WEST HACKBERRY PLANTINGS AND SEDIMENT ENHANCEMENT (C/S-19)
CS-19-MSPR-1296-3
PROGRESS REPORT NO. 3
for the period
June 29, 1994 to December 16, 1996

Project Status

The following data collection and analysis activities have been conducted since the previous progress report.

Vegetative Plantings: In October 1996, the vegetative plantings of California bulrush, *Scirpus californicus* (C. Meyer) Steud., were inspected to evaluate and document the effect of drought conditions and high salinity on planting survival during the year. Nearly all of the mature stems on the plantings were brown and appeared to be dead. In the 13 sampling plots inspected, all transplants in 7 plots were either absent or appeared to be dead, 2 live transplants were present in each of 2 plots, and 4 plots contained a significant growth of bulrush resulting from lateral growth of the original transplants. These observations suggest that significant decreases in overall survivorship have occurred since the last evaluation in July 1995 (Vincent and Sun 1996).

Project Description

The project, located about 6 mi west of Hackberry, Louisiana, was designed to evaluate the ability of vegetative plantings and hay-bale fences to abate wind-driven erosion along various shorelines in a deteriorated marsh. In April 1994, installation of 6,000 linear ft of hay-bale fencing was completed. In June 1994, approximately 4,750 trade-gallon-size plantings of California bulrush were installed. The fences and plantings were installed in three groups (A, B, and C) along the eastern, northwestern, and southern shorelines of a large, shallow, interior marsh pond, using different configurations of fences and plantings (figure 1). The fences are either straight or "V-shaped" segments, constructed parallel to shorelines. The California bulrush transplants were planted in two parallel rows on 5-ft centers, with the rows generally running parallel to adjacent shorelines.

The specific project objectives are to restore, protect, and enhance about 300 acres of inland wetlands by using vegetation plantings to minimize wetland erosion, and hay-bale fences to encourage sediment deposition. The specific goals are to reduce wind-driven wave erosion of marsh shorelines using California bulrush plantings, increase sediment deposition adjacent to hay-bale fences, and increase the amount of emergent and submersed aquatic vegetation.

Monitoring Design

Color-infrared aerial photography was taken once preconstruction in November 1993, and will be taken at year 3 postconstruction for use in documenting shoreline movement and determining ratios of vegetated-to-nonvegetated areas. Shoreline markers were installed at 100-ft intervals along shorelines west of Group A, fences 5 and 6, and in a reference area just to the south of Group A. The positions of these shoreline segments were surveyed in August 1994, and they will be resurveyed at years 3, 5, and 10 postconstruction to evaluate shoreline movement.

A 5% sample of the vegetation plantings, consisting of 16 randomly selected plots of 16 plants (8 plants on each of 2 rows) were monitored for survivorship (percent survival), species composition, and percent cover at 1, 6, and 12 mo postplanting. Monitoring of these variables in the sampling plots will be repeated at years 3, 5, and 10.

The values of the original vegetation planting data ranged from 0 to 1 and did not conform to a normal distribution. To allow for a two-way analysis of variance (ANOVA) with repeated measures, all data used in the ANOVA were transformed by logistic transformation using the following formula.

$$\log_e\left(\frac{1+x}{x}\right),\ \text{where}\ x = \text{original data} + 0.000001$$

In August 1994, sediment deposition and the occurrence of submersed aquatic vegetation (SAV) along the hay-bale fences was monitored along 16 transects (figure 2) established across and perpendicular to a subsample of 6 fences (A2, A6, B3, B4, C2, and C3). For use as a reference, two additional transects were established in open water away from the fences, one north of fence A6 and one south of the Group A fences. Subsequent surveys are planned for postconstruction years 3, 5, and 10.

In addition, the effect of salinity on planting success is being evaluated by using salinity data collected from an adjacent restoration project at Rycade Canal (C/S-02) (Weifenbach 1996).

Results/Discussion

Hay-bale fences: In May and June 1994, six hay-bale fences were selected and tagged for elevational transect surveys and two reference sites were located and marked. Shoreline markers were deployed along two sections of shoreline to be surveyed, one west of fence A6, and one southwest of the Group A fences. In August 1994, elevation transects were surveyed across the selected hay-bale fences and the two reference sites. Typical elevation profiles are provided in figures 3 and 4. In addition, the two sections of shoreline on which the shoreline markers were installed were surveyed to record the current position.

Hay bales did not remain intact for very long. By July 1994, the Groups A and C hay-bale fences were empty, while some hay remained in the Group B fences. In December 1994, an attempt was made to remedy this problem when Group A, fence A3, was modified and refurbished with hay bales, and fence A2 was refurbished with hay bales wrapped in plastic geogrid fabric. Within two weeks, all of the hay was washed out of the enclosures. In March 1995, the Natural Resources Conservation Service (NRCS) and Cameron Parish installed discarded Christmas trees in fences A3-A6. As of October 23, 1996, about 70% of the Christmas trees had remained intact in the enclosures. The next elevational transect survey is scheduled for July 1997.

The results to date suggest that hay-bale fences are ineffective at abating wave energy as designed and deployed in this environment because the wave action causes the hay bales to break apart. The use of hay bales consisting of longer lengths of straw, in combination with a wrapping of smaller mesh geogrid fabric may have been effective in more protected locations, such as the Groups B and C fences.

Vegetative Plantings Survival: In July 1994, sixteen 16-plant sampling plots were randomly selected and delineated for use in monitoring. Planting survival was evaluated in terms of four variables (Harper 1977), which are defined and calculated as follows.

$$\text{survival frequency} = \text{number of live plants inside plot at timepoint } x$$

$$\textit{survivorship } (l_x) = \textit{probability (at planting time) of surviving until age } x = \frac{\textit{no. live plants inside plot at timepoint } x}{\textit{original no. plants inside plot}}$$

$$\text{mortality } (d_x) = \text{probability (at planting time) of dying during age interval } x, x+1 = l_x - l_{x+1}$$

$$\text{mortality rate } (q_x) = \text{probability of a planting at age } x \text{ dying before the age of } x+1 = \frac{l_x - l_{x+1}}{l_x} = \frac{d_x}{l_x}$$

Summary statistics on the data from the vegetation surveys conducted at 1, 6, and 12 mo postplanting (figure 5, tables 1 and 2) indicate that survivorship (percent survival) decreased during the first 12 months postplanting, averaging 77.2%, 59.1%, and 55.6% at 1, 6, and 12 mo postplanting, respectively. However, the mortality rate decreased over the same time period (figure 5, table 2), suggesting that the surviving plantings were becoming established by 12 mo postplanting.

