The utility of the Rapid Riparian Assessment tool for predicting fish habitat in urban streams. A preliminary study in Ku-ring-gai Local Government Area, North Sydney, NSW

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Abstract

This study examines the effectiveness of an urban stream condition tool (referred to as the Rapid Riparian Assessment (RRA)), to assess the suitability of in-stream habitat for native fish species. The range, condition and locations of appropriate fish habitat within the Ku-ring-gai’s area are essential management data for the possible re-introduction of native fish species into local streams. Physical habitat quality and diversity were used as a proxy for fish abundance and diversity measures due to time and sampling constraints within national park areas. Fourteen sites were surveyed in detail with data collected on a range of relevant habitat variables including: bed composition, large woody debris availability, stream bank stability and shading, riparian vegetation condition, flow variability. Field sample sites were categorised into four conditions: poor, fair, good and excellent according to the Stream Sense Habitat Assessment System (SSHAS) developed in New Zealand. The derived scores were compared to RRA scores for the same site. The results suggest that the RRA is not, in its present form, a useful tool for predicting fish habitat quality or diversity. This is thought to be partly due to the different weighting given to the environmental variables measured using the RRA scheme and the SSHAS. As a result, a revised approach to field data collection is recommended that will permit simultaneous assessment of riparian and fish habitat condition. Although the results of the study should be regarded as a preliminary study, it is likely that the adoption of a modified approach will lead to a significant reduction in data collection time while permitting simultaneous assessment of riparian and in-stream fish habitat condition. It is recommended that additional work be carried out to improve the habitat scoring system as well as to test the assumptions between derived stream condition and effective fish habitat.

Keywords: Rapid Fish Habitat Assessment, Riparian Systems, Urban Streams and Urbanization

1. Introduction

Urbanization is a form of land-use change that is rapidly gaining in importance on a global scale. It has been estimated that 60% of the world’s population will live in urban areas by 2030 (US Census Bureau, 2001 in 1). Numerous studies have shown the negative impacts of urbanization on catchments and streams (see 1 for a recent overview), especially in Europe and the United States. The single most important factor identified so far is the increase of impervious surfaces in urbanized catchments, which in turn leads to numerous hydrological and geomorphic changes to local streams (1,2). Effective management and rehabilitation of these streams requires up-to-date data, continuous monitoring and good long-term management plans (3). Although most research to date has focused on the United States and Europe, impacts on Australian streams have been no less severe. The importance of protecting stream health and associated habitat diversity and biodiversity has been widely accepted, and recent developments in Australian Federal and State legislation reflect this shift in philosophy (Environmental Protection and Biodiversity Conservation (EPBC) Act, 1999). Such changes are also reflected in State legislation with the emphasis in water resource and environmental management shifting towards protection and sustainable use (NSW Water Management Act, 2000), regular environmental auditing and State of the Environment reporting meaning that local through to national environmental conditions are being assessed for pressures, risks and threats.

Towards achieving some of these aims, a Rapid Riparian Assessment (RRA) tool has been developed by Macquarie University together with Ku-ring-gai Municipal Council (KMC) to facilitate fast, accurate assessment of the condition of riparian zones within the Ku-ring-gai local government area (LGA). The RRA tool divides streams into reaches and gathers data on riparian buffer size, condition/composition, geomorphic characteristics of the stream system, types of and extent of direct human impacts and adjacent land use (4). Although the primary focus of this tool is on channel and
riparian zone condition, it has also proven effective in predicting the presence of weeds in the riparian zone, accounting for 66% of the variability in weed occurrence (Findlay, unpublished data). More recently, considerable interest has been expressed in maintaining and restoring native fish diversity in the urban and peri-urban streams in the area, with the KMC initiating native fish collection for restocking of streams, and aquarium and pond use. This initiative also reflects increasing concern about the continuing spread of exotic fish species in urban streams, to the detriment of native fish species, as has been observed in Ku-ring-gai.

