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Riparian, channel and environment (RCE) inventory, species composition and vegetation analysis of the streams in Tubay, Agusan Del Norte, Philippines

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Key words: *Riparian zone, ecotone, vegetation analysis.*

Abstract

Riparian zone possesses a wide variety of environmental processes. A study was conducted in Tubay, Agusan del Norte to assess the species composition, vegetation analysis and RCE Inventory of four selected water systems. A total of 1344 individual were recorded from 51 different species and most of the samples collected was from the family Poaceae. Vegetation analysis revealed that the study area was generally characterized by *Pandanus affinis* (75), *Eichhornia crassipes* (46.3), *Pistia stratiotes* (32.2), *Calamus microcarpus* (29.2), *Spenomeris chinensis* (28.2), *Chromolaena odorata* (27.5), *Phrynium interruptum* (26.1), *Selaginella plana* (25.1), *Sphagneticola trilobata* (25) and *Cocos nucifera* (24.1). Among the four study stations, Tagmamarkay had the most number of individuals followed by Dumlao, Bugnam and Upstream MBR. Moreover, Upstream MBR had the highest RCE score. The overall species diversity and species richness (1.82) were considered to be moderately high and the computed species evenness (0.85) were also high. The results suggest that the species abundance was most likely distributed evenly among other species in all study sites. The dominance of *C. microcarpus* and *P. affinis* resulted to a low species richness at Upstream MBR and the selected water systems ranged from fair to good condition.

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Introduction

Riparian zone is the transition between terrestrial and aquatic ecosystems, as an ecotone it supports great variety of plant communities (Gregory *et al.*, 1991). Riparian vegetation plays multiple function in maintaining balance in aquatic ecosystem and it influences the composition of various aquatic community. Roots by herbaceous and woody plants tend to stabilized stream banks thus minimize soil erosion and siltation (Bren 1993). It serves as a buffer that stop the passage of sediment pollutants like methylmercury that is controlled by biochemical processes in the riparian environment (Bishop *et al.*, 1995). In addition, riparian zone plays a significant role in controlling the fate of various contaminants such as nitrate in an agricultural landscape (Cey *et al.*, 1999 and Devito *et al.*, 1999). It could also give substantial amount of dissolve organic carbon to a stream environment which is essential in the transfer of organic material (Fiebig *et al.*,1990). Hence, riparian zone alteration could affect the whole river ecology (Tabacchi *et al*, 1998).

Philippines was considered to be one of the world's richest country when it comes to minerals like gold, nickel and copper (Aytin, 2014). Caraga Region in Northern Mindanao, Philippines was known for its potential in mineral deposits which then attracted several investors to utilize the region for several years now. Along with all the economic benefits that was brought by mining operations throughout the country was the fact that there was also higher risk in its ecological effects (Smolders *et al.,* 2003). Higher concentration of heavy metals in sediments and water threatens life that were found within. Sediment inputs from mining, inappropriate vegetation and modification are one of the major threats that could cause the degradation of riparian environment (Bren 1993).

Efforts such as constant monitoring using biological parameters within mining operation must be done regularly for management and biodiversity conservation. The data gathered in assessments must be the basis of future management initiatives of these growing mining activities. Riparian, Channel and Environmental inventory and vegetation analysis was used to assess physical and biological status of small streams (Petersen,1992). This study aimed to assess the species composition, vegetation analysis and riparian channel and environment inventory of the water systems in Tubay, Agusan Del Norte, Philippines.

Materials and methods

Study Area

This study was conducted last June-July 2015 at the water systems of Tubay, Agusan Del Norte, Philippines. There were four sampling stations for data collection. Station 1 (Bugnam) was located along (N 09°11'47.5", E 125°32'32.2", Site 2 (MBR) N 09°11'38.8", E 125°31'55.8", Site 3 (Dumlao) N 09°09'44.6", E 125°33'04.5" and Site 4 (Tagmamarkay) N 09°12'34.1", E 125°33'15.3". For each study site, three substations were established to gather samples for different study parameters. Study stations differed on their physical and biological features. Bugnam (study site 1) was the uppermost portion. This station was composed mostly of ferns, shrubs, trees and herbs. The density of riparian vegetation was less especially in the middle portion. Next station was Upstream Mountain Beach Resort (study site 2) located 260 meters from the rightmost portion of the resort. The width of the stream was narrow with large boulders of rocks. Banks of the uppermost stations were stable, firmly held by plant's roots. Further, Dumlao (study site 3) were established nearest the main road and the farthest station from mining site of Tubay. The last study site was at Tagmamarkay with muddy and turbid water. Some portions of the stream were clogged with water hyacinth.

