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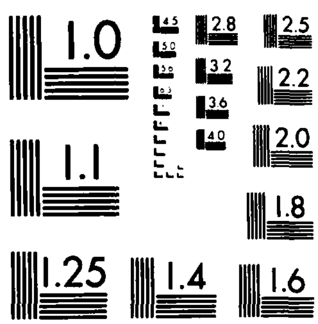

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Technical Report 964

SURVIVAL AND GROWTH OF RED MANGROVES (*Rhizophora mangle L.*) PLANTED UPON MARL SHORELINES IN THE FLORIDA KEYS

A Five-Year Study

H. W. Goforth, Jr.
NOSC

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1 May 1984
Final Report

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ADMINISTRATIVE INFORMATION

Work reported herein is a follow-up study of a project performed during the period July 1977 to May 1979. The initial results were reported in NOSC TR 506. Project initiation and development was a joint effort of NOSC and the Florida Keys Community College of Key West, Florida, where Mr. Goforth was an instructor.

Released by
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Under authority of
H. O. Porter, Head
Biosciences Department

ACKNOWLEDGMENTS

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Special appreciation is extended to R.R. "Robin" Lewis and Steve Lumbert of Mangrove Systems, Inc. for their willing and professional assistance in presenting this study for me at the Tenth Annual Conference on Wetlands Restoration and Creation (May 1983). Sincere gratitude is also expressed to Michael Salazar (NOSC Code 5131), whose support and concern for applied marine biological research were major factors in the publication of this document.

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Planting mangroves for stabilizing man-made marl shorelines in the Florida Keys is an environmentally preferred alternative to seawall and riprap construction. In June 1977, 126 mangroves were planted along three marl shorelines to determine the relative significance of (a) tidal height, (b) degree of exposure to erosion forces, and (c) plant size upon growth and survival. This report documents findings for plant survival and growth after 5 years.

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SUMMARY

Planting mangroves for stabilizing man-made marl shorelines in the Florida Keys is an environmentally preferred alternative to seawall and riprap construction. In June 1977, 126 red mangroves were planted along three marl shorelines to determine the relative significance of (a) tidal height (+0.3 m and 0.0 m); (b) degree of exposure to erosion forces (protected, exposed, and partially protected); and (c) plant size–propagule (type A), 1-year seedling (type B), and 2- to 3-year-old small trees (type C)–upon growth and survival. Sphagnum peat moss and seagrass detritus (wrack) were tested as organic amendments to the marl substrate. Planting procedures have been previously reported (Goforth and Thomas, 1979).

After 5 years, the respective plant survival rates for types A, B and C plants on the exposed shore were 0, 0, and 79%; the protected shore 64, 43, and 75%; and the partially protected shore 43, 64 and 93%. Height of type B plants was greater on the partially protected shore (66 cm) than on the protected shore (53 cm). Height of type C plants at the protected, exposed, and partially protected shores was 73, 80 and 74 cm, respectively. Combined plant survival was 68% at +0.3 m compared to 29% at 0.0 m tidal height, only 12% type A and B survived at 0.0 m. Survival rates for the three plant types (A, B, and C) were 36, 36, and 80% with an average vertical growth of 33, 28 and 20 cm, respectively. Representatives of all three plant types had matured and were fruiting, type C plants fruiting the most at 19%. The two organic amendments tested showed similar effects on survival, 54% for peat and 43% for seagrass wrack.

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CONTENTS

INTRODUCTION

The environmental role of mangroves as a natural shoreline stabilizer has been an accepted principle of wetlands ecology for many years. In the Florida Keys a majority of the shoreline is composed of an organically depauperate, compacted calcitic marl (Wanless, 1974). Under the proper conditions nature has been successful in gradually establishing a protective fringe of mangroves and associated vegetation along these shores (Davis, 1940; Thom, 1967; Savage, 1972; Carlton, 1974; Teas et al., 1976). Man, on the other hand, has been relatively successful in developing engineering alternatives for protecting shorelines from erosion forces. Engineering solutions, however, have failed to replace the biological role played by mangroves and other shoreline vegetation.