Given the availability of RRA condition scores, KMC wished to ascertain whether RRA score of a stream reach could be used to predict fish habitat quality. Local councils require rapid, cost-effective assessment methods if they are to achieve large-scale, long-term monitoring of urban stream habitat condition, this means that the use of surrogates is widespread in local government. This paper reports the findings of a study which tested the effectiveness of the RRA tool for identification of stream reaches with high fish habitat potential, comparing the ratings of 14 sites when assessed with RRA and the New Zealand-developed Stream Sense Habitat Assessment Scheme (SSHAS, 8) respectively. The principle aim of this study is thus to ascertain whether RRA in its current form can be used to predict the condition of fish habitat in urban streams. Ideally, this would be accomplished by direct sampling of fish abundance and diversity, and comparing these data the RRA scores. However, due to a number of legal, logistical and cost constraints it was decided to use the SSHAS. This tool uses physical habitat measures as a surrogate for actual fish diversity/abundance, a widely accepted approach in the literature (e.g. 5, 6 and 3). While this approach may not give a completely accurate picture of actual fish diversity, it is thought that such physical habitat measures are reasonable indicators of a reach’s generic fish habitat potential, and can thus be used to test the suitability of RRA. The report discusses problems with this type of approach to assessing habitat and recommendations for future assessment procedures, data collection and handling are made.

2. Background Information Ku-ring-gai Council Area

The Ku-ring-gai Council area covers part of the Hornsby Plateau, a geomorphic region in the northern part of the Sydney Basin. The area is largely composed of three interconnected, flat-topped shale ridges, drained by an extensive network of steep valleys and gullies, deeply incised into the Hawkesbury Sandstone bedrock, and is dominated by three major drainage basins: the Lane Cove River, Middle Harbor and Cowan Creek catchments. The LGA is bounded on 3 sides by National Parks, with 28% of LGA being bushland. Most of the area is urbanized with the total impervious surface area in the 20-40% range (7). Development is concentrated on the shale ridge-tops, because the steep, incised sandstone valleys are not suitable for extensive development. As a result, streams passing through these valleys contain a high proportion of intact, remnant riparian vegetation and thus are generally in better condition compared to the lower-order streams, which rise on the interfluves where urbanization is most intense (7).

3. Methods

3.1 Site Selection

The RRA protocol measures several physical parameters of the riparian zone and channel (both qualitatively and quantitatively) and scores them to obtain an overall reach condition score ranging from <98 (severely degraded) to >70 (excellent), (4). These parameters include measures such as riparian vegetation type and condition, vegetation buffer size, landuse type, channel condition, erosion and bank stability and evidence of chemical/biological contamination; details on data collection and the scoring system of RRA are beyond the scope of this paper, but can be obtained from Taylor et al (4). To test the effectiveness of RRA in predicting potential fish habitat in a particular reach, 14 sites previously assessed by Taylor et al using RRA were selected from a database of approximately 250 sites and compared to a score obtained using the SSHAS. Fourteen sites were deemed sufficient to achieve an indication of RRA suitability within the time frame available for the study.

For the selection of these 14 sites, reaches that were known to have the following conditions were discarded:

- Ephemeral streams: the limited scope of the study only allowed for a snapshot of habitat conditions and dry water courses do not have any habitat value as far as this study was concerned. This is not to say that these reaches do not perform important drainage and ecological functions.
• Chemical or sewage odors: sites which have been biologically or chemically contaminated in the past may provide physical habitat but are probably ecologically impaired and thus may offer limited habitat value.
• Have concrete or brick lined channels: concrete and brick lined channels offer no habitat value, irrespective of other factors.
• Systems that scored less than 27, i.e. below the “good” category in the RRA: given the limited scope of the study it was important to ensure that any sites investigated were unlikely to be totally degraded, in order to allow meaningful comparison to SSHAS. It was deemed important that the small number of sites chosen be representative of typical conditions within the catchment, anomalous conditions might strongly biased such a small sampling set.
• Sites with unusually steep slopes
• Sites where access was limited

