**List of Supplementary Materials**

S1: Overview of the distribution of specific survey sites along river Bregalnica profile including site-specific stream integrity rating and land use/cover in the corresponding basins

S2: Detailed overview of WHEBIP rating criteria, calculation specifics and applied alterations in regard to the original protocol first elaborated by Goforth and Bain (2010)

S3: Overview of the contribution of individual WHEBIP category metrics in the final WHEBIP stream integrity score for the 35 stream segments used in comparison with the site-specific sites

S4: Supplementary Material References

**Figure S1:** **Overview of the distribution of specific survey sites along river Bregalnica profile including site-specific stream integrity rating and land use/cover in the corresponding basins**



**Table S2: Detailed overview of WHEBIP rating criteria, calculation specifics and applied alterations in regard to the original protocol first elaborated by Goforth and Bain (2010)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Category metric\* | Metric descriptive characteristics (as originally provided by Goforth and Bain (2010) | Score | Upper French Creek watershed, USAGoforth and Bain (2010)\*\* calculation specifics | Bregalnica watershed calculation specifics | Supporting literature\*\*\* |
| 1. Dominant riparian land cover  | Forested; wooded wetland | 35 | Assessed with use of land-cover maps and aerial photographs. Assessment specifics and assessment references are not provided. | Determined by the dominant land use/cover group inside the 30, 50 and 100 m stream segment(s) buffer(s) area (30 m fixed buffer in Jovanovska *et al.* (2013)).Assessed with CLC 212: ***Forests:*** [311] Broad-leaved forest ; [312] Coniferous forest and[313] Mixed forest were rated highest; ***Brush/tall grass; wetland:***[243] Land principally occupied by agriculture, with significant areas of natural vegetation; [321] Natural grasslands; [323] Sclerophyllous vegetation and [324] Transitional woodland-shrub; ***Meadows and pastures:***[231] Pastures [331] Beaches, dunes, sands; [333] Sparsely vegetated areas; ***Altered/Anthropogenic habitats:***all other CLC categories (in the case of Bregalnica [112, 121, 131, 132, 211, 213, 221, 222 and 242Not assessed: [512] Water bodies Calculated by applying only the particular streams’ (30, 50, 100 m) segment buffer. | Many authors have examined the complex interaction between the stream and its adjacency and have confirmed the causal effects (Burcher *et al.* 2007) that the adjacent land use/cover has on the instream physical habitat and the stream communities (Roth *et al.* 1996, Naiman and Décamps 1997, Lammert and Allan 1999, Allan 2004, Miserendino *et al.* 2011, Gieswein *et al.* 2017) with Ferńandez *et al.* (2011)listing the adjacent land use amongst the most recorded river habitat characteristics.The selected buffer widths has been supported by Hawes and Smith (2005) and Valle *et al.* (2013) with consideration of the background theories of the river continuum (Vannote *et al.* 1980, Ward *et al.* 2002) and accounting for the dynamics of the river floodplain (Ward and Stanford 1995). |
| Brush/tall grasses; wetland  | 25 |
| Grazed grasses  | 5 |
| Row crop, construction, residential/commercialor no vegetation (bare soil) | 1 |
| 2. Estimated width of riparian area | >30m | 35 | Estimates the width of forest or wetland in the riparian area. Scores all other land covers as 1.Assessment specifics and assessment references are not provided. | Calculated as the area of riparian land cover inside a 50 m buffer of the stream segment divided with twice the stream segment length, thus representing the average width of the riparian belt.Assessed with combined use (intersection) of CLC 12 and Google Earth Imagery (specifically digitized layer of riparian vegetation used to assess the attributes of the immediate stream surroundings of river Bregalnica (given its significance as a carrying watercourse))  | Wider and disrupted riparian forests, with larger trees and values of vertical canopy structure support higher macroinvertebrate community richness (Seger *et al.