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Comparison of Revegetation of a Gas Pipeline Right-of-Way in Two Forested Wetland Crossings Involving Conventional Methods of Pipeline Installation and Horizontal Drilling, Nassau County, Florida

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Abstract

One year after pipeline installation, vegetation in the right-of-way (ROW) was inventoried at two stream floodplain crossings in Nassau County, Florida. Both sites were forested wetlands composed of *Acer rubrum, Fraxinus caroliniana, Liquidamber styraciflua, Nyssa ogeche, Quercus laurifolia,* and *Taxodium distichum*, together with other wetland trees. Pipeline installation across the Brandy Branch floodplain was by conventional ditching and backfill methods. Installation across the Deep Creek floodplain was by horizontal drilling after clearcutting the ROW. The latter method left tree stumps, understory vegetation, and soil layers intact, except for disruptions caused by logging. According to the inventory, vegetation at the drilled site was more diverse (nearly twice as many species occurring in the ROW as at the trenched site) and more robust (no unvegetated exposed soil compared to 15% at the trenched site). Differences between the ROW vegetation at the two sites can be attributed to both site differences and installation technologies used.

Introduction

Natural-gas-distribution pipelines traverse all types of terrain, including wetlands. Prior to the change in wetlands regulatory climate and public awareness of the late 1980s and 1990s, the construction of right-of-way (ROW) corridors through wetlands was often welcomed because ROWs provided public access.

With the promulgation of more stringent environmental regulations relating to development activities, including no-net-loss wetland policies, an evaluation of the historical impacts of pipeline ROWs through wetlands was needed to assess construction and reclamation methods, minimize permit delays, and estimate future construction costs. Careful evaluation is necessary because specific impacts may be beneficial to some plant and/or animal species while detrimental to others. Even slight alterations in topography, hydrology, soil structure, disturbance frequency, and available sunlight brought about by ROW construction and maintenance may be detrimental to certain sensitive species yet improve conditions for others. While ROWs may result in fragmentation of habitat, they frequently contribute to both habitat and species diversity.

Background

The Gas Research Institute (GRI) initiated the Corridors Program through contract with the Reclamation Engineering Division of Argonne National Laboratory to evaluate impacts of gas pipeline installations on wetlands. The goal of this program was to identify representative impacts of existing pipelines on the wetlands they traverse. To accomplish this, surveys of 12 existing wetland crossings were conducted. Sites were selected for evaluation based on three characteristics: elapsed time since pipeline installation, wetland type, and installation technique.

The program was designed to answer the following questions relating to the impacts of the ROWs on the wetlands through which they pass:

1. How are the plant communities that develop in the ROW different from those in the adjacent wetlands?
2. How does the ROW affect overall species diversity of the wetland?
3. To what degree and for what distance does the ROW alter the diversity of the adjacent wetland community?
4. Are there ROW construction and management practices that can enhance the positive contributions to habitat diversity and limit detrimental impacts in wetlands?

To provide answers to these questions, each of the 12 wetland surveys had these specific objectives:

1. Document the vegetative communities existing on the ROW and on the natural areas adjacent to the ROW that are not disturbed by ROW construction.
2. Evaluate similarities and differences between the plant communities on the ROW and on the adjacent natural area.
3. Document changes to the topography, soils, and hydrology attributable to the ROW construction.
4. Identify impacts on rare, threatened, endangered, or sensitive plant species caused by ROW construction.

Individual site reports are being prepared on the wetlands surveyed, along with an overview report that will synthesize and interpret data from the individual reports.

This paper presents partial results of field studies conducted at two crossings through forested wetlands of a recently installed pipeline in northeast Florida. These sites were of particular interest because of the different installation technologies used. Installation of the pipeline across the Deep Creek floodplain was by horizontal directional drilling, while installation across the Brandy Branch wetland was by open trenching. The focus of this paper is limited to revegetation of the ROWs at these two sites.