Along shorelines created with marl fill or shores where mangrove communities have been destroyed, only the typical slow-growing, stunted mangrove seedlings are found. Under a wide range of conditions, a variety of techniques have been attempted to plant/transplant 13 of the 72 species of mangroves (for a review, see Lewis 1981). Few studies, however, have employed an experimental design which included a number of controlled variables combined with long-term monitoring. Frequently, transplants are performed without the inclusion of controls or comparisons with natural revegetation rates. The crucial criterion of success must always be the degree of *long-term* survival and growth and reestablishment/creation of the desired ecological condition. The goal of this study was to test the effect of tidal height, erosion forces, and organic amendments upon the relative survival and growth of three developmental stages of red mangrove transplant stock (propagules seedlings, and small trees). The long term success of this study in establishing a protective fringe of mangroves upon a historically barren marl shoreline should provide encouragement to applied marine biologists.

AREA DESCRIPTION

The transplant and control sites for this study are located on the campus of Florida Keys Community College (FKCC) on Stock Island, Key West, Florida. The transplant stock came from a donor site in a mangrove swamp located nearby on Raccoon Key. Figure 1 shows the location of these sites and the average annual wind velocity and frequency (Boylan, 1974). Site A faced south and was the protected shore experiencing limited erosion. Site B faced east, was impacted to the greatest degree by the elements, and had experienced significant erosion before this study (1977). Site C faced north and was "partially protected" by a small mangrove island located 25 m to the north. Experimental Site C and control Site E were the only two shores experiencing equivalent exposure to erosion forces. Both control shores, sites D and E, were created from marl fill at the same time (1967) as the experimental transplant sites. All other sites were characterized by varying degrees of exposure and thus provided a basis for determining the relative survival and growth of the three types of transplant stock.

METHODS AND MATERIALS

Planting procedures involved the use of a hydraulic power auger to drill holes (0.41-m diameter and 0.45- to 0.61-m deep) in the packed marl shoreline. The loose marl removed from the augered holes was mixed 50:50 with one of two organic amendment treatments, sphagnum peat or seagrass detritus (wrack), and placed in the hole with a mangrove. The details of the planting procedures used in this study have been previously reported (Goforth and Thomas, 1979). In June 1977, 126 red mangroves were planted along three marl shorelines (i.e., 42 on each shore) to test the effect of tidal height (+0.3 m and 0.0 m), degree of exposure (protected, exposed, and partially protected); and plant size—propagules (type A), 1-year-old seedlings (type B), and small 2- to 3-year-old trees (type C). This report is a result of a site survey conducted in October 1982. The purpose of this survey was to determine the long term (5-year) survival and growth of the experimental treatments for a comparison with adjacent control shores. Tree height measurements were made from the substrate to the tallest growth bud and recorded to nearest 0.5 cm. Prop root and leaf counts were also made but have not been included in the data analysis because of the difficulty obtaining accurate values and the large percentage of "too numerous to count" data points.

