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SIX YEARS OF MONITORING ANNUAL CHANGES IN A FRESHWATER MARSH WITH SPOT HRV DATA

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DISCLAIMER

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ABSTRACT

Fifteen dates of spring-time SPOT HRV data along with near-concurrent vertical aerial photographic and phenological data from spring 1987 through spring 1992 were analyzed to monitor annual changes in a 150-hectare, southeastern floodplain marsh. The marsh underwent rapid changes during the six years from a swamp dominated by non-persistent, thermally tolerant macrophytes to persistent macrophyte and shrub-scrub communities as reactor discharges declined to Pen Branch. Savannah River flooding was also important in the timing of the shift of these wetland communities. SPOT HRV data proved to be an efficient and effective method to monitor trends in these wetland community changes.

INTRODUCTION

Study Area

The Savannah River Site (SRS), maintained by the U. S. Department of Energy (DOE), is a 777 km^2 area located in south central South Carolina. Five tributaries of the Savannah River run southwest from the SRS and into the floodplain swamp of the Savannah River. This swamp comprises 3.8 km^2 of which approximately one-half is bald cypress (Taxodium distichum)-water tupelo (Nyssa aquatica) swamp and the remainder is primarily hardwood islands or ridges. The swamp is flooded frequently in later winter or early spring from the Savannah River. Until early 1988, additional water also entered the swamp from once-through, secondary cooling water from nuclear reactors on the SRS. Water temperatures were elevated in the creeks receiving the cooling effluents and could exceed 40°C during the summer months. Elevated temperatures, plus water volumes approximately ten times the natural flow of the creeks, resulted in erosion from the stream channels and sediment deposition in the adjacent swamp. Cypress-tupelo vegetation was replaced in these "delta" areas by a variety of algal, herbaceous, and woody shrub-scrub and vine species which varied with the history and duration of the reactor operations (Sharitz et al., 1974a; Mackey, 1990). This paper describes the use of SPOT HRV data to monitor annual trends in one of these swamp deltas, Pen Branch Delta, during a six-year period, 1987 - 1992.

