

Riparian Vegetation Structure, Land-Use Disturbance, and Restoration Priorities: The Case of River Bortoh in Nkambe, North-West Region, Cameroon

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Abstract

Riparian corridors along small tropical streams are increasingly modified by agriculture, grazing, and fire, yet baseline ecological data for many such systems in Cameroon remain scarce. This study characterizes riparian vegetation structure, land-use disturbance, and hydrological condition along a 250-m surveyed reach of River Bortoh in Nkambe Central Subdivision, North-West Region, Cameroon. Five 50-m sites were assessed sequentially from upstream to downstream, with observations made on both riverbanks. A structured rapid-assessment protocol was used to record accessibility, vegetation, disturbance, and hydrological and geomorphic indicators. All sites were accessible and dominated by shrubland-grassland vegetation, with riparian width ranging from 20 - 50 m. Farming was High at four sites, and species of invasive concern, principally elephant grass (*Pennisetum purpureum*) and eucalyptus (*Eucalyptus grandis*), were recorded at four sites. Banks were visually stable at all sites and no recent flood evidence was observed; these observations describe conditions during the visit and do not establish longer-term hydrological or geomorphic stability. All five sites were considered suitable for quantitative baseline monitoring and targeted community-based restoration.

Keywords

Riparian Vegetation, Land-Use Disturbance, Rapid Ecological Assessment, River Restoration, Tropical Stream, Cameroon

1. Introduction

Riparian corridors, the vegetated zones bordering rivers and streams, perform dis-

proportionately important ecological functions relative to their spatial extent. They stabilize streambanks, buffer sediment and nutrient runoff, regulate water temperature, and provide habitat connectivity for both aquatic and terrestrial species (Naiman & Décamps, 1997; Corenblit et al., 2014). In tropical smallholder landscapes, however, these functions are frequently compromised by the conversion of riparian land to farmland, livestock grazing, and the use of fire for land clearing, all of which reduce vegetation cover, simplify plant community structure, and increase the risk of bank erosion (Twongyirwe et al., 2015; Sweeney & Newbold, 2014).

Small tropical streams draining agricultural landscapes are especially vulnerable to this pattern of disturbance because they are typically narrow, easily accessed, and embedded within densely farmed catchments where competing land-use pressures leave little room for wide vegetated buffers (Ferreira et al., 2020). Cumulatively, these pressures can degrade water quality, reduce biodiversity, and diminish the long-term productivity of the land the river corridor is meant to support, outcomes that are difficult to reverse once bank stability and vegetation cover are lost. Rapid, structured field assessment protocols have therefore become a standard first step in stream-corridor management, allowing practitioners to characterize disturbance and prioritize sites for intervention before committing resources to detailed quantitative monitoring (Petersen, 1992; Barbour et al., 1999).

River Bortoh, in Nkambe Central Subdivision, Donga-Mantung Division, is one such system. Despite supporting nearby farming and grazing communities, no baseline ecological data currently exist for the river corridor, making it impossible to assess the extent of existing disturbance, prioritize restoration interventions, or design an appropriately scaled monitoring programme. Ecological Balance Cameroon (EBC) therefore conducted a structured field assessment along River Bortoh to address this gap. The specific objectives were to: (i) evaluate the accessibility and logistical feasibility of candidate monitoring sites; (ii) characterize riparian vegetation structure and composition; (iii) document the type and intensity of land-use disturbance; (iv) assess hydrological and bank condition; and (v) establish a site-level baseline to guide a full quantitative survey and inform restoration planning.

2. Methodology

2.1. Study Area

The study was conducted along a section of River Bortoh in Nkambe Central Subdivision, Donga-Mantung Division, North-West Region, Cameroon, on 9 March 2026. Five sites were selected along the river corridor by purposive sampling to capture variation in accessibility, land use, and vegetation cover. The surveyed reach was 250 m long and was divided into five 50-m sites arranged sequentially from upstream to downstream (Sites 1 - 5). At each site, observations covered both riverbanks along the full 50-m longitudinal segment. The five site segments there-

fore represent the upstream-to-downstream order of the assessed reach; no separate gap between successive 50-m site segments was recorded. Site locations, including GPS coordinates and elevation, were recorded in the field for subsequent mapping and incorporation into the site-level database.

