EVALUATION OF THE ECOLOGICAL STATUS IN RIVERBANK SITES (PACORA, JUAN DÍAZ AND MATASNILLO) USING THE QBR RIPARIAN FOREST INDEX IN THE PROVINCE OF PANAMA, PANAMA

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ABSTRACT
Riparian forests or gallery forests are groups that are distributed throughout a body of water, it fulfils important ecological functions and at the same time supplies communities with the vital liquid. The objective of this work is to evaluate the ecological status of the forests in the sites of the river margins (Pacora, Juan Díaz and Matasnillo) applying the QBR index to the transept of 50 linear meters in each one of the rivers to be studied. This being a pioneering study in the country, the results that will be obtained will be a record for future studies in Latin America. It was carried out using the field form, which consists of four blocks that allow the quality of the riparian forest, rated according to degree of cover of the riverside area, structure of the roof, quality of the roof and degree of naturalness of the river channel. The lowest indices were obtained by the Matasnillo River with percentages of 5%, 10% and 15%, and the highest percentages in the Juan Diaz River Basin and the Pacora River with 100% in the headwaters; identifying that the watersheds that have less anthropic intervention have a better forest quality; concluding that the results of the ecological status of the evaluated basins show that in places with greater human settlements, the degradation of the riparian forest increases.
Keywords: ecosystem, evaluation, forest, index, Panama, QBR, quality, riverbank, rivers, water systems.

1 INTRODUCTION

The concept of ecological status is based especially on the determination of water quality by means of biological, hydromorphological and physical-chemical indicators, mainly the fauna and flora of rivers, lakes and reservoirs [1]. River banks are open systems with their own physical and biological properties. Due to the proximity and interaction with bodies of water, riparian vegetation constitutes a transition zone between terrestrial and aquatic ecosystems [2]. Riparian forests or also called gallery forests, are arboreal groups that occur across a large percentage of permanent water currents [3] being that in its lower basin areas would be the portion the forest that does not maintain a direct influence of marine salinity or with a vegetation composition dominated by species that are not mangroves. It fulfils ecological functions such as climate regulation, maintenance of water sources and flows, soil conservation, helps maintain ecological balance and biodiversity, limits erosion in basins and contributes to regulate climate variations due to climate change. They also supply rural communities with various products, such as wood, food, fuel, fibres or organic fertilizers [4]. Despite the importance of these forests in the different basins and micro basins studied in the Matasnillo,

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Juan Diaz and Pacora rivers; there are few studies that show the effects of its fragmentation and degradation. Different anthropic activities can generate loss of vegetation cover, contamination of water bodies and alteration in ecosystem composition that impact fauna groups diversity associated to these ecosystems [3].

The development of methodologies that allow us a rapid and efficient analysis of the state of water systems is a subject of great scientific growth [5], taking into account that the degradation of forests in recent decades is increasing due to bad practices in the same. The QBR is a rapid application index that integrates biological and morphological aspects of the river bed and its flooded area and allows us to evaluate the ecological status of the riparian forest in an easy and simple way [6,8], therefore, it could be one of the future tools to use.

In general, few methodological proposals are used to estimate the quality of riparian areas using indices that are easy to use and apply [3].

The information obtained through the QBR index is highly relevant considering that a good state of the natural environment has a decisive impact on the ecological quality of the riverbed in terms of water quality [5]. The objective of this work is to evaluate the ecological status of the **forests** in sites on the banks of the rivers (Pacora, Juan Díaz and Matasnillo) by applying the QBR index to six transepts of 50 linear meters in each of the rivers to be studied; This being a pioneering study in the country, the results that will be obtained will be a record for future studies to be carried out in Panama and Latin America.

2 MATERIALS AND METHODS

2.1 Study area

This study was carried out in the main rivers of three basins (Matasnillo river, basin 142, Juan Diaz River, basin 144 and Pacora river, basin 146), which are located within the political

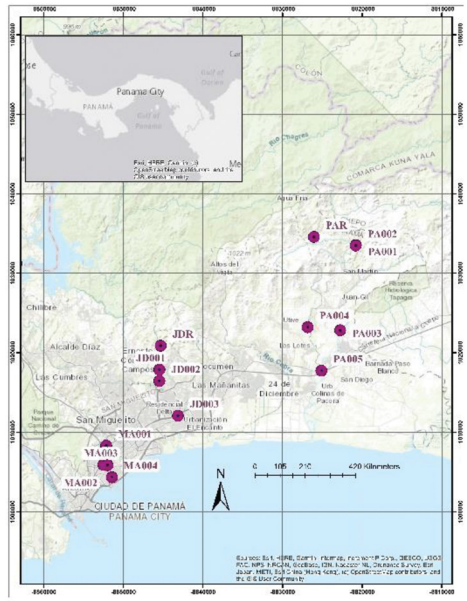

Figure 1: Selected sampling points within basins 142,144 and 146.

