Environmental Education and Hands-on Training on Mangrove Restoration Techniques at the University of the Virgin Islands Wetlands Reserve

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Abstract

Mangrove wetlands play an important role in coastal marine communities. Yet the number of mangrove areas in the Virgin Islands (VI) has significantly declined in the last 50 years because mangrove ecosystems were routinely bulldozed to make space for marinas and other coastal developments. In order to increase advocacy for mangrove habitat protection and restoration, the objectives of the project were to train a target group of 10 high school students on mangrove restoration techniques, begin restoration of a damaged mangrove forest and to increase awareness of the function of mangroves in reducing non-point source pollution.

Over a period of six months, student interns and Center for Marine and Environmental Studies (CMES) staff collected and planted 50 red mangrove (*Rhizophora mangle*) propagules and 200 black mangrove (*Avicennia germinans*) seeds. They were planted using different methods along transects with varying exposure to sun and water. After six months, only 2% of red mangroves and 0.05% of black mangroves survived. An additional planting of 100 red mangroves and 800 black mangroves took place in March with similar results (1% of red mangroves and 0.00% of black mangroves surviving.) A final attempt was made in May with 50 black mangrove seeds planted. Only one of the most recent black mangrove seeds survived over a month period. Further research into the natural hydrology and original ecology of the site is required in order to successfully restore the mangrove forest at the UVI Wetlands.

The environmental education portion of this program taught students about wetland ecosystems and species, and the important role they play in the health of other island resources. Once the basic lessons of wetland functionality were completed, the students were taught mangrove restoration techniques. An additional objective of the environmental education component was to increase awareness of the function of mangroves in reducing non-point source pollution to a larger audience. The student interns were provided with instruction on how to conduct educational tours for other youth groups at the UVI Wetlands. The students were able to conduct some tours before storms made the road to the site nearly impassable.

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Environmental Education and Hands-on Training on Mangrove Restoration Techniques

1. Introduction

Mangrove forests are diverse communities of salt-tolerant tree and other plant species. These communities live in the inter-tidal zones of tropical shorelines and estuaries. Mangrove trees have special adaptations that allow them to filter out salt. This allows them to live in areas with high salt concentration, where other plants would die. They are also adapted to living in a tidal area subject to periodic flooding.

Mangroves provide important habitat for many species of birds, invertebrates, fish and other organisms. They are important nursery areas for many of the Virgin Islands' commercially important reef and open-water fish species. Mangroves serve as natural filters for sediments and pollutants that flow off the land into our waters and help prevent floods, control erosion and protect shorelines from being damaged by waves.

2. Problem and Research Objectives

Mangrove wetlands play an important role in coastal marine communities. Yet the number of mangrove areas in the Virgin Islands (VI) has significantly declined in the last 50 years because mangrove ecosystems were routinely bulldozed to make space for marinas and other coastal developments.

Although mitigation has decreased the rate of mangrove habitat loss, limited awareness and a poor understanding of the role played by mangroves continue to hinder these efforts. There is a need to increase local awareness of the importance of mangroves in the VI and to demonstrate the benefits of restoring lost or damaged wetlands.

In order to increase advocacy for mangrove habitat protection and restoration, the objectives of the project were to train a target group of 10 high school students on mangrove restoration techniques, begin restoration of a damaged mangrove forest and to increase awareness of the function of mangroves in reducing non-point source pollution.

The University of the Virgin Islands (UVI) Wetlands Reserve is a 52 acre property located on the south shore of St. Croix. The site is owned and managed by UVI's Center for Marine and Environmental Studies (CMES). The UVI Wetland Reserve has been set aside as a nature preserve and for research and educational activities. It has two large salt ponds fringed by mangroves. The property receives runoff from a large watershed whose combined area is estimated as over 5000 acres. The UVI Wetlands Reserve was damaged by Hurricane Hugo in 1989 and by subsequent hurricanes and storms and has made very little progress in recovering. This project developed an educational program about mangroves and their pollution-reduction function by developing a hands-on training and education program focused at the UVI Wetlands Reserve.