2.2. Field Assessment Protocol

At each site, a structured field observation protocol, adapted from established rapid riparian and stream-corridor assessment frameworks, including the Riparian, Channel, and Environmental (RCE) inventory of Petersen (1992) and the physical habitat characterization component of the USEPA Rapid Bioassessment Protocols (Barbour et al., 1999), was used to record five categories of site-level data:

- 1) Accessibility indicators: access route type, distance to nearest road, terrain, and safety considerations, including human and wildlife presence.
- 2) Vegetation characteristics: dominant vegetation type, riparian width, dominant plant life forms, dominant species, and presence of species of invasive concern.
- 3) Disturbance and land-use indicators: evidence of farming, grazing intensity, logging/fuelwood extraction, fire signs, and waste dumping/pollution.
- 4) Hydrological and geomorphic characteristics: river flow status, bank condition, floodplain presence, and signs of recent flooding.
- 5) Suitability for detailed sampling: site representativeness, vegetation intactness, feasibility of establishing permanent monitoring plots, and overall recommendation for inclusion in the main baseline survey and restoration.

Data were collected through direct field observation at each site, supported by structured checklists to standardize recording across observers and minimize omission of key indicators. Both banks were surveyed at every site. Riparian width was measured as the horizontal distance from the edge of the water body outward to the point where the stream no longer interacts with or influences bank-side vegetation. The outer boundary was identified from the visible transition from stream-influenced vegetation and soil conditions toward upland vegetation and/or a clear topographic break.

2.3. Scoring, Classification, and Data Handling

Ordinal categories were assigned in the field based on direct observation against a standardized coding scheme: disturbance indicators (farming, grazing, logging/fuelwood extraction) were scored as None (0), Low (1), Moderate (2), or High (3); binary indicators (fire signs, waste/pollution, floodplain presence, recent flood signs) were recorded as Yes (1) or No (0); river flow status was scored as No flow (0), Low flow (1), Moderate flow (2), or High flow (3); and bank condition was recorded as Eroding (0) or Stable (1). For reproducibility, disturbance categories were operationalized using observable evidence within the assessed 50-m bank segment. None indicated no direct evidence; Low indicated

isolated evidence affecting less than approximately 25% of the observed bank segment; Moderate indicated repeated evidence affecting approximately 25% - 50%; and High indicated widespread or near-continuous evidence affecting more than approximately 50%, or extensive direct conversion of the riparian area. For grazing, evidence included livestock presence, tracks, dung, browsing, and trampling; for farming, cultivated plots, planting, clearing, or crop rows; and for logging/fuelwood extraction, cut stems/stumps, removed woody vegetation, or stacked fuelwood. Binary fire and waste indicators were recorded as Yes when visible evidence was present and No when none was observed. Species of invasive concern were recorded only at the species or taxonomic level where field observations indicated conspicuous colonization and the taxon was considered locally problematic as an aggressive or introduced colonizer. Because this rapid assessment did not include a formal invasive-status verification, the term “species of invasive concern” is used cautiously. The original record of “fern” was not retained as an invasive record because it is a broad group rather than a species-level identification and the field assessment did not establish its invasive status. The outcome categories were defined as follows: representativeness was Fair when a site typified the disturbed corridor but provided limited structural variation, and Good when it captured comparatively greater structural or habitat variation; vegetation intactness was Low when vegetation was strongly simplified and dominated by shrub-grass cover with clear disturbance, and Moderate when some additional structural complexity was retained despite disturbance; plot feasibility was Moderate when permanent plot establishment was possible but required minor access, clearing, or marking adjustments, and High when a stable, accessible area allowed plot establishment with minimal constraints; and a site was Recommended when it was accessible, sufficiently representative, and feasible for repeated baseline monitoring. Site-level scores were tabulated and compared descriptively across the five sites; given the small number of sites, no inferential statistical testing was performed, and comparisons are reported as observed patterns rather than statistically validated differences.

3. Results

3.1. Accessibility and Site Logistics

All five sites were accessible via footpaths and, in most cases, roads, with distance to the nearest road ranging from 10 m (Site 4) to 300 m (Site 2) (**Table 1**). Terrain was undulating and broadly consistent across all sites. Human activity was recorded as a safety consideration at every site, and wildlife presence was additionally noted at Sites 1, 3, and 4.