Sampling method

Plot Nested vegetation sampling method was used for plant diversity assessment, 10x10 main plots were laid along each transect for each area (Dice *et al.*, 2014, Kitching *et al.*, 1993). Shrub and trees that were

found within the main plot were recorded, 5m X 5m for herbaceous plants and 1m X 1m for grasses were documented for identification and classification down to species level.

Species Composition

Vegetation data in each area are collected for identification using a reliable identification guides and manuals (Moody *et al*., 1984, Madulid 1995, Rojo 1999, Langenberger *et al*., 2006, Madulid 2002). Listed plants were then used for species composition.

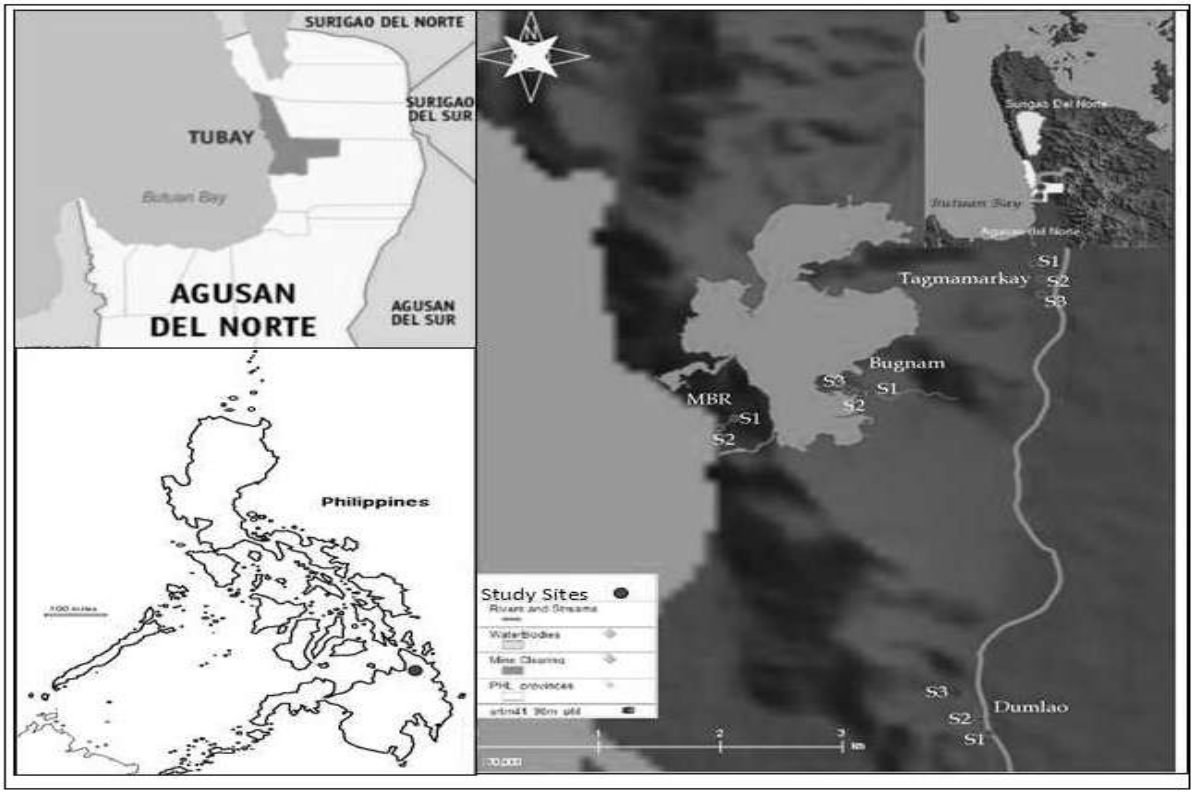

Fig. 1. Map of studied area showing the water systems of Tubay, Agusan del Norte, Philippines.

Biodiversity Measurement

Computation of diversity indices such as species richness, abundance, dominance, shannon's diversity, simpson's diversity and evenness were computed using the software Paleontological Statistical (PAST) version 2.17b.