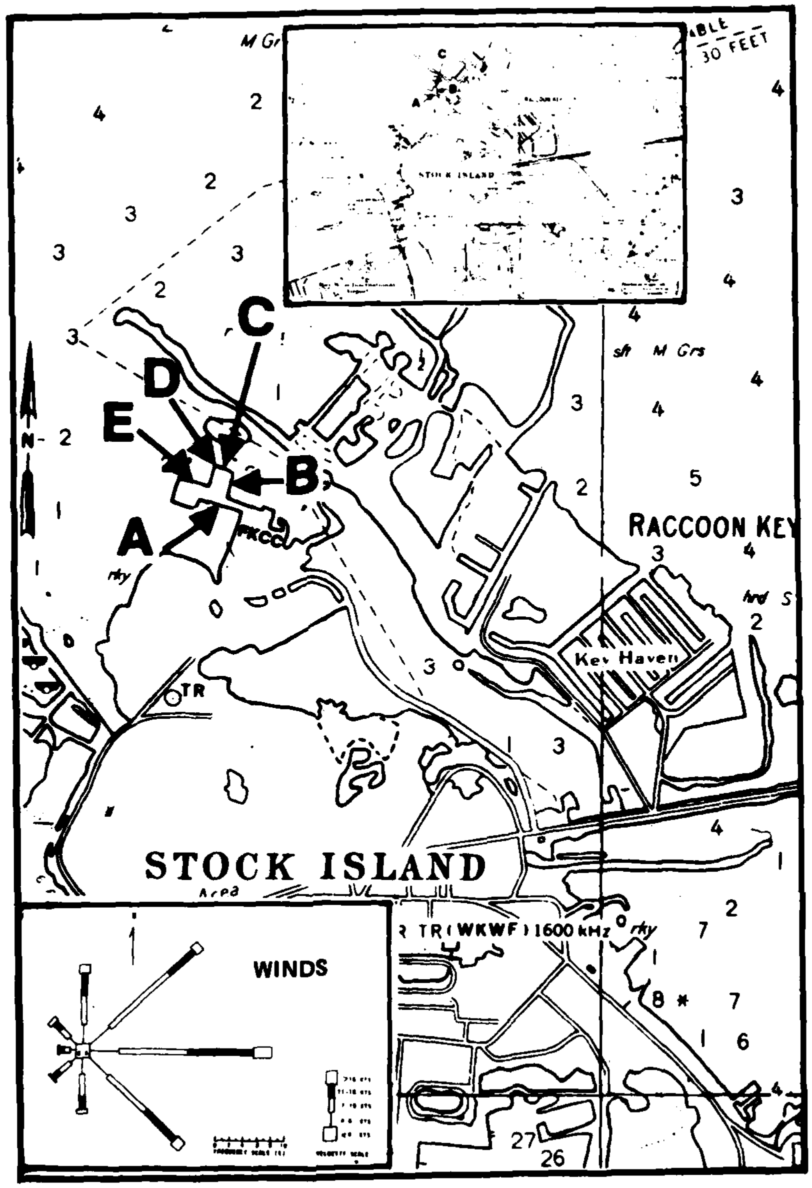

Figure 1. Mangrove transplant, control, and donor sites at Key West, Florida.

RESULTS AND DISCUSSION

PROPAGULES (TYPE A)

Survival of propagules varied between sites, depending on the degree of exposure (figure 2). The survival on the protected, exposed, and partially protected sites was 50, 0, and 43%, respectively. Propagule survival rates at the two tidal heights on the protected and partially protected shores were 75 and 83% at +0.3 m compared to 25 and 27% at 0.0 m. Since no propagules survived on the exposed shore, growth data for the last 3 years were confined to that from the protected and partially protected shores. Figure 3 shows a plot of propagule growth and survival during the 5 years since planting. These data indicate a significant initial loss of propagules on the exposed shore followed by a gradual reduction to zero. Growth rate of propagules during the first 2 years averaged 18.5 cm/yr but only 7.8 cm/yr during the next 3 years. The average height of propagules after 5 years was the same (59 cm) at both the protected and partially protected sites.