A two-way ANOVA with repeated measures was performed on the mortality data to measure changes in mortality rate among the three monitoring periods (0 to 1 mo, 1 to 6 mo, and 6 to 12 mo postplanting) and among three sampling groups (planting groups A, B, and C). The results of a two-way ANOVA indicate a significant decrease ($p<0.05$) in the mortality rate over time (table 3), from 0.228, between 0 and 1 mo postplanting, to 0.059 from 6 to 12 mo postplanting (figure 5, table 2). No significant difference in mortality rate was found among planting groups A, B, and C (table 3).

In October 1996, the vegetative plantings were inspected to evaluate and document the effect of drought conditions and high salinity in the planting area during 1996 on planting survival. Nearly all of the mature stems on the plantings were brown and appeared to be dead, and most of the remaining transplants did not bear obvious young, green shoots. However, the plantings are growing in approximately 2 ft of turbid water, and it is likely that additional new growth was submerged and was not apparent. The planting rows on the east side of the planting area appear to have been impacted the most. Vigorous growth of the transplants has developed only on the south end of planting row A1, and on rows B1 and B2 (figure 1).

In October 1996, only 4 of the 16 established sampling plots (B1-1, B2-1, B2-2, and B2-3) included growth so vigorous that the individual transplants were indistinguishable, 2 plots (A1-1 and C3-2) each included only 2 live plants, and all transplants in plots B2-4, C1-1, C1-2, C1-3, C2-1, C2-2, and C3-1 were either absent or appeared to be dead. Plots C2-3, C2-4, and C2-5 were not inspected in October 1996 because the poles marking the corner plant for these plots were missing. However, plots C2-3 and C2-4 were located on a section of planting row C2, where planting survival appeared to be 0%. Plot C2-5 was located on the north end of planting row C2, where the remaining transplants appeared to be indistinguishable due to considerable lateral growth.

The October 1996 observations suggest that significant decreases in survivorship have occurred since the last evaluation in July 1995 (Vincent and Sun 1996). A more thorough investigation of the plantings, including statistical analysis of survivorship, mortality rate, and percent cover, will be undertaken at 3 yr postplanting, in July 1997. This should allow ample time for the surviving transplants to produce new shoots, as salinity in the planting area returns to more normal levels.

<u>Vegetative Plantings Cover:</u> In the monitoring design for vegetative plantings (LDNR 1995), the percent cover of vegetation in a 1-m^2 subsample plot, centered around one corner plant within each 16-plant sampling plot, was to be used as a measure of the percent cover in each 16-plant plot. Using this method, the mean percent cover of bulrush in a 1-m^2 plot associated with each 16-plant sampling plot was 5% at 1 mo, 9% at 6 mo, and 45.2% at 12 mo postplanting (table 1). By 6 mo postplanting, the selected corner plants for vegetation sampling plots B2−4, C1−3, and C2−2 were absent, resulting in percent cover estimates of 0% for each of the 3 plots at 6 mo and 12 mo

postplanting, at which time the survivorship in these plots ranged from 19% to 75% (table 1). Therefore, the percent cover estimates from the associated 1-m^2 subsample plots are not representative of the canopy cover in these three 16-plant plots at 6 mo and 12 mo postplanting. It is not possible to make meaningful comparisons of the 1-mo postplanting percent cover data for these plots with subsequent data sets using this methodology.

To solve this problem, it was decided that for future data sets, percent cover will be recorded for each entire 16-plant sampling plot, rather than for only the 1-m^2 subsample plots. For comparison, the 1-mo postplanting monitoring data was extrapolated to estimate percent cover for each entire 16-plant sampling plot by assuming 5% cover for each live plant in a plot at 1 mo postplanting (table 4). This data will be compared to the next percent cover data set, to be collected at the end of year 3 in July 1997.

The data collected to date does allow for further evaluation of the percent cover observed in 13 of the 16 sampling plots, where the corner plant used to estimate percent cover remained alive through 12 mo postplanting (table 1). The results of a two-way ANOVA indicate a significant increase ($p<0.05$) in percent canopy cover over 12 mo postplanting (figure 6, table 3). The mean percent cover for these 13 sampling plots at 1, 6, and 12 mo postplanting was 5%, 12%, and 60.2%, respectively (figure 6, table 5). Significant difference ($p<0.05$) in percent cover was also found among planting groups A, B, and C (table 3).

From the preliminary data, it can be concluded that California bulrush plantings can be established in this environment in a relatively short time period. After an initial period of establishment, there was a significant decrease in mortality rate and a significant increase in percent cover during the first year postplanting (figures 5 and 6). Subsequent observations in October 1996 suggest that early establishment and rapid growth may also help to buffer the more vigorous transplants from extirpation as a consequence of dieback resulting from extreme environmental conditions, such as high salinity.

<u>Salinity:</u> Analysis of pre- (September 1993 to June 1994) and postconstruction (July 1994 to September 1995) salinity data from the Rycade Canal (C/S-02) project, which influences salinity in the West Hackberry Plantings project area, indicates that salinity averaged 4.0 ppt in the vicinity of the West Hackberry plantings during that period of record (Weifenbach 1996). This level of salinity falls within the known range of tolerance for California bulrush, which is characteristic of fresh-to-intermediate marsh vegetation (Chabreck 1972).

Unfortunately, salinity increased dramatically throughout the West Hackberry plantings area and remained above 6 ppt from April through October 1996 (LDNR 1996). Comparison of average monthly salinity from January through October for years 1993 through 1996 (figure 7), as recorded at 4 stations in the vicinity of the West Hackberry plantings (figure 1), shows that salinity averaged less than 6 ppt at all four stations for years 1993 through 1995, but averaged over 8 ppt at all four stations for the same period of record for 1996. In addition, salinity averaged slightly higher on the eastern half than on the western half of the West Hackberry plantings area (figures 1 and 7) for each year, further suggesting that dieback of the plantings was associated with high salinity.

A major contributing factor to the increased salinity recorded in 1996 was the presence of drought conditions in southwest Louisiana from February through July 1996 (Louisiana Office of State Climatology [LOSC] 1996), brought on by below normal precipitation (table 6), with the predominant wind direction promoting northward migration of high-salinity water for most months.