Vegetation Analysis

Riparian community were often described by the species that are said to be the most important in the community. Schmidt (2005), reported that it could be quantified by calculating its importance value. For every species, the following values were calculated: (1) Abundance= total number of individual; (2) Relative Abundance (RA)=abundance/total number of individuals of all species x 100; (3) Frequency= number of transects the species appeared; (4) Relative Frequency (RF) = frequency/ total frequency of all species x 100; (5) Importance Value (IV) = relative abundance + relative frequency.

Riparian, Channel and Environmental Inventory

The use of RCE has been made to assess the biological and physical in the lowland, agricultural landscape (Petersen, 1992). Evaluation to stream quality were categorize with particular scores showed in Table 1. Mean numbers of ranks were computed and the resulting values were used to compare the status of the four sites.

Results and discussion

Species Composition

Riparian vegetation in Tubay, Agusan Del Norte, Philippines were generally composed of herbs, trees, shrubs and vines (Figure 2). A total of 1344 individual were recorded and identified. Based on the collected data most of the species found in the study station were herb which was 50% of the total population, tress such as *Gmelina arborea, Geniostoma cumingianum, Cocos nucifera, Mangifera indica, Paraserianthes falcataria, Premna odorata, Shorea negronensis, Xanthustemon verdugonianus, Bambusa vulgaris* the different *Ficus* species from Moraceae family were all observed at the study area. Further, the presence of *Ficus* species is a good indication since *Ficus* were generally known as keystone species (Lambert and Marshall, 1991). *Ficus* species perform a critical role in the riparian environment for it could support large amount of organisms such as frugivores.

Table 1. Relative RCE score with the corresponding classification of steam quality.

Class	Score	Evaluation
I	273-340	Excellent
II	204-272	Very Good
III	134-203	Good
IV	66-133	Fair
V	15-65	Poor

Consequently, 21% of the whole study area is composed of shrubs and vines that is 2% respectively. One of the world's worst invasive species like *Mimosa pudica* and *Imperata cylindrica* (Mack, 1996) were also observe.

Biodiversity Measurements

Fifty-one (51) species of plants found from thirty-one (31) families were identified in this study. Most number of plants belonged to family Poaceae such as *Bambusa vulgaris, Chrysopogon zizanioides, Chrysopogon aciculatus, Imperata cylindrica, Panicum sp., Paspalum conjugatum, Paspalum vaginatum*. Among the the four study stations, Tagmamarkay had the most number of individuals followed by Dumlao, Bugnam and MBR (Table 2). Schmidt (2005) demonstrated that understorey flora and vegetation were suitable to assess the site condition and anthropogenic impact and thus it was now easy to characterize and evaluate biodiversity.

Table 2. Diversity indices of riparian vegetation in the four study stations in Tubay, Agusan Del, Norte, Philippines.

Indices	Bugnam	MBR	Dumlao	Tagmamarkay
Species	23	9	23	22
Individual	289	103	378	574
Dominance	0.207	0.331	0.197	0.25
Shannon	1.723	1.264	1.821	1.60
Simpson	0.793	0.669	0.803	0.75
Evenness	0.741	0.834	0.85	0.81

In addition to that, a number of factors such as light and nutrient availability affects the uniqueness of species diversity. It was observed that Tagmamarkay was dominated by herbs because of light factor. Lower number of trees could result to great canopy opening the reason why there was a higher degree of herbs and shrubs in Tagmamarkay and Dumlao. Tight vegetation at some portions of upstream MBR and the presence of trees such as *Shorea negronensis* and *Ficus pseudopalma* inhibits the development and

establishment of shade-intolerant herb-layer which was opposite compared to that of Tagmamarkay and Dumlao. Although Bugnam and Upstream MBR were found at the upper most portion of the study area it was just dominated by *Pandanus affinis* and *Calamus microcarpus* due to its high tolerance to utilize all the lights and nutrients availability that affects the species richness at Bugnam and Upstrem MBR. Further, Tagmamarkay and Dumlao both served as receiving basin from all the agricultural runoffs and thus considered to contain high level of nutrients. Colonizers such as *Mimosa pudica, Eichhornia crassipes, Pistia stratiotes,* and *Imperata cylindrica* that is known to be very flexible in changing environment (Mack, 1996).

Table 3. Representative plant species with highest computed Importance Value (IV) from Tubay, Agusan Del Norte, Philippines.

