULTS

ROW Spans, Area, and Length

Of the 3,041 spans included in the GIS layer, we characterized the vegetation in 1,059 spans using field surveys and 1,982 spans using aerial photography (Table 5.1). Although more spans were characterized using aerial photography, the length and area of ROW surveyed using field and aerial-photograph surveys was similar.

The greatest number of spans and total length and area of ROW are managed by ACE, followed by PSEG, and then JCP&L (Table 5.1). Although the number of spans that ACE manages is substantially greater than that of PSEG, the amount of ROW area managed by both is similar, indicating that ACE spans are much shorter and narrower than those of PSEG. Mean (± 1 SD) span area is 0.49 ± 0.61 ac for ACE, 4.04 ± 0.98 ac for PSEG, and 1.85 ± 1.24 ac for JCP&L. The amount of ROW area managed by JCP&L is much less than the other two companies (Table 5.1).

Table 5.1. The total number of spans, length, and area of Pinelands ROWs managed by each utility company and for which the existing vegetation was characterized using field surveys or aerial photographs. The percentage of the total is given for each.

Utility Company	Number of Spans		Length of ROW(mi)		Area of ROW (ac)	
ACE	2,570	85%	149	64%	1,263	47%
PSEG	256	7%	54	23%	1,034	38%
JCP&L	215	8%	30	13%	397	15%
Survey Method						
Field	1,059	35%	116	50%	1,509	56%
Aerial Photo	1,982	65%	117	50%	1,186	44%
Total	3,041		233		2,695	

Characterizing Existing ROW Vegetation

Forest or topped trees were present at 166 spans. About 125 (75%) of these spans were managed by PSEG, 36 (22%) by ACE, and 5 (3%) by JCP&L. Forest was dominant or co-dominant at 85 of the 166 spans (Table 5.2). Most of these spans were managed by PSEG. Tree sprouts, shrub-oaks, and scrub-shrub together were dominant or co-dominant at 1,405 spans and shrubs were dominant or co-dominant at 302 spans. Herbaceous cover was dominant or co-dominant at 1,339 spans. Most of these spans were ACE spans and many were associated with salt marsh, NJDEP food plots, and the ROW adjacent to the Conrail railroad. Bare ground was dominant or co-dominant for 189 spans.

Vegetation-management Prescriptions

A total of 59 different vegetation-management prescriptions were applied to the 3,041 spans (Appendix). The 59 prescriptions represented various combinations of cutting, mowing, and timing restrictions. A total of 2,431 spans involved mowing, 866 spans involved cutting, and 529 spans involved a timing restriction. Six spans also involved a survey for a single threatened and endangered plant species.

Table 5.2. Number of spans (n) and area (acres) for each utility company in which various land-cover types were dominant or co-dominant for 233 miles of ROWs in the Pinelands. The percentage of the total number of spans for each cover type is given in parentheses. The total number of spans and acres given here exceeds the actual totals because a span can have more than one co-dominant cover type.

	ACE			JCP&L			PSEG			Total
Land-cover Type	n	%	area	n	%	area	n	%	area	n
Forest	8	(9)	2	1	(1)	2	76	(89)	274	85
Tree Sprouts	202	(60)	114	50	(15)	86	83	(25)	345	335
Shrub-oaks	28	(56)	32	2	(4)	6	20	(40)	93	50
Shrubs	240	(79)	172	25	(8)	81	37	(12)	149	302
Scrub-shrub	962	(94)	417	36	(4)	53	22	(2)	86	1020
Herbaceous	1203	(90)	431	94	(7)	139	42	(3)	192	1339
Bare Ground	163	(86)	48	23	(12)	52	3	(2)	12	189

Timing Restrictions

Wetlands. Wetland timing restrictions applied to 41 of the 529 spans that involved a timing restriction (Appendix). Although the prescriptions varied slightly, all 41 prescriptions include cutting trees manually or mechanically from July 1 through October 31 (i.e., period of low water-table levels). The use of mats is also prescribed for these 41 spans. Mats are large flat wooden or fiberglass platforms placed on the ground to serve as a temporary access road for the operation of heavy equipment and to minimize soil disturbance, especially in wetlands. Wetland GIS data can be obtained from the most recent New Jersey Department of Environmental Protection land-use/land-cover dataset (see GIS data sources at the end of Task 1).