3.2. Vegetation Structure and Composition

Vegetation at all five sites was dominated by shrubland and grassland rather than closed-canopy riparian forest. Riparian width ranged from 20 m (Site 5) to 50 m

(Sites 1, 2, and 4). Dominant plant life forms were shrubs, herbs, and grasses at four sites; Site 5 additionally supported a tree component. Dominant species varied by site: fern and elephant grass (*Pennisetum purpureum*) at Sites 1 and 2; raffia palm (*Raphia farinifera*), acacia, and eucalyptus (*Eucalyptus grandis*) at Site 3; spreading rush (*Juncus patens*) and elephant grass (*Pennisetum purpureum*) at Site 4; and elephant grass and eucalyptus at Site 5. Species of invasive concern were recorded at four of the five sites: elephant grass at Sites 1 and 5, eucalyptus at Site 3, and *Cyperus* sp. and eucalyptus at Site 4. Site 2 was the only site with no species of invasive concern detected. “Fern” is retained as a dominant vegetation observation but is not classified as invasive because it was recorded only as a broad group rather than a species-level taxon.

3.3. Disturbance and Land-Use Indicators

Farming was the dominant disturbance across the corridor, scored High at four sites (Sites 1, 2, 4, 5) and Moderate at Site 3. Grazing intensity was highest at Site 2 (High) and lowest at Sites 3 and 5 (Low). Logging or fuelwood extraction was minimal overall, recorded as None at Sites 1 - 3, Moderate at Site 4, and Low at Site 5. Evidence of fire use was present at four sites (Sites 1 - 4) and absent only at Site 5. Waste dumping or pollution was recorded at a single site (Site 5) (**Figure 1**).

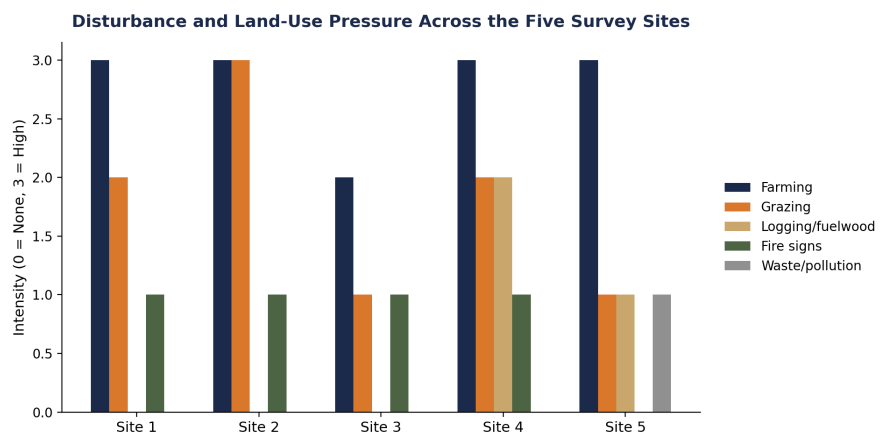


Figure 1. Disturbance and land-use pressure across the five field assessment sites along River Bortoh. The plot includes only farming, grazing, and logging/fuelwood extraction, which use the 0 - 3 ordinal intensity scale; fire signs and waste/pollution were binary indicators and are therefore excluded from this figure.

3.4. Hydrological and Geomorphic Characteristics

River flow was Low at four sites and Moderate at Site 5 (**Figure 2**). Bank condition was Stable at all five sites, with no active erosion recorded. No floodplains and no signs of recent flooding were observed at any site. These observations describe physical conditions during the field visit and do not establish longer-term hydrological or geomorphic stability.