Table 1: Codes and coordinates of the points studied.

Code	Coordinates	
	x	*y*
MA001	662638	997397
MA002	662314	995064
MA003	662823	995028
MA004	663364	993524
JDR	669349	1009785
JD001	669212	1006831
JD002	669211	1005437
JD003	671529	1001140
PAR	688289	1023313
PA001	693513.5	1022331.2
PA002	693479.6	1022271.6
PA003	691615	1011796
PA004	687568	1012143
PA005	689299	1006779

division of the Province of Panama. All of them share a humid and very humid tropical climate with annual rainfall varying from 2,600 to 5,500 mm, with a dry season (December to March) and a rainy season (March to December) and an average annual temperature of 28°C to 34°C. [7].

The stations were considered permanent for this sampling, marked by GPS georeferenced at the starting point (see Table 1).

2.1.1 Matasnillo river

Basin 142 corresponds to the rivers between Caimito and Juan Díaz. It is located on the Panamanian Pacific slope and occupies an area of 136.8 km^2. The main river in the basin is the Matasnillo, with a total length of 6 km, it runs from the mountains to the Bay of Panama, in the Pacific Ocean.

2.1.1.1. MA001 Station

It is an area with high anthropogenic intervention, where the riverbed is totally channelled; It has modified vegetation with species not typical of the riparian zones, where it is worth highlighting the Tectona grandis plantations.

The genus Ficus and the *Carludovica palmata* species predominate in the area. The families in the study area were: Moraceae, Meliaceae, Anacardiaceae, Verbenaceae, Rosaceae, Fagaceae, Meliaceae.

2.1.1.2. MA002 Station

It is a disturbed area, heavily intervened by anthropic activity, with little vegetation, it presents introduced species not typical of the riparian zones. The families present at this point were: Anacardiaceae, Fabaceae, Sapinfaceae, Pinaceae, Malvaceae, Moraceae.

2.1.1.3. MA003 Station
It is an ecosystem totally intervened by anthropic activity, with few species prevailing in the area, herbs. The families present in the area were: Fagaceae, Moraceae, Malvaceae, Rhizophoraceae.

2.1.1.4. MA004 Station
It is an ecosystem totally intervened by anthropic activity, with cultivated species typical of the riparian zones, the genus *Melicoccus* sp.

The families present in the area were: Anacardiaceae, Urticaceae, Sapinfaceae, Fabacea, Malvaceae.

2.1.2 Juan Diaz River
Basin 144 corresponds to the Río Juan Díaz and between Río Juan Díaz and Pacora; It is located on the Panamanian Pacific slope and occupies an area of 350.7 km^2, the main river in the basin is the Juan Diaz.

2.1.2.1. JDR Station
It is a totally conserved area, without anthropic intervention, where the *Anacardium exelsum* predominant species is found, it is a place with limited access to 4×4 vehicles and a walk of approximately 30 min.

2.1.2.2. JD001
It is a mature forest with little anthropic intervention, it has a high diversity of bryophytes and epiphytes, which reveals that there is good humidity. The families in the study area were: Malvaceae, Sapinfaceae, Fabaceae, Anacardiaceae.

2.1.2.3. JD002
It is a riparian forest with species of riparian forest, little intervened, shrubs and spaced herbaceous vegetation, highlighting the appearance of *Saccharum spontaneum L.; Carludovica palmata* and the genus Heliconia.

The families in the study area were: Fabaceae, Anacardiaceae, Sapinfaceae, Malvácea, Polygonaceae, Burseraceae, Rubiaceae, Melastomataceae.

2.1.2.4. JD003
It has an abundant understory, presence of *Saccharum spontaneum* L, genera such as *Urtica sp., Calathea sp., Heliconia sp.*; shrubs of the Piperaceae family, (poaceae mixed between *Saccharum spontaneum* L. and natural grasses.

