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Ecological evaluation of reach scale channel configuration for watershed management

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Abstract

Reach-scale channel configuration (RSCC) such as braided, meandering, wandering or straight channels could be use as target condition in river management of watershed scale. This study aims at revealing relations between hydro-geomorphological RSCC and ecological diversity, and suggests one methods in evaluation of river condition using only aerial photo. The investigation was conducted on the Kizu River located in central Japan, where riverbed degradation and vegetation expansion proceeded after dam construction and sand excavation over a 65-year period. In order to evaluate RSCC, we classified type of aquatic habitat structure as one of the ecological parameters and analysed relations between RSCC and habitat structures/diversity. According to relations RSCC and habitat structures, wandering channel types tended to have higher potential of lentic and lotic habitat quantity and quality than single or braided channel.

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Keywords: Reach scale channel configuration, ecological evaluation, aerial photo, habitat structure

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1. Introduction

Information of ecological river condition based on evaluation of ecosystem is essential for river restoration and management. However, ecosystem survey takes a lot of times and labour for covering wide area, and local observed data (especially just fauna or flora) could be difficult to apply for river management in wide/watershed scale. Thus,

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ecological target indices for river management in watershed scale require. Reach-scale channel configuration (RSCC) such as braided, meandering, wandering, or anastomosing and straight channels could be use as target condition. RSCC can be classified by hydraulic-geomorphic parameters such as discharge and slope [1], depth-grain size ratio and width-depth ratio, sediment load and lateral stability [2]. These distinctive relations of RSCC patterns to hydraulic parameters indicate that we could predict changes in RSCC patterns from both empirical and computational data on hydraulic and geomorphic conditions including flow regimes or sediment supply. Therefore, if we could formulate the interrelationships among RSCC, habitat structure and ecological functions, hydro-geomorphic prediction of RSCC could be a powerful device for prediction of changes in a river ecosystem under human impacts on basin environments.

In this study, RSCC was evaluated by habitat structure and diversity as parameter of ecological diversity. Ecological characteristics of streams such as flora and fauna, biodiversity, and productivity are closely related to the reach scale geomorphology [3]. As most stream animals need a set of different habitats in different stages of their life cycles, such as deep-slow for feeding, backwater for resting, and gravel bars for spawning of some fish and invertebrates [4]. Thus, 'habitat heterogeneity hypothesis' [5] states that an increase in the number of habitats and/or an increase in their structural complexity leads to increased species diversity.

This study aims at revealing relations between hydro-geomorphological RSCC and habitat structure, and suggest one methods for evaluation of river condition using only aerial photo. The investigation was conducted on the Kizu River located in central Japan, where riverbed degradation and vegetation expansion proceeded after dam construction and sand excavation over a 65-year period. We classified type of habitats, and analysed relations between RSCC and habitat structures/diversity. And we discuss the appropriate target image of RSCC in terms of habitat structures in the Kizu River.

2. Methods

2.1. Study Site

The study area was established in the lower reaches (0~26km) of the Kizu River, a tributary of the Yodo River in central Japan. The Kizu River is a typical sandy river by weathered granite mountains in the upper stream, a basin with an area of 1,596 km^2. A total of 5 dams, Takayama Dam (constructed in 1969), Syourenji Dam (1970), Murou Dam (1974), Nunome Dam (1992), and Hinachi Dam (1999), are located in the basin. The peak discharge of the river is caused by seasonal typhoons in summer and autumn. The largest flood event occurred in 1959 and reached almost 6000 m^3/s, whereas intensity of peak discharge decreased by about 3,000m^3/s after the dam construction. The annual mean bed-load transported to the lower reach was estimated to be about 183,000m^3/y in the 1960s, but about 23,000 m^3/y in the 2000s. Due to sediment reduction resulting from the dam construction and sand excavation between 1958 and 1963, riverbed degradation was accelerated and has been continued in the lower reach (0 -10 km) until now [6]. In addition, reduction of peak discharge and sediment supply resulted in an expansion of vegetation including wood-land on the active channel and islands as well as on the terrace [7].

2.2. Materials

Aerial photos taken by the Yodogawa River Bureau between 1948 and 2010 were used to examine long-term changes in RSCC and habitat structures in the Kizu River. The orthorectified and georeferenced photos taken in 1948, 1961, 1971, 1979, 1990, 2002 and 2010 were compiled and overlaid sequentially using ArcView (Version 10, ESRI). We divided the study area into 2 km units according to the mean wavelength of meandering channels (mean wavelength: 1.93 km, range: 1.6-2.6 km).

2.3. Reach-scale geomorphic parameters

RSCC types were classified by [8] were used to show conditions of the Kizu River (26 km: No. 0 ~No. 26) (Table 1). RSCC types were classified using two geomorphic parameters (number of channels and sinuosity). Those types were specifically divided into single, slightly wandering (SW), quite wandering (QW), bifurcated wandering