Site Descriptions

The two sites are located approximately 6 mi (10 km) apart near the town of Baldwin in the southwest tip of Nassau County, Florida. The climate of Nassau County consists of long, warm, humid summers with mild winters. Average annual precipitation is about 55 in. (140 cm), with 65% of the rain occurring between June and October, when average monthly rainfall is between 5 and 8 in. compared with 2 to 3.6 in./mo in winter. Both sites are forested wetlands on floodplains of creeks that have seasonal flooding. Both are within areas mapped as Ellabelle soil (Soil Conservation Service 1991b), which is listed as a hydric soil by the U.S. Department of Agriculture in *The Hydric Soils of the United States* (Soil Conservation Service 1991a).

Site Histories

Both sites were forested wetlands (Cowardian et al. 1979) supporting stands of bottomland hardwoods, pines, and bald cyprus. Although it is likely that some logging has occurred within these sites, there were no remnants of cut stumps or other evidence of recent logging in the areas undisturbed by pipeline construction. However, the forest at the Brandy Branch Site had larger trees and less understory than did the forest at the Deep Creek Site, which may indicate more recent logging had occurred at the Deep Creek Site.

Clearing of the 50-ft (15-m) ROWs were completed during February and March 1991. This involved hand-cutting of woody vegetation at ground level and removal of logs and debris with bulldozers. Low stumps and root systems were left intact at the drilled site but were removed as necessary for access of trenching and construction equipment at the trenched site. Pipeline construction through both sites occurred during May. An attempt was made to segregate the topsoil at the trenched site, but this was unsuccessful because of high water levels at the time of trenching. Final cleanup of the trenched site was delayed until December because of high water levels at the time of pipeline installation. Cleanup involved removal of stumps, silt fences and turbidity control barriers, and final grading. Erosion control devices were allowed to remain between the uplands and the wetlands and between the floodplains and their stream channels at both sites.

Both sites were allowed to revegetate naturally without seeding, liming, or fertilizing. Maintenance plans called for hand-pulling invasive species one year after completion of construction. This had not yet taken place at the time of sampling in July 1992. The wetlands will not be mowed, but selective hand-cutting of trees will be done as necessary to maintain access to the pipeline for surveillance, as required by DOT, 49 CFR 192. The uplands adjacent to the wetlands were stabilized by fertilizing with a 13-13-13 fertilizer at a rate of 100 lb/acre and seeding with bahia grass (*Paspalum notatum*), Bermuda grass (*Cynodon dactylon*) and panic grass (*Panicum fasiculatum*) at 100, 50, and 20 lb/acre.

Methods

Site Description

Data collection was designed to meet the goals and objectives of the GRI Corridors Program. General site habitat data, including topography, water levels, water-flow direction, soil conditions, and the structure of plant communities, were recorded on the basis of general reconnaissance of each site. Soil characteristics, observed on a sample taken using a hand corer, were compared with soil descriptions for Ellabelle soils (Soil Conservation Service 1991b).

Vegetative Sampling

Vegetative sampling was carried out along five transects established at 30-m intervals along the midline of the ROW. Each transect was perpendicular to the midline and extended 30 m from the midline in both directions, ending in the natural areas on either side of the ROW. Vegetational data for the ROW were collected from two sampling plots along each transect, each 2 x 5 m, for a total of 10 plots. Each plot extended from the midline of the ROW for 5 m along the transect in either direction. Herb stratum data for the natural areas were collected from similar 2 x 5 m plots extending along each transect from 17.5 to 22.5 m from the midline of the ROW. Shrub, sapling, tree, and vine strata data for the natural area were collected from 10 x 20 m plots extending along each transect from 10 to 30 m from the midline of the ROW.

Plant data for the herb stratum in the ROW and in the natural areas consisted of areal cover estimates for each species in each plot. Data for the shrub and sapling strata consisted of areal cover estimates for each species within the 10 x 20 m plots. Tree stratum data consisted of species identification and basal area, measured as diameter breast high, for each tree within the 10 x 20 m plots, while vine data consisted of numbers of vines of each species within each of these plots. Strata definitions used were those of the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* (Federal Interagency Committee for Wetland Delineation 1989) hereafter referred to as the 1989 Federal Manual. This manual was in effect at the time the Corridors Program was initiated, but data is compatible for use with other manuals.