3. Methodology and Accomplishments

In order to achieve the objectives CMES staff first solicited for student interns to assist with the project (5/02). This was done by putting a notice in the paper and alerting high school teachers of the opportunity. As a result, several students were given an orientation/training session on wetlands, mangroves and the project (6/02). Students were then given a training session on-site at the UVI Wetlands (6/02) and the area to be restored was identified (6/02).

3.1. Mangrove Restoration Component

The restoration of the mangrove site began with the collection of ripe red mangroves (*Rhizophora mangle*) propagules. Ripeness is determined when propagules fall off a tree or, ideally, when they can be picked off a tree with minimal resistance. The students assisted with the first mangrove planting in July 2002 by planting 50 red mangroves at the site. For this project the propagules were planted in the traditional method, which entails collecting ripe propagules and planting them in the substrate. The traditional method has been recommended by the Army Corps of Engineers (Lewis and Streever, 2000). The propagules were placed in a 5 cm deep hole and planted on 1-meter centers seaward of the mean high tide line (see Map 1). Added benefits of using the traditional planting method over the other methods include cost-effectiveness, less labor intensive, and no foreign materials left at the site.

The 200 black mangrove (*Avicennia germinans*) seeds were collected during the summer of 2002, when they appeared to be ripe on the tree. Seeds were then germinated in tree cones using a mixture of mud from the site and Promix® media. The seeds were grown for 10 weeks before being planted. This method of germination was used instead of hand-broadcasting due to low survival rates (1-2%) of hand-broadcasted seeds (Lewis and Haines, 1981). The seedlings were watered using fresh water for the first 2 weeks, then 50% seawater, followed by 100 % seawater the last week before planting. After this time, the germination rate was low (<55%) so an additional 90 seeds were planted in a media composed of a higher percentage of Promix®. These seeds grew well and were put in the UVI greenhouse for several weeks (7/02-9/02). After the black mangrove seedlings were about 6 inches tall, they were removed from the greenhouse and exposed to a greater amount of sunlight in an attempt to "harden" them to full exposure (10/02). CMES staff and the student interns planted the black mangroves seedlings in December 2002 and January 2003. These seedlings were planted into the substrate on 1-meter centers landward of the high tide line (see Map 1).

After planting, the site was monitored by CMES staff and student interns. The monitoring consisted of direct counts of all plants for survival, and height and numbers of leaves on the plants. Monitoring of the site on mid January 2003 showed that only 10% of the black mangrove seedlings were still viable and very few of the red mangrove propagules showed any signs of germination.

In March 2003, 800 black mangrove seeds and 100 red mangrove propagules were collected to try additional plantings using alternative methods. The seeds were collected

near the UVI Wetlands Reserve when it was determined that they were ripe. The CMES staff and student interns placed the black mangrove seeds on the surface of the substrate with no water cover at one foot intervals along 26 transects. All seeds were placed along the Eastern shore of East Pond (see Map 2). The 100 red mangrove propagules were planted in the former red mangrove planting area in about 4" of water in four transects parallel to the shore (see Map 2). Also noted was that as of this planting, only two black mangrove seedlings remain from the December and January plantings. Neither of the seedlings appeared to be especially healthy; both having wilted, brown leaves.

In May 2003, a comprehensive monitoring of the original 800 black mangrove seeds was taken. The majority (~650) were still present, but very obviously dead. This indicated that the seeds were not washed out or depredated. Of the 100 red mangroves planted, one remained alive after 6 weeks in addition to the one remaining from a 2002 planting. During this time, the black mangrove trees were seeding, so another planting was planned.

50 black seeds were collected from seeding trees at the site. These seeds were grouped into 10s. 5 plots were set up in an area just east of the entrance road where there were numerous young black seedlings. One seed was placed in a modified plastic bottle. The other seeds were spaced around the bottle in close proximity. One plot was set in heavy shade, one in light shade and three in full sun. Of the three in full sun, one was placed on a small ridge (always dry), one in the bottom of the ditch (usually wet), and one in between. The seeds were watered six days after being placed. They appeared to be doing well and one was starting to sprout (small ridge, full sun). 5 days later, only the seeds in full and partial sun remained green, but none was sprouting.

