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ASSESSING THE ECOLOGICAL STATUS OF WOODY PLANT SPECIES AT ERODED SITES OF ABIA AND IMO STATES, NIGERIA.

M. C. DIKE

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ABSTRACT

Woody plant species up to 0.10 m and above in height growing in and within 0.5 m from the edges of ten gully erosion areas of Abia and Imo states of Nigeria were enumerated in January and July 2000 through July 2003. Questionnaires were served to find the causal factors of each gully. The plants were enumerated and classified into their life form. The index of similarity according to Sorensen was used to determine the similarity of the sites. It was observed that a combination of factors contributed to form a gully. The gullies were caused by discharge from road culverts, 80%; run off from building, 70%; footpath, 60%; deforestation, 30% and flood 10%. A total of 49 plant families comprising 100 species were identified at the sites. The families *Cyperaceae* and *Euphorbiaceae* had the highest representation of species. The Phanerophytes, Therophytes and Chamaephytes were represented by 57.5%, 23.8% and 13.7%, respectively. A combination of grasses such as *Acroceras zizanioides, Cynodon dactylon* and *Perotis indica* and some tree species such as *Antiaris toxicaria, Entandrophragma utile, Gossweilerodendron balsamiferum, Khaya ivorensis, Nauclea diderrichii* and *Terminalia superba* were recommended for planting in and near gullies at a espacement of 1.0 x 1.0 m. The slope angle ranged from 55 to 122 degrees. The sites were similar. Variations in the species composition were not recorded within the studied period. The study revealed that some previous attempts to control gully erosion with *Gmelina arborea* failed because many of the trees were carried into the gullies by flood. It was concluded that the use of monoculture plant species in erosion control project should be minimized.

KEY WORDS: Woody plant, erosion, gullies and enumeration.

INTRODUCTION

Nigeria has two major vegetation types: forest and savanna (White, 1983). These vegetation types cover many soil types and slopes occurring in reliefs ranging from hills, ridges to undulating dissected plains. In the processes of crop cultivation, road construction and other uses of land, large portions of the vegetation up to 150 m^2 are cleared and often burnt (Okigbo, 1987; Tafesse, 1992; Dike, 2003). Consequently, the protective functions of the vegetation on the cleared portions of the soil are lost (Okali *et al*, 1987; Nigerian Environmental Study/ Action Team, (NEST) 1991; Ofomata, 2001). The soil is left bare therefore exposing it to both more rays of the sun and direct hits by rain droplets. The rays of the sun cause the soil to crack more especially during the dry season. When it rains, the combined impacts of rain droplets and flood often trigger off splash, sheet and gully erosions. Erosion is caused also by footpaths in steep slopes and by improperly located drainage channels (Ofomata, 2001). A gully erosion is a long and wide opening made by water runoff in the ground (Igbozurike, 1993). In Nigeria, soil erosion occurs in all soil types, but areas having weakly consolidated sediments of the Tertiary to Cretaceous Formation are highly susceptible to severe gully erosion (Ofomata, 2001), when the soil is left bare.

Erosion is mainly controlled by either planting effective plant species or mechanically using either concrete structures or bench terraces (Schwab, *et al.*, 1993). In some places, the two methods were used simultaneously (Okorie, 1991;NEST, 1991; Ofomata, 2001). Occasionally, grazing, livestock, rodent or farmers damaged the physical structures. In few cases, there were either poor maintenance of the channels and chambers or dumping of refused in the channel leading to blockages and collapses. In some areas there could be insufficient information for the engineer carrying out the construction (Herweg, 1992) leading to collapses, thereby creating more problems than it was intended to solve. However, the use of plants in erosion control is cheaper (Okorie, 1991; Igbozurike, 1993) and could be carried out by individuals having little skill in either engineering or in silviculture. Vegetation intercepts rainfall and minimizes splash, run off and soil movement. The effectiveness of erosion control is more pronounced where the upper and lower canopy tree species formed a more or less closed canopy. The raindrops fall on the upper and lower canopy trees. Before the raindrops could get to the shrubs, herbs and debris; most of the potential energy used in breaking the soil particles is lost.

Kio and Okorie (1987) estimated that 15 million tonnes of soil was lost annually to erosion in southeastern Nigeria. Also Romas and Merinho (1980) working at northeastern part of Brazil recorded the erosion of 115.4; 8.6 and 1.2 tonnes of soil per hectare from plots that were bare, with herbaceous vegetation and with shrubs and tree cover, respectively. Maass (1992) working at Chamela region of the Jalisco state, Mexico also recorded the loss of 99.8; 5.0 and 0.20 tonnes of soil per hectare from maize, mulch and forest plots, respectively. Consequently trees and shrubs provided the highest resistant to soil erosion. Enwezor (1976) recorded high soil acidity, low cation exchange capacity and low Nitrogen, Potassium, Phosphorus and Sulphur in areas where gullies occur in southeastern Nigeria. Maass (1992) also recorded the tremendous loss of those essential plant elements including Sodium, Calcium and Magnesium. The loss of those essential plant elements and the topsoil could lead to poor establishment of some plant species. Few plant species that require very small quantity of the above minerals or have deep roots could presumably be abundant and survive better at these gully areas.