Threatened and Endangered Species. Threatened and endangered plants and animals were associated with a total of 891 spans (Table 5.3). Fifteen animal species were associated with 559 spans and 27 plant species were associated with 417 spans. The same species record may be associated with more than one span and a span may contain multiple records of the same species or different species. The mean, minimum, and maximum number of species associated with a particular span was 1, 3, and 26 species.

For animals, the Pine Barrens treefrog (144 spans) and northern pine snake (92 spans) were associated with the greatest number of spans, whereas the frosted elfin (4 spans), northern harrier (4 spans), vesper sparrow (3 spans), and bobolink (2 spans) were associated with the fewest number of spans. For plants, Knieskern's beaked-rush (176 spans) and Pine Barrens reedgrass (146 spans) were associated with the greatest number of spans, whereas American mistletoe (5 spans), yellow fringed orchid (5 spans), small-headed beaked-rush (5 spans), and slender beaked-rush (3 spans) were associated with the fewest number of spans.

Timing restrictions for T&E species were included in the prescriptions of 488 of the 529 spans with a timing restriction (Appendix). Most of the T&E timing restrictions involved mowing prescriptions. T&E surveys were included as part of the prescription in a single case (American mistletoe, *Phoradendron leucarpum*), totaling six spans. A survey is required because mistletoe grows in the canopy of trees, the six spans are forested, and the prescription for these spans is to cut the forest. If mistletoe is determined to be present in any of those spans, the prescription calls for the utility company to submit a plan to the Pinelands Commission that thoroughly describes the actions to be taken to minimize harm to the plant.

Table 5.3. The number of spans associated with known occurrences of threatened and endangered plant and animal species. The same species record may be associated with more than one span and a span may contain multiple records of the same species or different species.

CommonName	Scientific Name	Number of Spans
Animals		
Bobolink	*Dolichonyx oryzivorus*	2
Vesper Sparrow	*Pooecetes gramineus*	3
Frosted Elfin	*Callophrys irus*	4
Northern Harrier	*Circus cyaneus*	4
Grasshopper Sparrow	*Ammodramus savannarum*	8
Red-shouldered Hawk	*Buteo lineatus*	9
Corn Snake	*Elaphe guttata guttata*	9
Cope's Gray Treefrog	*Hyla chrysoscelis*	17
Cooper's Hawk	*Accipiter cooperii*	25
Red-headed Woodpecker	*Melanerpes erythrocephalus*	25
Osprey	*Pandion haliaetus*	41
Timber Rattlesnake	*Crotalus horridus horridus*	42
Barred Owl	*Strix varia*	55
Northern Pine Snake	*Pituophis m. melanoleucus*	92
Pine Barrens Treefrog	*Hyla andersonii*	144
Plants		
Slender Beaked rush	*Rhynchospora inundata*	3
American Mistletoe	*Phoradendron leucarpum*	5
Yellow Fringed Orchid	*Platanthera ciliaris*	5
Small-head Beaked-rush	*Rhynchospora microcephala*	5
Bog Asphodel	*Narthecium americanum*	8
Pine Barren Bellwort	*Uvularia puberula var. nitida*	10
Narrow-leaf Primrose-willow	*Ludwigia linearis*	11
Awned Meadow-beauty	*Rhexia aristosa*	13
Reversed Bladderwort	*Utricularia resupinata*	13
Curly Grass Fern	*Schizaea pusilla*	14
Sandplain Flax	*Linum intercursum*	15
Stiff Tick Trefoil	*Desmodium strictum*	19
Canby's Lobelia	*Lobelia canbyi*	19
Little Ladies'-tresses	*Spiranthes tuberosa*	19
Wand-like Goldenrod	*Solidago stricta*	23
New Jersey Rush	*Juncus caesariensis*	29
Floatingheart	*Nymphoides cordata*	31
Pine Barren Rattlesnake-root	*Prenanthes autumnalis*	46
Slender Nut-rush	*Scleria minor*	56
Pine Barren Smoke Grass	*Muhlenbergia torreyana*	57
Pine Barren Boneset	*Eupatorium resinosum*	59
Barratt's Sedge	*Carex barrattii*	74
Swamp Pink	*Helonias bullata*	77
Pine Barren Gentian	*Gentiana autumnalis*	94
Elliptical Rushfoil	*Croton willdenowii*	117
Pine Barren Reedgrass	*Calamovilfa brevipilis*	146
Knieskern's Beaked-rush	*Rhynchospora knieskernii*	176
Total Number of Unique Spans with Animal Records		559
Total Number of Unique Spans with Plant Records		417
Total Number of Unique Spans with Plant or Animal Records		891