* 2012, Tanaka *et al.* 2016, Vimos-Lojano *et al.* 2017) and are crucial for preservation of biodiversity (Bennett 1990, Roy *et al.* 2007, Valle Junior *et al.* 2015) and serve as a filter of the watershed nutrient input (Naiman and Décamps 1997, Tabacchi *et al.* 1998, Rios and Bailey 2006). Riparian habitat is also positively related to river habitat heterogeneity (Barquín *et al.* 2011). The ratings provided by Goforth and Bain (2010) are supported by the Riparian, Channel, and Environmental (RCE) protocol (Petersen 1992) and similar width and continuity rating is presented in the Riparian Quality Index (del Tánago and de Jalón Lastra 2011). |
| 5-30m | 25 |
| <5m | 1 |
| 3. Riparian canopy continuity along stream reach | No breaks in riparian canopy 35 | 35 | Estimates riparian canopy continuity using aerial photographs.Assessment specifics and assessment references are not provided. | Calculated as the percentage of the stream segment length that is intersected with the 15 m buffer (5 m buffer in Jovanovska *et al.* (2013)) of the riparian land cover, thus representing the riparian canopy continuity.Assessed as WHEBIP 2 |
| Breaks compose up to 10% of canopy 25 | 25 |
| Breaks compose 10–50% of canopy 10 | 10 |
| Breaks compose more than 50% of canopy | 1 |
| 4. Presence of wetlands  | Wetlands dominate riparian area | 20 | Assessment specifics and assessment references are not provided. | Calculated as the area of wetland land cover categories inside a 30, 50, 100 m buffer of the stream segment (30 m fixed buffer in Jovanovska *et al.* (2013)). Assessed using a digitized vector of wetland habitats, complemented by the land use data files and CLC 12 | Lateral connection between the river and the floodplain has a great importance for river ecosystems (Ward and Stanford 1995). When the communication between the wetlands and the river courses is not impeded wetlands are a source of biodiversity and have a significant role in improving stream-water quality (Verhoeven *et al.* 2006, Richardson *et al.* 2011) |
| Wetlands compose up to 50% of riparian area | 10 |
| No wetlands present | 5 |
| 5. Estimated percentage of land cover beyond riparian zone as cropland or pasture | <25% | 25 | Calculated as a % of land cover beyond riparian area as cropland or pasture.Assessed using land-cover maps and aerial photographs.Assessment specifics and assessment references are not provided. | Calculated as the percentage of agricultural land in the basin of the analysed stream segment. Area under pasture was not considered because of the extensive management of both hilly and mountain pastures in Bregalnica basin, and following the findings of Miserendino *et al.* (2011) that if the functions of the riparian belt are preserved, areas under pasture still supported rich communities of invertebrates, increasing overall biodiversity.The following CLC 12 categories were considered in the assessment:[211] Non-irrigated arable land[213] Permanently irrigated land[221] Vineyards[222] Fruit trees and berry plantations[242] Complex cultivation patterns and [243] Land principally occupied by agriculture, with significant areas of natural vegetation | The amount and the intensity of agricultural land use in the basin and the decrease in natural cover (e.g. Forests) have a negative effect on river integrity. The decrease in naturalness in the basin (mostly associated to intense agriculture) is often related to hydromorphological alterations, changes in physical habitat quality, nutrient enrichment and deprivation of stream communities richness (Roth *et al.* 1996, Allan *et al.* 1997, Blanco *et al.* 2007, Clapcott *et al.* 2012, Kail and Wolter 2013, Valle *et al.* 2013, Bruno *et al.* 2014, dos Santos and Esteves 2015, Feld *et al.* 2016, Tanaka *et al.* 2016, Segurado *et al.* 2018) etc.  |
| 25-49% | 15 |
| 50-75% | 5 |
| ≥75% | 1 |