A return trip at the end of May 2003 showed that only the seeds in full shade were still green. The seed in the bottle, with partial shade, was still mostly green.

3.2. Environmental Education Component

According to studies done by the Environmental Protection Agency's Office of Communications, Education and Media Relations, environmental education is a unique way to engage students in a hands-on, investigative learning process. It provides a real world context for learning and linking those lessons to the needs of the community (EPA 1999). The environmental education portion of this program taught students about wetland ecosystems and species, and the important role they play in the health of other island resources. This was, in part, to enhance their understanding of ecosystem interconnectivity and how the actions of people in the community can affect these systems. In order to minimize the impacts on these systems, the community must first understand how they function. Once the basic lessons of wetland functionality were completed, the students were taught mangrove restoration techniques. As discussed in the Mangrove Restoration component, the interns assisted with the planting and monitoring the growth and survival of mangroves at the site.

A second objective of the environmental education component was to increase awareness of the function of mangroves in reducing non-point source pollution to a larger audience. The student interns were provided with instruction on how to conduct educational tours for other youth groups at the UVI Wetlands (7/20-10/02). The tours included information on the importance of mangroves as well as information on the restoration project (See Appendix 1). By conducting tours, the students reinforce what they have learned. In addition, there is the added benefit of allowing other students to see their peers doing outreach activities. This increases the sense of stewardship by both the student interns, as well as their peers. In addition to the tours, additional educational signage was installed at the site to enhance information dissemination during self-guided tours and monitor the progress of the planted mangrove seedlings.

An additional outreach component of this project included the development of a website where basic information and initial results on the project can be found. (http://rps.uvi.edu/VIMAS/wrripage.html).

4. Principal Findings

4.1. Mangrove Restoration Component

Monitoring conducted at the site showed that only a few red and black mangrove seedlings had survived the transplant. Of the original 50 red mangrove propagules, only one out of 50 (2%) survived over 6 months. Of the 200 black seedlings planted in December 2002 and January 2003, only one out of 200 (.05%) survived over 3 months. A subsequent planting with differing conditions (different elevations, level of shade) showed similar results (1/03).

Based on these results, additional research was done in an attempt to find ways to increase mangrove survival at the site. The question was put out on the mangrove discussion list and several responses were received. In addition, individuals who had been involved with mangrove restorations were contacted to discuss our results. All researchers suggested an alternative approach to black mangrove planting. Despite previous advice to the contrary (Lewis and Haines, 1981), the individuals on the discussion list suggested that rather than starting the plants in the greenhouse, a better approach would be repeated broadcasting of seeds. A low survival rate (<10%) would still be expected, but it would be higher than the previous method of transplanting seedlings which easily shocks black mangroves, decreasing survival.

Black mangrove seedlings were hand seeded around the site in 26 transects. A subsequent monitoring trip later in March by CMES staff showed that approximately ¼ of the observed seeds were germinating. An additional ¼ of the seeds were fairly dark in color, potentially indicating weak health. There was no indication of washing out or depredation of the seeds, however it seemed that the seeds placed on moister substrate were marginally more successful than those placed on very dry substrate.

A comprehensive monitoring trip in May showed that of the original 800 seedlings, around 80% remained, but nearly all were dead. Again, this supports the finding that there was no indication of washing out or depredation of the seeds. Of the 100 red mangrove propagules planted, only one remained alive.

4.2. Environmental Education Component

CMES had a total of 21 students involved in the planting, monitoring, maintenance and interpretative tours at the UVI Wetlands Reserve site (See appendix 1). They took six trips to the site for planting and monitoring and an additional two trips for tour training spending a total of 236 hours in the field. All student interns showed great enthusiasm for the restoration and monitoring of the mangroves. The students benefited from learning about the life cycle of the mangrove and its important role in our ecosystem. They learned the tour materials quickly and were eager to begin giving tours. Unfortunately, CMES encountered problems getting as many student groups out to the wetlands as expected. Shortly after the students were trained, a series of heavy storms damaged the road to the Reserve making it impassable without a 4-wheel drive vehicle. The student interns were able to conduct four tours with a total of 48 people prior to the storms, but transportation complications made further tours unrealistic.