Vegetation-management and Maintenance Flexibility

Because of the specific nature of the vegetation-management prescriptions and the inability to include every possible scenario for every span, we incorporated some flexibility into the ROW plan regarding the implementation of the vegetation-management prescriptions and other ROW maintenance activities. Based on discussions with the utility company and NJBPU representatives, we identified the following eight topics in which flexibility was desirable.

Presence of Trees or Topped Trees. Individual large-diameter trees or topped trees may not have been noticed during field surveys because vegetation was tall in some spans and obscured the view of parts of the span. This was a problem particularly with some of the longer and wider spans managed by PSEG and JCP&L. Trees or topped trees may also have been missed because we relied on aerial-photograph interpretation for characterizing vegetation in many other spans. For safety and reliability reasons, utility companies should be permitted to cut these individual trees or topped trees even if the prescription for that span does not provide for cutting trees. For example, if some trees or topped trees are present within a span that was assigned a mowing prescription, the trees should be removed either manually or mechanically prior to the mowing operation. Utility companies should also be able to cut trees and branches along the ROW boundaries that grow to a point in which they are capable of falling on transmission lines. These danger trees should be cut manually or mechanically in uplands and manually in wetlands.

Woody Debris. To reduce woody debris that can prevent desired shrub and herbaceous vegetation from sprouting, all branches that result from cutting trees in uplands should be chipped into a vehicle on the access road and removed from the ROW. Logs in uplands should be chipped and removed or stacked on the ROW so that they do not interfere with future vegetation management. In wetlands, all branches and logs that result from cutting trees should be chipped into a vehicle on the access road and removed from the ROW. Woody debris that typically results from mowing should not have to be removed from the ROW unless the amount of debris is excessive and prevents shrub and herbaceous vegetation from sprouting.

Height Restrictions. Because part of the goal of the ROW project was to create and maintain relatively stable and sustainable early successional habitats that ensure transmission reliability and safety, many of the vegetation-management prescriptions are designed to encourage the establishment of stable shrub-dominated communities. Although most Pinelands shrub species remain relatively short, depending on the vegetation-height requirements established by the utility for a particular span, some shrubs may eventually become tall enough to pose safety and reliability concerns. If and when this occurs, utility companies should have the ability to cut the shrubs using whatever vegetation-management prescription was assigned to the span.

Timing Restrictions. The timing restrictions applied to spans associated with T&E records were conservative to provide maximum protection for the species. Because many mowing prescriptions contain a timing restriction, utility companies may have difficulty completing the prescribed mowing work within the allowed activity window. Therefore, only when necessary, utility companies should be permitted to mow up to 15 days before the beginning of the timing window and up to 15 days after the end of the timing window.

Span Boundaries. The span polygons in the GIS layer were not intended to represent the exact boundary of the easement owned by the utility company or the boundary of the ROW currently managed by the utility company. As mentioned in Task 1, the polygons provided a means to represent the ROW spans geographically and to attach vegetation-management prescriptions. Because the existing managed ROW may extend beyond the span boundaries delineated in the GIS layer, the vegetation-management prescription associated with each span should be able to be applied to that span outside the GIS lines, but within the boundaries of the existing managed ROW. Although the existing managed ROW was usually discernable on an aerial photograph, it was most obvious when viewed from the ground. This ROW plan does not provide for vegetation management beyond existing managed-ROW boundaries.

