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Erosion causes many environmental and property damage problems along the shorelines of natural and man-made lakes. The research reported here was conducted at the Walter F. George Reservoir which lies between Georgia and Alabama. The lake is characterized by water level fluctuations of 5 or more feet and occasional strong wave actions. Beginning in 1994, several experiments were conducted using biotechnical methods to control damage from wave action. Coconut fiber logs, straw bales wrapped in poultry netting, large round hay bales, and bundled logs anchored to the shoreline were all evaluated for their potential to control wave damage to the shoreline. While these materials were effective at normal water levels in calm weather all eventually failed either because of excessive flooding or storm driven wave action. Several species of wetland and terrestrial plants were planted behind the breakwaters with short term success but all were destroyed by wave action when the breakwaters failed. A greenhouse experiment using substrate from the site showed a strong response to fertilizer nitrogen by both wetland and terrestrial plants.

TITLE

DEVELOPMENT OF BIOTECHNICAL METHODS TO CONTROL SHORELINE EROSION

TYPE OF REPORT (TECHNICAL FINAL PROGRESS)

FINAL REPORT

AUTHOR(S)

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Alabama A&M University

Development of Biotechnical Methods to Control Shoreline erosion

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Contractor:	Department of Plant and Soil Science Alabama A&M University P. O. Box 1208 Normal, Alabama 35762
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FINAL REPORT DECEMBER 1, 1999

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Development of Biotechnical Methods to Control Shoreline Erosion

Executive Summary

Erosion creates numerous problems along the shorelines of natural and man-made lakes including more than 5000 miles of shoreline on U.S. Army Corps of Engineers lakes. In addition to causing damage to property and siltation of waterways eroding shorelines offer little habitat for fish and wildlife.

The Walter F. George Reservoir is a long narrow lake about 50 miles in length and 1 to 3 miles in width which was created about 40 years ago by damming the Chattahochee River at Ft. Gaines, Ga. The lake is characterized by water level fluctuations of about 5 feet causing large fluctuations in shoreline width and occasionally strong wave action from the west. Bank undercutting and sloughing is common on both shorelines.

Beginning in 1994 a number of experiments were conducted in an effort to develop low cost biotechnical methods of shoreline erosion control. While engineering solutions would likely have been effective the cost is usually more than $100 per foot and a cheaper solution was needed. We evaluated a number of fairly cheap breakwater materials which we hoped would control wave action until vegetation could become established.

In the first experiment we compared coconut fiber logs 1 foot in diameter by 10 feet long which cost $10 per linear foot. With straw bales wrapped in poultry netting which cost less than $3 per foot. Labor cost and stakes added an additional $1.00 to $1.50 per linear foot for these materials. We then planted an assortment of terrestrial and wetland plants behind the breakwaters at various times during the next year. Over the next 2 years several episodes of severe flooding and wave action destroyed these breakwaters and the plants behind them.

In the next experiment large round hay bales were placed in a 400 foot row along the western shoreline this breakwater was destroyed in less than 2 months by a flood which caused the bales to float out of position.

An additional breakwater was built using logs which were bundled together with steel cable and anchored to the shoreline with Duck bill anchors . This breakwater was destroyed when high waves moved the logs out of the cable wrappings.

The experiences with these biotechnical breakwaters lead us to believe that in situations with the great water level fluctuations and high waves which exist at this lake, only engineered solutions such as rip-rap, sheet piling, and concrete revetments will successfully stop erosion.

Introduction

Erosion can create numerous problems along the shorelines of a variety of waterways including natural and man-made lakes and saltwater areas. Kreutzwiser (1987), Marsh (1990), and several others have discussed the effects of beach and bluff erosion in the Great Lakes region. In the situations which they reported, serious property damage sometimes occurs because of extensive real estate development along the lake shores in the U.S. and Canada as well as because of the intense storms which can develop on these large bodies of water. Serious property damaging erosion also frequently occurs along salt water shorelines, particularly in conjunction with hurricanes.

Shoreline erosion problems at Corps of Engineers (CE) reservoir projects, according to Allen and Wade 1990, were reported by 19 CE Districts that responded to an inquiry from The Waterways Experiment Station. Within the reporting districts' areas of operation, 161 reservoirs were considered to have shoreline erosion problems. Severe erosion was reported on over 5,000 miles of shoreline, with another 5,000 miles being affected by minor erosion. Damage to private property was cited at 132 projects. Other types of damage included archaeological/cultural sites (79 projects), fish and wildlife habitat (62) projects, water quality (41 projects), and reduction of project life and storage capacity. Siltation from erosion can degrade the environment for bottom dwelling micro and macro invertebrates and vertebrates as well as reducing the useful life of reservoirs.

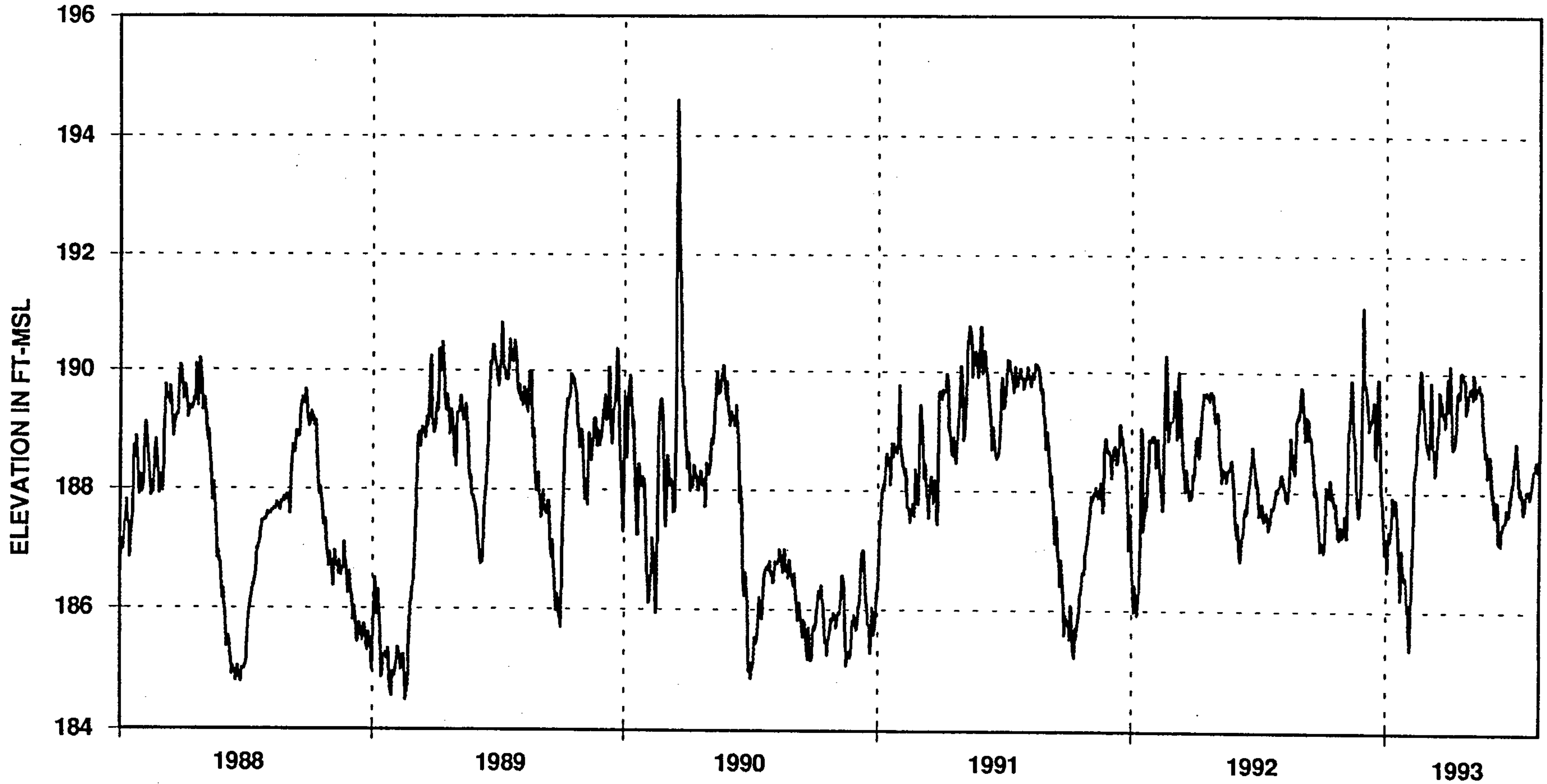
In addition to being subjected to erosive forces, bare shorelines offer little benefit to aquatic and terrestrial wildlife. A shoreline vegetated at and below the waterline with a variety of aquatic plant species can become a mini-wetland which is a habitat for amphibious creatures such as frogs and salamanders and can serve as spawning areas for various species of fish and crustaceans. Hammer and Bastian (1989), reported that wetlands are now seen as being valuable for stabilizing shorelines and reducing erosion.