| 6. Estimated percentage of land cover beyond riparian area as forest or brush | >75% | 35 | Assessed as a % of land cover beyond riparian area as forest or brush.Assessed using land-cover maps and aerial photographs.Assessment specifics and assessment references are not provided. | Calculated as the percentage of forests in the basin of the analysed stream segment.The following CLC 12 categories were considered in the assessment:[311] Broad-leaved forest[312] Coniferous forest[313] Mixed forest[323] Sclerophyllous vegetation[324] Transitional woodland-shrub |
| 50-75% | 20 |
| 25-49% | 10 |
| <25% | 1 |
| 7. Riparian land cover for upstream stream segments | Forested | 50 | Assessed using land-cover maps and aerial photographs.Includes riparian land cover of tributaries converging to form segment.Assessment specifics and assessment references are not provided. | Same as WHEBIP 1, calculated for upstream segment (incl. tributaries). Lowest score is assigned if the upstream stream segment riverbed has been hydromorphologicaly altered by dam construction or has a hydro accumulation reservoir. | Aside from the land use pressures acting at the reach and catchment scale, the river integrity is also significantly affected by the attributes of its upstream and those of its tributaries (Kail and Hering 2009, Kail and Wolter 2013, Feld *et al.* 2016) with upstream river habitat degradation seen as a dominant stressor (Lorenz and Feld 2013, Gieswein *et al.* 2017) |
| Brush/tall grasses | 40 |
| Grazed grasses | 10 |
| Row crops or bare soil | 1 |
| 8. Subbasin land cover for stream segments immediately upstream | >75% intact | 3 | Assessed using land-cover maps and aerial photographs.Includes subbasin areas of tributaries converging to form stream segment.Assessment specifics and assessment references are not provided. | Same as WHEBIP 6, calculated for upstream segment (incl. tributaries)Lowest score is assigned if the upstream stream segment riverbed has been hydromorphologicaly altered by dam construction or has a hydro accumulation reservoir. |
| 50–75% intact | 20 |
| 25–49% intact | 10 |
| <25% intact | 1 |
| 9. Stream segment subbasin land gradient | Low gradient | 20 | Assessed using topographic map.Assessment specifics are not provided | Calculated as the most common of the three terrain slope range categories in stream segments’ subbasin (1. [0-4]; 2. [4-8]; 3. [>8] degrees slope). Assessed using the Digital Elevation Model (ASTER GDEM). | Land gradient in this case serves as a “weight” of the upstream-downstream turnoff in the final score. Slope together with distance from source is also used by Gieswein *et al.* (2017) to account for natural biological response patterns. |
| Moderate gradient | 15 |
| High gradient | 10 |
| 10. Point source pollution | No point sources likely | 25 | Assessed using land-cover maps and aerial photographs.Sewage treatment plants, mines, construction, barnyards, cow trails and roads are considered.Assessment specifics and assessment references are not provided. | Calculated as the presence or absence of intersection between the union of populated places/settlements vector and point sources pollution vector (digitized polygon-vectors) with a) stream segments (for differentiation between the low and middle score) and b) stream segments’ subbasin (for differentiation between middle and high score). The buffer width on populated places/settlements varied from 30 m, 50 m to 100 m (fixed 50m buffer in Jovanovska *et al.* (2013)) depending on the settlement type (tourist settlements, scattered/ clumped village type) and the degree of impact that the settlements have on the specific stream segment (low, medium and high). The buffer width of other single identifiable source of pollution ranged from 250 m for industrial centres, factories, disposal sites and dumps going up to 500 m for mines depending on the character and the degree of impact of the pollution source (only wastewater discharge points were considered in Jovanovska *et al.* (2013)).Assessed using a digitized vectors, complemented by the land use data files and CLC 12 | Various studies have confirmed that settlements (Paul and Meyer 2001, Roy *et al.* 2001, Wang and Kanehl 2003, Miltner *et al.* 2004), mines (Alderton *et al.* 2005, Ramani *et al.* 2014) and industrial centres (Imoobe and Koye 2011, Walakira and Okot-Okumu 2011) impact the stream biotic integrity.  |