Access-road Maintenance. ROW access roads require periodic maintenance to ensure that utility companies can access their ROWs for site visits, vegetation management, periodic transmission-line work, and emergency situations. To minimize disturbance outside the footprint of the existing access road, the access road should be filled or graded within the original width and elevation of the existing road. Clean fill composed of sand and gravel that is obtained from a local Pinelands source should be used to minimize the establishment of non-native species. Utility companies should be permitted to manage vegetation as needed within the boundaries of the existing access road using the vegetation-management prescription provided for that span. The construction of new access roads or permanent structures, such as culverts and bridges, are not covered under this ROW plan.

Emergency Situations. Utility companies often conduct ground and aerial inspections to determine imminent threats to transmission reliability, such as dead trees or trees leaning towards the transmission wires. Utility companies should be permitted to remove these danger trees as needed using manual or mechanical methods in uplands and manual methods in wetlands. Utility companies should also be permitted to clear vegetation when necessary to access the ROW for other emergency situations, such as pole failure and downed transmission lines.

Habitat Conversion. Utility companies should be able to propose additional vegetation-management prescriptions that are intended to establish a low-growth, characteristic Pinelands vegetation community in areas dominated by vegetation that is not characteristic of the region. To prevent coppice growth in spans with large-diameter trees that are prescribed to be cut, utility companies should be encouraged to harvest trees in uplands and wetlands using equipment that minimizes root and stump sprouting.

RECOMMENDATIONS

We recommend that the Pinelands Commission implement the New Jersey Pinelands Electric Transmission Right-of-way Maintenance Plan and that the three utility companies follow the plan. The ROW plan includes this report and the associated GIS layer, which contains a unique identifier for each span, the utility company responsible for the vegetation management, whether or not the span was characterized using field or aerial-photo surveys, data collected on the existing vegetation, the vegetation-management prescription, and the area of each span in acres. The 59 different vegetation-management prescriptions that apply to the 3,041 spans in the ROW span layer are given in the Appendix. The GIS layer is available on the Commission's web site at www.state.nj.us/pinelands/.

The recommendations contained in this ROW plan represent a joint effort between representatives of the Pinelands Commission, Rutgers University, Atlantic City Electric (PHI), Jersey Central Power and Light, Public Service Enterprise Group, and the New Jersey Board of Public Utilities. Because one of the goals of the ROW project was to minimize the need for individual Pinelands Commission permit reviews, we recommend a notification and inspection process be established in lieu of individual permit reviews. To keep reporting and record keeping to a minimum, utility companies should notify the Commission at the end of each year of the vegetation-management activities that were completed, indicating whether or not any timing restrictions were exceeded, access road or other maintenance was completed, and emergency situations occurred. Commission staff should conduct an annual inspection of the spans that were managed to verify that management and maintenance activities occurred according to the ROW plan.

Because the ROW plan was intended to be dynamic, the Executive Director should be able to approve relatively minor changes to the plan and a more formal process should be developed for more substantial changes to the plan. Finally, we recommend that a long-term monitoring program be established to evaluate the effectiveness of the various vegetation-management prescriptions and whether or not the goals of the project (see Introduction) have been met.

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APPENDIX. Fifty-nine vegetation-management prescriptions and the number of spans with each prescription for the bulk-transmission-line rights-of-way in the Pinelands.