5. Conclusions and Future Research Needs

CMES has compared data with two other mangrove restoration projects in the USVI. The first, Sugar Bay mangrove restoration project in the Salt River Estuary on St. Croix planted 946 red mangrove propagules and had a 17.5% survival rate after a year; far less than was hoped. The Lameshur Bay mangrove restoration project on St. John has planted 740 red mangrove propagules with a survival rate of 4.3%, 250 black mangrove seedlings with a survival rate of 0.00% and 500 white mangroves with 0.00% survival. In each of these studies, as well as the UVI Wetlands Reserve project, the main focus of research was propagation and planting methodology. None looked into other possible treatment methods for mangrove restoration.

According to the US Army Corps of Engineers report on mangrove restoration, mangrove habitats should be able to self-repair or undergo successful secondary succession in 15-30 years after a stressor if the normal hydrological conditions return (Lewis and Streever, 2000). According to several other restoration experts (U. Kaly, G. Jones, Watershed Ecology Team, U.S. EPA Office of Wetlands, Oceans and Watersheds) restoring normal hydrology is the most important part of mangrove restoration. In order to achieve this, research into the normal tidal hydrology and natural ecology of the site or healthy mangroves near the site needs to be done. Costs for such studies can be quite large and were not possible under this project. However, possible future research could focus on the historical hydrology of the UVI Wetlands Reserve mangrove forest and compare it with that of nearby, healthy mangroves. Future research should involve the five critical steps necessary to achieve successful mangrove restoration (Lewis and Streever, 2000).

1) Understand the autoecology (individual species ecology) of the mangrove species at the site;
2) Understand the normal hydrologic patterns that control the distribution and successful establishment and growth of targeted mangrove species;
3) Assess modifications of the original mangrove environment that currently prevent natural secondary succession;
4) Design the restoration program to restore appropriate hydrology and, if possible, utilize natural volunteer mangrove propagules recruitment for plant establishment;
5) Only utilize actual planting of propagules, collected seedlings, or cultivated seedlings after determining that natural recruitment will not be successful.

6. Acknowledgments

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7. Literature Cited

Kaly, U.L. and G.P. Jones. "Mangrove restoration: a potential tool for ecosystem management of coastal fisheries. *Ambio* 27(8), 656-661

Lewis, R.R. and K.C. Haines. 1981. Large Scale Mangrove Planting on St. Croix, U.S. Virgin Islands: Second Year, p. 137-148. In D.P. Cole (Ed.), Proceedings of the 7th Annual Conference on Restoration and Creation of Wetlands. Hillsborough Community College, Tampa, Florida.

Lewis, R.R., and B. Streever, 2000. "Restoration of mangrove habitat," *WRP Technical Notes Collection* (ERDC TN-WRP-VN-RS-3.2), U.S. Army Engineer Research and Development Center, Vicksburg, MS. *www.wes.army.mil/el/wrp*

U.S. Environmental Protection Agency, 1999. "Environmental Education Improves our Everyday Lives" (EPA 171-F-98-015). Office of Communications, Education and Media Relations. *www.epa.gov/enviroed/pdf/15envtraining.pdf*

U.S. Environmental Protection Agency, 1999. "Environmental Education Advances Quality Education". (EPA 171-F-98-016). Office of Communications, Education and Media Relations. *www.epa.gov/enviroed/pdf/16advancequality.pdf*

U.S. Environmental Protection Agency, 2000. "Principles for the Ecological Restoration of Aquatic Resources". (EPA841-F-00-003). Office of Water (4501F), United States Environmental Protection Agency, Washington, DC. 4 pp.