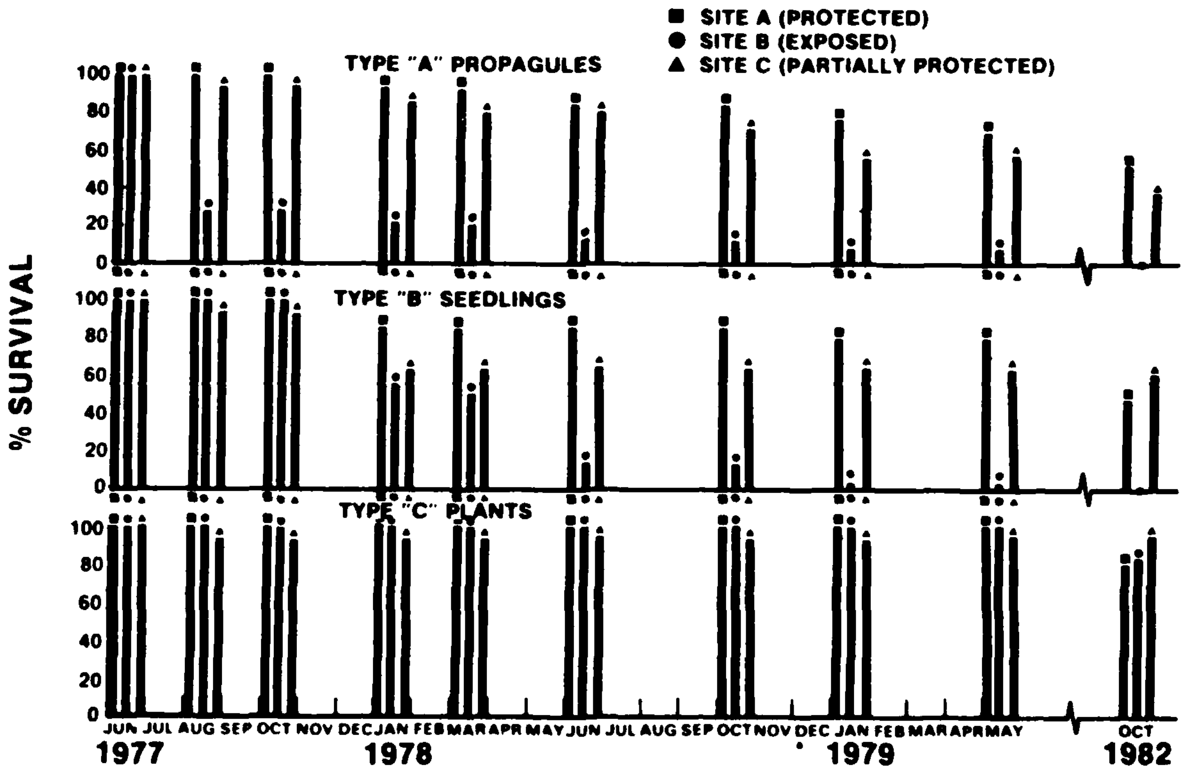

Figure 2. Survival of transplanted red mangroves (1977-1982).