Okorie (1991) recorded that biological erosion control has been ignored as a result of the underestimation of its efficacy. Often the amount required for mechanical erosion control was beyond the reach of many Nigerian communities. Some of such communities did appeal to the government for assistance and before the estimated amount was received, the gully had increased in length, width and depth. Further attempts to control the erosion with the estimated amount resulted in poor quality job and in some other cases led to uncompleted work. Uncontrolled gully erosion pollutes streams and fills reservoirs with eroded sediments; destroys

M. C. DIKE, Dept. of Forestry and Environmental Management Michael Okpara University of Agriculture, Umudike, Nigeria.

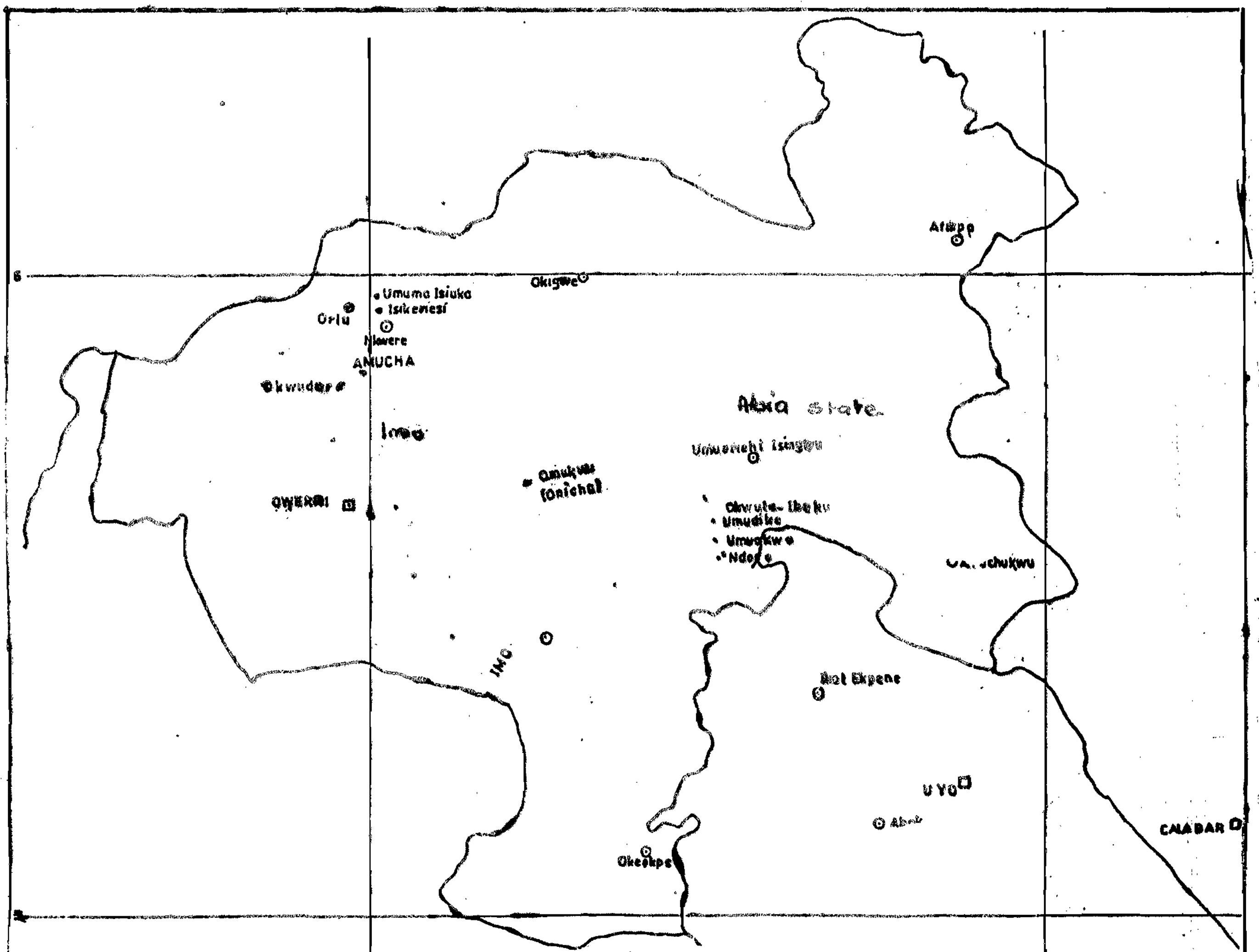

Fig. 1: A map of the 10 study erosion sites in Abia and Imo State, Nigeria.

highways; roads; schools and residential and commercial buildings on its path (Aneke, 1985; NEST, 1991) and presents an unpleasant sight.