The families in the study area were: Malvaceae, Ficidae, Urticaceae, Anacardiaceae, Fabaceae, Piperaceae, Lauraceae, Muntingiaceae.

2.1.3 Pacora river
Basin 146 corresponds to the Pacora River; it is located on the Panamanian Pacific slope and occupies an area of 367.5 km^2, the main river of the basin is the Pacora.

2.1.3.1. PAR Station
It is a totally conserved area, without anthropic intervention, a place with limited access to 4×4 vehicles; the vegetation is pre-dominated by *Anacardium exelsum*. On the way you can see human settlements and the extension of the agricultural frontier.

2.1.3.2. PA001 Station

A part of the river very intervened by anthropogenic activity was taken, with the predominance of the introduced species *Saccharum spontaneum L.*, distributed in patches, *Carludovica palmata* and genera such as Heliconia and Cyperus.

The families in the study area were: Anacardiaceae, Fabaceae, Anonanceae, Malvaceae, Araliaceae, Urticaceae, Melastomataceae, Leguminosae, Burseraceae.

2.1.3.3. PA002 Station

It is an area with typical vegetation of the riparian zone, very intervened by anthropic activity, again the presence of *Saccharum spontaneum* L. was observed, and a predominance in the genus Cyperus. The families in the study area were Anacardiaceae, Malvaceae, Lauraceae, Burseraceae, Fabaceae, Urticaceae, Zygophyllaceae Rutaceae.

2.1.3.4. PA003 Station

It is a riparian forest with typical species of the area, with high anthropic intervention, presence of Poaceae colonies, with the Inga genus predominating. The families in the study area were: Anacardiaceae, Malvaceae, Urticaceae, Fabaceae, Moraceae, Sapotaceae.

2.1.3.5. PA004 Station

It was found an area heavily intervened by anthropic activity, grasses predominate, few trees in the riparian zone. The families in the study area were: Anacardiaceae, Fabaceae, Malvaceae, Urticaceae, Verbenaceae.

2.1.3.6. PA005 Station

It was found an area heavily intervened by anthropic activity, grasses predominate, few trees in the riparian zone. The families in the study area were: Anacardiaceae, Malvaceae, Urticaceae, Verbenaceae, Fabaceae, Moraceae.

2.2 Data Collection

Two-week sampling was conducted in three seasons (parts/faces or maybe steps) of the year (rainy season, dry season, and transition season). The sampling points were selected within the upper, middle and lower basin, taking into account the characteristics indicated in the Muneé methodology [8]. Upon reaching the study area, the linear transepts of 50 m on each side of the river were marked with fluorescent flagin and the QBR index was applied to the riparian forest.

2.3 Calculation of the QBR index

According to Muneé [8] the index consists of four independent blocks (Degree of cover of the riverside area, structure of the roof, quality of the roof and degree of naturalness of the river channel.

Each block has the same importance and is scored individually, where the minimum is 0 and the maximum 25. The final result will be obtained from the sum of the 4 blocks. The score obtained at the end allows us to establish the quality of the riparian forest which goes from 0 at least and 100 at most, to compare it with the values of the quality table, where five levels of quality are distinguished, each represented with a colour [Table 2].

Table 2: Quality status for the QBR-PAN 2 index *(Source: Muneé et al. 2003).*

Quality status for the QBR-PAN index		
Riverside habitat quality classes	Colour QBR	Representative colour
Riparian habitat in natural conditions	≥95	Blue
Some disturbance, good quality	75–90	Green
Major alteration, good quality	55–70	Yellow
Strong alteration, poor quality	30–50	Orange
Extreme degradation, poor quality	≤25	Red

3 RESULTS AND DISCUSSION

The ecological evaluation of the Matasnillo, Juan Diaz and Pacora rivers includes the calculation of the QBR sub-indices that represent the different hydromorphological characteristics of the river bed. The results of the study carried out in three periods with different climatic situations (dry season, rainy season and transition season are compiled in (Figure 2) and (Table 3).

The values obtained at the Matasnillo river sampling stations (stations MA001, MA002, MA003 and MA004) show that the riparian forest of the Matasnillo river basin has an extreme degradation from its source to its mouth; with bids ranging from 5% to 15%, as seen in (Table 3).