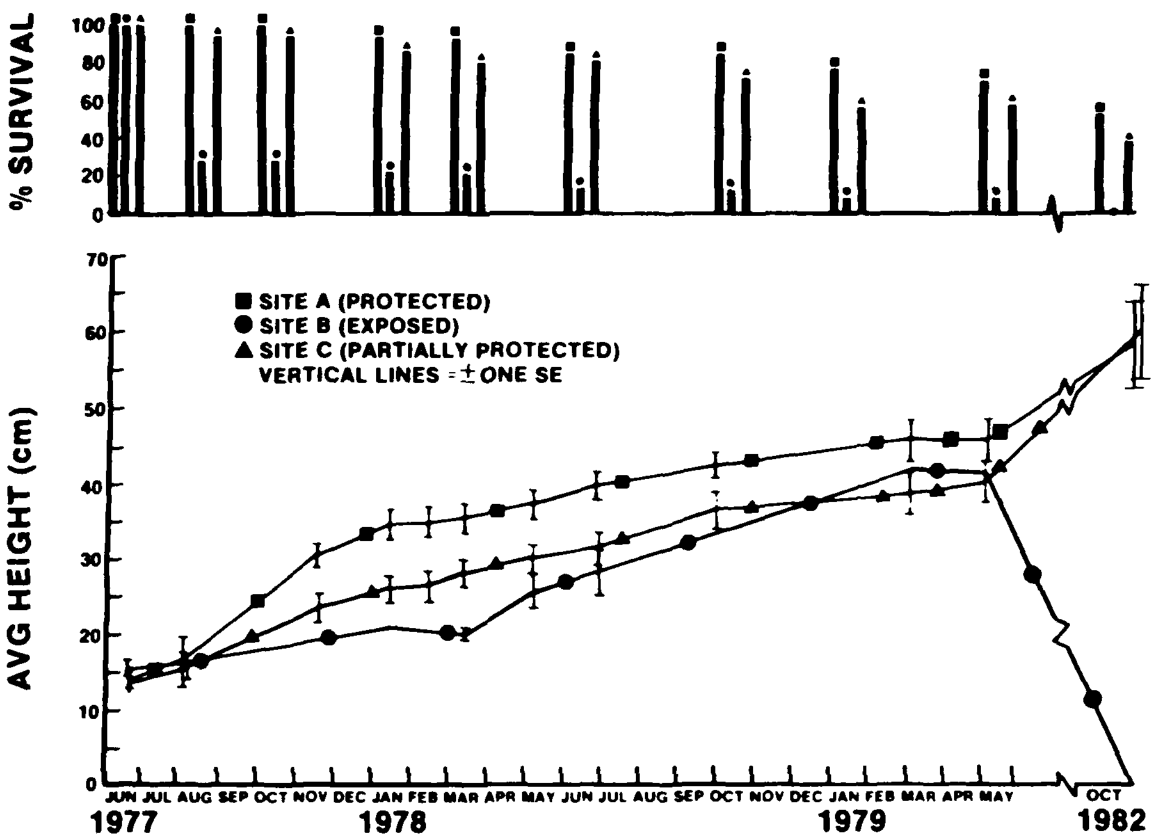

Figure 3. Survival and growth of red mangrove propagules (type A) (1977-1982).

SEEDLINGS (TYPE B)

Survival of seedlings after 5 years was 50, 0, and 64% for the protected, exposed, and partially protected sites, respectively (figure 2). Seedling survival at the +0.3 m tidal level (100 and 78%) was significantly greater than at 0.0 m (0 and 22%) for the protected and partially protected sites, respectively. Seedling height and growth was greater on the partially protected shore (66 cm) than on the protected shore (53 cm) (figure 4). Vertical growth rates for seedlings during the 5 years were relatively steady at 3–4 cm/yr for the protected site, and 5–6 cm/yr for the partially protected site. The average height of seedlings after 5 years was not significantly different from that of propagules (59 cm versus 61 cm). The total survival percentage for seedlings (36%) was also similar to that for propagules (36%). The main difference between survival of these two plant types on the exposed shore was the rate of loss. For the exposed site, the propagules had their greatest losses during the first 2–3 months, whereas seedling losses were delayed until the second year (figure 2). On all shores, the survival trends after 2 years were essentially identical for both propagules and seedlings: final survival statistics were the same after 5 years, with 15 of 42 of each type plant surviving.