References

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Construction Start:	November 1, 1993	
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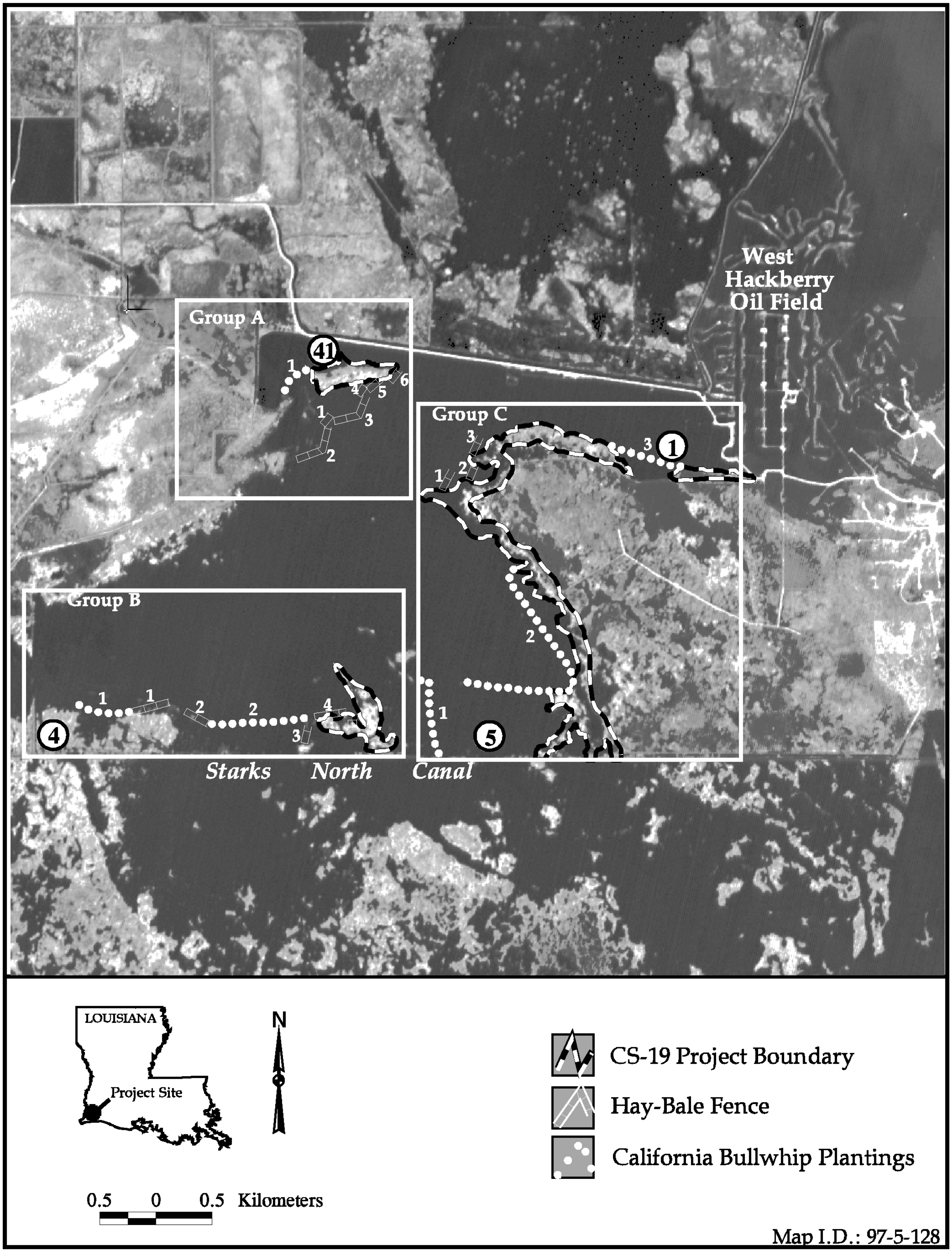


Figure 1. West Hackberry Plantings and Sediment Enhancement (CS-19) project area showing locations of restoration features.