Species that occurred within the ROW between transects and within the natural areas between transects were also identified and recorded. Voucher specimens of each plant were collected and preserved.

Data Analysis

Wetland fidelity, origin, and growth form were recorded for each species as given in the *National List of Plant Species that Occur in Wetlands: Southeast (Region 2)* (Reed 1988). ROW plot data analyses for each site are based on 10 plots and include total number of species present; total coverage for all species, defined as the sum of the average cover estimates for each species; identification of dominant species; comparisons of the two ROW communities based on numbers of species within each wetland indicator category; and calculations of a Shannon-Wiener species diversity index (Brower et al. 1990) by the formula

$$D = -\sum p_i \log_2 p_i$$ where p_i = decimal fraction of the total vegetative cover contributed by the ith species.

In addition, two wetland indices were calculated for each site. One wetland index was the prevalence index value (PIV), a weighted value, calculated by the formula from the 1989 Federal Manual modified by substituting relative percent cover for point frequency:

$$PIV = \frac{RPC_{OBL} + 2RPC_{FACW} + 3RPC_{FAC} + 4RPC_{FACU} + 5RPC_{UPL}}{100}$$

where

RPC_{OBL} = relative percent cover (RPC) of obligate wetland species,
RPC_{FACW} = RPC of facultative wetland species,
RPC_{FAC} = RPC of facultative species,
RPC_{FACU} = RPC of facultative upland species, and
RPC_{UPL} = RPC of upland species.

Definitions of obligate (OBL), facultative wetland (FACW), facultative (FAC), facultative upland (FACU), and upland (UPL) species are based on the plants' fidelity to wetlands and can be found in Reed (1988).

The second wetland index was an unweighted average wetland value (AWV) calculated using numbers of species in each category and the formula,

$$AWV = \frac{OBL + 2FACW + 3FAC + 4FACU + 5UPL}{\text{Total number of species}}$$

For the purpose of this paper, data from the natural areas adjacent to the ROW at each site were used for general site comparisons.

Results and Discussion

General Ecology of the Sites

The ROW surface at the drilled site had no standing water except in the bottom of several small stream channels, where the water surface was approximately 1 m below the surrounding floodplain. In contrast, the trenched site had an area of seepage and shallow standing water near the center of the sampling site. At least some of the standing water can be attributed to small alterations of relief at final grading, since the only surface water in the adjacent areas that had been undisturbed by pipeline installation occurred in drainage channels. The ROW at the drilled site was completely vegetated by a robust herb stratum 1 to 2 m tall, which shaded the entire soil surface, including the cut stumps. The only breaks in this vegetation were those caused by the stream channels. At the trenched site, ROW vegetation was less dense, with some exposed soil in areas where subsoils remained at the surface and in areas adjacent to the standing water where soils were poorly consolidated. Soil cores taken with a hand probe where transects crossed the edges of the ROW revealed profiles, textures, and colors consistent with the description for Ellabelle soils for both sites.

The forested wetlands adjacent to the ROW, which had been undisturbed by pipeline construction, also showed both hydrological and vegetational differences. The soils appeared better drained at the drilled site, where the drainage channels were deeper, with the surface of the water in the channels about 1 m below the general soil surface as compared with 20-40 cm below at the trenched site.

Vegetational differences between the sites are summarized in Table 1. Trees at the trenched site were more

(INSERT TABLE 1 HERE)

numerous and larger, with total basal area for all trees almost double that at the drilled site. Saplings and shrubs had greater coverage at the drilled site than at the trenched site, while the herb stratum was less dense. Total numbers of species in the natural areas at the two sites were similar, as were the number of species in each stratum; an exception was vines, where the drilled site had three times as many as the trenched site. These difference may reflect better drainage of the drilled site and/or more recent logging. Because trees at the drilled site were somewhat smaller and the ROW was oriented east-west rather than north-south, the ROW at the drilled site was exposed to longer periods of full sunlight during the summer, when the sun is near its zenith.

Thus, although both sites consisted of forested wetlands within several miles of each other and contained similar tree species, they had differences that were likely to affect the rate and composition of ROW revegetation.