Literature on plant species used for effective erosion control in southeastern Nigeria is scanty. Okafor (1986) recommended the use of *Anacardium occidentale*, *Pentaclethra macrophylla, Dactyladenia barteri* and *Bambusa vulgaris* in controlling erosion in southeastern Nigeria. However, the use of *Anacardium occidentale* in erosion control was objected by several writers (Okali, *et al*, 1987; Ofomata 2001) on the bases that *Anacardium occidentale* had shallow spreading rooting system, dense wide spreading crown and low rate of decay of leaves. There is the need to understand plant species that are abundant at gully erosion areas. These abundant plants could be grouped to highlight those that are both economic (Lancaster, 1960) and suitable for effective gully erosion control. According to Onyekwelu, (1987); Ofomata (2001) planting of any tree might not give the desired result. This paper reports the study on plant species enumerated in or close to ten erosion gullies in southeastern Nigeria. The result would be useful in controlling erosion in numerous communities and schools where gully erosion poses serious problem. These species could also form the basis of field trials against gully erosion.

MATERIAL AND METHODS

Study Areas, Climate and Vegetation

The areas studied were Umudike; Okwuta-Ibeku; Umuoriehi Isingwu; Umuokwo; Ndoro; Okwudor; Amucha: Umuma-Isiaka; Isiekenesi and Omukwu (Onicha). These areas lie within Abia and Imo States of Nigeria (Figure 1; Table 1). Abia and Imo States of Nigeria with a total area of 10578.98 square kilometers lie between latitudes $4^{0}05^{1}$ and $5^{0}57^{1}$ N and longitudes $6^{0}10^{1}$ and $8^{0}05^{1}$E. The climate is of the equatorial type. The minimum and maximum topsoil temperatures were 19.0^{0}C and 45.0^{0}C, respectively. There are two seasons in the year, a wet season and a dry season. The wet season starts from mid-March till mid November with a dry spell in the first week of August. A combination of large raindrops and ice often fall at the beginning of the wet season. Hailstone is rare and when it falls, it covers few local government areas. For example, within the duration of this study, it was only at Amawom and Umudike communities, in Ikwuano Local Government Area of Abia State, Nigeria, that hailstone fell in the year 2002. The total annual rainfall ranged between 1500 and 3000 mm (Dike, 2003). Each year there were two peaks in rainfall in June/July and in September. The driest period was from the month of December through January. The local dry and dusty harmattan wind blew intermittently at that period. For the two months, the total monthly rainfall ranged between 1.00 and 50.00 mm. At all seasons, the humidity was high and on the average above 60 percent at nights and early mornings. The humidity fluctuated and could be as low as 40 percent between 1300 and 1500 GMT more especially during the peak of the dry season.

The vegetation is tropical rain forest (White, 1983). Most of the areas originally mapped as forest is currently made up of secondary forest regrowth in various degrees of degradation. Presently, the characteristic climax and

Table 1: The state, local government area, latitude and longitude of the ten gullies sites studied at Abia and Imo states, Nigeria.

	Erosion site	Abbreviation of sites	State	Local Government Area	Latitude	Longitude
1.	Umudike	Ume	Abia	Ikwuano	05°29'N	07°33'E
2.	Umuokwo	Umo	Abia	Ikwuano	05°30'N	07°34'E
3.	Umuoriehi Isingwu	Umi	Abia	Umuahia North	05°32'N	07°29'E
4.	Okwuta Ibeku	Oka	Abia	Umuahia North	05°33'N	07°31'E
5.	Ndoro	Ndo	Abia	Ikwuano	05°27'N	07°34'E
6.	Okwudor	Okr	Imo	Njaba	05°44'N	07°01'E
7.	Amucha	Ama	Imo	Njaba	05°45'N	07°04'E
8.	Umuma – Isiaka	Uma	Imo	Ideato – South	05°48'N	07°08'E
9.	Isiekenesi	Isi	Imo	Ideato – South	05°48'N	07°07'E
10.	Omukwu (Onicha)	Omu	Imo	Aboh – Mbaise	05°31'N	07°20'E

Table 2: The number of gully erosion sites enumerated at the Local Government Areas of Abia and Imo States of Nigeria.

	Local Government Area of Abia State	Number of erosion sites yet recorded	Local Government Area of Imo State	Number of erosion sites yet recorded
	Aba North	8	Aboh Mbaise	28
	Aba South	2	Ahiazu Mbaise	5
	Arochukwu	15	Ehime Mbano	7
	Bende	43	Ezinihitte Mbaise	5
	Ikwuano	27	Ideato	33
	Isiala Ngwa North	9	Ikeduru	14
	Isiala Ngwa South	11	Isiala Mbano	6
	Isikwuato	20	Isu	12
	Obingwa	27	Mbaitoli	22
	Ohafia	34	Ngor Okpala	4
	Ukwa East	7	Nkwerre	5
	Umuahia North	41	Obowo	4
	Umuahia South	36	Oguta	67
	Umunneochi	12	Ohaji/Egbema Orlu	11 14
Total		293	Orsu Oru Owerri	13 7 26 283 Grand Total 576 erosion sites

Source: Ministry of Environment, Abia and Imo States, Nigeria.

emergent tree species such as *Entandrophragma angolense, Nauclea diderrichii,* and *Triplochiton scleroxylon* are frequent only at reserved areas within forest reserves and fetish groves. Land is used mainly for subsistent agriculture (Okigbo, 1987) and in few areas for mining. Each year, every community marks out an area not less than 1000 hectares where farming would be carried out. In many communities, it takes between 3 and 5 years for a return to the same piece of land. Both Abia and Imo States lie within the weakly consolidated sediments of the Tertiary to Cretaceous false –bedded sandstone (Ofomata, 2001).

