1 INTRODUCTION

Bio-engineering is defined as the use of plants or vegetation for engineering purposes. Bio-engineering for soil slope stabilization utilizes living plant materials, viz., stems, branches, and roots, to provide mechanical and hydrological support to the soil against erosion. Although the use of vegetation for soil slope stabilization and erosion control is well known in the Caribbean, there has not been a systematic approach nor a strong conscious effort to use vegetation in this way.

Soil erosion by water occurs in the following forms:

- raindrop impact or splash erosion;
- rill erosion where the runoff water concentrates in narrow channels or rills;
- sheet erosion which is the removal of soil particles from sloping land in thin sheets by water runoff;
- soil slippage or slumping which is the sliding of soil above a failure plane;
- gully erosion which is the removal of soil resulting in large channels;
- river and stream bank erosion;
- beach and coastal area erosion.

Most vegetation if it is close to the ground and covers the soil surface completely will prevent raindrop impact, rill erosion, and sheet erosion. However, vegetation which is not perennial, or dies back during the dry season, or is destroyed by dry season fires will not adequately protect the soil. If the ground under the trees is bare, splash, rill, and sheet erosion can occur from the raindrops falling within the drip circle of the trees. The height and architecture of the canopy are two plant factors which can influence the energy, spatial distribution, and erosivity of the falling raindrops.

The ability of plant roots to improve soil surface structure is an important factor in erosion control. Improved soil surface structure increases infiltration and reduces runoff and erosion. Therefore, prolific deep rooting systems, especially fibrous root systems are very desirable.

Land slippage can be shallow or deep depending on the structure of the soil profile and the depth to the slip plane. Grasses and shrubs may not be able to hold the soil against slippage if the slopes are steep, slip planes are deep, and rainfall is heavy. However, trees may be effective under these conditions especially if the tree roots are deep and well distributed.

Many rivers and streams in the Caribbean may run dry or at very low flow rates in the dry season but may overflow their banks in the wet season. Hence, river and stream bank erosion is prevalent in the wet season and is promoted by the velocity, turbulence, and sediment load of the water flow. Grasses, shrubs, and trees that can tolerate waterlogging can protect the banks against erosion.

Engineers have normally sought remedies for soil slope stabilization in traditional engineering structures to protect civil works. Many road building contracts however, require the contractors to vegetate the roadside embankments. In for example Trinidad, vetiver (*Vetivera zizanioides*) is the plant species that is recommended but it would appear that adherence to the recommendations are not enforced. Consequently, embankments are invaded by volunteer plant species which may not be the most appropriate species for stabilizing the slope, since they may possess a poor root system which cannot effectively stabilize the soil or they may not completely cover the ground.

In the Caribbean, only a few species are recommended or are used specifically for soil slope stabilization. Besides vetiver which is also recommended as contour grass barriers particularly on agricultural land, *Gliricidia*, *Leucaena*, and *Acacia* spp. are used for slope stabilization and gully control mainly because of their ease of establishment, rapid growth, and resistance to drought. Vegetation suitably selected for the environmental conditions and for engineering purposes can substitute for, or be supportive of, engineering structures. In these cases, bio-engineering can reduce the high cost of protection associated with engineering structures or provide a cost-effective level of protection.

There is no systematic information on the suitability of plant species for bio-engineering under prescribed environmental conditions in the Caribbean. If plant species are to survive and effectively perform their engineering function, they must be adapted to the soil, rainfall, temperature, humidity, wind, and other environmental conditions such as grazing, fires,

flooding, salinity, and seaspray. This study aims to identify and to recommend plant species which are suitable for soil slope stabilization under specific environmental conditions and engineering purposes. The study was undertaken exclusively in Trinidad but the findings would be applicable to other Caribbean islands under similar environmental conditions and, indeed, to other countries in the humid tropics.

It was not possible to scientifically test the response of the species to these conditions. Recommendations are based on careful observations and the knowledge of local experts. Where all the relevant information has not yet been verified the recommendations are tentative and should be adopted with caution. It is proposed that further knowledge gained from field tests would be used to update the recommendations.

1.1 *Scope of the Resource Book*

Since very few species are currently used for soil slope stabilization in the Caribbean this resource book is aimed at providing the engineer, agriculturalist, forester, and environmentalist faced with the problems of slope stability, with a wider selection of suitable species.

The book is intended as a guide to the selection of vegetation that is suitable or has potential for stabilizing slopes under a range of conditions. It also recommends species that can be used for specific types of erosion control. Based on the field observations there is a high level of confidence in the ability of the recommended species to stabilize slopes. However, the rate of spread and the potential to become a weed could not be assessed. Therefore, there is need to adopt the recommendations cautiously where this is indicated. Future field monitoring will contribute to the upgrading of the recommendations.