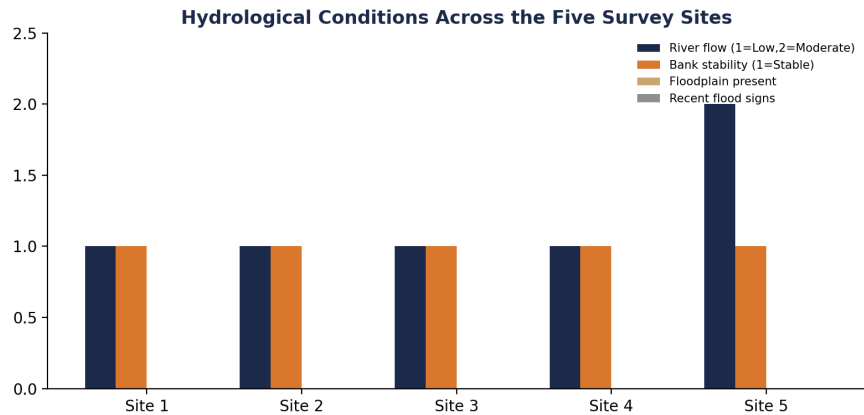


Figure 2. Hydrological and geomorphic conditions across the five field assessment sites along River Bortoh.

3.5. Suitability for Detailed Sampling

All five sites were judged appropriate for detailed ecological survey and monitoring. Sites 1 - 3 were rated Fair and Sites 4 - 5 Good in overall representativeness of the river ecosystem. Vegetation intactness was Low at four sites and Moderate at Site 4. Feasibility of establishing permanent monitoring plots was Moderate at four sites and High at Site 5. All five sites were recommended for inclusion in the main baseline survey.

The classification criteria applied to these outcomes were: Fair representativeness, typical disturbed corridor conditions with limited structural variation; good representativeness, comparatively greater structural or habitat variation; Low vegetation intactness, strongly simplified shrub-grass vegetation with clear disturbance; moderate vegetation intactness, some retained structural complexity despite disturbance; moderate plot feasibility, permanent plot establishment possible with minor logistical constraints; high plot feasibility, stable and accessible area permitting plot establishment with minimal constraints; recommended, site accessible, sufficiently representative, and feasible for repeated baseline monitoring.

Table 1. Site-level field assessment results across five sites along River Bortoh.

Parameter	Site 1	Site 2	Site 3	Site 4	Site 5
Access route	Footpath/ road	Footpath	Footpath/ road	Footpath/ road	Footpath/ road
Distance to nearest road (m)	125	300	100	10	20
Terrain	Undulating	Undulating	Undulating	Undulating	Undulating
Dominant vegetation type	Shrubland, grassland	Shrubland, grassland	Shrubland, grassland	Shrubland, grassland	Shrubland, grassland
Riparian width (m)	50	50	25	50	20
Dominant plant life forms	Shrubs, herbs, grasses	Shrubs, herbs, grasses	Shrubs, herbs, grasses	Shrubs, herbs, grasses	Trees, shrubs, herbs, grasses

Continued

Dominant species recorded	Fern, elephant grass	Fern, elephant grass	Raffia palm (<i>Raphia farinifera</i>), acacia, eucalyptus (<i>Eucalyptus grandis</i>)	Spreading rush (<i>Juncus patens</i>), elephant grass (<i>Pennisetum purpureum</i>)	Elephant grass, eucalyptus
Species of invasive concern present	Yes (elephant grass)	No	Yes (eucalyptus)	Yes (<i>Cyperus</i> sp., eucalyptus)	Yes (elephant grass)
Farming pressure	High	High	Moderate	High	High
Grazing intensity	Moderate	High	Low	Moderate	Low
Logging/fuelwood extraction	None	None	None	Moderate	Low
Fire signs	Yes	Yes	Yes	Yes	No
Waste dumping/pollution	No	No	No	No	Yes
River flow status	Low	Low	Low	Low	Moderate
Bank condition	Stable	Stable	Stable	Stable	Stable
Floodplain present	No	No	No	No	No
Recent flood signs	No	No	No	No	No
Site representativeness	Fair	Fair	Fair	Good	Good
Vegetation intactness	Low	Low	Low	Moderate	Low
Feasibility of plot establishment	Moderate	Moderate	Moderate	Moderate	High
Recommended for main survey	Yes	Yes	Yes	Yes	Yes

4. Discussion

The field assessment results indicate that the river Bortoh riparian corridor is under sustained but non-uniform agricultural pressure. Farming was scored as a high-intensity disturbance at four of the five sites, consistent with the broader pattern observed across small tropical streams embedded in smallholder farming landscapes, where riparian land is often the most accessible and fertile land available to farmers (Ferreira et al., 2020; Sweeney & Newbold, 2014). The frequent evidence of fire, recorded at four of five sites, most likely reflects its use in land preparation and clearing, and represents a recurring source of vegetation disturbance that would not be captured by a single-visit survey.