| Point source likely within drainage area | 10 |
| Point source likely adjacent to stream | 1 |
| 10a. Point source pollution upstream | No point source upstream (incl. tributaries) | -20 | Not considered | Same as WHEBIP 10, calculated for upstream segment(s) (incl. tributaries) | Included considering the important role of upstream river habitat quality and that of its tributaries referred to previously (WBP 7 and 8) |
| Point source likely within the drainage area upstream (incl. tributaries) | -10 |
| No point sources upstream (incl. tributaries) | 0 |
| 11. Presence of roads | No roads present | 25 | Assessed using maps and aerial photographs.Considered due to the causal effects of increased availability to resources: e.g. logging, farm, gravel. Crossings with bridges or culverts are considered.Assessment specifics and assessment references are not provided. | No significant hydromorphological alterations | ***All major hydromorphological alterations are considered.*** Calculated as the presence or absence of intersection between a) the stream and the buffer of a vector comprising hydromorphological disturbances and alterations (determining the lowest score) and b) intersection between 30m buffer of the stream segment and the vector comprising hydromorphological disturbances and alterations (for differentiation between the middle and high score). Buffer width (5m, 10m and 50m) depends of the character and the degree of impact of the hydromorphological disturbance. Roads, bridges, sand quarries, canals, river barrages, reservoirs and accumulations have been taken as relevant input data on hydromorphological disturbances. Assessed using a digitized vectors, complemented by the land use data files and CLC 12In Jovanovska *et al.* (2013) a fixed 30 m buffer is applied and only roads and bridges have been considered (same as Goforth and Bain. 2010) | A number of studies have confirmed the rivers are affected by hydromorphological alterations, especially dams (Vinson 2001, Bredenhand and Samways 2009, Belmar *et al.* 2013, Kail and Wolter 2013, Aguiar *et al.* 2016). Aside from the well-studied fragmentation effect of roads, they also play a role in increasing the runoff pollution (Krein and Schorer 2000, Helmreich *et al.* 2010). |
| Roads present, within 30 m of stream or crossing with bridges or culvert | 10 | Alterations within 30 m of the stream segment |
| Roads present: crossings through streambed or active construction | 1 | Alterations directly intersect with the stream segment |
| 12. Existence of conservation activity | Conservation actions for >10 years | 25 | Assessed using land cover maps, aerial photographs and input from county land planners, county extension and conservation organizations.Riparian fencing, soil conservation, set-asides are considered.Forest and wetland dominated areas receive the highest score. Other assessment specifics and assessment references are not provided. | Calculated by the time length of a conservation activity in a stream segments’ vicinity (the presence of a protected area in a 50 m buffer (depends of the type and effect of the conservational activity the buffer can be changed) of a stream segment). If a stream segment’s WHEBIP category 6 score has been high - 35 (76-100 % forest or brush in the subbasin), then the score of WHEBIP category 12 becomes high (25). Assessed using the national Representative network of protected areas | Existing conservational activities in the basin (especially along the stream) are a reference to high naturalness. Protected areas are generally considered to support high naturalness and high valued free flowing rivers (Mancini *et al.* 2005, Nel *et al.* 2007). |
| Conservation actions within 5–10 years | 15 |
| Conservation actions within <5 years | 10 |
| No conservation action | 1 |