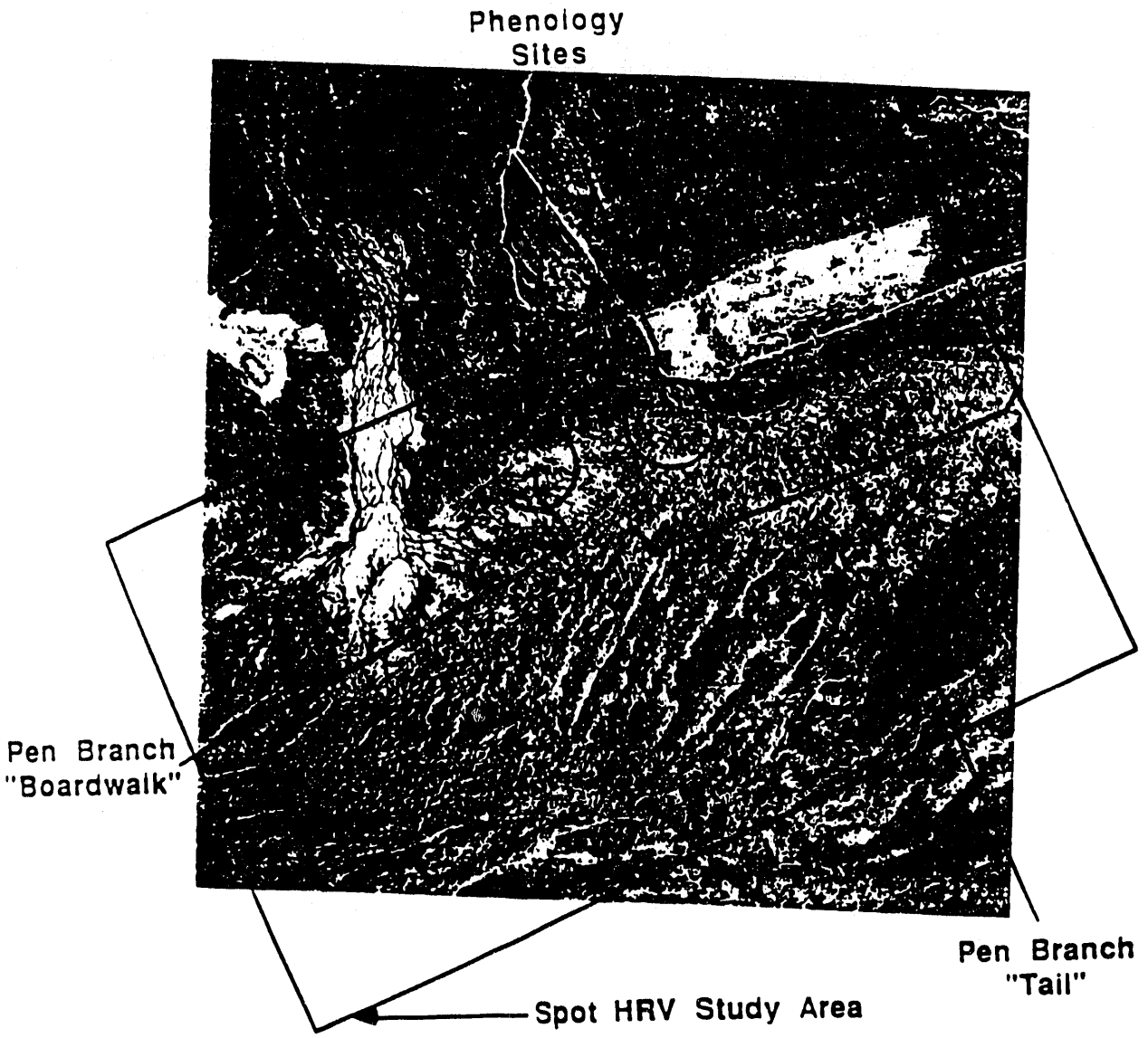

FIGURE 1. Pen Branch Delta Area Evaluated for Wetlands Using SPOT HRV Data for 1987 through 1992. Locations of phenology sites are shown also.

Previous Studies

The Pen Branch Delta, as with the other delta areas of the SRS Savannah River swamp, is a dynamic area undergoing seasonal, annual, and natural successional changes. The development of vegetation types on the Pen Branch Delta are dependent on a variety of factors, including reactor operations, thermal conditions on the delta, and flooding patterns of the Savannah River (Scott et al., 1985; Sharitz and Lee, 1985; Jensen et al., 1987). Several evaluations of the wetland patterns of the Pen Branch Delta have been conducted in recent years using aerial photographic surveys (Sharitz et al., 1974b; Repaske, 1981; Tinney et al., 1986), multispectral scanner (MSS) aircraft surveys (Christensen, 1987; Christensen et al., 1986, 1988; Jensen et al, 1987), and ground based surveys (Christy and Sharitz, 1980; Dunn and Scott, 1987; Huenneke and Sharitz, 1986; Scott et al., 1985; Sharitz and Lee, 1985). In general, these surveys indicate that the Pen Branch Delta, at least through 1985, was continuing to expand at a rate of about 5 to 10 hectares per year, primarily along a terrace bordering the northern edge of SRS Savannah River Swamp (Figure 1). Expansion into this Pen Branch Delta "tail" area may be primarily related to thermal effluent from Pen Branch being directed along the terrace edge in a southeastern direction by flood waters from the Savannah River during late spring and summer floods (Scott et al., 1985; Jensen et al., 1987). Once reactor operations are halted, rapid revegetation of exposed mud flats and sandbar islands occurs (Martin et al., 1977; Jensen et al., 1986). These revegetation patterns consist of a variety of annual herbaceous plants, including both persistent and non-persistent wetland species, as well as the development of shrub-scrub wetlands within a few years following reactor shutdown (Sharitz et al., 1974a, 1974b). Analysis of SPOT HRV data from 1987 through 1989 (Mackey, 1990) and of airborne MSS data from 1987 through 1992 (J. Blohm, personal communication, EG&G, Las Vegas, NV) indicate continued rapid change in vegetation patterns on this delta since reactor operations declined.

Data Collection, Analysis, and Results

In 1985, a series of phenological observations were begun on the Pen Branch Delta. One location was at the Pen Branch Delta "boardwalk" and the second was at the Pen Branch Delta "tail" area (Figure 1). Estimates of percent leaf emergence and/or expansion primarily of cypress was recorded. Data on the principal herbaceous wetland plants included relative height, flowering and emergent status. Reference photography was also collected.