The Matasnillo river presented a high anthropic intervention because the basin passes through the centre of the city, which caused a degradation of the vegetation cover and the connectivity of the riparian forest due to the need for companies to expand their construction areas. According to [9] in urban and rural areas, the canals are strangled or covered by constructions, which also magnifies the recurrent floods. These and other activities have intensified exponentially throughout history, currently reaching an alarming deterioration that continues to endanger aquatic and riparian ecosystems, as well as the quality of life and safety of the towns bordering the banks.

As it does not have its own vegetation, the basin suffers a high level of contamination in its tributaries, thus reducing the quality of the water and the diversity of species [10].

The riparian forest of the Juan Diaz River (JDR) and the Pacora river (PAR); both reference stations obtained a score of 100%. Obtaining a score >95 is indicative of a riparian habitat in natural conditions, of excellent quality; thus, giving a blue coloration as shown in (Table 3).

According [12] Riparian forests play a particularly important role, bands of riparian vegetation shade the water and reduce its temperature during hot days, stabilize the banks, reduce the risks of erosion and offer a habitat to many plant and animal species.

On the other hand, the Juan Diaz River sampling stations (JD001, JD002) had high scores (Table 3) indicating a good quality status for these two stations, however its lowest point (JD003) showed an indicative of strong alteration.

The stations (PA001, PA002, PA003, PA004) of the riverside forest of the Pacora river are within the good quality range (see Table 2) with scores between 75% and 90% based on the table of quality ranges (Table 2); and the last station (PA005) with 25% (Table 3), indicative of strong alteration, poor quality.

Of the three rivers evaluated, the Pacora is the one that has the healthiest riparian forest quality. This is because it is a river that is far from urban constructions and human settlements

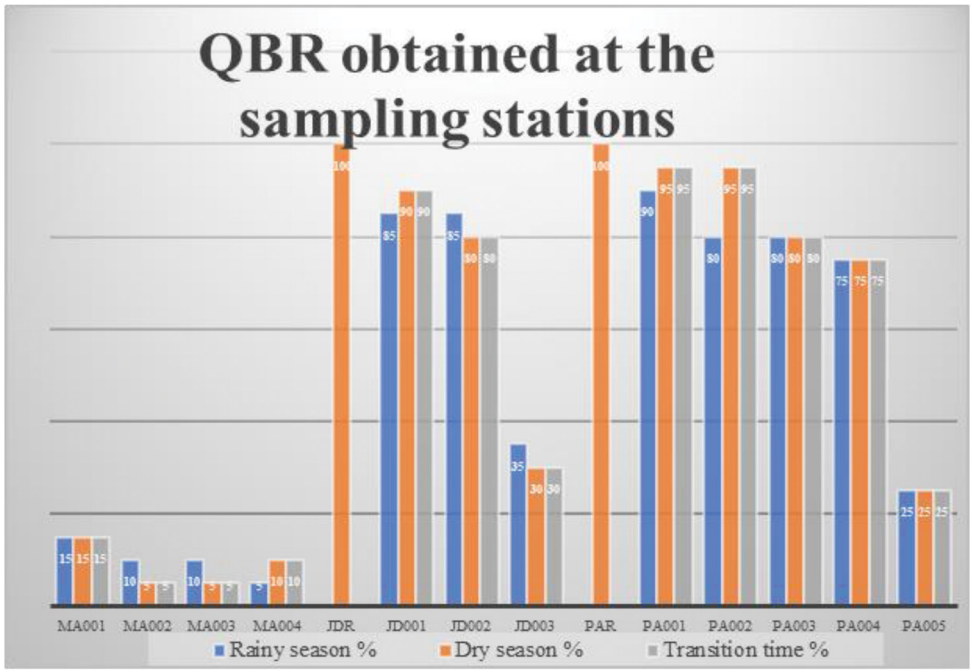

Figure 2: QBR values obtained at the 14 sampling points (see Table 1, codes and coordinates of the points studied).