\*Category metrics presented in the table follow on those originally provided by Goforth and Bain (2010). In the case of Bregalnica watershed few category metrics have been rephrased (following on Jovanovska *et al.* (2013). See Figure 1 and Table S3.

\*\*Criteria by Goforth and Bain (2010) are “developed based on published relationships between stream ecosystems and surrounding landscapes, the authors’ field experiences, and on-site stream assessments” [e.g., fish Index of Biotic Integrity (IBI)] (Karr, 1981) and Riparian, Channel, and Environmental (RCE) protocol developed by Petersen (1992). Assessment specifics and assessment references are not provided.

\*\*\*Considering that land use pressures do not act in isolation, much of the papers used as a supporting literature focus on both catchment and local scale, some dealing with the multiscale effects and interactive pathways of stressors and examined species specific responses.

**Table S3:** **Overview of the contribution of individual WHEBIP category metrics in the final WHEBIP stream integrity score for the 35 stream segments used in comparison with the site-specific sites**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *Site survey locality code* | *WBP1* | *WBP2* | *WBP3* | *WBP4* | *WBP5* | *WBP6* | *WBP7* | *WBP8* | *WBP9* | *WBP10* | *WBP10a* | *WBP11* | *WBP12* | *WHEBIP score* | *WHEBIP rating* |
| 1 | 25 | 35 | 10 | 1 | 15 | 20 | 50 | 20 | 10 | 1 | 0 | 1 | 1 | 189 | good |
| 2 | 25 | 35 | 35 | 1 | 15 | 10 | 50 | 1 | 10 | 1 | -20 | 10 | 1 | 174 | Good |
| 3 | 25 | 25 | 1 | 1 | 1 | 1 | 1 | 1 | 10 | 10 | -10 | 1 | 1 | 68 | Poor |
| 4 | 25 | 35 | 10 | 1 | 1 | 1 | 40 | 10 | 15 | 10 | -20 | 1 | 1 | 130 | Fair |
| 5 | 25 | 35 | 10 | 1 | 25 | 20 | 1 | 10 | 10 | 1 | -20 | 1 | 1 | 120 | Fair |
| 6 | 25 | 35 | 25 | 1 | 1 | 1 | 1 | 10 | 15 | 1 | -20 | 1 | 1 | 97 | Fair |
| 7 | 1 | 25 | 1 | 1 | 1 | 1 | 1 | 1 | 15 | 1 | -20 | 1 | 1 | 30 | Poor |
| 8 | 25 | 35 | 10 | 1 | 5 | 1 | 1 | 1 | 15 | 1 | -20 | 1 | 1 | 77 | Poor |
| 9 | 25 | 35 | 25 | 1 | 15 | 10 | 40 | 1 | 10 | 1 | -20 | 25 | 1 | 169 | Good |
| 10 | 35 | 35 | 25 | 1 | 15 | 1 | 40 | 20 | 15 | 25 | -20 | 25 | 1 | 218 | Good |
| 27 | 35 | 35 | 35 | 1 | 25 | 35 | 50 | 30 | 10 | 25 | 0 | 25 | 25 | 331 | Excellent |
| 31 | 35 | 35 | 35 | 1 | 25 | 35 | 50 | 30 | 10 | 25 | 0 | 25 | 25 | 331 | Excellent |
| 32 | 5 | 25 | 10 | 1 | 25 | 10 | 40 | 10 | 10 | 1 | -20 | 1 | 1 | 119 | Fair |
| 33 | 1 | 25 | 1 | 1 | 15 | 20 | 1 | 1 | 10 | 1 | -10 | 25 | 1 | 92 | Fair |
| 34 | 35 | 35 | 25 | 1 | 25 | 20 | 1 | 10 | 10 | 1 | 0 | 1 | 1 | 165 | Good |
| 35 | 1 | 25 | 10 | 1 | 1 | 1 | 40 | 1 | 15 | 1 | -20 | 10 | 1 | 87 | Fair |

Watershed Habitat Evaluation and Biotic Integrity Protocol (WHEBIP) metric descriptions and rating criteria for each metric according to Goforth & Bain (2010), rephrased: *Dominant riparian land cover (WBP1):* forest (35); riparian scrubland, grassland and wetland (25); meadows and pastures (5); altered, anthropogenic habitats (1); *Width of Riparian Belt (WBP2):* > 30 m (35); 5–30 m (25); < 5 m (1); *Riparian canopy continuity (WBP3):* No breaks in the riparian canopy (35); Breaks up to 10% of canopy (25); Breaks of 10-50% of canopy (10); Breaks compose >50% of canopy (1); *Presence of Wetlands (WBP4):* Wetlands dominate riparian area (20); Wetlands compose up to 50% of riparian area (10); No wetlands (1); *Agriculture in the drainage area (WBP5):* 0-25% (25); 26-50% (15); 51-75% (5); 76-100% (1); *Forest or scrubland in the drainage area (WBP6):* 76-100% (35); 51-75% (20); 26-50% (10); 0-25% (1); *Upstream riparian land cover (WBP7):* forest (50); riparian scrubland, grassland and wetland (40); meadows and pastures (10); altered, anthropogenic habitats (1); *Upstream forest or scrubland (WBP8):* 76-100% (30); 51-75% (20); 26-50% (10); 0-25% (1); *Land Gradient (WBP9):* Low or flat (20); Moderate (15); High (10); *Point Source Pollution (WBP10):* No point source(s) likely (25); Point source(s) likely within watershed (10); Point source(s) likely along stream (1); *Point source pollution upstream* (WBP10a) No point sources upstream (0); Point sources within the drainage area upstream (-10); Point sources adjacent upstream (-20); *Hydromorphological alterations (WBP11):* No significant hydromorphological alterations (25); Alterations within 30 m of the stream segment (10); Alterations directly intersect with the stream segment (1); *Conservation Activity (WBP12):* Conservation actions for > 10 yrs (25); Conservation actions 5-10 yrs (15); Conservation actions within <5 yrs (10); No conservation actions (1); *WHEBIP rating:* p - poor, f - fair; g - good; vg - very good; e – excellent. For site survey codes position see Figure 2.