Appendix 1

Outline of UVI Wetland Tour

Pre-Tour:

1) Please limit the number of students on each tour to 15. We want to avoid the impact of large groups on wildlife.

2) What to bring: see handout

3) Pre-tour activity: There are three, locally produced, very good videos which can serve to introduce coastal habitats: "Mangroves: an Ecosystem in Jeopardy," "Salt Ponds: Nature's Water Pollution Prevention System," and "Our Virgin Islands, Coastal and Marine Ecosystems of the V.I." They are available free to teachers from DPNR/Fish and Wildlife. Call 775-5762 and ask for Donna Griffin to get copies.

4) Parking: We are currently in the process of installing a fence on the east boundary of the site which will include a gate near the large tamarind tree. Call my office (692-4046) to make sure it is unlocked so that you can park. Do not park on the access road because you will block access to the house at the end of the road.

5) Rules: Please go over the sheet (see handout) on restricted activities before arriving at the site.

Tour

1) Introduction to the site: see UVI Wetlands Reserve brochure.

2) Discuss the importance of plants as an introduction to the first part of the hike, the dry forest. Be sure to discuss the medicinal importance of plants.

3) Hike up the road to the start of the trail and look at the sign which gives a map of the site and the trail.

4) Visit each marked plant and discuss them as desired, see plant handout. Discuss the importance of species diversity and protecting all species.

5) Make a short stop at number 20, before crossing the dirt road into the mangrove area. Tell students to walk quietly, carefully (watch for low branches, holes and stumps) and single file until they get to the pond. This will maximize chances of seeing birdlife at the pond.

6) Once everyone has had a chance to see the birds, discuss the importance of mangroves and the special adaptations they have to their environment (see video). Point out the black and white mangroves and their differences. Also discuss endangered species and the birdlife in the ponds.

7) Walk back to road stopping to discuss the plants along the way. Continue looking for plants until you get to the tamarind tree. Stop the class as you start down the road to the beach. Have the class stay on the right side of the road as you point out the manchineel tree, which is very poisonous.

8) Continue down the road to the path. Stop briefly as you pass the pond to view any birds.

9) When you get to the beach stop to discuss the beach habitat and what sand is composed of (marine organisms i.e. algae, coral, shells, etc.). Point out seagrass in the water and washed up on the beach. Discuss the importance of the seagrass ecosystem. Note the presence of the cliffs to the east where the endangered white-tailed tropicbird nests.

10) Walk down the beach and note several plants on the way to the pond. Cut inland near the large seagrape trees to the salt ponds.

11) When at the salt ponds, note the fiddler crabs and explain that the male crab has one
12) large claw where the female crab has two claws of equal size. Do not allow students to handle the crabs.

13) Discuss the importance of salt ponds (see video). Note birdlife.

14) Walk back to car.

Post-tour:

1) Summarize important points.

2) Fill out evaluation form and send to VIMAS at UVI (see Wetlands brochure for address).