The Walter F. George Reservoir was created on the Chattahoochee River between Georgia and Alabama when the Walter F. George Dam was constructed near Ft. Gaines, Georgia about 40 years ago. It is a relatively long, narrow lake about 1 to 3 miles in width and approximately 50 miles long. The shoreline is characterized by many unvegetated steep banks which are several feet in height. As a result of wave action and rainfall these banks contribute silt to the reservoir. Because they are not vegetated they do not provide useful habitats for either aquatic or terrestrial wildlife.

Damage to private property has resulted because insufficient shoreline was purchased by the government before the lake was constructed. The water level in the lake varies from about 184.5 to 190 feet above sea level on a fairly regular basis because of navigation requirements and seasonal conditions. There is a navigation window about once a month at which time water is released from the lake to increase the depth of the Appalachicola River downstream to the minimum depth for barges. This results in a drop of several feet in the lake level. The level is then allowed to rise gradually until the next navigation window. Because of this fluctuation the lake is alternately at full pool with the waves lapping at the shoreline or has a dry beach as much as 40 or 50 feet in width. Almost all the erosion occurs when the lake is a full pool or above and the waves undercut the banks causing the soil to slough off into the water. The most sever wave action is due to winds blowing across the lake, however, boat wakes also cause some problems.

Typical fluctuations in lake elevations

W.F. GEORGE ELEVATIONS



Background

The most successful shoreline vegetation programs should have the capability of preventing erosion and additional soil loss from exposed beaches and bluffs along freshwater lakes and also result in improved habitats for both aquatic and terrestrial species of wildlife.

Vegetation which is established above the waterline should include both herbaceous and woody species. This type of cover can reduce or prevent erosion caused by wave action as well as that caused by rain and overland flow of surface water. In addition, it can provide habitat for numerous species of birds and small animals. When vegetation is extended below the water line emergent plants can reduce the force of waves as well as holding soil by root activity. The emergent as well as submerged vegetation which occurs below the water line can serve as a spawning area for fish, crustaceans and certain amphibians and thus will have the potential for improving the sports fishery status of the lake.

Allen et al. (1989) characterized a plant community of various herbaceous species adapted to areas from 45 cm above the waterline to 150 cm below the waterline. The listed species included some growing only on dry land, others growing only in water, and still a third group adapted to the transition zone where it is neither wet nor dry. Howard and Allen (1988) described the adaptation zones of several woody species in relationship to the distance above the waterline of streams. According to their description, black willow and cottonwood are two species particularly well adapted for shoreline plantings.

New vegetation along shorelines must often be protected from wave action until it becomes well established. Several techniques for doing this have been suggested, including temporary or moveable rafts made of used tires or utility poles which can disrupt wave action while vegetation is getting established.

Hoeger (1988) described a system of floating islands developed in Germany for use in protecting shorelines from erosion. The islands are equilateral triangles about 2 m long and can be fastened together in any desired combination. They can be planted with several types of aquatic vegetation which helps in wave control. Fiber rolls and erosion control carpets made from coconut fiber can be planted with wetland plants to control erosion until plants become well established.

Kaufmann (1991) has been granted a patent for a biodegradable cardboard sheet material with projections and depressions in which plants can be set. This material is said to moderate wave energy until plants can become established.

Fuller (1988) reported on the use of concrete block revetments to control erosion, but this system is not low cost.

Procedure

In cooperation with U.S. Army Corps of Engineers, Waterways Experiment Station scientists, several research sites were selected along the shoreline of the Walter F. George Reservoir where erosion potential currently exists. The various sites have different slopes and present different aspects with regard to wave action.

After selection, the individual sites were evaluated to determine possible courses of action for vegetation establishment. Preliminary determinations included the slope, both above and below the full pool waterline, the nutrient status and pH of substrates above and below the waterline, and the soil texture and water holding capacity of the area above the waterline.

Based on the preliminary site evaluation, herbaceous plant species were selected for revegetating that portion of the shoreline which is above the full pool waterline. Fertilizers was used as need was indicated by soil tests for terrestrial vegetation. Vegetation establishment on the drawdown area was not practical because the substrate in that area was an extremely compacted clay which did not provide a satisfactory rooting medium. In several selected areas where wave action was likely to inhibit successful establishment of vegetation various temporary, low cost breakwater structures, were evaluated to determine their effectiveness in aiding vegetation establishment.

Success in vegetation establishment was determined by evaluating covers for density, effectiveness against wave action and other erosive forces, and usefulness as wildlife habitat for aquatic and terrestrial species.

Experiment 1

The first shoreline erosion control research was initiated in 1994 adjacent to the Cotton Hill Campground on the east side of the Walter F. George Reservoir and about 10 miles north of Ft. Gaines, Georgia. The basic objectives were to evaluate different kinds of breakwater structures and several plant species to provide shoreline protection.

Because most of the erosion occurs full pool, we determined that the most effective control would likely be to interdict wave action near the full pool level and revegetate the beach sand which had accumulated between the high water line and the toe of the backslope. We initially thought wave protection near the full pool level would allow the establishment of soil holding vegetation in a few months. As we noted above, it probably was not physically feasible and also unnecessary to vegetate the broad beach area exposed at low water level.

Coconut fiber (coir) logs which were 10 feet long and 1 foot in diameter were compared with wheat straw bales (14 inches x 18 inches by 3 feet) wrapped in poultry netting to provide protection from wave action. These breakwater materials were placed at an elevation of 189 feet in sections of 100 feet of each material replicated 3 times. We placed an additional 150 feet of straw bales at one end. Thus, approximately 750 feet of shoreline was treated. Both the coconut fiber logs and straw bales were secured in place with 3-foot wooden stakes placed 2 feet apart on each side then wired together on top of the breakwater material.

The coconut fiber logs cost about $10 per linear foot delivered at the job site while the straw bales cost less than $3 per foot including the cost of the poultry netting and the labor for wrapping. The cost of wooden stakes added about $0.75 per linear foot. Breakwater materials were installed on April 20-23, 1994. The labor cost for installing these materials added an additional $1.00 to $1.50 per linear foot of shoreline.