**S4: Supplementary Material References**

Aguiar, F.C., Martins, M.J., Silva, P.C., and Fernandes, M.R., 2016. Riverscapes downstream of hydropower dams: Effects of altered flows and historical land-use change. *Landscape and Urban Planning*, 153, 83–98.

Alderton, D.H.M., Serafimovski, T., Mullen, B., Fairall, K., and James, S., 2005. The chemistry of waters associated with metal mining in Macedonia. *Mine Water and the Environment*, 24 (3), 139–149.

Allan, D., Erickson, D., and Fay, J., 1997. The influence of catchment land use on stream integrity across multiple spatial scales. *Freshwater Biology*, 37 (1), 149–161.

Allan, J.D., 2004. Influence of land use and landscape setting on the ecological status of rivers. *Limnetica*, 23 (3–4), 187–197.

Barquín, P., Fernández, D., Álvarez-Cabria, M., and Peñas, F.J., 2011. Riparian quality and habitat heterogeneity assessment in Cantabrian rivers. *Limnetica*, 30 (2), 329–346.

Belmar, O., Bruno, D., Martínez-Capel, F., Barquín, J., and Velasco, J., 2013. Effects of flow regime alteration on fluvial habitats and riparian quality in a semiarid Mediterranean basin. *Ecological Indicators*, 30, 52–64.

Bennett, A.F., 1990. Habitat corridors and the conservation of small mammals in a fragmented forest environment. *Landscape Ecology*, 4 (2–3), 109–122.

Blanco, S., Bécares, E., Cauchle, H.-M., Hoffrnanrr, L., and Ecto, L., 2007. Comparison ot biotic indices tor water quality diagnosis in the Duero Basin (Spain). *Arch. Hydrobiol. Suppl*, 161, 3–4.

Bredenhand, E. and Samways, M.J., 2009. Impact of a dam on benthic macroinvertebrates in a small river in a biodiversity hotspot: Cape Floristic Region, South Africa. *Journal of Insect Conservation*, 13 (3), 297–307.

Bruno, D., Belmar, O., Sánchez-Fernández, D., Guareschi, S., Millán, A., and Velasco, J., 2014. Responses of Mediterranean aquatic and riparian communities to human pressures at different spatial scales. *Ecological Indicators*, 45, 456–464.

Burcher, C.L., Valett, H.M., and Benfield, E.F., 2007. The land-cover cascade: Relationships coupling land and water. *Ecology*, 88 (1), 228–242.

Clapcott, J.E., Collier, K.J., Death, R.G., Goodwin, E.O., Harding, J.S., Kelly, D., Leathwick, J.R., and Young, R.G., 2012. Quantifying relationships between land-use gradients and structural and functional indicators of stream ecological integrity: Stream integrity along land-use gradients. *Freshwater Biology*, 57 (1), 74–90.

Feld, C.K., Segurado, P., and Gutiérrez-Cánovas, C., 2016. Analysing the impact of multiple stressors in aquatic biomonitoring data: A ‘cookbook’ with applications in R. *Science of The Total Environment*, 573, 1320–1339.

Ferńandez, D., Barquín, J., and Raven, P.J., 2011. A review of river habitat characterisation methods: indices vs. characterisation protocols. *Limnetica*, 30 (2), 217–234.

Gieswein, A., Hering, D., and Feld, C.K., 2017. Additive effects prevail: The response of biota to multiple stressors in an intensively monitored watershed. *Science of The Total Environment*, 593–594, 27–35.

Goforth, R.R. and Bain, M.B., 2010. Assessing stream integrity based on interpretations of map-based riparian and subbasin properties. *Landscape and Ecological Engineering*, 8 (1), 33–43.

Hawes, E. and Smith, M., 2005. Riparian buffer zones: Functions and recommended widths. *Prepared for Eightmile River Wild and Scenic Study Committee*.

Helmreich, B., Hilliges, R., Schriewer, A., and Horn, H., 2010. Runoff pollutants of a highly trafficked urban road – Correlation analysis and seasonal influences. *Chemosphere*, 80 (9), 991–997.

Imoobe, T. and Koye, P., 2011. Assessment of the Impact of Effluent from a Soft Drink Processing Factory on the Physico-Chemical Parameters of Eruvbi Stream Benin City, Nigeria. *Bayero Journal of Pure and Applied Sciences*, 4 (1), 126–134.