According to the Federal Department of Agriculture and Land Resources (FDALAR, 1990), the soil is moderately deep and consists of imperfectly drained sandy clay loam. In some areas, the soil is very deep and well drained sandy loam. The relief is made up of undulating and dissected plains with minor hills. There are numerous permanent streams but the two main rivers are Cross River and Imo River. The parent soil material is the Pre-Cambrian basement complex.

METHODOLOGY

The lists of all the recorded gully erosion sites in Abia and Imo States were obtained from the Ministry of Environment of each state (Table 2; Appendices 1, 2). A reconnaissance survey was carried out using a landrover vehicle with the registration number 201CC 99. Out of a total of 576 observed and recorded erosion sites in the two states, ten gullies each greater than 10.0 m in width and 5.0 m in depth were randomly selected. At each of the selected gully erosion site, the main gully and other auxiliary gully units were physically identified and examined. To investigate the causal

Table 3: Morphometry of ten gully sites in Abia and Imo states of Nigeria

MAIN GULLY

State	Site	Number of observed major gully units	Observed major causal factors	Total length (m)	Width (m) Maxim.	Width (m) Minim.	Depth (m) Maxim.	Depth (m) Minim.	Estimated area of both active and non-active Km^3	Mean slope (degrees) remove	deposit	wall
Abia	Umudike	1	Footpath, discharge from buildings and culverts	136	32.8	6	31.7	2	0.21	60	3	60-74
Abia	Okwula-Ibeku	3	Discharge from culverts and building	242	38.2	3	38	2	0.45	62	4	60-82
Abia	Umuoriehi Isingwu	2	Discharge from road culvert and school buildings	487	42	4	37	3	0.37	65	2	75-80
Abia	Umuokwo	1	Deforestation and footpaths	420	40	3	35	2	0.79	60	2	61-82
Abia	Iyi Ndioru	1	Foothpaths and deforestation	241	46	3	38	2	0.26	60	3	60-81
Abia	Okwudor	5	Discharge from buildings culverts foothpaths	670	136	2	37	3	0.06	45	3	60-80
Imo	Umuma-Isiaka	2	Discharge from culverts	608	32	2	34	2	0.81	59	2	60-70
Imo	Isiekenesi	2	Deforestation discharge from culverts and buildings	205	32.4	6	36	2	0.77	68	2	62-77
Imo	Amucha	3	Discharge from building, foothpath and culverts.	420	22	2	115	2	1.50	63	2	61-74
Imo	Omukwu-Onicha	4	Flood, discharge from schools, culverts and foothpaths.	1542	159.6	7	194	4	1.32	115	3	55-79
Abia-Imo		1-5		136-1542	22-159	2-7	34-194	2-4	0.21-1.5	45-115	2-4	55-82

factors of the ten gullies, at each gully site, 30 questionnaires were served to 30 men living at the nearest community to the gully. All the woody plant species up to and above 0.10 m in height growing inside or within 0.5 m from the edge of a selected gully were enumerated twice each year on January 10-15 and July 10-15 starting from January 2000 through July 2003. Enumeration started from the hill top and ended at the place where soil materials were deposited. Samples of all woody plant species were collected and identified at the Forestry Research Institute, Herbarium at Ibadan. The slope of the gully sites was measured using Abney level made in England (Stanley). The cultural beliefs of the people of the areas where the gullies occur were considered before recommending plants for erosion control. The relative abundance of plant species was calculated for each plant species using the formula

$$\text{Relative abundance} = \frac{n}{N} \times 100$$

Where n represents the number of individuals plant species and N is the total number of individuals identified at the sites. The Raunkiaer plant life form was used to classify the plant species encountered at the sites. The list of economic trees as was listed by Lancaster (1960) was used to group the trees into economic and non-economic trees. The similarity of the sites was calculated using index of similarity according to Sorensen (Mueller – Dombois and Ellenberg, 1974).

RESULTS AND DISCUSSION

The causal factors of the ten gullies are summarized in Table 3. The total number of families, species and the relative abundance of plant species encountered at the studied sites are shown in Table 4. Figure 2 shows the life form spectrum of the plants encountered. The similarities of the sites are shown in Table 5. The gullies were caused by discharge from road culverts, 80%; run-off from buildings, 70%; foothpaths, 60%; deforestation, 30% and flood, 10%. The causal factors occurred singly or in combinations Table 3. When the causal factors were combined the gully was extensive and deep. It was observed that a combination of flood, run-off from buildings and discharge from road culverts caused most of the gully erosions. When it rained, water arising from buildings converged to form flood. At Omukwu (Onicha), it was observed that flood flowed for a distance of 7.4 kilometers. As it flowed and joined another flood which flowed for 5.7 kilometers from a different slope, the speed, volume and abrasive property increased. They were more severe when flood from one slope meets another flood from a different slope as was observed at Amucha, Okwudor and Omukwu (Onicha). Improperly located culverts such as those at the Enugu – Port Harcourt Express way and run-off from Umuoriehi Primary and Secondary school buildings caused the Umuoriehi – Isingwu gully. It was observed that the sandy nature of the study area and the heavy annual rainfall were instrumental to the numerous deep gullies found in the areas.