Table 3: QBR index results in the 14 sampled points.

code	Punctuation		
	Rainy season %	Dry season %	Transition time %
MA001	15	15	15
MA002	10	5	5
MA003	10	5	5
MA004	5	10	10
JDR		100	
JD001	85	90	90
JD002	85	80	80
JD003	35	30	30
PAR		100	
PA001	90	95	95
PA002	80	95	95
PA003	80	80	80
PA004	75	75	75
PA005	25	25	25

are minimal. [12] Channels and their banks have been affected by human practices that induce changes in land use, such as the extension of urban and agricultural areas, exploitation of timber banks and stone materials, industry, which is why with as the years go by, the riverside forest is degrading.

4 CONCLUSION

The ecological status of the forests of the Matasnillo, Juan Diaz and Pacora rivers were evaluated by applying the QBR index, thus obtaining a valuation in terms of quality ranges, it was revealed that the area with the lowest scores was the Matasnillo river basin, presenting extreme degradation, indicative of poor quality, with rates of 15% in the upper basin, up to 5% in the lower basin.

The application of the QBR was made based on the "adaptation of the index to the project with emphasis on the riparian areas, and was validated with the field application".

The results obtained through the QBR are a key point in order to create action plans that allow us to recover the most affected areas, and thus having fixed sampling points can be monitored from time to time to see their progress.

See the current ecological status of the watersheds and therefore maintain an original database to track their ecological status. The results of the ecological status of the evaluated basins show that in places with greater human settlements, the degradation of the riparian forest increases.

REFERENCES

[1] Ecological and Environmental characterization of white roll as a natural space to define the reference conditions in extension of the directive, online https://www.researchgate.net/publication/45372438_Caracterizacion_ecologica_y_ambiental_del_Arroyo_Blanco_como_espacio_natural_para_definir_las_condiciones_de_referencia_en_aplicacion_de_la_Directiva_Marco_del_Agua. Accessed on: 15 Nov. 2021.

[2] Structure and composition of the riparian vegetation of the Tembembe riverravine, Morelos, Mexico. Online https://www.researchgate.net/publication/26549415_Estructura_y_composicion_de_la_vegetacion_riberena_de_la_barranca_del_rio_Tembembe_Morelos_Mexico. Accessed on: 15 Nov. 2021.

[3] Assessment of riparian forest quality, using a simple and fast method in two tropical dry forest rivers (Tolima, Colombia). Online. file:///C:/Users/Monti/Downloads/Dialnet-EvaluacionDeLaCalidadDelBosqueDeRiberaUtilizandoUn-5644630.pdf. Accessed on: 15 Nov. 2021.

[4] The problem of Boques. Online https://www.ecoportal.net/temas-especiales/suelos/el_problema_de_los_bosques/ Accessed on: 15 Nov 2021.

[5] Evaluation of riverbank and river habitat through the QBR and IHF indices. Online https://scielo.conicyt.cl/scielo.php?script=sci_arttext&pid=S0717-65382009000100009 Accessed on: 15 Nov. 2021.

[6] Quality of the riverside forest of the El Tunal river, Durango, Mexico; by applying the QBR index. Online https://www.researchgate.net/publication/262462060_Calidad_del_bosque_de_ribera_del_rio_El_Tunal_Durango_Mexico_mediante_la_aplicacion_del_indice_QBR Accessed on: 29 Nov. 2021.

[7] FAO 2015, informe regional. Online http://www.fao.org/nr/water/aquastat/countries_regions/pan/printesp1.stm Accessed on: 15 Nov. 2021.

[8] MUNNÉ et al. A Simple Field Method for Assessing the Ecological Quality of Riparian Habitat in Rivers and Streams: Qbr Index. Aquatic Conservation: Marine And Freshwater Ecosystem. 148, 152. 2003.

[9] DELIMITATION OF RIVERBANKS AND STREAMS. Online https://agua.org.mx/biblioteca/delimitacion-de-riberas-de-rios-y-arroyos/ Accessed on: 16 Nov. 2021.

[10] Problematic function and restoration of rivers and riverbanks. Online https://www.researchgate.net/publication/284188780_Funcion_problematica_y_restauracion_de_rios_y_riberas Accessed on: 16 Nov. 2021.
[11] Quality of riparian forest in the Utcubamba River basin, Amazonas, Peru. Online http://www.scielo.org.pe/pdf/arnal/v25n2/a18v25n2.pdf Accessed on: 16 Nov. 2021.
[12] Ecology of the riparian zones. Online. https://www.redalyc.org/pdf/629/62912107.pdf Accessed on: 29 Nov. 2021.