Species	Relative Abundance	Relative Frequency	Importance value
Pandanus affinis	40.045	35	75
Eichhornia crassipes	28.96	17.39	46.3
Pistia stratiotes	19.18	13.04	32.2
Calamus microcarpus	14.21	15	29.2
Spenomeris chinensis	18.28	10	28.3
Chromolaena odorata	14.5	13.04	27.5
Phrynium interruptum	16.13	10	26.1
Selaginella plana	15.78	9.35	25.1
Sphagneticola trilobata	11.98	13.04	25
Cocos nucifera	6.72	17.4	24.1

Table 4. Summary of RCE score, type, class and color codes.

Area	Score	Class	Color codes	Type
Bugnam	112	IV	Brown	Fair
Upstream MBR	202	III	Yellow	Good
Dumlao	138	III	Yellow	Good
Tagmamarkay	153	III	Yellow	Good

These species took advantages to invade some portion in Tagmamarkay and Dumlao river. Massive agricultural activity and other disturbances were also factors that affected the species richness in the whole study area. Shannon-Weiner Index (H') was used to analyze the diversity at each site. For this study, the overall species diversity and species richness was considered to be moderately high and the computed species evenness (0.85) was also high (Odum and Heald, 1972). The results suggest that the species abundance was most likely distributed evenly among other species in all study sites.

Vegetation Analysis

Vegetative distribution in riparian community depends upon a lot of factors including light, temperature, hydrology and the ability of soil and sediments to hold water (Brinson, 1990; Tabacchi *et al.*, 1998). It was shown in Table 3 that study area was generally characterized by *Pandanus affinis* (75), *Eichhornia crassipes* (46.3), *Pistia stratiotes* (32.2), *Calamus microcarpus* (29.2), *Spenomeris chinensis* (28.2), *Chromolaena odorata* (27.5), *Phrynium interruptum* (26.1), *Selaginella plana* (25.1), *Sphagneticola trilobata* (25) and *Cocos nucifera* (24.1). Several research about riparian ecosystems gives emphasis on the frequency of natural disturbances (e.g. flash flood, wind storm) that helps

plant succession rate within riparian environment (Tabacchi *et al*., 1998; Wissmar and Swanson, 1990). Plants with high importance value were usually herbs especially in Dumlao and Tagmamarkay. *Eichhornia crassipes* is a floating weed that was known as one of the worst weeds in temperate and tropical region because it has the ability to multiply and spread very quickly (Xie and Yu, 2003).

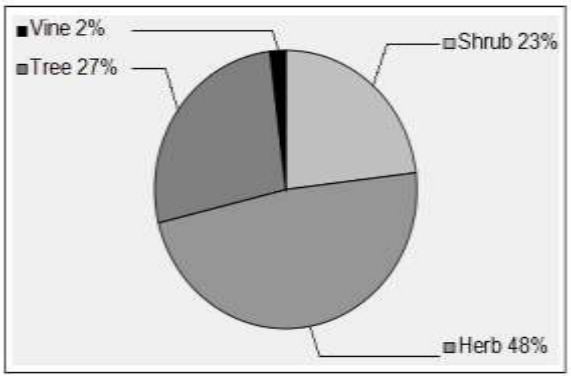

Fig. 2. Percent (%) composition of plants according to its habit found at the streams of Tubay, Agusan Del Norte, Philippines.

Nevertheless, water hyacinth as well as *Pistia stratiotes* were utilized as an efficient remedy to remove agro-industrial waste polluted water (Xia and Ma, 2006; Zimmels *et al*., 2006; Naiman *et al*, 1993). Further, two distinct plant groups were shown in figure 3. Bugnam and Upstream MBR were located at the upper most portion while Dumlao and Tagmamarkay were found at the lower elevation, the topography and soil type were somehow one of the major factors that contributed to these results. These analyses were also true with non-metric multidimensional scaling (nMDS) in figure 4.

Non-metric multidimensional scaling was used to ordinate unique plant community of the four study sites of Tubay, Agusan Del Norte, Philippines. Graphical presentation was showed in figure 5 that Upstream MBR (replicate 2) got the lowest plant diversity and Dumlao (replicate 1) obtains the highest. Low species diversity in Upstream MBR could be due to light competition (Hautier *et al*., 2009). Migration capacity of plants with high importance value that were mostly found at Dumlao and Tagmamarkay was an important factor explaining their high biodiversity (Naiman *et al*, 1993).