A total of 49 plant families comprising 100 species were encountered at the 10 study erosion sites. The families *Cyperaceae* and *Euphorbiaceae* with 8 and 6 species, respectively had the highest representation of species. The families *Moraceae, Apocynaceae* and the sub-families *Mimosoideae* each were represented by five species. The family *Annonaceae*, and sub family *Papilionoideae* each were represented by four species. The families *Convolvulaceae* and *Lecythidaceae* and the sub-family *Caesalpinioideae* were represented by three species. There were 8 and 29 other families represented by two and one species, respectively (Table 4). These families are similar to those reported for a secondary forest regrowth at Umudike, Nigeria (Dike, 2003). There were 61 trees out of a total of 100 plant species identified. Of the trees, 31.15 per cent had deep tap roots of up to four meter long; 65.57 per cent had shallow tap root of less than 4.0 meter and 3.28 per cent had fibrous roots (Table 4).

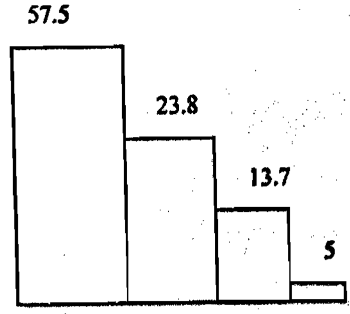

Figure 2. The life form spectrum of the species enumerated at 10 erosion gullies of Abia and Imo State, Nigeria.

Table 4: The families, species, per cent frequency and relative abundance of plant species that were enumerated at 10 gully erosion sites at Abia and Imo states of Nigeria.

Family/sub-family	Species	Locations										Percent frequency	Relative abundance
		Abia					Imo						
		Ume	Umo	Umi	Oka	Ndo	Okr.	Ama	Uma	Isi	Omu		
Adiataceae	Pteris togoensis	+						+			+	30	0.23
Amaranthaceae	Alternanthera sessilis	+	+	+	+	+	+	+	+	+	+	100	2.05
Ampelidaceae	Cissus arguta	+	+	+	+						+	50	0.30
Anacardiaceae	Mangifera indica	+					+				+	30	0.09
Annonaceae	Cleistopholis patens	+	+	+	+	+	+	+	+	+	+	100	2.14
	Neostenanthera myristicifolia				+						+	20	0.09
	Uvaria chamae	+	+	+	+	+	+	+	+	+	+	100	0.78
	Xylopia rubescens		+									10	0.02
Apocynaceae	Funtumia elastica	+	+	+	+	+	+	+	+	+	+	100	0.92
	Hedranthera barteri	+	+	+	+	+	+	+	+	+	+	100	0.51
	Landolphia dulcis	+									+	20	0.05
	Rauvolfia vomitoria	+	+	+	+	+	+	+	+	+	+	100	2.69
Asteraceae	Chromolaena odorata	+	+	+	+	+	+	+	+	+	+	100	2.97
Athyriaceae	Diplazium sammatii	+	+	+	+		+		+	+	+	80	1.08
Bambuseae	Bambusa vulgaris	+	+	+	+	+	+	+	+	+	+	100	2.14
Bombacaceae	Ceiba pentandra	+			+	+	+	+	+	+	+	80	1.36
Burseraceae	Canarium schweinfurthii	+				+						20	0.28
	Dacryodes edulis		+				+			+	+	40	0.37
	Santiria trimera	+						+		+	+	40	0.32
Caesal pinioideae	Afzelia africana	+	+	+	+	+	+	+	+	+	+	100	1.18
	Anthonotha macrophylla	+	+	+	+	+	+	+	+	+	+	100	2.30
	Berlinia grandiflora		+	+	+	+	+	+	+	+	+	100	0.25
	Brachystegia eurycoma	+	+	+	+	+	+	+	+	+	+	100	2.16
	Daniellia ogea	+				+			+		+	40	0.12
	Dialium guineense	+	+	+	+	+	+	+	+	+	+	100	1.54
Celastraceae	Hippocratea pallens	+					+				+	30	0.35
Commelinaceae	Commelina erecta	+	+	+	+	+	+	+	+	+	+	100	0.48
	Palisota hirsuta	+	+	+	+	+	+	+	+	+	+	100	0.92
Convolvulaceae	Ipomoea aquatica	+	+	+	+	+	+	+	+	+	+	100	0.30
	Merremia aegyptiaca										+	10	0.09
	Momordica charantia				+	+	+	+	+	+	+	70	0.21
Cyperaceae	Acroceras zizanioides	+	+	+	+	+	+	+	+	+	+	100	0.18
	Cyperus difformis				+							10	0.09
	Fimbristylis littoralis	+		+		+	+	+	+	+	+	100	0.16
	Hypolytrum heteromorphum	+	+	+	+	+	+	+	+	+	+	100	0.25
	Paspalum scrobiculatum	+	+	+	+	+	+	+	+	+	+	100	0.32
	Rhynchospora corymbosa	+	+	+	+	+	+	+	+	+	+	100	1.52
	Scleria naumanniana	+	+	+	+	+	+	+	+	+	+	100	0.78
	Scleria verrucosa	+				+					+	30	0.09
Dennstaedtiaceae	Pteridum aquilinum	+	+	+	+	+	+	+	+	+	+	100	1.64
	Tetracera alnifolia	+									+	20	0.37
Ebenaceae	Diospyros suaveolens	+									+	20	0.05
Erythroxylaceae	Erythroxylum coca					+						10	0.07
Euphorbiaceae	Alchornea cordifolia	+	+	+	+	+	+	+	+	+	+	100	5.62
	Antidesma vogelianum						+				+	20	0.16
	Bridelia stenocarpa	+	+	+	+			+	+			60	2.26
	Macaranga barteri	+	+	+	+	+	+	+	+	+	+	100	3.55
	Maprounea membranacea	+										10	0.69
	Microdesmis puberula	+	+	+	+	+	+	+	+	+	+	100	3.06
Ficoidaceae	Trianthema portulacastrum										+	10	0.14
Gleicheniaceae	Gleichenia linearis	+			+			+				30	0.16
Hydrophyllaceae	Hydrolea palustris	+	+	+	+	+	+	+	+	+	+	100	1.80