Each 100 foot section of breakwater was further divided into 20-foot sections each of which was planted with 60 plants of one of the following five species of wetland plants; blue flag iris (*Iris virginica*), soft rush (*Juncus effusus*), maiden cane (*Panicum hemitomon*), three square rush (*Scirpus americanus*) and soft stem bulrush (*Scirpus validus*). One row of plants was set immediately in front of the breakwater with three rows being set behind it. Plants were set using pine tree planting bars to make holes. A 9 gram Agriform™ fertilizer tablet (analysis 22-8-2) was placed in the soil about 2 inches away from the roots of each plant. All planting was completed on May 12 and 13, 1994.

Initial weather conditions were unfavorable for plant establishment in that no rain fell for about 2 weeks after planting and the lake level fell to about 187 feet resulting in a dry beach area several yards in width adjacent to the plantings. However, significant plant survival was observed. During June, sufficient rain fell to assure good plant growth.

The entire region was subjected to a tropical storm in late June which resulted in the lake level rising about 3 feet above full pool.

When the water receded enough for a good visual assessment of the situation, we found that sand and silt had been deposited behind the coconut fiber logs and wire wrapped straw bales to essentially the full depth of these breakwater structures. This deposited material had completely covered the plants set in May resulting in 100 percent stand loss, however it resulted in about one foot of soft, easily planted substrate.

The positive aspect of this happening was that it demonstrated the possibility of building shoreline by installing structures which can trap sand and silt washed toward shore by wave action. While we only accumulated about one foot of sandy soil in this situtation, the placement of higher barriers further out in the lake might result in even greater accumulations.

In early August 1994 a mixture of Blackwell switchgrass (Panicum virgatum) and common bermudagrass (Cynadon dactylon) was seeded on the sandy area between the waterline and the toe of the bank. The approximate seeding rate was about 20 lbs. of switchgrass and 5 lbs. of bermudagrass per acre. Fertilizer at the rate of 400 lbs./ac of 13-13-13 was broadcast on the seeded area. When the area was inspected in mid-September a good stand of grass about 2 inches to 4 inches in height was present, however, it appeared to be quite nutrient deficient. Therefore it was fertilized again at the same rate. The grass strip was 6 to 8 feet in width and several hundred feet long.

In mid-September 1800 soft stem bulrush) and 600 duck potato (*Sagittaria lancifolia*) plants were set in a strip about 4 feet in width behind the coconut fiber logs and straw bales. Forestry grade fertilizer tablets (9 gm 22-8-2) were placed adjacent to each plant.

After planting, the lake level remained near full pool for several weeks and the establishment of soft stem bulrush was good along several hundred feet of shoreline.

In early 1995 the water was allowed to rise several feet above full pool in order to reduce a commercial flooding hazard on Andrews Lake downstream. This resulted in all the soft stem bulrush and most of the bermudagrass and switchgrass plants being covered with sand and killed.

In the spring of 1995 the sandy area behind the breakwater was again replanted with *Spartina patens* and *Spartina bakeri*. These plants became established and grew well throughout the 1995 growing season. The area was pounded by a hurricane in September 1995. While the plants sustained some damage, many survived. This event, however, destroyed the wire wrapped straw bales.

The winter of 1995-1996 was characterized by an unusual amount of high water and wind from the west which blew directly across the lake and against the treated shoreline. This resulted in the complete destruction of the remaining coconut fiber log breakwater and all plants that had been previously established.

Conclusions from this experiment:

1. Breakwater structures utilizing wire wrapped straw bales and coconut fiber logs were effective in trapping sand and developing a good planting surface along the shoreline.
2. Planting should be delayed for several months after breakwater construction to allow sand to accumulate to the height of the breakwater so that plants are not covered by deposited sand.
3. This type of breakwater is not effective on impounded lakes where flooding can occur or where the lake is sufficiently wide relative to prevailing wind direction that waves several feet in height occur.
4. *Spartens patens, Spartina bakeri,* switchgrass and common bermudagrass all grew well on accumulated sand when fertilized until destroyed by high water.
5. The methods tried in this experiment are most likely to be effective where large variations in lake level and heavy wave action do not occur.

Experiment 2

Another biological material which has been proposed for use as a temporary breakwater to aid vegetation establishment is large round hay bales. We selected a site near White Oak Campground on the western shore of the same reservoir to evaluate this material. The bales were rolled from bahiagrass (*Paspalum notatum*) growing below the dam on the Walter F. George Reservation. A commercial hay cutter baled the hay and delivered it to the job site.

Eighty bales weighing 1000 to 1200 lbs each were placed in a row on the shoreline at an elevation of approximately 187 feet in December 1994. This created a protected area about 400 feet in length. Both ends of the row were tied in to the hillside to prevent waves from flowing behind them. With the bales placed at 187 feet we expected that about 40% of the lower end of the bales would be in the water at full pool. We thought that the bales would trap sand as the water rose and would become too heavy to float even in high water.

Because there was no vehicular or tractor access to the area where we wished to do this experiment the Corps of Engineers personnel loaded the bales on a barge then used a small crane to place the bales along the shoreline while working from the lake. While the hay bales were relatively cheap, placement was expensive because it required the services of 2 men plus a barge, crane and towboat for most of a day. After the bales were in place we planted the area between the bales and the hillside with soft stem rush and duck potato.

The January 1995 high water episode described above was also responsible for destroying this installation. The lake level rose above the tops of the bales and caused them to float out into the lake. Since this was thought to be an isolated incident the Corps of Engineers personnel salvaged enough of the bales to create a new breakwater about 200 feet in length, however, within a few months the waves destroyed this also.

Conclusion

Round hay bales appear to have little usefulness in shoreline revegetation with the possible exception of lakes with a stable water level and minimum wave action. At any rate, useful life of round bales in water is probably not much more than 6 months, thus revegetation would have to move rapidly.

Experiment 3

Hollis Allen of the Waterways Experiment Station successfully used logs which were bundled together with cables and anchored in place to control wave action on a lake in South Dakota. We evaluated a variation of his technique at a location on the eastern shore of the Walter F. George reservoir near the Cool Branch Park. This site was about 5 miles south of Georgetown, Geogia.

The construction took place in January 1997. Because an adequate amount of drift wood was not available a the site and adjacent trees could not be cut, a truckload of logs was purchased from a pulpwood contractor. The logs were delivered to the nearest road access to the site and dragged into place along the shoreline with a small farm tractor.

The breakwater was centered at approximately the full pool level (189 ft) and built about 1.5 ft in height. After the logs were placed they were wrapped with 1/4 inch steel cable at 4 ft intervals. The wrapping cables were also run through the eye of cables on Duck Bill™ anchors which were driven to a depth of 3 ft. A 0.5 inch steel cable was anchored to a tree at each end of the breakwater and fastened to each wrapping cable along the length of the breakwater. All cable fastenings were accomplished with the use of U-bolt cable clamps. The breakwater was 300 feet long. At the time of construction we planned to wait 3 to 6 months for sand and silt to accumulate behind the breakwater to the height of the breakwater before establishing vegetation.

While the completed breakwater appeared to be well secured, it was destroyed by wave action within 2 or 3 months. An inspection of the site revealed that no anchors were pulled loose and none of the cable connections failed. The logs appeared to have slipped out of the wrapping cable loops in a lengthwise manner due to severe wave action during the spring. When we inspected the site in May the structure was more than 50% destroyed.