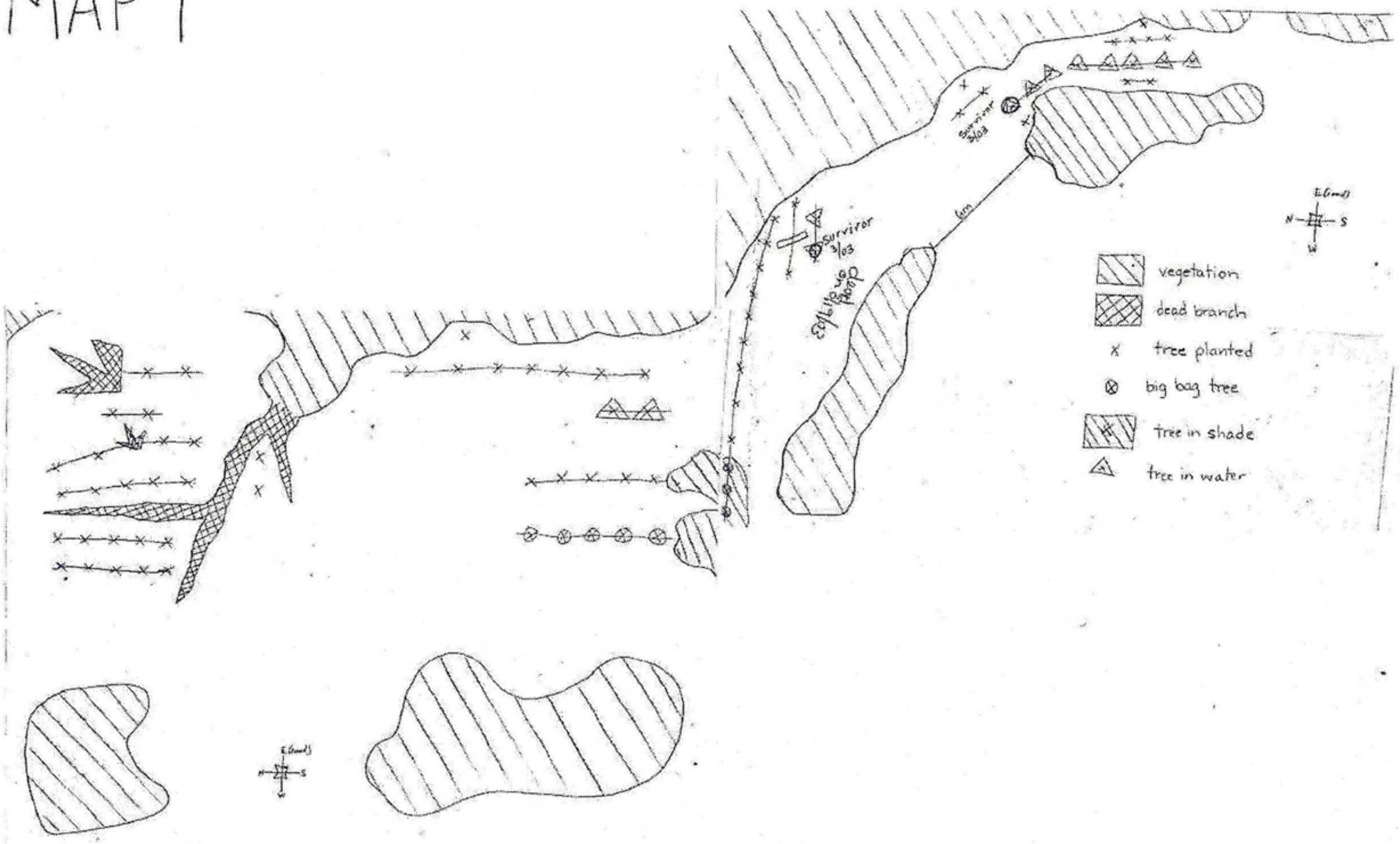
3) Be sure that no garbage (wrappers, cans, etc.) is left at the site.