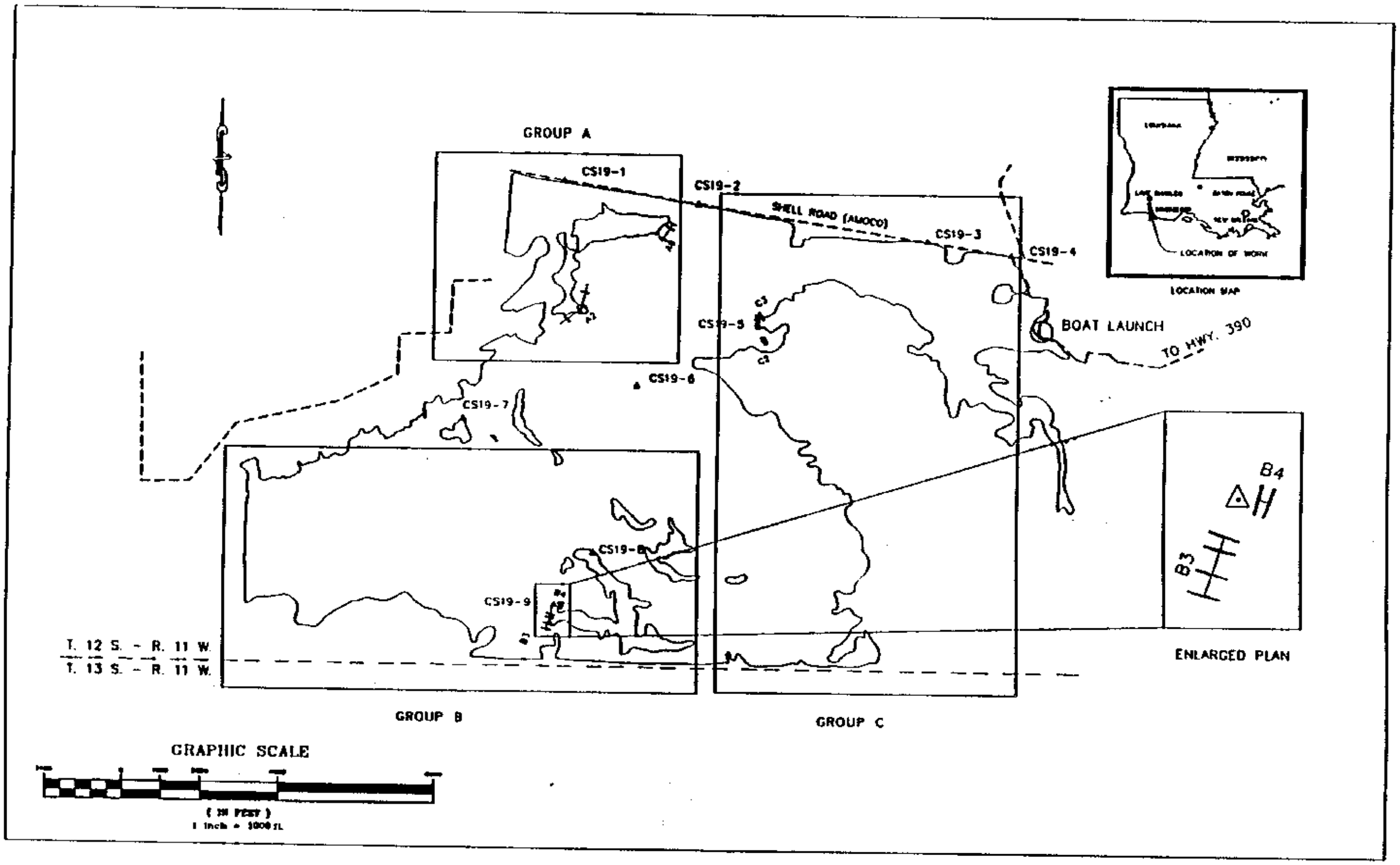
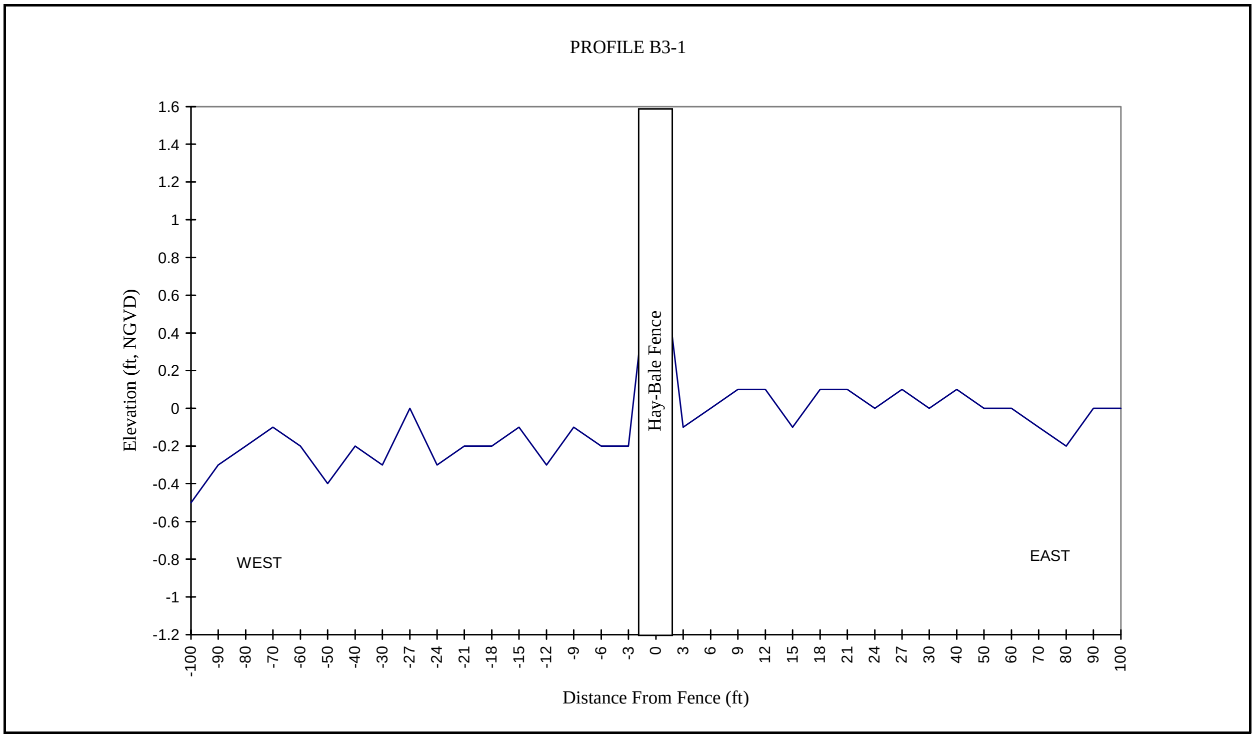


Figure 2. West Hackberry Plantings and Sediment Enhancement (C/S-19) project area map showing locations of hay bale fences and shorelines selected for surveying.