Table 1 lists the dates of SPOT HRV data used in this study, as well as the dates and types of vertical aerial photography which were available to assist in evaluation of the wetlands mapped with the SPOT HRV data. The SPOT HRV data were collected in the green (0.50 - 0.59μm), red (0.61 - 0.68 μm), and near-infrared (0.79 - 0.89 μm) bands, with a nominal pixel size of 20 meters. All SPOT data were obtained at the 1B processing level. Subsets of the data were processed for an area of the Pen Branch Delta as shown in Figure 1, using unsupervised classification techniques (Jensen, 1986). Cluster maps were generated for each date of SPOT HRV data, grouped, and recoded to one of several wetland landcover types as summarized in Table 2. Comparisons to aerial photography were made where possible. The use of satellite thematic mapper data and/or aircraft MSS data (especially in the green, red, and mid-infrared bands) to provide wetlands data of the SRS has proven valuable in the past. Accuracies of 70 to 85% for mapping wetland cover types from open water, freshwater marsh, shrub-scrub, to cypress-tupelo swamp forest have been realized (Jensen et al., 1983; Christensen et al., 1986, 1988; Jensen et al., 1986; Christensen, 1987; Brewster and Tinney, 1984). Similar accuracies would be expected with SPOT HRV data (Tateishi and Mukouyama, 1987). Flow data in Pen Branch and the Savannah River were available from the USGS annual water year reports for South Carolina.

Table 1

Dates of SPOT HRV Data and Supplementary Vertical Aerial Photography Used for Classification of Pen Branch Delta Wetlands

Year	SPOT HRV Date	Vertical Aerial Photography Date	Type	Scale	Source
1987	Apr. 09*	Apr. 20	NC	1:16700	EG&G
	Apr. 24**	Apr. 21	NC	1:20500	EG&G
	May 04*	Apr. 21	NC	1:20700	EG&G
	Aug. 22*	-	-	-	-
	Oct. 22*	Oct. 27	FCIR	1:20000	NASA
1988	Apr. 17*	Apr. 29	NC	1:15900	EG&G
	May 02**	Apr. 29	NC	1:19900	EG&G
	-	Apr. 29	NC	1:7960	EG&G
	May 08*	May 18	NC	1:19900	EG&G
	Oct. 25*	-	-	-	-
1989	Jan. 28*	Jan. 28	NC	1:20000	FS
	-	Mar. 26	FCIR	1:40000	NAPP
	-	Apr. 27	NC	1:7540	EG&G
	May 17**	May 02	NC	1:19000	EG&G
	Nov. 10	-	-	-	-
1990	Jan. 26	-	-	-	-
	Apr. 04*	Apr. 12	FCIR	1:19900	EG&G
	-	Apr. 16	NC	1:19900	EG&G
	May 11**	-	-	-	-
	Sep. 20	-	-	-	-
	Oct. 16	-	-	-	-
1991	Feb. 02	-	-	-	-
	Mar. 05	-	-	-	-
	Apr. 02	Apr. 18	FCIR, NC	1:19500	EG&G
	-	Apr. 24	FCIR	1:3980	EG&G
	-	Apr. 24	FCIR	1:19900	EG&G
	May 02**	May 02	FCIR, NC	1:19900	EG&G
	-	Sep. 20	NC	1:19900	EG&G
1992	-	Jan. 31	FCIR	1:20000	FS
	Mar. 14	-	-	-	-
	Apr. 04	-	-	-	-
	-	Apr. 23	FCIR	1:5970	EG&G
	-	Apr. 23	FCIR	1:9950	EG&G
	-	Apr. 23	FCIR	1:19900	EG&G
	May 05**	May 02	FCIR	1:19900	EG&G
	-	May 04	FCIR	1:19900	EG&G

* - Dates of SPOT HRV data analyzed
** - Dates of SPOT HRV data summarized in Table 2
NC - Natural Color
FCIR - False Color Infrared
EG&G - EG&G Energy Measurements, Inc., Las Vegas, NV
FS - Forest Service, SRS, Aiken, SC
NASA - National Aeronautics and Space Administration
NAPP - National High Altitude Photographic Program