Jovanovska, D., Avukatov, V., Melovski, L., and Hristovski, S., 2013. Rapid assessment of stream integrity on stream segments in the upper Vardar watershed in Skopje region. *Macedonian Journal of Ecology and Environment*, 15 (1), 33–48.

Kail, J. and Hering, D., 2009. The influence of adjacent stream reaches on the local ecological status of Central European mountain streams. *River Research and Applications*, 25 (5), 537–550.

Kail, J. and Wolter, C., 2013. Pressures at larger spatial scales strongly influence the ecological status of heavily modified river water bodies in Germany. *Science of The Total Environment*, 454–455, 40–50.

Krein, A. and Schorer, M., 2000. Road runoff pollution by polycyclic aromatic hydrocarbons and its contribution to river sediments. *Water Research*, 34 (16), 4110–4115.

Lammert, M. and Allan, J.D., 1999. Assessing biotic integrity of streams: effects of scale in measuring the influence of land use/cover and habitat structure on fish and macroinvertebrates. *Environmental Management*, 23 (2), 257–270.

Lorenz, A.W. and Feld, C.K., 2013. Upstream river morphology and riparian land use overrule local restoration effects on ecological status assessment. *Hydrobiologia*, 704 (1), 489–501.

Mancini, L., Formichetti, P., Anselmo, A., Tancioni, L., Marchini, S., and Sorace, A., 2005. Biological quality of running waters in protected areas: the influence of size and land use. *Biodiversity & Conservation*, 14 (2), 351–364.

Miltner, R.J., White, D., and Yoder, C., 2004. The biotic integrity of streams in urban and suburbanizing landscapes. *Landscape and Urban Planning*, 69 (1), 87–100.

Miserendino, M.L., Casaux, R., Archangelsky, M., Di Prinzio, C.Y., Brand, C., and Kutschker, A.M., 2011. Assessing land-use effects on water quality, in-stream habitat, riparian ecosystems and biodiversity in Patagonian northwest streams. *Science of The Total Environment*, 409 (3), 612–624.

Naiman, R.J. and Décamps, H., 1997. The ecology of interfaces: riparian zones. *Annual review of Ecology and Systematics*, 621–658.

Nel, J.L., Roux, D.J., Maree, G., Kleynhans, C.J., Moolman, J., Reyers, B., Rouget, M., and Cowling, R.M., 2007. Rivers in peril inside and outside protected areas: a systematic approach to conservation assessment of river ecosystems. *Diversity and Distributions*, 13 (3), 341–352.

Paul, M.J. and Meyer, J.L., 2001. Streams in the Urban Landscape. *Annual Review of Ecology and Systematics*, 32, 333–365.

Petersen, R.C., 1992. The RCE: a Riparian, Channel, and Environmental Inventory for small streams in the agricultural landscape. *Freshwater Biology*, 27 (2), 295–306.

Ramani, S., Dragun, Z., Kapetanović, D., Kostov, V., Jordanova, M., Erk, M., and Hajrulai-Musliu, Z., 2014. Surface Water Characterization of Three Rivers in the Lead/Zinc Mining Region of Northeastern Macedonia. *Archives of Environmental Contamination and Toxicology*, 66 (4), 514–528.

Richardson, C.J., Flanagan, N.E., Ho, M., and Pahl, J.W., 2011. Integrated stream and wetland restoration: A watershed approach to improved water quality on the landscape. *Ecological Engineering*, 37 (1), 25–39.

Rios, S.L. and Bailey, R.C., 2006. Relationship between Riparian Vegetation and Stream Benthic Communities at Three Spatial Scales. *Hydrobiologia*, 553 (1), 153–160.

Roth, N.E., Allan, J.D., and Erickson, D.L., 1996. Landscape influences on stream biotic integrity assessed at multiple spatial scales. *Landscape ecology*, 11 (3), 141–156.

Roy, A., Rosemond, A.D., Leigh, D.S., Paul, M.J., and Wallace, J.B., 2001. Effects of changing land use on macroinvertebrate integrity: identifying indicators of water quality impairment. *In*: K.J. Hatcher, ed. *Proceedings of the 2001 Georgia Water Resources Conference*. Presented at the Georgia Water Resources Conference, Athens, Georgia: Institute of Ecology, the University of Georgia, 229–232.