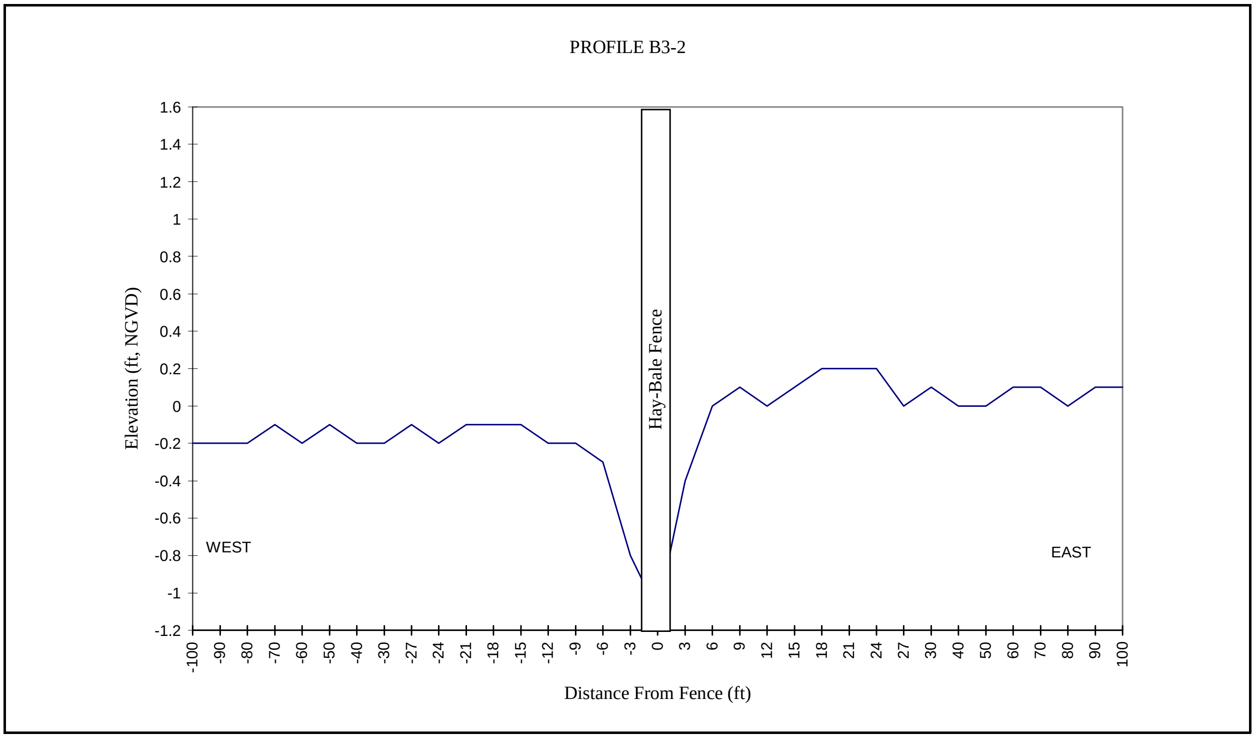
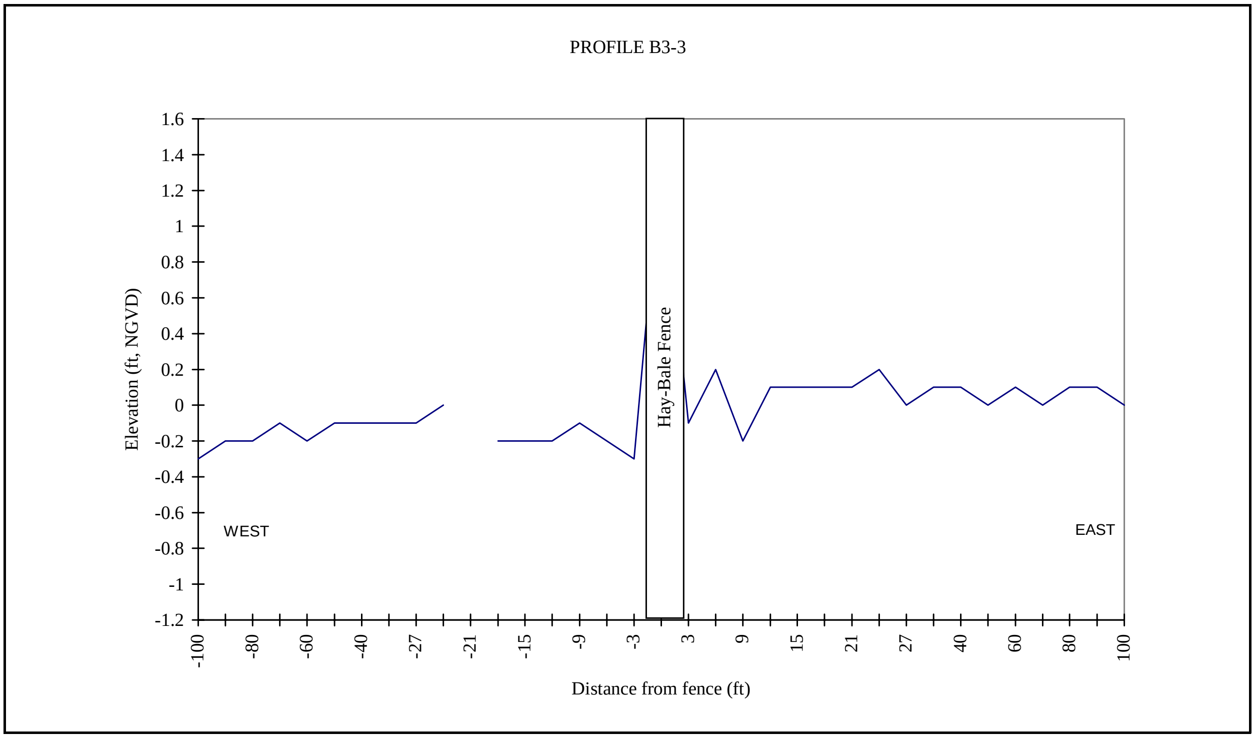


Figure 3. Elevational profile transects 1 and 2 across hay-bale fence B3 in the West Hackberry Plantings and Sediment Enhancement project area, Cameron Parish, Louisiana, surveyed August 1994. (See figure 2 for locations of fence and transects).