The installation cost of this breakwater was $9500 or approximately $31.75 per linear foot. We had another bid of about $13,000 from a different contractor who proposed to work from a string of barges. He planned to cable the logs together on the barges and place them along the shoreline using a crane.

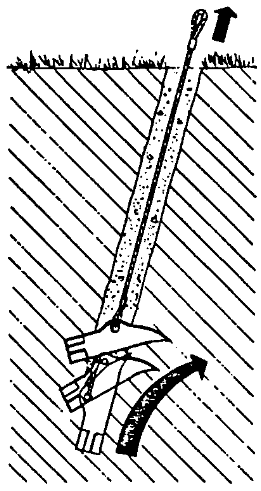
We found that it was very difficult to work along the shoreline with this project. The undisturbed hillside above the shoreline was covered with trees so that it was necessary to drag the logs into place along the beach area. The sand was barely stable enough to support a tractor under the best of conditions and was very unstable wherever a seep came out from the bank. In warm weather it would have been possible to tow the logs along the shoreline with a boat but it would still be difficult to get them into the proper place, particularly if the lake level was low. In addition, there is significant wave action on many days particularly on the eastern shore of the lake. This would increase the difficulty and danger associated with floating logs into place.

After the log structure failed no further effort was made to vegetate this section of shoreline.

Description of Duckbill anchors and the installation process

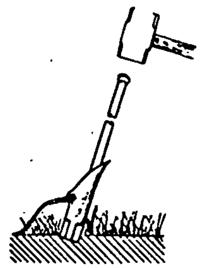
How Duckbill Works

The Duckbill Anchor is driven into the soil using a hammer and drive rod. As the anchor is being driven it is actually compacting the soil around the anchor body. Once the anchor is to the proper depth the drive rod is removed. An upward pull on the cable rotates the anchor into load lock position. The anchor cuts into and further compacts the undisturbed soil. This method is far superior to conventional anchors that disturb the soil during installation.

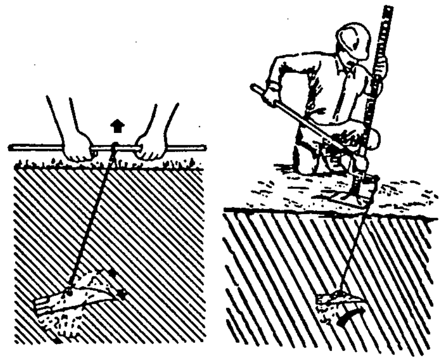


Undisturbed soil

Installation

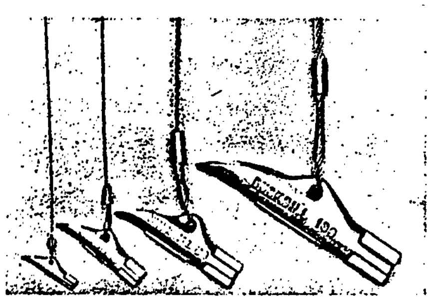


1. Using heavy hammer and steel drive rod, drive anchor into ground at desired angle until only top half of cable loop remains above ground. (One rod drives hundreds of anchors.)



2. Remove rod, pull up on cable. This rotates anchor into load lock position. Smaller models can be set by hand. Larger models require jack, come along or other device. Tie rope, cord or cable to loop, run it to object being anchored.

Specifications



40 68 88 138

Model Number	Holding Power In Normal Soil	Safety Factor Minimum Cable Breaking Strength	[2]Galvanized Steel Cable	Cable Length	Anchor Weight	Standard Pak And Weight
40-DB1	300 lbs.	480 lbs	1/16 7×7 GAC	20″	1 oz.	50/box 3.7 lbs.
68-DB1	1,100 lbs.	1,700 lbs.	1/8″ 7×7 GAC	2½ ft.	4.5 oz.	24/box 7 lbs.
[1]88-DB1	3,000 lbs.	7,000 lbs.	1/4″ 7×19 GAC	3½ ft.	14 oz.	12/box 11 lbs.
[1]138-DB1	5,000 lbs.	9,800 lbs.	5/16″ 7×19 GAC	5 ft.	2.5 lbs.	12/box 32 lbs.

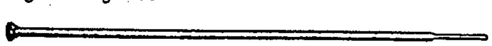
[1]88 and 138 have a wear resistant thimble eye in top loop.

[2]Foresight Products can custom cable any of our anchors for your requirements.

Duckbill Standard Drive Rods

Model 40

DR-2 -3/8″ round 2′ long steel hand drive rod with 1/4″ tip and large striking head



Model 68

DR-1 -1/2″ round 3′ long steel hand drive rod with large striking head. Power rod available on request.

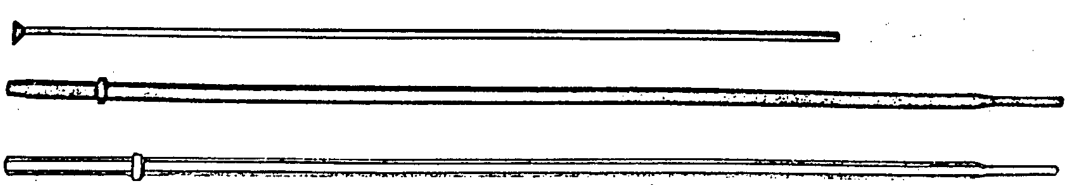
DR-1 HD (Heavy Duty) 3/4″ round 3′ long steel hand drive rod with large striking head. Tip is turned down to 1/2″.

Model 88

DR-3-3/4″ round 4′ long steel hand drive rod with large striking head

GR-1— 7/8″ × 4¼″ shank, 5½′ oa length for use with gasoline drivers.

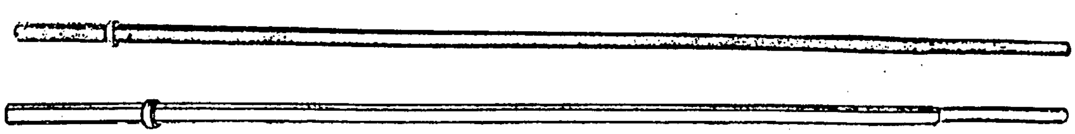
PR-1— 1⅛″ × 6″ shank, 5½′ oa length for use with pavement breakers.



Model 138

GR-2— 7/8″ × 4¼″ shank, 5½′ oa length for use with gasoline drivers.

PR-2— 1⅛″ × 6″ shank, 5½′ oa length for use with pavement breakers.



Further information is available from Foresight Products, Inc., 6430 East 49th Drive, Commerce City, Colorado 80022. Phone 1-800-325-5360 or (303) 286-8955.

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US. Patent numbers 4,044,513 and 4,096,673 and other international patents. Additional patents pending.

Experiment 4

In early 1998 several hundred kilograms of sandy beach soil was collected from a site on the eastern shore of the Walter F. George Reservoir adjacent to the Cotton Hill Campground near Ft. Gaines, GA. This was the site of earlier revegetation attempts. The soil had a pH of 7.8 and 1 ppm P, 2.5 ppm K, 31 ppm Mg, 260 ppm Ca, and an insignificant amount of N. The soil was air dried and thoroughly mixed before placing in pots. Plastic pots were lined with 3 mil plastic bags and filled with 7 kg of soil each. All pots were uniformly fertilized with P and K at a rate equivalent to 50 kg/ha of each calculated on a weight basis. Triple superphosphate and potassium chloride were the nutrient sources. Nitrogen (N) in the form of urea was applied differentially at the rates equivalent to 0, 50 and 100 kg/ha. A micronutrient mix consisting of zinc (Zn), iron (Fe), copper (Cu), manganese (Mn), and boron (B) was applied to half the pots so that N variables were evaluated with and without micronutrients. After all amendments were added to pots the soil in each pot was throughly mixed in a bucket and replaced in the pot. There were 3 replications of each fertilizer treatment for each plant species. After the pots were fertilized and mixed they were randomized on greenhouse benches.