Roy, A.H., Freeman, B.J., and Freeman, M.C., 2007. Riparian influences on stream fish assemblage structure in urbanizing streams. *Landscape Ecology*, 22 (3), 385–402.

dos Santos, F.B. and Esteves, K.E., 2015. A Fish-Based Index of Biotic Integrity for the Assessment of Streams Located in a Sugarcane-Dominated Landscape in Southeastern Brazil. *Environmental Management*, 56 (2), 532–548.

Seger, K.R., Smiley, P.C., King, K.W., and Fausey, N.R., 2012. Influence of riparian habitat on aquatic macroinvertebrate community colonization within riparian zones of agricultural headwater streams. *Journal of Freshwater Ecology*, 27 (3), 393–407.

Segurado, P., Almeida, C., Neves, R., Ferreira, M.T., and Branco, P., 2018. Understanding multiple stressors in a Mediterranean basin: Combined effects of land use, water scarcity and nutrient enrichment. *Science of The Total Environment*, 624, 1221–1233.

Tabacchi, E., Correll, D.L., Hauer, R., Pinay, G., Planty-Tabacchi, A.-M., and Wissmar, R.C., 1998. Development, maintenance and role of riparian vegetation in the river landscape. *Freshwater Biology*, 40 (3), 497–516.

del Tánago, M.G. and de Jalón Lastra, D.G., 2011. Riparian Quality Index (RQI): A methodology for characterising and assessing the environmental conditions of riparian zones. *Limnetica*, 30 (2), 235–254.

Tanaka, M.O., Souza, A.L.T. de, Moschini, L.E., and Oliveira, A.K. de, 2016. Influence of watershed land use and riparian characteristics on biological indicators of stream water quality in southeastern Brazil. *Agriculture, Ecosystems & Environment*, 216, 333–339.

Valle, I.C., Buss, D.F., Baptista, D.F., Valle, I.C., Buss, D.F., and Baptista, D.F., 2013. The influence of connectivity in forest patches, and riparian vegetation width on stream macroinvertebrate fauna. *Brazilian Journal of Biology*, 73 (2), 231–238.

Valle Junior, R.F., Varandas, S.G.P., Pacheco, F.A.L., Pereira, V.R., Santos, C.F., Cortes, R.M.V., and Sanches Fernandes, L.F., 2015. Impacts of land use conflicts on riverine ecosystems. *Land Use Policy*, 43, 48–62.

Vannote, R.L., Minshall, G.W., Cummins, K.W., Sedell, J.R., and Gushinc, C.E., 1980. The river continuum concept. *Can. J. Fish. Aquat. Sci.*, 37, 130–137.

Verhoeven, J., Arheimer, B., Yin, C., and Hefting, M., 2006. Regional and global concerns over wetlands and water quality. *Trends in Ecology & Evolution*, 21 (2), 96–103.

Vimos-Lojano, D. j., Martínez-Capel, F., and Hampel, H., 2017. Riparian and microhabitat factors determine the structure of the EPT community in Andean headwater rivers of Ecuador. *Ecohydrology*, 10 (8), :e1894.

Vinson, M.R., 2001. Long-term dynamics of an invertebrate assemblage downstream from a large dam. *Ecological Applications*, 11 (3), 711–730.

Walakira, P. and Okot-Okumu, J., 2011. Impact of Industrial Effluents on Water Quality of Streams in Nakawa-Ntinda, Uganda. *Journal of Applied Sciences and Environmental Management*, 15 (2), 289 – 296.

Wang, L. and Kanehl, P., 2003. Influences of Watershed Urbanization and Instream Habitat on Macroinvertebrates in Cold Water Streams. *Journal of the American Water Resources Association*, 39 (5), 1181–1196.

Ward, J.V., Malard, F., and Tockner, K., 2002. Landscape ecology: a framework for integrating pattern and process in river corridors. *Landscape Ecology*, 17 (1), 35–45.

Ward, J.V. and Stanford, J.A., 1995. The serial discontinuity concept: extending the model to floodplain rivers. *Regulated Rivers: Research & Management*, 10, 159–168.