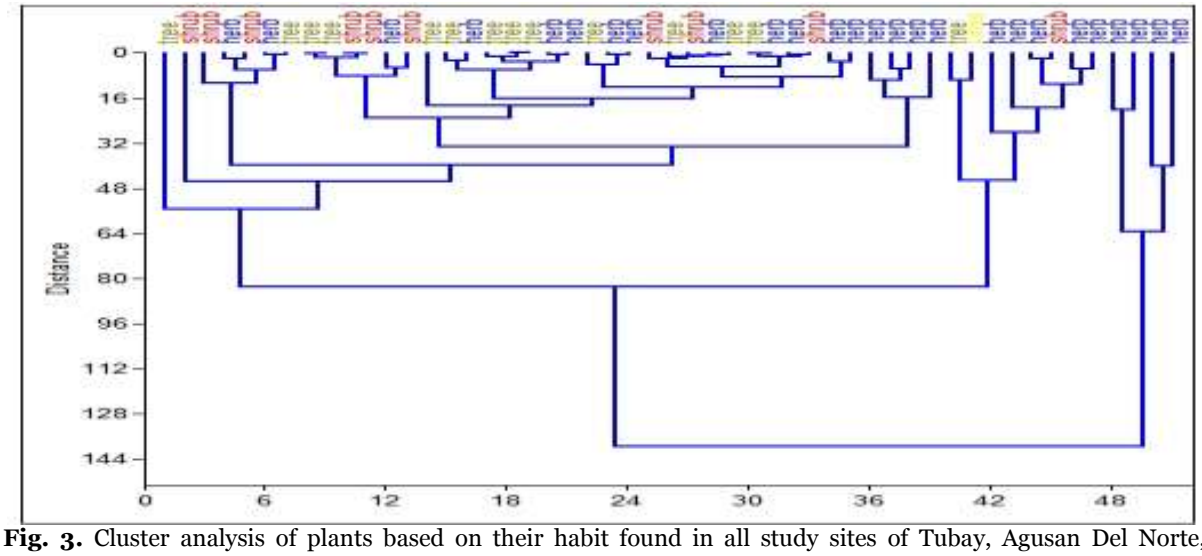

Fig. 3. Cluster analysis of plants based on their habit found in all study sites of Tubay, Agusan Del Norte, Philippines.

Riparian, Channel and Environment Inventory

For Riparian, Channel and Environment Inventory, initial calibration was done at the water systems of Tubay, Agusan Del Norte, Philippines.The class scores and colors can be utilized to overlap with the biological parameters (Petersen, 1992). RCE

depended on physical structure of riparian zone, channel morphology and biological data. After adding up the total scores in each site it was shown in table 5 that Bugnam obtained 112 that belongs to class IV with brown color code indicated that the water type is fair. Bugnam got the lowest score among the four study sites with the presence of generalist species of fish.

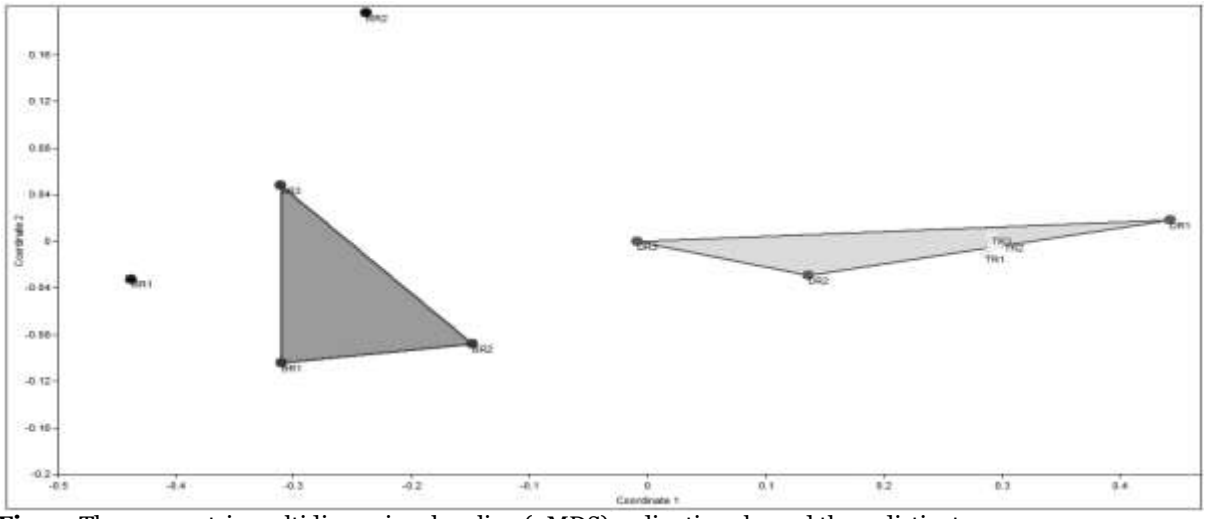

Fig. 4. The non-metric multidimensional scaling (nMDS) ordination showed three distinct group.