Vegetation-management Prescription	# of Spans
Cut topped trees manually or mechanically and mow from December 1 through April 30. Mow during subsequent management from December 1 through April 30.	1
Cut topped trees manually or mechanically and mow, but avoid mowing shrub patches. Mow during subsequent management, but avoid mowing shrub patches.	10
Cut topped trees manually or mechanically and mow. Mow during subsequent management.	10
Cut trees and topped trees manually or mechanically and mow from December 1 through April 30. Mow during subsequent management from December 1 through April 30.	2
Cut trees and topped trees manually or mechanically and mow from November 1 through January 31. Mow anytime during subsequent management.	1
Cut trees and topped trees manually or mechanically and mow. Mow during subsequent management.	27
Cut trees and topped trees manually or mechanically. Mow uplands and remove trees by hand in wetlands during subsequent management.	1
Cut trees from November 1 through January 31 and mow. Mow during subsequent management.	2
Cut trees manually and mow access road berm only from November 1 through March 31.	3
Cut trees manually anytime or mow from November 1 through March 31.	25
Cut trees manually anytime or mow trees from November 1 through March 31, avoid mowing shrub patches.	4
Cut trees manually because of high orv use. Do not mow.	2
Cut trees manually from November 1 through January 31 and mow. Mow anytime during subsequent management.	1
Cut trees manually from November 1 through January 31. Do not mow.	1
Cut trees manually from November 1 through March 31. Do not mow.	2
Cut trees manually or mechanically and mow from December 1 through April 30. Mow during subsequent management from December 1 through April 30.	2
Cut trees manually or mechanically and mow from November 1 through January 31. Mow anytime during subsequent management.	2
Cut trees manually or mechanically and mow from November 1 through March 31. Mow from November 1 through March 31 during subsequent management.	5
Cut trees manually or mechanically and mow. Mow during subsequent management.	36
Cut trees manually or mechanically anytime in uplands and using mats from July 1 through October 31 in wetlands. Mow in uplands and cut trees manually in wetlands during subsequent management.	4
Cut trees manually or mechanically around tower.	2
Cut trees manually or mechanically from November 1 through January 31 and mow. Mow during subsequent management.	4
Cut trees manually or mechanically using mats from July 1 through October 31. Leave shrubs intact. Cut trees manually during subsequent management. Do not mow.	31
Cut trees manually or mechanically. Do not mow.	4
Cut trees manually or mechanically. Leave shrubs intact. Mow during subsequent management.	1
Cut trees manually or mow trees only from November 1 through March 31, avoid mowing shrub patches.	1
Cut trees manually, but leave shrubs intact. Cut trees manually during subsequent management.	1
Cut trees manually, mow access road berm only.	7

APPENDIX. (continued)

Vegetation-management Prescription	# of Spans
Cut trees manually. Do not mow.	561
Cut trees manually. Mow access road berm only and mow from December 1 through April 30.	1
Cut trees manually or mechanically, avoid mowing shrub patches.	5
Mow from December 1 through April 30, but avoid mowing shrub and herbaceous patches.	3
Mow from December 1 through April 30, but avoid mowing shrub patches.	10
Mow from December 1 through April 30.	146
Mow from December 1 through March 31, but avoid mowing shrub and herbaceous patches.	2
Mow from December 1 through March 31, but avoid mowing shrub patches.	5
Mow from December 1 through March 31.	88
Mow from December 1 to April 30.	1
Mow from July 1 through February 1.	1
Mow from November 1 through January 31.	12
Mow from November 1 through March 31 in uplands and remove trees by hand in wetlands.	2
Mow from November 1 through March 31, but avoid mowing shrub and herbaceous patches.	16
Mow from November 1 through March 31, but avoid mowing shrub patches.	4
Mow from November 1 through March 31.	126
Mow in uplands and cut trees manually in wetlands from December 1 through April 30.	5
Mow in uplands and cut trees manually in wetlands from December 1 through March 31.	10
Mow in uplands and cut trees manually in wetlands from November 1 through March 31. Avoid mowing shrub patches.	1
Mow in uplands and cut trees manually in wetlands.	74
Mow in uplands, but avoid mowing shrub patches. Cut trees manually in wetlands.	4
Mow in uplands, mow access road berm, and cut trees manually in wetlands from November 1 through March 31.	1
Mow pasture as needed and cut trees manually in remainder of span.	1
Mow trees from December 1 through March 31, but avoid mowing shrub patches.	3
Mow west of road and cut trees manually east of road from December 1 through March 31.	1
Mow, but avoid mowing shrub and herbaceous patches.	16
Mow, but avoid mowing shrub patches.	82
Mow.	1,660
Mow. Cut trees manually during subsequent management.	2
Survey for Phoradendron leucarpum (American mistletoe). If present, develop a plan, if absent, cut trees manually or mechanically using mats from July 1 through October 31. Leave shrubs intact. Remove trees manually during subsequent management.	6
Total Number of Spans	3,041