One series of pots (representing all fertility treatments) was seeded to bahiagrass (*Paspalum notatum*), switchgrass or planted with started plants plugs of marsh hay cordgrass (*Spartina patens*). Plants in these pots were grown under terrestrial conditions and watered sufficiently to maintain good growth. Another series of pots was planted with started plants of cattail (*Typha latifolia*), soft rush, soft stem bulrush, and maidencane. These wetland plants were maintained under flooded conditions for the life of the experiment. All species were planted on May 19, 1998.

Analysis of soil from the research site

REPORT ON SOIL TESTS
AUBURN UNIVERSITY
SOIL TESTING LABORATORY
AUBURN UNIVERSITY, AL 36849-5411

NAME D.A. MAYS
ADDRESS P.O. BOX 1208
CITY NORMAL, AL 35762

COUNTY MADISON
DATE 7/15/99

LAB No.	SENDER'S SAMPLE DESIGNATION	CROP TO BE GROWN	SOIL* GROUP	SOIL TEST RESULTS: pH**	SOIL TEST RESULTS: Phosphorus P***	SOIL TEST RESULTS: Potassium K***	SOIL TEST RESULTS: Magnesium Mg***	SOIL TEST RESULTS: Calcium Ca***	RECOMMENDATIONS: LIME-STONE	RECOMMENDATIONS: N	RECOMMENDATIONS: P_2O_5	RECOMMENDATIONS: K_2O
					Pounds per acre				Tons/acre	Pounds per acre		
26887	GREENHOUSE EXPERIMENT	LBS/ACRE	1	7.8	2	5	62	520	0.0	---	---	---

THE NUMBER OF SAMPLES PROCESSED IN THIS REPORT IS 1
FOR FURTHER INFORMATION CALL YOUR COUNTY AGENT: (205)532-1578

* 1. Sandy soils (CEC < 4.6 $cmol_c kg^{-1}$)
2. Loams & Light clays (CEC = 4.6-9.0 $cmol_c kg^{-1}$)
3. Clays and soils high in organic matter(CEC > 9.0 $cmol_c kg^{-1}$)
4. Clays of the Blackbelt(CEC > 9.0 $cmol_c kg^{-1}$)

** 7.4 or higher - Alkaline 6.6-7.3 - Neutral 6.5 or lower - Acid 5.5 or lower - Strongly Acid

*** Extractable nutrients in pounds per acre

APPROVED Hamilton Bryant

The grasses were harvested for yield on October 1, 1998. Wetland plants were initially harvested on January 27, 1999, refertilized with N at the original rate and harvested again on March 24, 1999. Following each harvest all plant tissue was dried at 60°C prior to weighing than ground for chemical analysis to determine N concentration.

Results and Discussion

Wetland Species

With all wetland plants dry matter yield was increased significantly by the addition of nitrogen (N). Softrush and cattail produced significantly higher yield than the other species with no N application. As the nitrogen rate was increased to 100 kg/ha, cattail and maidencane produced more dry matter yield than other species. However, the increase in N rate from 50 to 100 kg/ha with or without micronutrients did not significantly increased the yield of cattail. The increase in N rate plus micronutrient produced higher yield only with maidencane and soft stem rush (Table 1). The addition of micronutrients at the low N level did not significantly increase the dry matter yield of wetland plants except for soft rush. However, the addition of micronutrient with high N (100 kg/ha) increased dry matter yield significantly in maidencane and soft rush, while the dry matter yield of cattail decreased slightly by the application of micronutrient (Table 1).

Cattail and soft stem rush did not respond to N and micronutrient application with regard to stem count (number of stem per pot). Soft rush and miadencane on the other hand responded significantly to the application of N and micronutrients by increasing the number of stems grown per pot. The addition of micronutrients at each level of N increased the stem count significantly compared to the application of N alone (Table 1).

Nitrogen uptake by wetland plants was measured at each harvest. The N uptake increased in the second cut compared to the first cut, however, the application of N with or without micronutrients did not significantly increase the N uptake by wetland plants (Table 2).

Grass Species

Dry matter yield of bahiagrass, switchgrass, and cordgrass significantly increased with the increase in N rate from 0 to 100 kg/ha, except for cordgrass for which there was no significant yield increase by increasing the N rate from 50 to 100 kg/ha. The addition of micronutrients did not significantly increase the dry matter yield of any grass species (Table 3). With no fertilization as well as with both N rates cordgrass dry matter yield was significantly greater than bahiagrass and switchgrass probably because started plugs rather than seed were planted. Switchgrass dry matter yield was greater than bahiagrass with both N rates. The application of micronutrients did not increase the dry matter yield of these grasses (Table 3). The application of 100 kg/ha N plus micronutrients significantly increased the N uptake of bahiagrass and switchgrass over center and lower N rate 50 kg/ha or no N, but there was no significant increase in N uptake by cordgrass (Table 3).

Table 1. Dry matter yield and stem count of four wetland plants. Yield is total of two cuts.

Nitrogen Rate	Cattail		Maidencane		Soft Stem Rush		Soft Rush	
Kg/ha	Yield (g/pot)	Stem count stem/pot	Yield (g/pot)	Stem count stem/pot	Yield (g/pot)	Stem count stem/pot	Yield (g/pot)	Stem count stem/pot
0	10.4 a(b)*	1.7 a	7.3 a(a)	7.7 a	6.6 a(a)	4.7 a	11.7 a(b)	9.0 a
50	20.7 bc	2.3 a	17.4 b(bc)	10.0 b	12.2 b(a)	6.3 a	15.5 b (ab)	20.3 b
100	23.0 b(b)	2.3 a	20.2 bc(a)	16.0 b	16.3 c(a)	6.3 a	14.8 b(a)	13.7 b
50+m[1]	19.6 b(b)	1.3 a	11.9 b(a)	21.7 c	10.8 b(a)	4.7 a	23.3 c(b)	26.3 c
100+m	18.0 b(a)	1.6 a	24.1 c(b)	20.0 c	18.0 c(a)	7.3 a	21.6 c(b)	29.0 c

[1] m indicate that micronutrients were applied

*Values followed by the similar letter outside the parentheses within each column are not significantly different for yield and stem at 5% level (DMRT). Letters in the parentheses are for the yield comparison of plants in each row.

Table 2. Nitrogen concentration of four wetland plant (%).