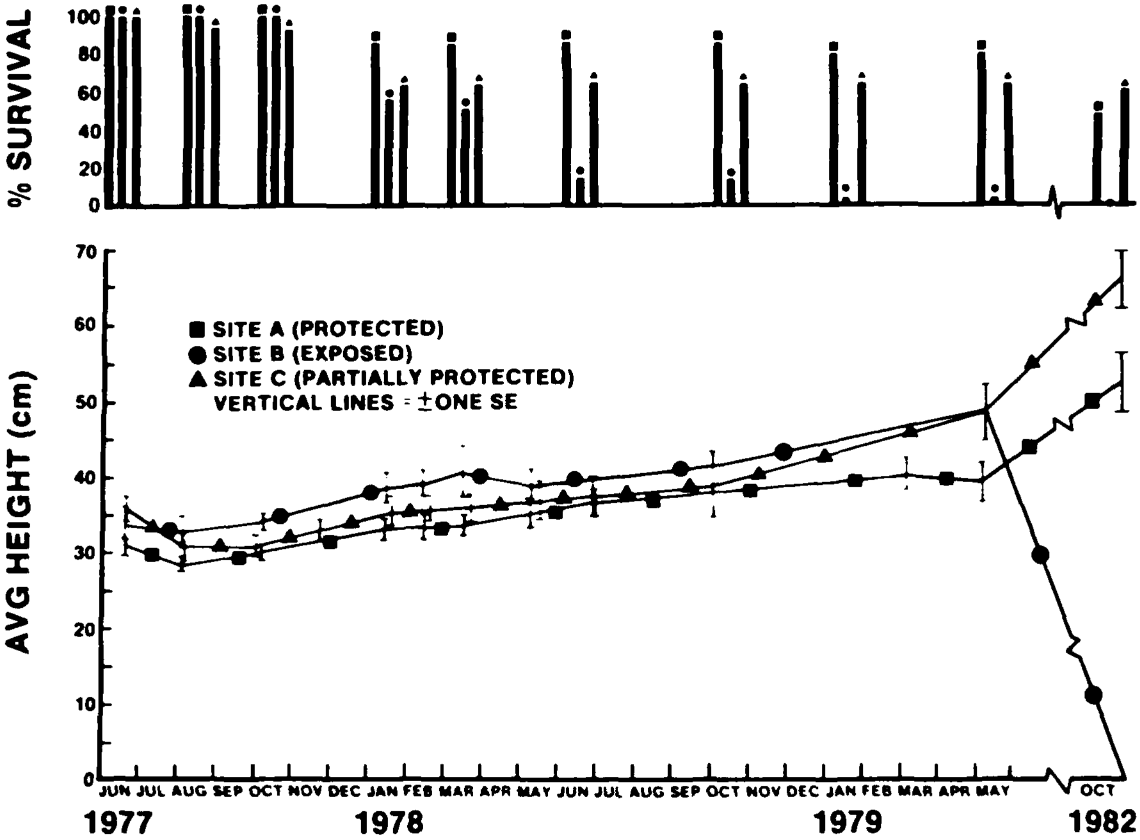

Figure 4. Survival and growth of red mangrove seedlings (type B) (1977-1982).

SMALL TREES (TYPE C)

Transplanted small trees exhibited the greatest survival at all sites and were the only surviving plants on the exposed shore. Survival for small trees was 79, 75, and 93% for the protected, exposed, and partially protected sites, respectively (figure 5). The average survival for all small trees was 80%, with 34 of the original 42 plants remaining after 5 years. The greatest loss of small trees occurred during the last 3 years, decreasing from an overall survival of 98 to 80%. Growth of small trees during the first 2 years was directed towards lateral branching and prop root and leaf production. The small vertical growth (approximately 6 cm) that occurred during that time was difficult to quantify due to the settling of these plants into the substrate (see Pulver, 1976). Vertical growth during the last 3 years (1979-1982), however, was significant and averaged 6.5 cm/yr. Lateral growth and prop root development of small trees continued during the last 3 years but were not quantified. The average height of all small trees was 76 cm, representing an average vertical growth of 20 cm after 5 years (site B, figure 6; site C, figure 7). Maturation and fruiting were evident in October 1982, with 19% of the small trees bearing fruits or flowers.