3.2 Site Assessment and the SSHAS
To allow a statistical comparison between RRA score and fish habitat value for these sites it was necessary to employ a method that collected data in a semi-quantitative format using numerical scores. A habitat assessment sheet was designed, incorporating elements of the New Zealand-developed SSHAS (8) and the RRA datasheets. Collectively, this allowed for a rapid, detailed semi-quantitative assessment of the sites, based on physical characteristics. Sites are ranked according to 5 equally weighted SSHAS categories: In-stream cover, stream-flow variation, embeddedness of boulders and cobbles, bank erosion and stability as well as riparian zone vegetation/condition and are assigned a rating according to their overall score. A maximum of 8 points are allocated to in-stream cover, stream-flow variation, embeddedness of boulders and cobbles, higher scores indicating better condition. Bank erosion/stability and riparian zone vegetation/condition are allocated 4 points for the left and right banks respectively, and the final score aggregated to a maximum of 8. A reach can thus receive a maximum of 40 points. Rating categories are given in Table 1. It should be noted that the SSHAS has not previously been tested in Australia, but its generic applicability means that this is unlikely to be an issue.

Table 1: This table shows the scores a stream reach must achieve to be classed as excellent, good, fair or poor under the SSHAS.

<table>
<thead>
<tr>
<th>Score</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 – 34</td>
<td>Excellent</td>
</tr>
<tr>
<td>33 – 26</td>
<td>Good</td>
</tr>
<tr>
<td>25 – 17</td>
<td>Fair</td>
</tr>
<tr>
<td>16 – 10</td>
<td>Poor</td>
</tr>
</tbody>
</table>

3.3 Data Analysis
Once the data was collected in the field, the SSHAS score and rating of each site was calculated as described in the previous section. The RRA score of each site, obtained from the work undertaken by Taylor et al (4), was compared to the SSHAS score and this data was displayed in bi-variate plots. The relationship between RRA and SSHAS score was then tested for significance (5%) in the statistical package Minitab 14, using a simple linear regression model. There are some risks associated with using a statistical approach on such a small sample; some uncertainty remains in the model.

4. Results
The majority of the sites assessed fall within the “Good” category of the SSHAS, with only 2 and 3 rated as Excellent or Fair, respectively (see Table 2 for RRA and SSHAS scores). The mean score obtained for the sites (28.0) indicates that, on average, the sites selected offered good habitat value.
Figure 1: Linear Regression, RRA Score vs. SSHAS Score. There is no relationship between a site’s RRA score and its SSHAS score, only 1.3% of the SSHAS score is explained by a site’s RRA score.

As indicated by the high p-value of 0.31 and low R-squared of 0.09 (Figure 1) there is no significant relationship between RRA score and SSHA. The prominence of the outliers strongly suggest that these reaches do not offer high habitat potential for fish, in spite of relatively high RRA score. Site LCKP06, for example, scored a very high 63.3 for RRA but only 22 for fish habitat. The riparian vegetation at this site is in excellent condition, but there is very little in-stream habitat available, little water flow, and virtually no stream-flow variation. Additionally, there is a small sand slug moving through the stream system at this point. The situation is similar for the other outliers: good riparian vegetation and buffer condition, but little in-stream cover and stream-flow variation.

5. Discussion and Management Implications

5.1 Applicability of RRA
The adoption of physical habitat structure and diversity as a surrogate for actual fish abundance or diversity is an approach that has been widely used in the literature (see below). It has been argued that the habitat value of a stream reach depends on physical characteristics of the reach (5, 6 and 3), as physical structure limits type and variety of habitat available at a certain location. A reach with diverse structure offering cover, such as LWD, boulders, aquatic macrophytes and heterogeneous stream-flow characteristics such as pool and riffle sequences, backpools and a variety of substrate types will provide a much more varied habitat to macro-invertebrates and ultimately to different fish species than a homogenous sand-bed stream (e.g. 5 and 9).