Hypericaceae	Harungana madagascariensis	+	+	+	+	+	+	+	+	+	+	100	2.28
Lecythidaceae	Anthocleista djalonensis		+		+							20	0.71
	Anthocleista vogelii				+	+	+				+	40	0.14
	Mostuea hirsuta	+										10	0.14
Melastomataceae	Heterotis rotundifolia	+	+	+	+	+	+	+	+	+	+	100	0.58
	Azadirachta indica	+	+	+			+	+	+		+	70	0.32
Meliaceae	Carapa procera	+	+	+	+	+	+	+	+	+	+	100	0.28
Mimosoideae	Albizia adianthifolia	+	+	+	+	+	+				+	70	1.01
	Albizia ferruginea						+				+	20	0.99
	Parkia bicolor					+						10	0.05
	Pentaclethra macrophylla	+	+	+	+	+	+	+	+	+	+	100	0.09
	Piptadeniastrum africanum	+	+	+	+	+	+	+	+	+	+	100	1.098
Moraceae	Antiaris toxicaria	+									+	20	0.69
	Ficus exasperata										+	10	0.16
	Milicia excelsa	+	+	+	+	+	+	+	+	+	+	100	2.42
	Musanga cecropioides	+	+	+	+	+	+	+	+	+	+	100	0.81
	Treculia africana	+									+	20	1.15
Myristicaceae	Pycnanthus angolensis	+	+	+	+	+	+	+	+	+	+	100	2.58
	Eucalyptus camaldulensis	+	+		+		+				+	50	0.37
Myrtaceae	Psidium guajava	+			+		+				+	40	0.81
Nymphaeaceae	Nymphaea lotus	+	+	+	+	+	+	+	+	+	+	100	1.87
Ochnaceae	Lophira alata			+							+	20	0.78
Onagraceae	Ludwigia decurrens	+	+	+	+	+	+	+	+	+	+	100	2.86
Palmae	Elaeis guineensis	+	+	+	+	+	+	+	+	+	+	100	1.06
	Raphia hookeri	+	+	+	+	+	+	+	+	+	+	100	2.81
Panadanaceae	Pandanus candelabrum	+			+					+		30	0.18
	Angylocalyx oligophyllus		+	+		+	+	+		+	+	70	0.67
Papilionoideae	Baphia nitida	+	+	+	+	+	+	+	+	+	+	100	2.35
	Millettia thonningi					+						10	0.92
	Pterocarpus mildbraedii	+				+		+	+		+	50	1.96
	Pterocarpus soyauxii	+	+	+	+	+	+	+	+	+	+	100	2.60
Passifloraceae	Adenia cissampelioides				+						+	20	0.18
	Barteri nigritiana	+	+	+	+	+	+	+	+	+	+	100	3.25
Poaceae	Andropogon tectorum	+				+					+	30	0.30
Sapindaceae	Blighia sapida	+			+	+		+		+	+	60	0.16
	Lecaniodiscus cupanioides					+		+				20	0.09
Selaginellaceae	Selaginella myosurus	+	+	+	+	+	+	+	+	+	+	100	2.35
Simaroubaceae	Quassia undulata		+		+	+	+	+	+	+		70	0.30
Sterculiaceae	Octolobus angustatus					+						10	0.09
	Cola hispida	+	+	+	+	+	+	+	+	+	+	100	0.78
Tiliaceae	Grewia brevis				+			+				20	0.16
Rosaceae	Dactyladenia barteri	+	+	+	+	+	+	+	+	+	+	100	1.15
Rubiaceae	Psydrax parviflora	+				+	+	+	+	+		60	0.67
	Rothmannia hispida			+			+	+				30	0.16
Rutaceae	Zanthoxylum gillettii		+			+		+		+		40	0.35
Verbanaceae	Vitex grandifolia		+	+	+	+	+	+	+			70	0.32
	Gmelina arborea		+	+	+	+	+	+	+	+		80	0.62
Ulmaceae	Trema orientalis	+	+	+	+	+	+	+	+	+	+	100	0.71
Total	100												100

Representations are as at Table 2.