Nitrogen Rate	Cattail		Maidencane		Soft Stem Rush		Soft Rush	
Kg/ha	First Cut	Second Cut	First Cut	Second Cut	First Cut	Second Cut	First Cut	Second Cut
0	0.82 a*	1.57 a	0.85 a	1.78 a	1.04 a	1.52 a	0.80 a	1.35 a
50	0.83 a	1.79 a	0.55 a	1.65 a	0.99 a	2.02 a	0.77 a	2.10 a
100	0.80 a	2.29 a	0.49 a	2.07 a	0.98 a	2.26 a	0.83 a	2.18 a
50+m[1]	1.05 a	2.06 a	0.55 a	2.68 a	0.97 a	2.04 a	0.79 a	1.83 a
100+m	1.02 a	2.29 a	0.61 a	2.43 a	0.68 a	2.27 a	0.88 a	2.18 a

[1] m indicate that micronutrients were applied

*Values followed by the same letter in each column are not significantly different at 5% level (DMRT)

Table 3. Dry matter yield and N concentration of three grass species

Nitrogen rate Kg/ha	Bahiagrass g/pot	Nitrogen Uptake %	Switchgrass g/pot	Nitrogen Uptake %	Cordgrass g/pot	Nitrogen Uptake %
0	0.87 a(a)*	0.89 a	0.70 a(a)	0.86 a	5.91 a(b)	0.72 a
50	2.69 b(a)	1.37 a	4.35 b(b)	1.18 a	11.16 b(c)	0.85 a
100	6.77 c(a)	1.56 a	6.54 c(a)	1.45 a	12.00 b(b)	1.25 a
50+m[1]	5.53 bc(a)	1.28 a	4.63 b(a)	1.30 a	10.92 b(b)	1.65 a
100+m	7.02 c(a)	2.05 b	6.68 c(a)	1.81 b	12.73 b(b)	1.58 a

[1] m indicate that micronutrients were applied

*Values followed by the similar letter outside the parentheses within each column are not significantly different for yield and stem at 5% level (DMRT). Letters in the parentheses are for the yield comparison of plants in each row.

Summary and Conclusions

1. None of the biotechnical shoreline stabilization methods evaluated in this project were effective for the following apparent reasons:
   a. The great routine fluctuation in lake level (5 feet ±) meant that wetland plants were not adequately watered all the time if planted near the high water line but were periodically covered with too much water if set near the low waterline. Since the beach area varied in width by as much as 40 or 50 feet there was not a suitable planting area for wetland plants.
   b. Because the prevailing winds blow across the lake, which is a mile or more in width at many places, waves several feet in height can often occur which damage or destroy newly planted vegetation before it can become well established.
   c. At least 3 severe flooding events took place in a 2-year period causing severe damage to vegetation wave control structures each time. Assuming this is a typical frequency successful erosion control using these methods may never be possible.
2. Most shoreline damage occurs when the lake is at full pool. Most of the exposed shoreline at low water has a gentle slope with a very compacted clay substrate. Little erosion from natural waves or boat wakes appears to occur when the lake level is 2 or more feet below full pool. Only when the lake is full do waves undercut the banks and cause sloughing and erosion. The simple expedient of keeping the lake below full pool except when there is a need to accumulate water for a navigation window would keep shoreline damage to a minimum.
3. Damage to shorelines could be significantly reduced by cutting trees standing on sections of the bank which have been undercut by waves or soon will be. When trees break loose the root masses carry large amounts of soil into the lake. While

this would entail some expense it is probably one of the cheaper effective things that could be done.

4. In those areas where valuable private or government property are threatened by continued erosion conventional engineering solutions will probably produce the best results. These include rip-rap, concrete revetments, sheet piling and gabbions or perhaps combinations of these solutions.
5. The greenhouse experiment as well as soil tests and observations in the field indicated that the fertility level of sand on the plantable shoreline areas is very low. Good growth on any areas where vegetation can be establishing will require significant inputs of NPK fertilizer.

Personnel:

PI	Dr. David A. Mays Department of Plant and Soil Science Alabama A&M University
Co-PI	Dr. Karamat R. Sistani Presently with USDA-ARS Mississippi State, MS

Graduate Students:

1. Wesley Todd Willoughby
2. Mario Green

Mr. Willoughby worked on this project for about 1 year then switched to a wastewater treatment project with other funding and received an M.S. Degree. Mr. Green left the University without completing his project.

Mr. O. B. Ernest and Mr. Ron Puhr, site managers at the Walter F. George Reservoir and their associates rendered valuable service in helping to expedite this project.

Publications and Presentations

Sistani, K. R. and D. A. Mays. Evaluation of nitrogen needs of terrestrial and wetland plant species for use in shoreline erosion control. Status: Preparation completed; to be submitted to the Journal of Soil and Water Conservation.

Presentations at Meetings

Mays, D. A. and K. R. Sistani. 1997. Biotechnical methods of shoreline stabilization at the Walter F. George Reservoir: Difficulties encountered. Society of Wetland Science Annual meeting, Bozeman MT., June 1-6.

Mays, D. A. and K. R. Sistani. 1999. Fertilizer Responses of wetland and terrestrial plants growing on river sand. American Society of Agronomy Annual Meeting Salt Lake City, UT October 30-November 4, 1999.

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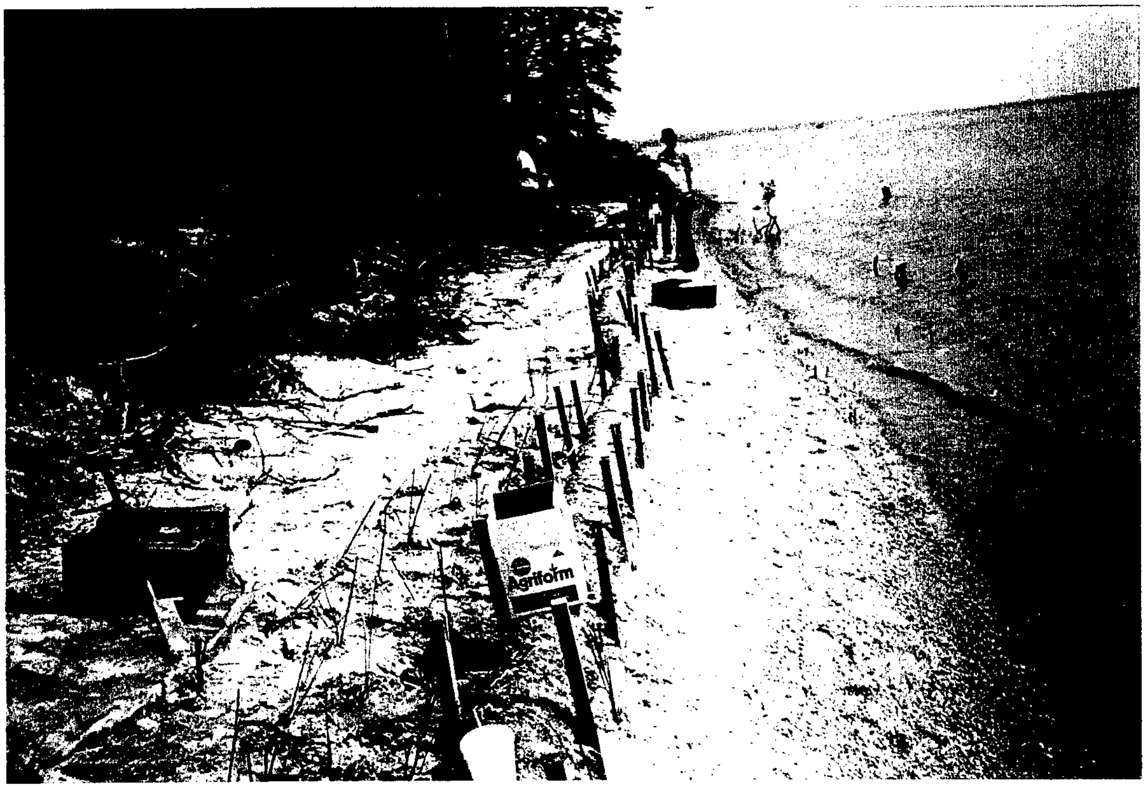
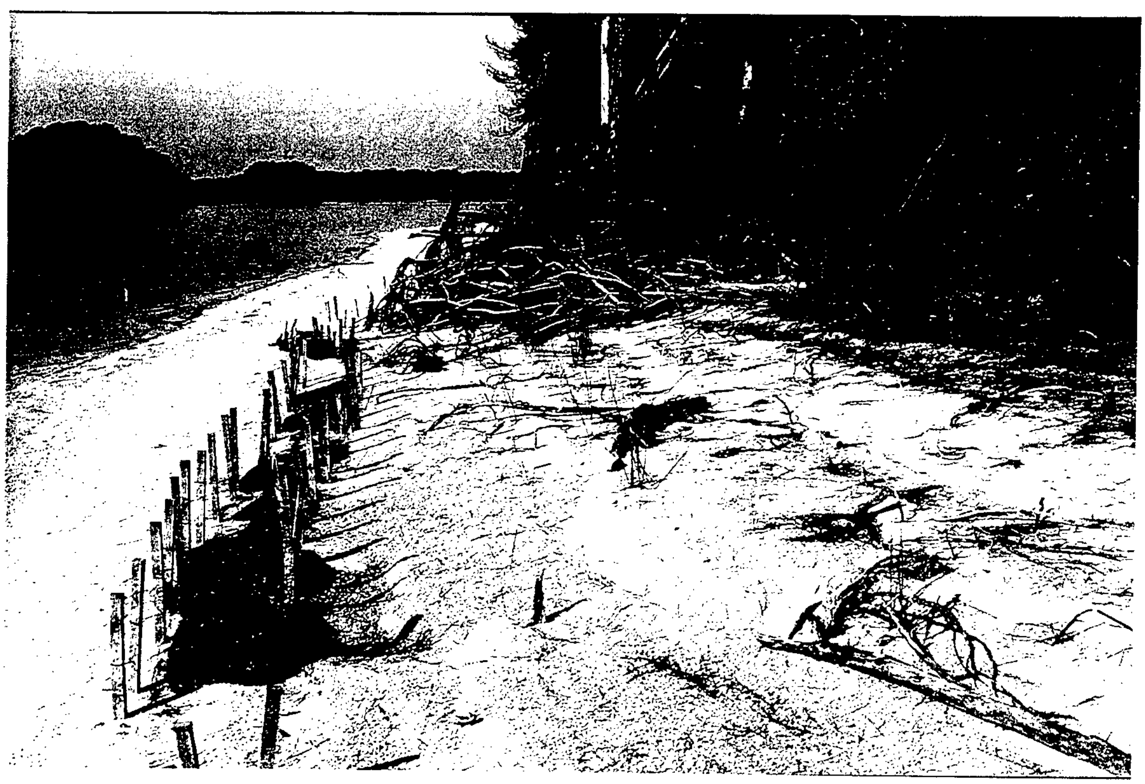