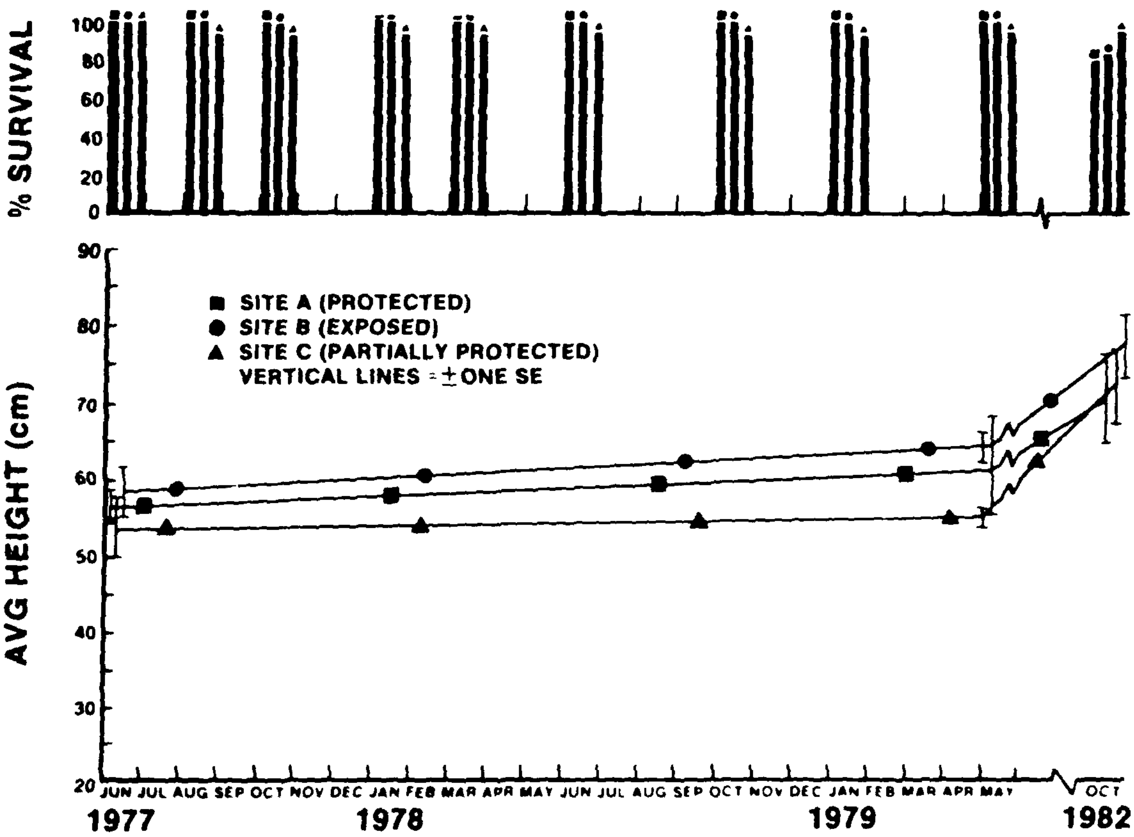

Figure 5. Survival and growth of red mangrove trees (type C) (1977-1982).

Figure 6. Typical growth pattern exhibited by type C plants on the exposed shoreline (site B) aft

Figure 7. Typical growth pattern exhibited by type C plants on the partially protected shoreline (site C) after 5 years (1977-1982).

TIDAL HEIGHT AND DEGREE OF EXPOSURE

Survival for all plant types was greater (68%) at the +0.3-m tidal height than at 0.0 m (29%) at all sites. Figures 8, 9, 10 and 11 show the conditions on the protected and exposed shores (sites A and B) before and 5 years after the transplant. The difference in mangrove community development at these sites is quite evident and may be explained by differences in rates of organic debris accumulation. Figure 12 shows the condition of sites D and E (control shorelines) 15 years after placement of marl (1982).