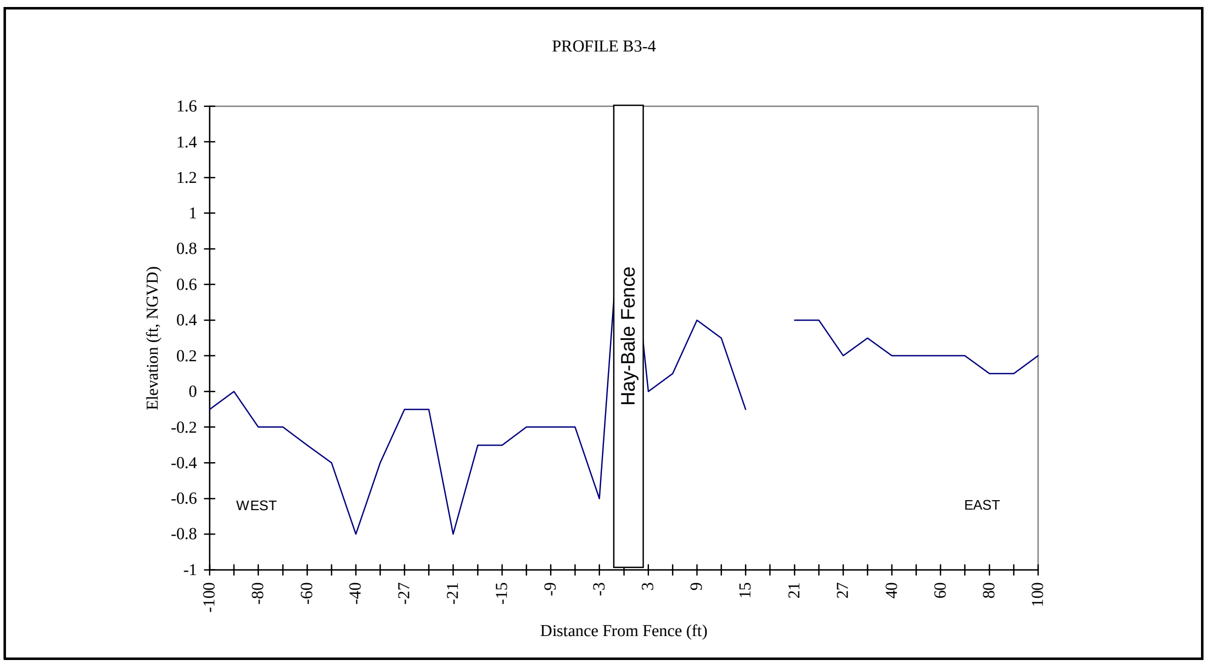
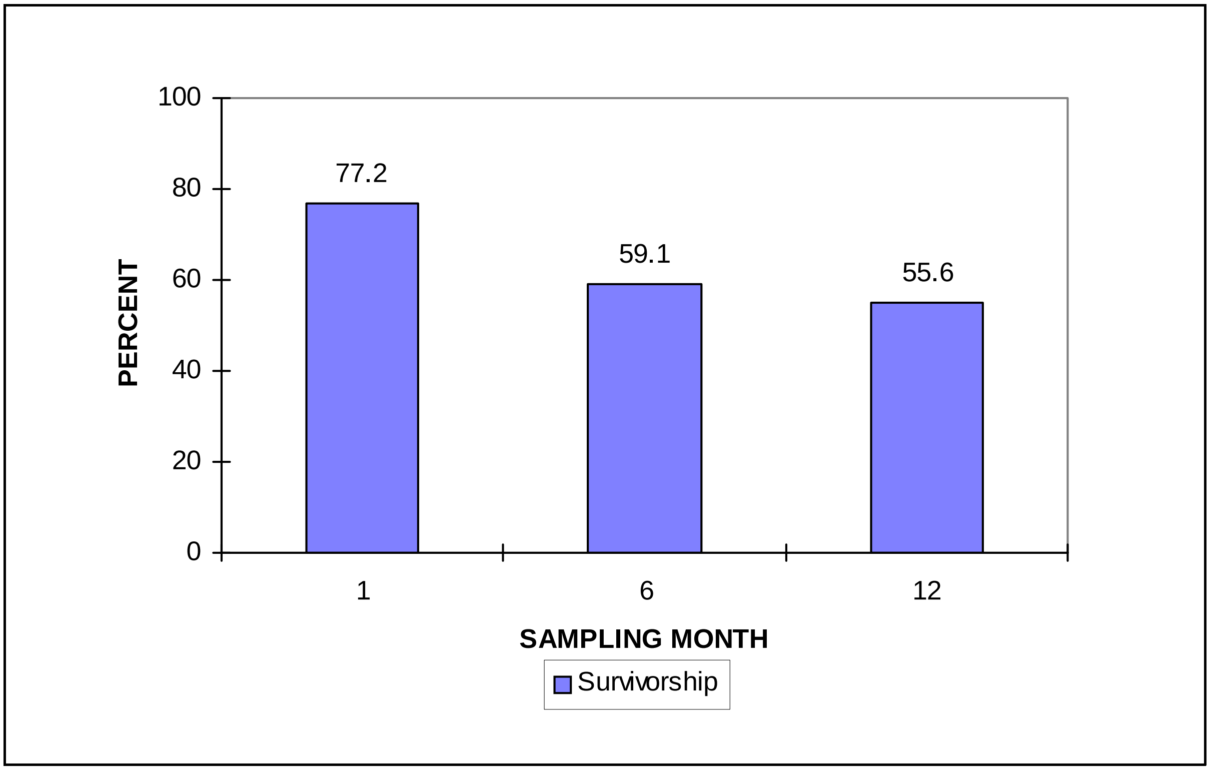


Figure 4. Elevational profile transects 3 and 4 across hay-bale fence B3 in the West Hackberry Plantings and Sediment Enhancement project area, Cameron Parish, Louisiana, surveyed August 1994. (See figure 2 for locations of fence and transects).



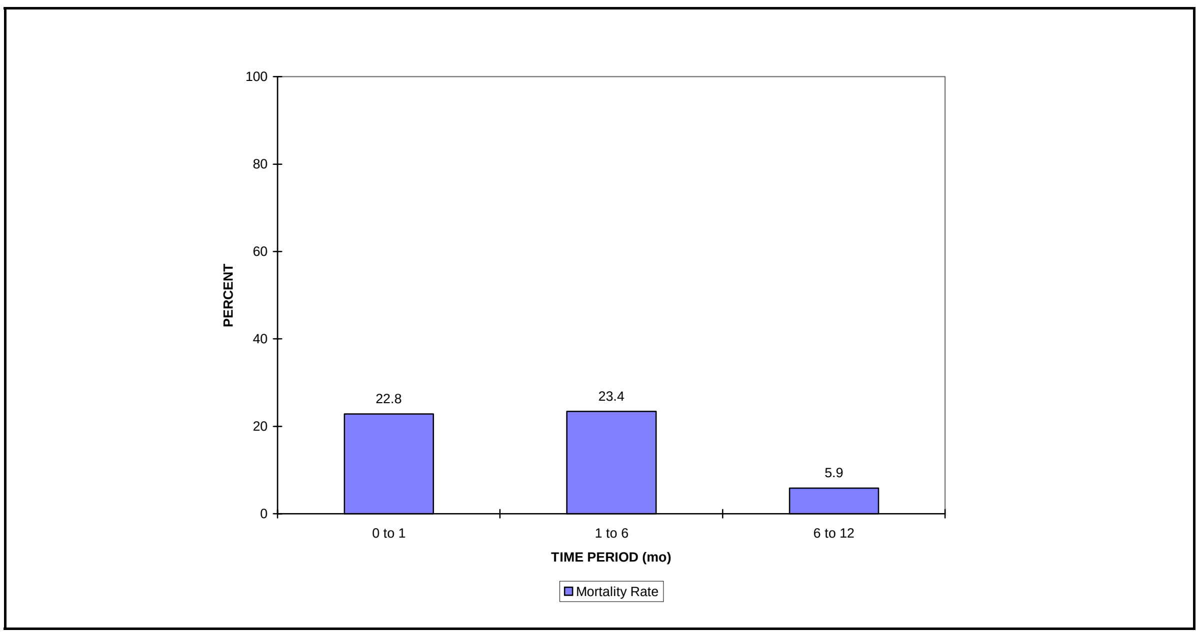


Figure 5. Mean survivorship and mortality rate of California bulrush plantings in 16 random sampling plots, from August 1994 to July 1995, as observed at 1, 6, and 12 mo postplanting. The mortality rate, determined for consecutive time periods 0 to 1, 1 to 6, and 6 to 12 mo postplanting, decreased significantly ($p<0.05$) from 6 to 12 mo postplanting.

