Developing an index of natural character to monitor change in river condition in response to river engineering

L'élaboration d'un indice de caractère naturel pour suivre les évolutions de l'état d'une rivière en réponse à l'ingénierie fluviale

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RÉSUMÉ

L'ingénierie de la rivière en change la condition et les milieux, ce qui se traduit par des changements géomorphologiques. Ce document présente une approche pour quantifier ce changement en réponse à l'ingénierie à l'aide d'une simple évaluation de la géomorphologie des flux à l'échelle d'un bief. Elle est basée principalement sur une analyse d'images aériennes, augmentée par l'utilisation de balayage laser aéroporté (LiDAR) et un travail de terrain ciblé. L'évaluation de l'ampleur des changements géomorphologiques génère un indice de caractère naturel. Cette approche offre un moyen rapide et économique d'évaluation de la diversité géomorphologique, vis-à-vis de la qualité des milieux ou de la condition de la rivière, qui est fonction de la structure physique d'un tronçon de la rivière. Nous suggérons l'intégration d'un indice de caractère naturel (NCI) comme outil pour surveiller les conditions de base et toute détérioration ultérieure du milieu, en réponse à l'activité humaine dans le chenal de la rivière.

ABSTRACT

River engineering changes river condition and habitat, which is reflected in geomorphic change. This paper sets out an approach to quantify this change in response to engineering using a simple assessment of stream geomorphology at a reach scale. This is based primarily on aerial photo interrogation, augmented by the use of airborne laser scanning (LiDAR), and developed by targeted fieldwork. Assessing the extent of geomorphic change generates an index of natural character. This approach provides a rapid, cost-effective means of assessing geomorphic diversity, vis-à-vis habitat quality or river condition, which is dependent on the physical structure of a river reach. We suggest the use of a natural character index (NCI) be incorporated as a tool to monitor baseline conditions and any subsequent deterioration of habitat in response to human activity in the river channel.

KEYWORDS

natural character, NCI, New Zealand, river geomorphology, river habitat

1. INTRODUCTION

Interrogating archive aerial photography that pre-dates river management schemes in New Zealand provides a means of assessing the pre-intervention 'natural character' of a reach. Reach characteristics can then be compared with more recent imagery to assess the extent to which reach geomorphology has changed following intervention. This can then be used as a baseline from which to measure future reach adjustment. Airborne laser mapping (LiDAR) provides a means of assessing floodplain and channel geomorphology in greater detail, precisely defining floodplain and channel parameters and identifying previous channel courses. Targeted fieldwork to quantify key parameters likely to change in response to river engineering (e.g. substrate characteristics) can be incorporated to refine understanding of reach character. As such the NCI can be used as an ongoing tool to monitor river condition in modified reaches before, during and after river engineering, as well as at sites upstream and downstream of river works to provide context for the impacts of intervention and disentangle human-induced change from naturally-driven changes.

NCI is not a detailed descriptor of river condition, unlike e.g. the Morphological Quality Index (MQI) (Rinaldi *et al*., 2013), or habitat assessment protocol (Parsons *et al*., 2004). However, its value lies in the relative ease and rapidity afforded by such a desk-based and targeted field assessment. It should not be understood as an absolute measure of habitat diversity and quality, but as a means of quantifying relative changes in geomorphic characteristics and habitat quality between successive phases of human intervention in river channels. Its usefulness lies in providing a simple score, which can be re-measured as part of ongoing river monitoring. Deterioration of the score should be avoided by deploying appropriate river management strategies, and rehabilitation schemes may seek to establish improvements in NCIs of degraded reaches. As such, NCI provides a useful, simple approach to quantifying habitat quality, which has hitherto been overlooked, particularly in New Zealand.

2. METHODOLOGY

Georectified aerial photography and LiDAR data were provided for this study by Greater Wellington Regional Council (GWRC) for three rivers in the GWRC region: Otaki, Waikanae and Hutt (Figure 1). Analysis was conducted in ArcMap® GIS, version 10.0 using LiDAR imagery dating from 2003, aerial photographs dating from 2010 and historically (Hutt- 1951, Otaki – 1939 and Waikanae – 1952) as well as topographic maps for each river. Each river is managed via a series of sub-reaches, which formed the basis for parameter measurement. The parameters measured are identified in the Results.