Graphical representation and statistical testing indicate that there is no relationship between RRA and fish habitat score, i.e. RRA cannot be used to accurately predict habitat value of a particular stream reach (Figure 1). Although the RRA gathers much of the same data as used in the SSHAS, this data is handled and weighted very differently. RRA score is heavily weighted towards buffer size and condition (4), whereas the habitat scoring system only allocates 1/5 of the score to riparian vegetation condition; in-stream structure and stream-flow characteristics receive the bulk of the score. It has been widely recognized that stream geomorphology and ecological functioning of streams are linked to buffer size and quality. Miltner et al (10), for example, found that the biological integrity of streams in rapidly urbanizing catchments in Ohio, USA, was maintained when riparian systems and floodplain remained relatively intact. However, it may be wrong to assume that this is always the case, or entirely
Table 2: Study Reach Locations, GPS coordinates and respective RRA and SSHAS scores.

<table>
<thead>
<tr>
<th>Location</th>
<th>Code</th>
<th>GPS Coordinates</th>
<th>SSHAS Score</th>
<th>RRA Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Branch Cowan Creek</td>
<td>CCBC13</td>
<td>0328914 6268517</td>
<td>34</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>CCBC18</td>
<td>0328738 6267437</td>
<td>30</td>
<td>49</td>
</tr>
<tr>
<td>Ku-Ring-Gai Creek</td>
<td>CCKC01</td>
<td>0330844 6269607</td>
<td>33</td>
<td>70</td>
</tr>
<tr>
<td>Avondale Creek</td>
<td>LCAV02</td>
<td>0325993 6262707</td>
<td>21</td>
<td>60.2</td>
</tr>
<tr>
<td>Coups Creek</td>
<td>LCCC01</td>
<td>0323747 6265816</td>
<td>27.5</td>
<td>49.3</td>
</tr>
<tr>
<td>Fox Valley Creek</td>
<td>LCFV08</td>
<td>0325685 6265364</td>
<td>31</td>
<td>49.7</td>
</tr>
<tr>
<td></td>
<td>LCFV09</td>
<td>0324249 6264607</td>
<td>26</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>LCFV10</td>
<td>0324348 6264813</td>
<td>17</td>
<td>37.1</td>
</tr>
<tr>
<td>George Christie</td>
<td>LCGC02</td>
<td>0323523 6264789</td>
<td>28</td>
<td>40</td>
</tr>
<tr>
<td>Lane Cove</td>
<td>LCKP05</td>
<td>0324500 6262451</td>
<td>34</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>LCKP06</td>
<td>0324418 6262744</td>
<td>22</td>
<td>63.3</td>
</tr>
<tr>
<td></td>
<td>LCKP12</td>
<td>0323930 6263378</td>
<td>31</td>
<td>61.6</td>
</tr>
<tr>
<td></td>
<td>LCLQ01</td>
<td>0326418 6261397</td>
<td>29.5</td>
<td>40</td>
</tr>
</tbody>
</table>

applicable to fish habitat quality. Long-term maintenance of stream quality (e.g. channel form, base flow, flow regime, sediment supply) and actual, available fish habitat are not one and the same; fish have more immediate requirements such as shelter, good water quality, adequate food supply as well as longer-term requirements for breeding and recruitment (11).

5.2 Measuring riparian condition and fish habitat quality concurrently

The fact that much the same data is needed for both assessment schemes offers an opportunity to fulfill both fish habitat monitoring and riparian zone condition objectives at the same time. A simple way to achieve this would be to amend the field assessment sheet so that it collects all data needed for both Fish Habitat and RRA scoring. This data would then be collected in one field session, and entered into a central database. The tools’ scoring and weighting system remain separate, and the data needed for each is extracted separately from the database and is then assessed through the appropriate scoring system, with their different weighting and emphasis, providing the managing agency with both a fish habitat and riparian condition assessment (see Figure 2). The great advantage of using this approach is that it allows for the generation of additional information for environmental management strategies, with little increase in time spent collecting data in the field, and is thus of great benefit to any local government management initiative.
Figure 2: Proposed method for simultaneous RRA and fish habitat condition data collection and interpretation