It was only *Antiaris toxicaria*, *Brachystegia eurycoma*, *Diospyros mespiliformis*, *Entandrophragma utile*, *Gossweilerodendron balsamiferum*, *Khaya ivorensis*, *Milicia excelsa*, *Nauclea diderrichii*, *Piptadeniastrum africanum* and *Terminalia superba* that were listed as economic trees by Lancaster (1960). Measurements made of some of the exposed roots of some of the plants at the erosion sites revealed that these trees have deep tap root system and many lateral roots of upto 4.0 m. They also belong to either the emergent or upper canopy tree species. The seeds of the ten trees have rapid germination (Okali and Onyeachusim, 1990). Although the seedlings of *Milicia excelsa* were attacked by *Phytolyma lata* (White, 1964), germination experiment carried out at the University of Agriculture, Umudike, Nigeria revealed

Table 5. Similarity of the erosion sites studied at Abia and Imo States Nigeria.

	1	2	3	4	5	6	7	8	9	10
1	100	75.38	77.16	77.94	79.41	80.88	78.52	79.69	75.97	86.67
2		100	92.04	85.25	80.65	86.89	84.30	87.72	86.96	75.00
3			100	84.03	80.99	87.39	86.44	90.09	85.71	76.69
4				100	80.00	84.38	83.46	85.00	82.64	77.46
5					100	83.08	86.82	86.89	86.18	76.39
6						100	85.04	88.33	87.60	83.10
7							100	90.76	90.00	75.18
8								100	90.27	76.12
9									100	75.50
10										100

Table 6: Some observed physical characteristics of some plant at the 10 studied gully erosion sites in South-eastern Nigeria.

Species	Life character	Root length (m)	Maximum cover m^2	Reproduction	Observed Character
Acroceras zizanioides	perennial	0.30-0.62	0.51-0.82	Seeds	Very good soil binder
Diplazium sammatii	perennial	0.05-0.08	1.5-3.5	Seeds plant rhizome	Root form a mat like holding soil stem
Paspalum scrobiculatum	perennial	0.36-0.71	0.37-0.65	Seeds	Fall on each other to control water flow
Rhynchospora corymbosa	perennial	0.3-1.10	3.5-8.5	Seeds	Has deep and good root system
Selaginella myosurus	annual	0.01-0.25	0.05-0.07	Seeds	Covered the ground well but burnt during dry season.

that the attack could be controlled using some environmentally friendly insecticides such as Decise (Chimezie, oral comm.). Observations at the erosion sites showed that the ten trees have high rate of decay of their leaves and many other tree seedlings were seen growing under the shade cast by the crown of each tree. The high rate of decay of their leaves agreed with the report that the leaves of some Nigerian rain forest tree species decomposed completely between 16 and 52 weeks (Egunjobi, 1974; Ola-Adams, 1978).

Some tree species that were abundant were *Alchornea cordifolia, Anthocleista vogelii, Cleistopholis patens, Dactyladenia barteri, Pterocarpus soyauxii, Pycnanthus angolensis* and *Raphia hookeri*. Of these, it is only *Pycnanthus angolensis* that has good bole, tap root system and allowed the growth of other tree seedlings under the shade cast by its crown. It was observed at the studied sites that some farmers planted *Dactyladenia barteri* to provide yam sticks, firewood and presumably control soil erosion. Unfortunately the tree has poor rooting system. Of interest is the absence of *Mitragyna ledermannii, which* grows well in waterlogged areas. The absence of the tree species could be attributed presumably to lack of its seeds and seedling banks. Dike (2003) recorded that fruits and seeds of most of the canopy tree species have poor dispersal appendages. He observed also that many farmers destroyed seeds and seedling bank during weeding operations resulting in poor representation of many plant species in abandoned farm lands. Some other plants that occurred frequently were *Acroceras zizanioides, Bambusa vulgaris, Diplazium sammatii, Paspalum scrobiculatum, Rhynchospora corymbosa* and *Selaginella myosurus*. It was observed that each of these plants existed either in colonies or in a mixture of other plants. The stem of *Diplazium sammatii* branched into two within a distance of between 1.0 and 2.5 m. Numerous fibrous roots were produced which bound the soil firmly. However, the leaves were few and covered an area between 1.5 and 3.5 m^2. *Rhychospora corymbosa* produced deep fibrous roots of between 0.3 and 1.10 m. The leaves covered between 3.5 and 8.5 m^2. *Acroceras zizanioides* and *Paspalum scrobiculatum* grew better in or 2.0 m away from a stream. *Selaginella myosurus* has short fibrous roots of between 0.01 to 0.25 m. The stem and leaves readily burn during the dry season (Table 6).