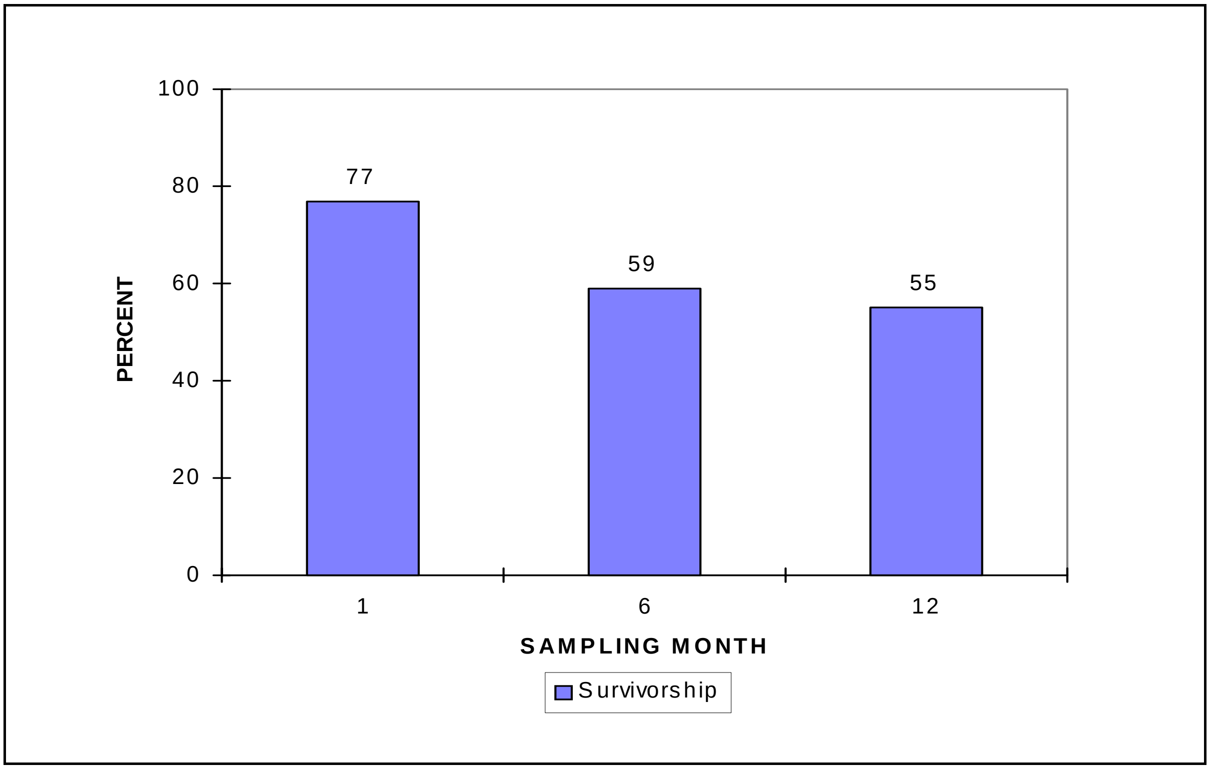


Figure 6. Mean survivorship and percent cover of California bulrush plantings in 13 random sampling plots, from August 1994 to July 1995, as observed at 1, 6, and 12 mo postplanting. (Note: only the 13 plots for which percent cover data was available at 6 and 12 mo postplanting are included in this graph.)

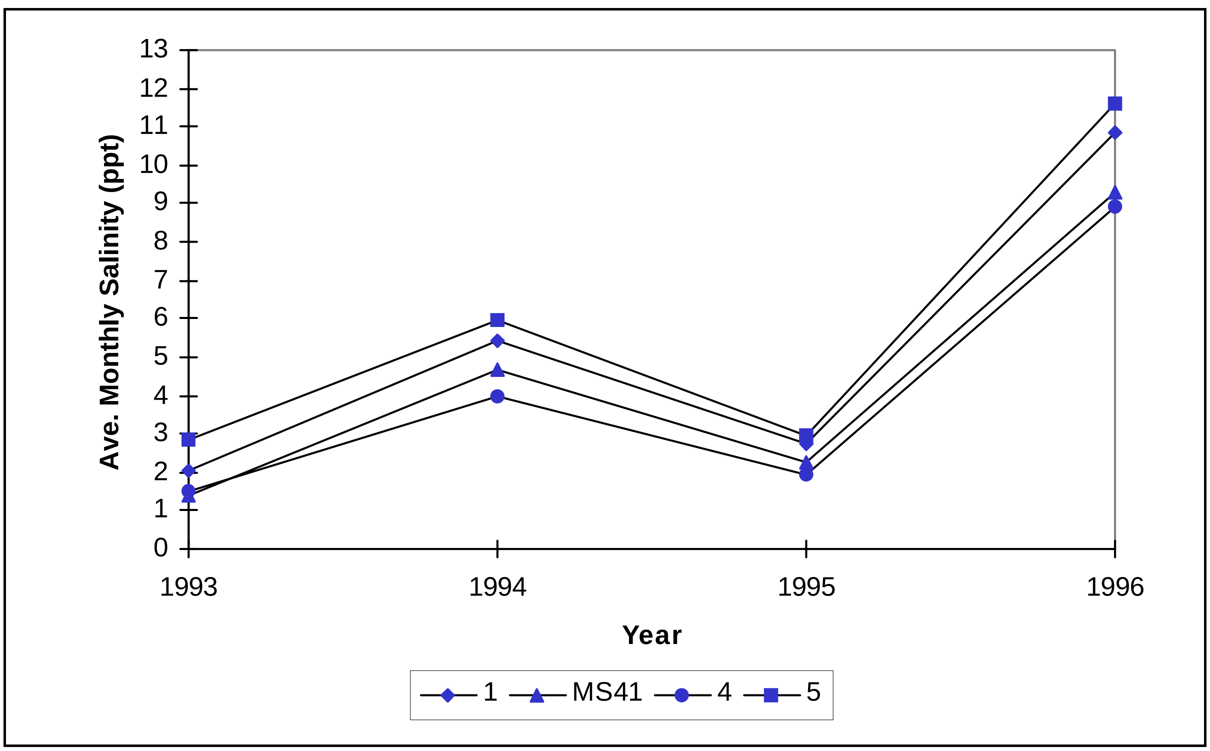


Figure 7. Average monthly salinity from January through October for years 1993 through 1996 in the West Hackberry Plantings project area at stations 1, MS412, 4, and 5. (Based on monthly and bimonthly data collected by LDNR/CRD for the Rycade Canal (C/S-02) project [LDNR 1996].)