Table 2 provides estimates of the relative quantities of wetlands in the Pen Branch Delta. Other than bottomland hardwood and cypress-tupelo, four types of wetland cover types currently dominate the Pen Barnch Delta area. These include deep and/or open water areas, non-persistent emergent marsh (NPE), persistent marsh, and shrub-scrub communities which consist primarily of willow (Salix spp.) and buttonbush (Cephalanthus occidentalis). Since Ludwigia frequently overgrows shallow water, mudflats,and sandbars on the Pen Branch Delta by late summer or early fall, these cover types were included with the NPE cover class along with areas of shallow water covered by duckweed. Late April to mid-May proved to be the best time of year to distinguish the wetland types from each other with discrimination in the summer and early fall more difficult (Jensen et al., 1986; Mackey, 1990).

In 1987, K Reactor operated at nominal half-power and there was an increase in the expansion of the Ludwigia and cattail (Typha spp.) communities. Ludwigia expanded into the shallow water, mudflat areas of the central delta and the cattails expanded primarily in the Pen Branch "tail" area. In mid-April 1988, K Reactor was shut down for upgrades and flows in Pen Branch decreased from levels near 400 cubic feet per second (CFS) to 50 - 60 CFS in 1989 and 1990. This decrease in flow is reflected in a decline in the deep/open water areas as evaluated with the SPOT HRV data (Table 2). As the Pen Branch Delta became drier in 1988 through 1990, it also became more difficult to distinguish areas of Ludwigia dominance from areas dominated by cattail beds. Part of this difficulty is generated as a result of large beds of dead "brown" biomass from the Ludwigia and cattail beds still being present in the spring having been carried over from the previous summertime growth as evident in the aerial and ground phenology photography. Furthermore, some areas in the lower Pen Branch stream corridor north of the upper delta began to resemble "old field" sites. Similar invasion of "old field" species has been observed in the drier portions of the Four Mile Creek corridor and delta on the SRS since C Reactor shutdown in late June 1985 (K. McLeod, personal communications, SREL, University of Georgia, SRS, Aiken, SC).

Since ~~After~~ 1990, the main portion of the Pen Branch Delta has become increasingly dominated by more persistent cattail beds and from the invasion of shrub-scrub species, primarily willow and buttonbush (Table 2). The overall shift from more thermally and flood tolerant herbaceous wetland communities to wetland communities dominated by persistent and shrub-scrub species is likely to continue as both the cooling water temperature and flows remain reduced in the Pen Branch Delta following implementation of cooling tower operations. Seasonal and annual SPOT HRV data provide a means to monitor the large scale and long term trends in this wetland when combined with supplemental phenological and flow data.

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Table 2

Major Wetland Cover Types based on Classification of SPOT HRV Data for the Pen Branch Delta, Spring 1987 through 1992 (units in hectares)

		Year and Date of SPOT HRV Data Used					
	Wetland Cover Type	1987 Apr. 24	1988 May 2	1989 May 17	1990 May 11	1991 May 12	1992 May 5
1.	Deep/Open Water	13.1	4.0	0.0	1.1	23.2[b]	26.2[b]
2.	Non-Persistent Emergent Marsh (NPE)						
2a.	Shallow-Water/Mud Flats	65.5	29.0	0.4	11.4	-	-
2b.	Ludwigia spp.	34.0	56.8	97.4[a]	92.2	66.2[b]	31.8[b]
2c.	Duckweed	3.2	10.1	3.6	0.1	0.3	-
	Sub-Total NPE	102.7	95.9	101.4	103.7	66.5	31.8
3.	Persistent Emergent Marsh (PE), primarily Cattails (Typha spp.)	31.2	38.5	*	6.0	44.8	55.5
4.	Shrub-scrub	-	-	-	11.7	3.4	23.6
5.	Total	147.0	138.4	101.4	122.5	137.9	137.1

a In May 1988, it was not possible to distinguish between the non-persistent beds of Ludwigia spp. and stands of cattails in theSPOT HRV data.

b In May 1991 and 1992, the Pen Branch Delta was wetter from springtime Savannah River flooding and moderate flows to Pen Branch, thus it was difficult to sort between shallow-water/mudflats and Ludwigia beds. This difficulty probably accounts for an apparent increase in deep water areas.

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