Vegetation across the corridor was consistently dominated by shrubland and grassland rather than intact riparian forest, and species of invasive concern, particularly elephant grass and eucalyptus, were present at four of five sites. This pat-

tern of simplification is consistent with long-term or repeated disturbance rather than a single land-clearing event, and suggests that natural forest regeneration is being suppressed by ongoing farming and grazing pressure rather than by a one-time historical clearing episode. Site 2, which recorded no species of invasive concern alongside the corridor's highest grazing intensity, is a notable exception; this combination may reflect either more recent disturbance (insufficient time for invasive establishment) or localized site conditions unfavorable to the taxa recorded elsewhere, and warrants closer attention in follow-up sampling. The invasive designation should nevertheless be interpreted cautiously because the rapid assessment did not include formal verification of invasive status.

The field observations indicate that the corridor had stable banks at the time of assessment: banks were stable at all sites, and no floodplain formation or recent flood evidence was recorded anywhere along the surveyed reach. These observations support a description of physical conditions during the visit, but they do not establish long-term hydrological or geomorphic stability. The observed shrub-grass cover may be contributing to bank stability, but seasonal discharge, erosion rates, flood frequency, and channel adjustment were not measured. Consequently, restoration planning should treat the apparent physical stability as a favorable current condition to be monitored rather than as evidence that the system is permanently stable.

Restoration priorities differ across sites. Site 2 combines the lowest invasive-species pressure with the highest grazing intensity, making it a candidate for grazing-management interventions paired with protection of existing native cover. Site 5, despite recording the corridor's only waste-dumping evidence, showed the highest feasibility for monitoring-plot establishment and the only site with a tree component (including a tree component), suggesting it may be the strongest candidate for an initial restoration demonstration plot. Sites 1, 3, and 4 combine elevated farming pressure with reduced vegetation intactness, specifically High farming/Low intactness at Site 1, Moderate farming/Low intactness at Site 3, and High farming/Moderate intactness at Site 4. These sites likely require a combined approach of buffer-zone agreements with adjacent farmers and active revegetation rather than passive recovery alone.

Limitations

These findings should be interpreted with the limitations of a rapid field-assessment design in mind. First, disturbance and vegetation indicators were assigned using ordinal, observer-based scoring rather than quantitative measurement (e.g., percent cover, species counts, sediment or discharge measurement), which limits statistical comparison between sites and introduces a degree of subjectivity into category assignment. Second, the assessment was conducted at a single time point, and therefore cannot capture seasonal variation in flow, vegetation phenology, or disturbance intensity. Third, the five sites, while arranged to capture variation along the surveyed reach, are not a statistically representative or randomized sam-

ple of the full river system, and findings should not be extrapolated beyond the surveyed reach without further sampling. These limitations are inherent to the rapid-assessment design and mean the results should be treated as indicative rather than definitive.

5. General Conclusion

This field assessment demonstrates that the River Bortoh riparian corridor, though ecologically simplified and under sustained agricultural and grazing pressure, had stable bank conditions during the field visit and remains a strong candidate for targeted restoration. All five assessed sites are accessible, logistically feasible for repeated monitoring, and recommended for inclusion in a full baseline survey. Quantitative follow-up sampling, including replicated vegetation plots, water-quality measurement, and seasonal repeat assessment, is needed to confirm these preliminary patterns, establish statistically robust baseline values, and inform the design of a site-specific, community-engaged restoration programme along River Bortoh. The absence of visible flood evidence and the stable bank condition observed during this single visit should not be interpreted as proof of longer-term hydrological or geomorphic stability.

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Author Contributions

L. B. Tata and N. C. Benardin jointly contributed to the field data collection, data organization, analysis, and interpretation of the results. L. B. Tata coordinated the study and led the preparation of the paper, while both authors contributed to reviewing and editing the final paper. Both authors approved the final version for publication.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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