Table 1. Survivorship (percent survival) of California bulrush plantings in 16-plant sampling plots, and percent cover in associated 1-m^2 subsample plots, from August 1994 to July 1995, as observed at 1, 6 mo, and 12 mo postplanting. Mean values are for all sampling plots (n=16) and associated subsample plots.

	1 Month		6 Months		12 Months	
Plot	**% Survival (entire plot)**	**% Cover (1-m^2 plot)**	**% Survival (entire plot)**	**% Cover (1-m^2 plot)**	**% Survival (entire plot)**	**% Cover (1-m^2 plot)**
A1−1	**88**	**5**	**50**	**5**	**50**	**2**
B1−1	**75**	**5**	**69**	**20**	**69**	**100**
B2−1	**75**	**5**	**75**	**18**	**75**	**100**
B2−2	**94**	**5**	**94**	**15**	**94**	**100**
B2−3	**100**	**5**	**94**	**5**	**94**	**100**
B2−4	**94**	**5**	**75**	**0***	**63**	**0***
C1−1	**75**	**5**	**31**	**3**	**19**	**3**
C1−2	**94**	**5**	**69**	**3**	**63**	**3**
C1−3	**38**	**5**	**38**	**0***	**25**	**0***
C2−1	**38**	**5**	**0**	**0**	**0**	**0**
C2−2	**56**	**5**	**25**	**0***	**19**	**0***
C2−3	**63**	**5**	**50**	**10**	**44**	**50**
C2−4	**94**	**5**	**81**	**10**	**81**	**100**
C2−5	**94**	**5**	**75**	**40**	**75**	**100**
C3−1	**69**	**5**	**50**	**5**	**50**	**25**
C3−2	**88**	**5**	**69**	**10**	**69**	**40**
Mean	**77.2**	**5**	**59.1**	**9**	**55.6**	**45.2**

***Corner plant used to estimate percent cover in this associated 1-m^2 plot was dead or absent at 6 and 12 mo postplanting.**

Table 2. Partial life table of California bullwhip (*Scirpus californicus*) plantings in the West Hackberry Vegetative Planting project area, based on means of data collected from sixteen 16-plant sampling plots, from August 1994 to July 1995, at 1, 6, and 12 mo postplanting.

Age (mo)	Survival Frequency (n)	Survivorship	Mortality	Mortality Rate
0	**16**	**1**	**0.228**	**0.228**
1	**12.3**	**0.772**	**0.181**	**0.234**
6	**9.3**	**0.591**	**0.035**	**0.059**
12	**8.8**	**0.556**	**-**	**-**

Table 3. The results of a two-way ANOVA on mortality rate (n=16) and percent cover (n=13) of California bulrush plantings, from August 1994 to July 1995, as observed at 1, 6, and 12 mo postplanting. The data were transformed by logistic transformation using the formula $\log_e[(1+X/X]$, where X = original data + 0.000001.

		Mortality Rate	Percent Cover
SOURCE	**DF**	**F-VALUE**	**F-VALUE**
Group	**2**	**1.39 ns**	**8.06 ***
Row (group)	**3**	**0.26 ns**	**0.06 ns**
Month	**2**	**7.04 ***	**3.51 ***
Group × Month	**4**	**0.33 ns**	**2.4 ns**
Row (group) × Month	**6**	**1.14 ns**	**0.33 ns**

ns = not significant; * = significant (p<0.05).

Table 4. Estimates of percent cover for California bulrush plantings within each entire 16-plant sampling plot, as observed at 1 mo postplanting (August 1995).

Plot	No. Live Plants	% Cover For Plot
A1−1	14	4.4
B1−1	12	3.8
B2−1	12	3.8
B2−2	15	4.7
B2−3	16	5.0
B2−4	15	4.7
C1−1	12	3.8
C1−2	15	4.7
C1−3	6	1.9
C2−1	6	1.9
C2−2	9	2.8
C2−3	10	3.1
C2−4	15	4.7
C2−5	15	4.7
C3−1	11	3.4
C3−2	14	4.4
Mean:	12.3	3.9

Table 5. Mean survivorship (percent survival) of California bulrush plantings in 16-plant sampling plots, and mean percent cover in associated 1-m^2 subsample plots, from August 1994 to July 1995, as observed at 1, 6, and 12 mo postplanting, for all sampling plots except B2-4, C1-3, and C2-2, in which the corner plants used to estimate percent cover for the plot were dead or absent at 6 and 12 mo postplanting (n=13).

1 Month		6 Months		12 Months	
% Survival (entire plot)	% Cover (1-m^2 plot)	% Survival (entire plot)	% Cover (1-m^2 plot)	% Survival (entire plot)	% Cover (1-m^2 plot)
80.5	5	62.1	11.8	60.2	55.6

Table 6. Monthly and cumulative climate data from January through September 1996 for the southwestern Louisiana division (Allen, Beauregard, Calcasieu, Cameron, and Jefferson Davis parishes). Compiled with data from Louisiana Office of State Climatology (1996).

Month	Monthly Mean Precipitation (inches)	Cumulative Departure From Normal (inches)	Monthly Palmer Drought Severity Index	Monthly Predominant Wind Directions
Jan	3.33	-1.75	±Normal	S, N, SW, NW
Feb	1.51	-4.41	Mild	SW, S, N, NE
Mar	1.58	-6.97	Mild	S, SW, NW, N
Apr	3.22	-7.54	Mild	S, SW, SE
May	1.38	-11.52*	Moderate	S, SW, SE
Jun	6.01	-10.75	Mild	S, SW, SE
Jul	4.98	-11.81	Moderate	SW, SE
Aug	8.77	-8.89	±Normal	NE, E, SE, S
Sep	7.33	-6.77	Moist Spell	NE, E, SE, S, N

*** Indicates highest May departure on record for the southwestern Louisiana division.**