Comparison of Row Vegetation at the Two Sites

Seventy-four species of vascular plants occurred within plots in the ROW at the drilled site, while 38 occurred in ROW plots at the trenched site. One of the species at the drilled site was a shrub-size sprout from a green ash (*Fraxinus pennsylvanica*) stump; however, because it was not part of the herb stratum and will likely be removed during maintenance, it was not included in further site analysis. Seven of the species at the drilled site were introduced species, while five introduced species occurred at the trenched site. Ten species at the drilled site and seven at the trenched site had only annual growth forms. The ROW at the drilled site had 56 native perennial species as compared with 26 at the trenched site. However, the percentages of native perennials at the two sites were similar, with 77% at the drilled site and 68% at the trenched site.

The sum of the average coverages for all species at the drilled site was 131.5% as compared with 102.8% at the trenched site. There was no unvegetated soil at the drilled site, while 14.6% of the soil surface was not covered by vegetation at the trenched site.

Dominant species are listed in Table 2. The same species, shade mudflower (*Micranthemum umbrosum*), was the

(INSERT TABLE 2 HERE)

leading dominant at both sites. However, it had an average coverage of 24.2% at the drilled site as compared with 49.5% at the trenched site, giving it relative percent coverages of 18.4% and 48.2%, respectively. This species is an introduced perennial forb that is classified as an obligate wetland species (Reed 1988). The high relative percent coverage of shade mudflower results in over 50% of the trenched-site coverage consisting of introduced species. The lower number of species and unequal coverages are also reflected in a Shannon-Wiener diversity index of only 0.85 for the trenched site as compared with 1.37 for the drilled site.

Numbers and percentages of species at each site in each of the wetland indicator categories are listed in Table 3.

(INSERT TABLE 3 HERE)

Sixty-seven percent of the species at the drilled site were wetland species, either obligate or facultative, while 79% of the species at the trenched site were wetland species. Although the number of species in these two categories is higher for the drilled site, the percentage is lower. The lower percentage of wetland species at the drilled site correlates with the observation that the drilled site was better drained. Neither site had any upland species in the ROW.

The greater fidelity to wetlands of the plants at the trenched site is also reflected in the PIVs and AWVs for the two sites, as given in Table 4. The 1989 Federal Manual defines sites where the dominant species have a PIV of less

(INSERT TABLE 4 HERE)

than three as having hydrophytic vegetation. All the dominants at the trenched site were obligate wetland species. Not only were the sites dominated by wetland species, but their vegetation was composed predominantly of wetland species, as indicated by the PIVs and AWVs for all species. Thus, both sites supported wetland vegetation. Bahia grass, an introduced FACU species that occurred in the ROW at both sites and as a dominant at the drilled site, may have been introduced into the wetlands from the adjacent uplands, where it was sown.

Conclusions

A comparison of the vegetation that has developed within the ROW at two wetland crossings, one where the pipeline was installed by horizontal drilling and the other where installation was by open trenching, indicates that within a period of one year, both sites had developed diverse vegetative communities composed of a majority of native perennial species. However, the vegetative community at the drilled site was (1) more robust, having a higher total coverage and no exposed soil surface; (2) more diverse, having both a greater number of species present and greater equitability in coverage between species as indicated both by a greater number of dominant species and a higher Shannon-Wiener index; and (3) slightly less hydric, as evidenced by higher numbers and percentages of facultative and facultative upland species and higher PIVs and AWVs for dominant species and for all species.

It is tenable that both general site differences and the different installation technologies were important in contributing to ROW vegetational differences. The major site differences likely contributing to vegetational differences were the better drainage and somewhat less shading of the ROW at the drilled site. Although this site had as many OBL wetland species as did the trenched site, it had much higher numbers of FACW, FAC, and FACU species.