In its present form, the Stream Sense scoring system only gives a rough impression of habitat availability/condition, i.e. it is very much a quick assessment approach. To achieve a more rigorous analysis for fish habitat management additional criteria such as water quality and macro invertebrate assemblage may be required, but these are difficult to include if a rapid, cost-effective assessment method is desired. Thus, while the best method to determine fish habitat quality (in terms of data quality) is direct sampling of biota, logistical, legal and cost considerations makes this an unviable option for local governments desiring to monitor fish habitat quality. Under these constraints some restrictions to data quality are unavoidable.

5.3 Issues

The above approach (Figure 2) depends on several assumptions being fulfilled. Excluding RRA sites with a score > 27 could potentially bias the results, masking greater fish habitat quality variability. This is supported by the fact that the SSHAS scores for the study sites are generally in the “good” to “excellent” range, none are classed as “poor” and the small sample size of the study could exacerbate the problem.

Physical habitat measures may not be as good a surrogate for actual fish habitat availability as argued in the literature. Recent findings by Walsh et al (12) show that improvement of physical habitat in urban streams had no effect on macro-invertebrate diversity. Walsh (13) postulates that pollutants, washed in after storms, and altered hydrological regime are the limiting factor for stream health. To what extent these findings are applicable to fish populations has not been studied, but the potential implications for habitat availability studies, such as this one, are significant. Flow regime and water quality data would have to be included even in “quick” habitat assessment schemes, making them much more costly and time-consuming. These criteria only provide useful information when carried out over a long, continuous period of time, and require a high volume of samples, thus negating a rapid assessment procedure. Alternatively a composite physical habitat and macro-invertebrate assessment could be carried out when conducting the simultaneous RRA and fish habitat assessments.

It is also important to note that the habitat score obtained using a scheme akin the one in this study can only provide a generalized picture of habitat availability. Clearly, specific requirement will differ between species. An important factor that has not been considered by the approach of this study is the large-scale disruptions to fish populations by barriers to fish migration, such as weirs, found in most urban streams. Another factor not accounted for is the presence of aggressive exotic species such as the
Eastern Mosquito Fish (*Gambusia holbrooki*, Girard 1859) and Carp (*Cyprinus carpio*, Linnaeus 1758). The ability of these species to out-compete native fish may restrict native fish distribution, even when suitable habitat is available. Additionally, it is of great importance to monitor sites over an extended period of time to provide a more accurate inter-annual and inter-seasonal reflection of stream condition. Establishing a photographic time-series (see Figure 2) of all sites would also provide an opportunity for visual assessment of changes over longer periods of time. This approach has been in use in parts of the United States for some years now, and has also been adopted by some NZ and Canadian environmental protection and monitoring agencies. Finally, it is important to note that this pilot study’s findings are preliminary, and a larger study to confirm our results should be carried out to confirm the findings presented herein. For these reasons it is suggested that a small-scale sampling project be undertaken to test the assumptions, or, if the resources are available, a comprehensive study of the distribution of native and exotic fish species within the catchments.

6. Conclusions

Preliminary analysis strongly suggests that there is no direct relationship between RRA score and habitat value, as assessed using the SSHAS. This may be caused, in part, due to differences in the weighting of similar factors for riparian health and fish habitat assessment. However, due to similar data requirements it is suggested that the RRA data collection could be modified to include fish habitat requirements, which would allow both RRA and Fish Habitat Assessment to be carried out simultaneously. This will reduce fieldwork duration and cost, permitting more accurate, effective and wide-ranging long-term monitoring. Further research with the objective of establishing the validity of physical habitat as a surrogate for fish abundance or diversity is recommended before adopting the combined approach, as is the use of a more rigorous scoring system. The inclusion of water-quality and flow regime data in this process is of great importance as these factors can control habitat availability and quality in urban streams. It is of great importance, however, to keep costs at a minimum if the goal of affordable habitat monitoring by local governments is to be met.

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