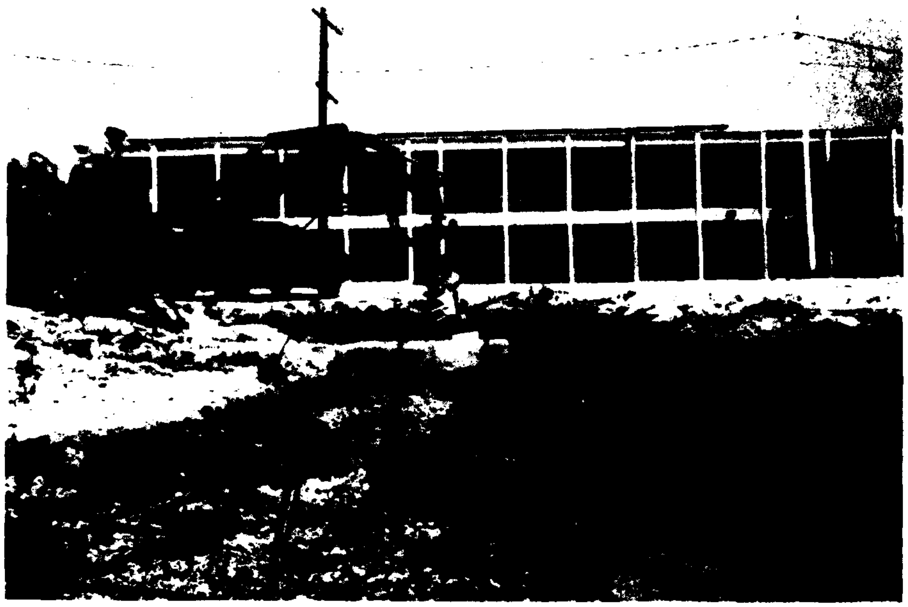

Figure 8. Condition of protected shoreline (site A) in 1977 (10 years after placement of marl).

Figure 11. Revegetated condition of exposed shoreline (site B) in 1982 (5 years after mangrove transplant).

Figure 12. Eroding, unvegetated condition of control shorelines (sites D, foreground and E, background) in 1982 (15 years after placement of marl).

DISCUSSION AND CONCLUSIONS

The results of this study indicate that partially protected shorelines may be planted with either propagules or 1-year-old seedlings which will achieve similar survival and growth rates. Exposed shorelines however, *must* be planted with small trees (at least 2 to 3 years old) to withstand erosion forces. Since all plants exhibited greater growth on the more exposed shores, there appears to be a beneficial effect of accumulated seagrass and other organic detritus. However, quantitative data to support this contention were not collected in this study.

On exposed shorelines, strong winds affect the three types of transplanted mangroves differently. The shorter (average height = 0.33 m) transplant stock (propagules and seedlings) suffered greater losses, possibly due to becoming buried under an accumulation of anaerobic debris similar to the conditions that occurred after hurricane Donna (Craighead, 1971). The larger mangrove plants exhibited greater growth and survival possibly because they were taller (average height = 0.56 m) and not buried; were better anchored (more prop roots), and they benefited from the accumulation of organic detritus around their bases. This supports the recommendation by Pulver (1976), that small trees (0.5-1.5 m tall) in lieu of seedlings, should be transplanted for rapid shore revegetation. The larger mangroves are more effective in capturing debris and establishing an organic mulch.

It appears that the unusually windy weather in the Keys during the past few winters may have been responsible for the observed decrease in survival of propagules and seedlings and the increase in growth of the larger trees. In sharp contrast to the transplanted shorelines the natural vegetation of the control shores (sites D and E) was limited to a few small seedlings. Without the protection afforded by transplanted mangroves, these shores have continued to erode throughout the 5 years of this study.

Naturally occurring seedlings, like those on the control marl shores, are seen throughout the Florida Keys. However, they often die before maturing or exist in a stunted form for many years (Teas et al., 1976). The energy requirements for the initial establishment and growth of mangrove propagules on marl shorelines appear to be adequately met by storage products in the mature propagule or by nutrients on the substrate surface. Nutrients and/or energy requirements needed to support advanced growth of mangroves appear to be inadequate on most barren marl shorelines.

Tidal height of the transplant is an extremely critical factor in determining the survival of all three plant types, especially propagules and seedlings. Smaller mangrove plants, lacking prop roots and heavy foliage, are more susceptible to physical damage from drifting debris and are subjected to greater physiological stress due to greater relative submersion at the lower tidal level. Teas et al., 1976, describe how some Florida land developers have killed mangroves by altering the water levels to increase the percentage of prop root submergence. In this study and others (Lewis, 1979 and Lewis and Haines, 1981), small differences in the tidal height of the experimental transplants produced significant differences in survival rates due to greater stresses at the lower tidal level.

The long-term success (i.e., survival, growth, and maturation) demonstrated by this study supports the use of small trees and propagules of red mangroves for the creation and restoration of shoreline vegetation. Using (1) a power auger to loosen the substrate, (2) organic amendments to augment available nutrients, and (3) stakes for anchoring transplants appears to provide the ingredients necessary for establishing mangrove communities on barren marl shorelines.

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Figure 6 Typical growth pattern exhibit