The site at which open-trenching technology was used had several aspects that contributed to less vegetational development at that site. One significant factor was the delay of final grading from May until December 1991. Thus, at the time of sampling, only 7-8 months had elapsed since final disturbance rather than 13-14 months as at the drilled site. This also meant that the site had been vulnerable to surface erosion for a greater period of time. A second factor was slight alterations in surface relief that resulted in areas of pooled water on the surface. A third factor was the presence of small deposits of subsoils on the surface, because topsoil salvage was not possible. These may have resulted from stump removal. A fourth factor was areas of poorly consolidated soils, especially over the trench in wetter areas. While it is not possible to assign importance to these factors, it is likely that each affected vegetational development at this site.

It appears that disturbance to top soil at the drilled site during tree removal was adequate to stimulate considerable seed germination, while being sufficiently restricted to allow regeneration from rootstocks and other vegetative organs with reproductive potentials. Only one stump sprout was observed.

While the establishment of a dense and diverse vegetative community at the drilled site was rapid and spontaneous, it should not be concluded that drilling is sufficiently advantageous to justify the additional expense. Inherent differences between these sites were important factors in the more vigorous revegetation of the drilled site and had timing and/or rainfall patterns allowed prompt closure of the trenched site, vegetation at that site may have also developed more rapidly. Increased attention to compaction of soils in the trench, precise elevation of the ROW surface, and removal of subsoils from the surface would all contribute to faster revegetation. While there are advantages to rapid and vigorous revegetation of pipeline ROWs, the question of how important the vegetational differences between the sites are to the overall ecology of these wetlands merits discussion. The ROW within each wetland had a more dense and more diverse herb stratum than was found in the adjacent natural areas undisturbed by pipeline construction. At each site, the ROW contributed to both species and habitat diversity within the wetland. Follow-up studies at various intervals of lapsed time will be necessary to determine how long the vegetational differences between these two ROWs persist and the direction succession will take at each site.

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Table 1 Comparison of the Vegetation in the Natural Areas at the Drilled and the Trenched Sites

	Drilled Site	Trenched Site
Number of Trees per Hectare	385	520
Basal Area of Trees (m^2/ha)	24.69	48.63
Number of Vines per Hectare	101	12
Total Percent Cover for Saplings (%)	26.8	10.5
Total Percent Cover for Shrubs (%)	34.6	16.1
Total Percent Cover for Herbs (%)	24.2	43.0
Number of Species in the Tree Layer	11	11
Number of Species of Woody Vines	6	2
Number of Species in the Sapling Layer	12	11
Number of Species in the Shrub Layer	15	15
Number of Species in the Herb Layer	40	46
Total Number of Species in All Layers	53	56

Table 2 Dominant Species for the ROW at the Trenched and Drilled Sites

Site	Species	Wetland Indicator	Relative Percent Cover (%)
Trenched Site	Shade mudflower (*Micranthemum umbrosum*)	OBL	48.2
	Loose-flower water-willow (*Justica ovata*)	OBL	18.6
	Total Percent Cover of Dominants		66.8
Drilled Site	Shade mudflower	OBL	18.4
	Bahia grass (*Paspalum notatum*)	FACU+	8.5
	Leathery rush (*Juncus coriaceus*)	FACW	6.8
	Wool-grass (*Scirpus cyperinus*)	OBL	6.2
	Cypress witchgrass (*Dichanthelium dichotomum*)	FAC	6.1
	Grass-leaf rush (*Juncus marginatus*)	FACW	5.1
	Total Percent Cover of Dominants		51.1

Table 3 Numbers and Percentages of Species by Wetland Indicator Category for Each Site

Wetland Indicator Category	Number of Species		Percentage of Species (%)	
	Drilled Site	Trenched Site	Drilled Site	Trenched Site
OBL	20	19	27	50
FACW	29	11	40	29
FAC	12	5	17	13
FACU	9	2	12	5
UPL	0	0	0	0
UNID*	3	1	4	3
Total	73	38	100	100

*This category includes plants which could not be identified to species and therefore could not be assigned to a wetland indicator category.

Table 4 Comparison of PIVs and AWVs for the Drilled and Trenched Wetlands

		PIV	AWV
Drilled Site	All Species	2.06	2.14
	Dominants Only	1.97	2.17
Trenched Site	All Species	1.26	1.73
	Dominants Only	1.00	1.00

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