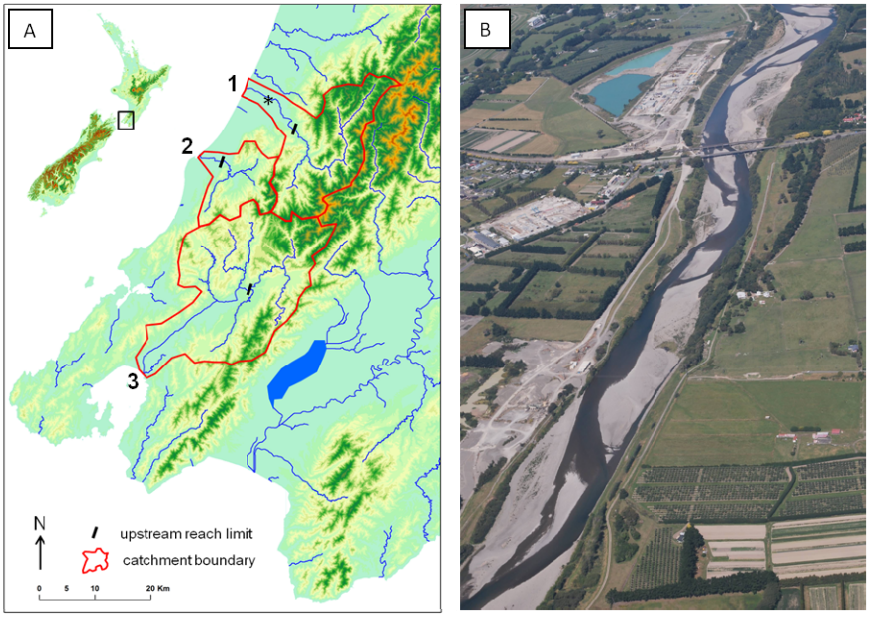

Figure 1. A. Catchment and reach locations: 1. Otaki River (11.8 km reach length), 2. Waikanae River (4.3 km reach length), 3. Hutt River (28.3 km reach length, main stem). B. Otaki River at XS600-490 (cf Table 1 and * in Figure 1A), typical of laterally constrained wandering rivers in this region, photo is looking upstream, bridges are State Highway 1 and railway respectively. Photo: ICF 31 March 2013.

3. RESULTS

Channel and floodplain widths were averaged for each management reach. The ratio of the mean value in 2010 to the mean historic value was then recorded for each reach. Table 1 provides exemplar results from the Otaki River. Channel sinuosity and braiding index (or thalweg length) were calculated for each management reach as a whole. A ratio of 1 indicates no change in parameter. A ratio <1 indicates a reduction in parameter value, indicating a decline in geomorphic diversity and habitat quality, whilst a ratio >1 indicates an improvement in river condition and habitat quality. The overall NCI value for each management reach is derived as a median of the parameter ratios for that reach. The use of the median in preference to the mean avoids skewing of data by single extreme values.

Table 1. NCI parameter ratios and overall median NCI, Otaki River

	XS220–XS120	XS370–XS220	XS490-XS370	XS600-XS490	XS720–XS600	XS860–XS720	XS1020 – XS860	XS1180–XS1020	**Median**
Sinuosity	0.92	0.91	0.99	0.83	0.86	1.21	0.97	0.97	**0.95**
Active channel	0.47	1.13	1.01	0.75	0.68	0.94	0.62	0.84	**0.79**
Bankfull channel	0.24	0.26	0.34	0.62	0.25	0.57	0.71	0.92	**0.45**
Permitted Floodplain	0.10	0.11	0.23	0.34	0.84	0.36	0.82	0.97	**0.35**
Thalweg length	0.41	0.59	0.79	0.47	0.94	1.53	1.06	1.01	**0.87**
Pools	0	0.32	0.64	0	0	0.75	1.26	0	**0.16**
OVERALL NCI	**0.41**	**0.32**	**0.64**	**0.62**	**0.68**	**0.75**	**0.82**	**0.92**	**0.71**

4. DISCUSSION

Evaluation of river natural character via a score based on geomorphic variables is inevitably highly generalised, since river morphology continuously varies downstream, in response to changing boundary conditions of discharge, gradient and sediment. It is nevertheless important that river character be classified using relatively homogenous reaches, so that variability in geomorphology and habitat within a reach does exceed that variability between reaches. This study has attempted to ensure this is the case by using reaches defined by current river managers in each river, as coherent management reaches, although hard and fast boundaries may be difficult to discern. It is important to make an assessment at this homogenous reach scale because the NCI of extended reaches masks substantial deterioration of river condition at the sub-reach scale at which the river is managed. If NCI is to be used as a management tool, it must be applied at the appropriate scale. Furthermore, appropriate parameters must also be measured: e.g. there is little to be gained in quantifying a braiding index if the river is only locally divided or lacks proper medial bar development.

With these limitations in mind it is our intention to refine the NCI approach using targeted field-based analysis of key habitat-forming parameters. Research is currently underway in the Hutt River to assess both the sensitivity of the NCI approach and its relevance for informing current practice. To do this, parameters including surface grain size and bed compaction based on field measurements are quantified upstream of river works, as well as at the modified site and downstream of the works site. Aerial photographs of these reaches before and after engineering will also be interrogated to derive the proportion of active channel that is riffle, pool, run and bar at these locations. This will enable the pre-engineering baseline (“natural” condition) to be compared with the effects of river works on these parameters, generating an NCI value which assesses the impacts of specific activity in the river channel. Assessment of reaches upstream and downstream of the works site will permit identification of any natural change trajectories in the channel, e.g. due to downstream progression of coherent bedload sheets, or the impact of a particular flow event.

LIST OF REFERENCES

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