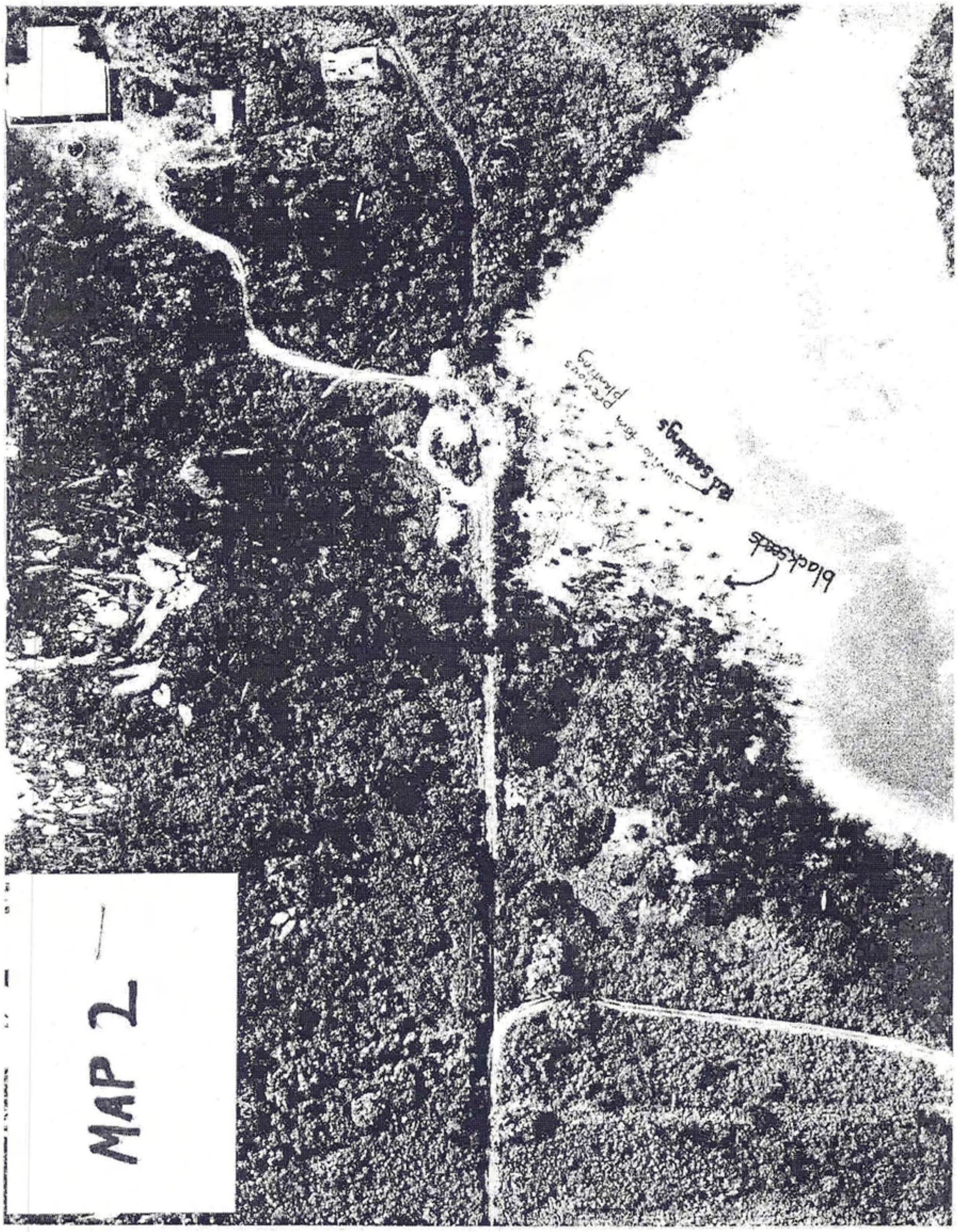
Appendix 2

Students involved with the project and academic level at time of involvement

Name	Grade	School
Lamin Jackson	9	Good Hope School
Daniel Hodge	11	Educational Complex
Amaris Chew	10	Educational Complex
Candace Cornwall	10	Educational Complex
Michael Camacho	12	Central High School
Manuel Camacho	11	Central High School
Amalee Lockhart	12	Educational Complex
Dennis Andrew	12	Educational Complex
Cyril Andrew	7	Volunteer
Velma Edwards	10	Educational Complex
Mia Russell	12	Educational Complex
Arianna Smith	10	Educational Complex
Latoya Barton	12	Educational Complex
Avante Barton	12	Educational Complex
Ira Hobson	12	Educational Complex
Laurel Smithen	12	Educational Complex
Matthew Stone	10	Educational Complex
Debbra Douglas	11	Educational Complex
Jason Slayer	12	Educational Complex
Unita Randolph	11	Educational Complex
Trisha Victor	11	Educational Complex

MAP 1


survivor 3/03
dead on 8/19/03
vegetation
dead branch
tree planted
big bag tree
tree in shade
tree in water


MAP 2
survivors from previous planting
red seedlings
blackseeds