It was observed that some farmers deliberately burn up grasses during the dry season. At Okwuta-Ibeku and Umuoriehi – Isingwu erosion sites, some farmers cultivated *Manihot esculenta, Zea mays* and *Dioscorea species* at the sides and floor of some gullies. The observation limits the use of grasses alone for erosion control in southeastern Nigerian rainforest. Okorie (1991) noted that *Vetiveria zizanioides* improved soil fertility and was effective in erosion control. It is doubtful if subsistent farmers would not plant their arable crops at gully areas planted up with *Vertiveria zizanioides* thereby creating more problems than it was meant to solve.

Some plant species that are by culture not deliberately cut by the people of southeastern Nigeria include *Albizia zygia, Cola acuminata, Cola nitida, Dennettia tripetala, Detarium microcarpum, Entandrophragma utile, Garcinia kola, Irvingia gabonensis, Khaya ivorensis, Treculia africana* and *Elaeis guineensis*. These trees should be useful in gully erosion areas. Among the plant species encountered, Phanerophytes, Therophytes and Chamaephytes were represented by 57.5; 23.8 and 13.7 percent; respectively (Figure 2). The erosion sites were similar to one another (Table 5) presumably because these sites have similar agricultural activities; soil type, lie within the tropical rainforest zone and have heavy rainfall.

It was observed that the gradient of the sides of the gully varied even between adjacent sides. The slope varied from 55 to 122 degrees. Often at the gully head, the slope ranged from 85 to 122 degrees. It was observed that the steepness of the slope was instrumental to the cracking and caving in of the surrounding soil. At the site where soil material was deposited, the slope varied from two to five degrees. The total length of each main gully ranged between 136 and 1542 m. The main gully could divide into two or more gullies (Table 3). It was observed that the length of a gully depended on which gully the causal factors were very active on. The maximum width of each gully ranged from 32 and 159.6 m. The maximum depth ranged from 34 to 194 m. It was observed that the maximum depth did not occur where the gully had the maximum width. The width was very narrow in many places especially at some stony or clayey areas.

CONCLUSION AND RECOMMENDATION

At the on set of the gully erosion, the sides and floor of the gully had soil. When the soil was eroded, exposing the side, there were no vascular plants at the exposed sides and floor. Vascular plants that could come in were mainly from exposed roots, seed rain and seeds stored in the soil. According to Dike (1992) most of the seeds stored in the soil were within the 0-0.1 m from the top soil. It was observed that each gully was 30 m deep (Table 3) and the seed stored in the soil would be very poor as the depth increases. It is not certain when and which desirable tree species could come in to colonize the sides and floor of the gully. A combination of desirable tree species and perennial grasses is recommended for planting at gully erosion sites. At the study sites, such desirable economic and emergent trees, with deep tap root system (Keay, *et al* 1964), live for over 50 years and the tree architecture allows for the growth of other plant seedlings, include *Antiaris toxicaria, Brachystegia eurycoma, Entandrophragma utile, Gossweilerodendron balsamiferum, Khaya ivorensis, Milicia excelsa, Nauclea diderrichii, Piptadeniastrum africanum, Pycnanthus angolensis, Quassia undulata* and *Terminala superba*. These trees should be planted in a mixture at espacement of 0.5 x 0.5 m to enable the canopy close within the shortest possible period. Selective thinning should be done within six months. Initially, the sides and floor of the gully should be planted up with some hydrophytic plants such as *Diplazium sammatii* and *Rhynchospora corymbosa* at mashy sections and terrestrial plants such as *Acroceras zizanioides, Cynodon dactylon, Chrysopogon aciculatus, Paspalum scrobiculatum, Perotis indica*, and *Pennisetrum purpureum* , at the drier area (Table 6). These grasses could minimize the quantity of soil carried away by erosion (Maass 1992) before the tree species grow to form a closed canopy. Climbers on the trees should be uprooted because the climbers on the tree seedlings often cause the bending of the leading shoot thereby contributing to the death of such tree seedlings (Jones, 1956; Dike, 2003). As the least erosion activity occurs in areas having a mixture of trees and shrubs (Romas and Merinho, 1980; Maass, 1992), the top of the gully, should be planted with desirable trees at least 10.0 m from the edge of the gully at an espacement of 1.0 x 1.0 m to control infiltration capacity. Planting such trees should be done along the length of the gully. The villagers who live around the erosion areas should be made to understand that the soil serves human being better if activities contributing to erosion such as deforestation and frequent burning of forests are reduced. Moreover, each community should endeavour to have good roads and at least two functional bore holes to minimize the effects of footpaths as causal factor of erosion.

The use of some monoculture plantation tree species such as *Azadirachta indica, Eucalyptus camaldulensis, Gmelina arborea, Hevea brasiliensis* and *Pinus caribaea* in erosion control should be minimized. This is because the areas studied lie within the tropical rainforest zone (White, 1983). The forest is made up of a complex mixture of woody plant species (Dike, 2003). The reduction of the vegetation to monoculture could be detrimental to the soil nutrient and consequently to the plants that protect the soil from erosion.

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