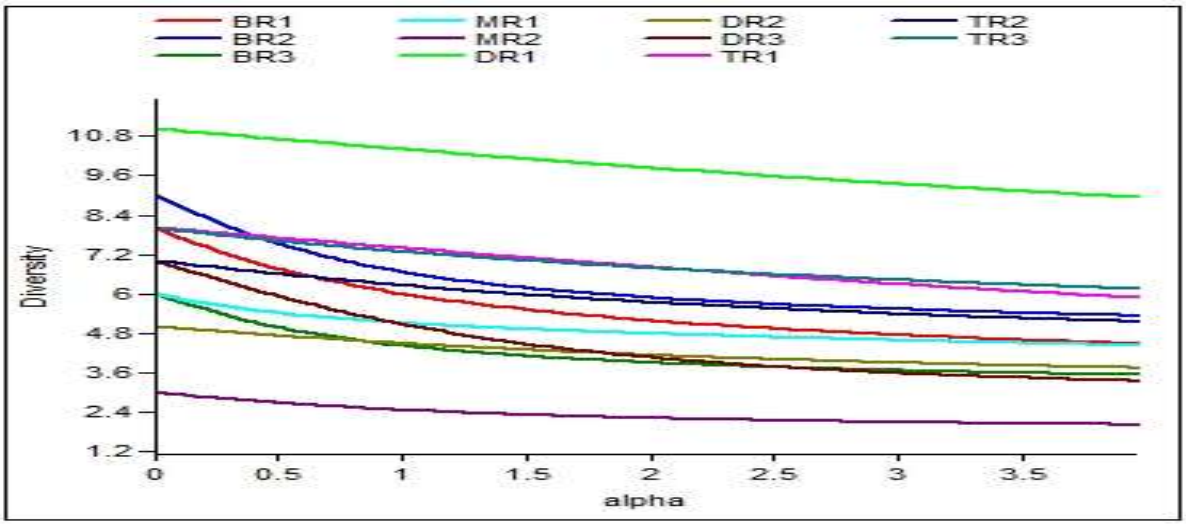

Fig. 5. Diversity profile of 11 replicates from study sites showing highest (Dumlao) and lowest (Upstream MBR) plant diversity.

The effect of anthropogenic activity could be reflected on fish community due to food-chain related circumstances (Ryan, 1991) or even direct impacts to a particular species of fish. In addition, it was also observed that frequent breaks in vegetation and stream-bank erosion was common. Fine sediments prevent the attachment of algal cells and eliminates aquatic macrophytes (Brookes, 1986). Physical characteristics such as substrate appearance suggest that the stream needs minor modification. Rocks and logs were there but it was filled with sediment. Further, Upstream MBR obtained a score of 202 which meant that the water was still in a good condition.

The presence of rocks, shading from thick well developed vegetation with patches of moss and undisturbed channel with well washed sediments in

Upstream MBR was indeed an indication of a good condition stream. Consequently, in Table 4 Dumlao and Tagmamarkay both gave similar results after RCE inventory. These streams were both found in low agricultural landscape that serve as a catchment basin that receives all runoffs from higher elevation streams. Based on inventory, both sites were dominated by mixed row crops and pastures, banks were firmed but loosely held by herbs and shrubs. It was also known that both sites have uniform bottom of sand and silt.

Conclusion

Data collected revealed that the study sites were generally composed mostly of herbs. Light demanding herbs and grasses were highly observed at Tagmamarkay and Dumlao. Competition (light, nutrient availability) and dominance of *Calamus microcarpus* and *Pandanus affinis* results to low species richness at Upstream MBR. Riparian zone analysis (RCE) and riparian vegetation were studied to assess habitat quality and characteristics. RCE scores for four study sites- Bugnam, Upstream MBR, Dumlao and Tagmamarkay showed that stream and river condition were ranged from fair to good ratings (112-202). Upstream MBR got the highest score due to its unique attributes (intact vegetation, presence of large boulders of rocks and clearer water). Protection and improvement along riparian zones was highly recommended.

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