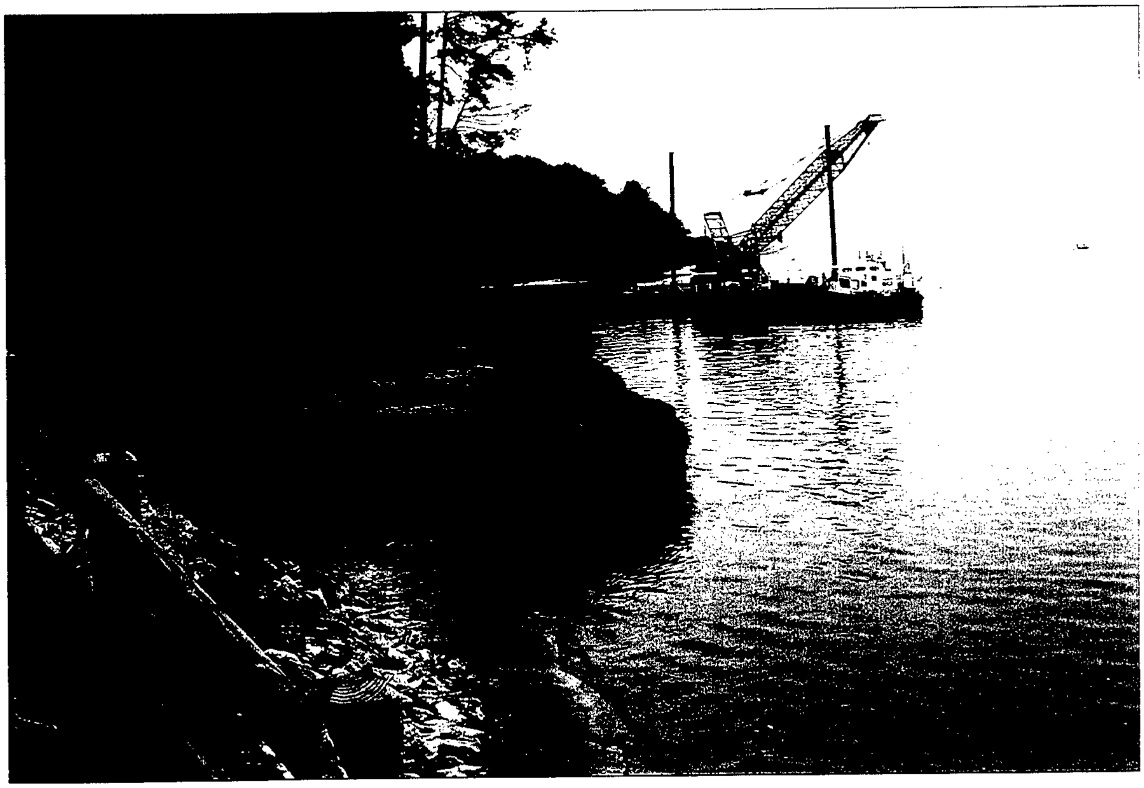
12 inch coconut fiber log breakwater.

Chicken wire wrapped straw bale breakwater.

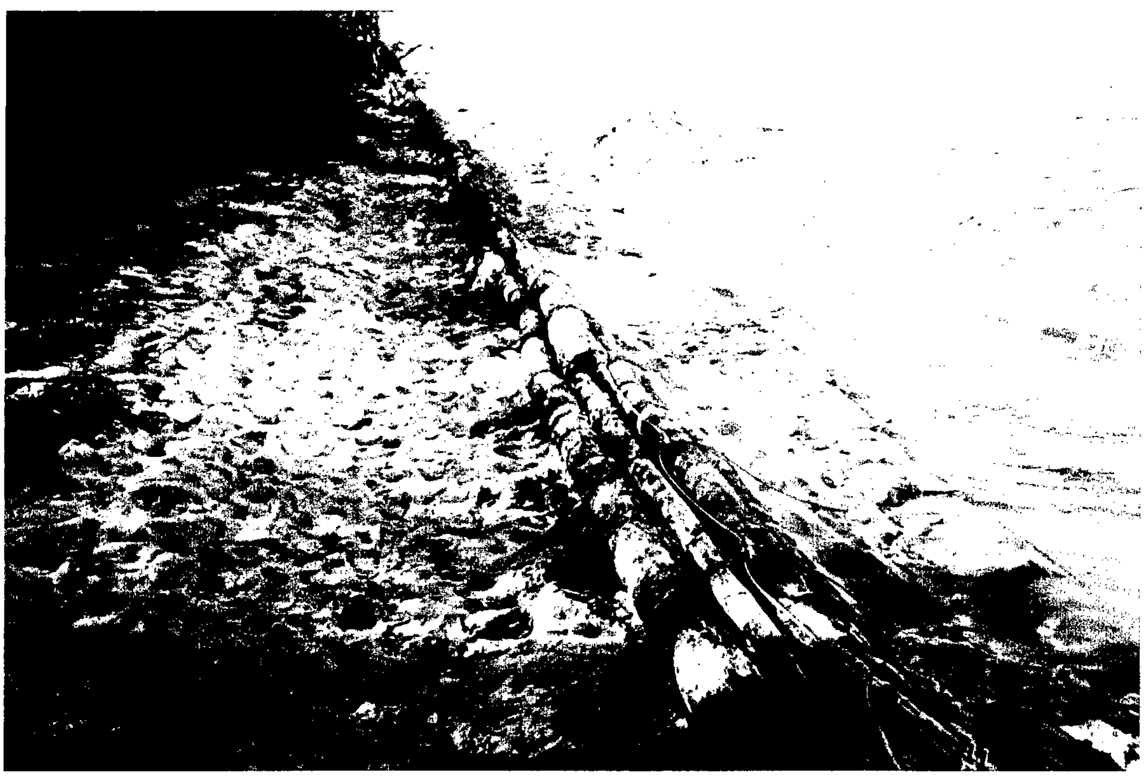
Vegetation growing behind breakwater.



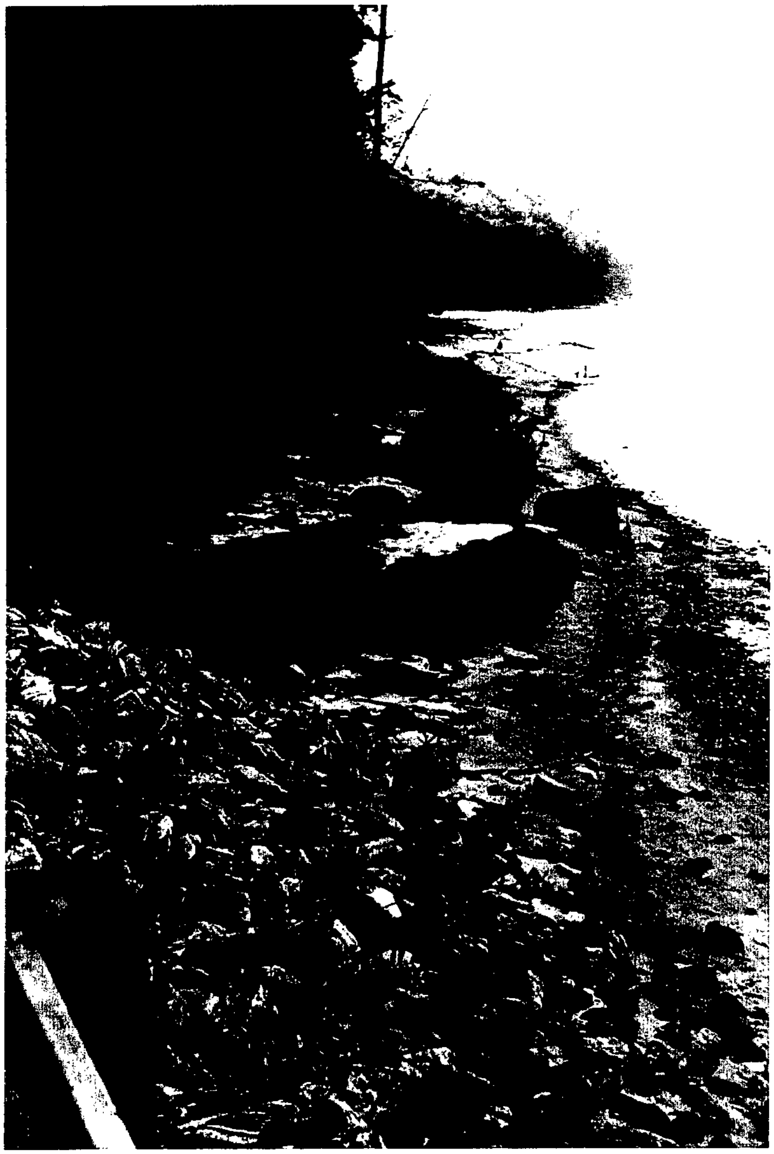
Storm associated with Gulf Coast hurricane destroyed breakwater and vegetation.



Large round hay bales placed as a breakwater.

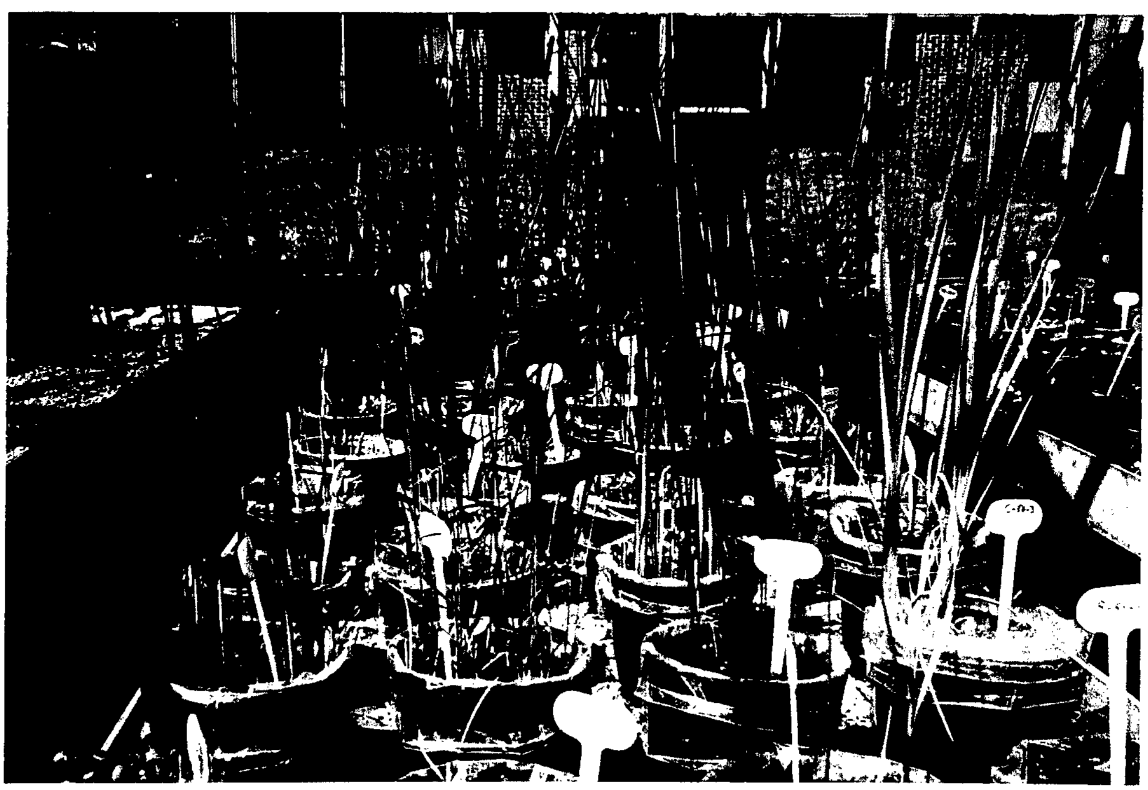


Pine logs cabled together and anchored with Duck Bill™ anchors.



Hay bale breakwater was destroyed by flooding.

Newly planted wetland plants.



Wetland plants ready for harvest.