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Evaluating the influence of road networks on landscape and regional ecological risk—A case study in Lancang River Valley of Southwest China

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ABSTRACT

In this paper, the methods of GIS buffer, spatial comparison, and scenario analysis were used to elucidate the influence of roads on landscape within Lancang River Valley. The results showed that forest and shrub land decreased while farmland and constructed land increased in the past 20 years in the study area. Also, the ecosystem's change rate near roads increased while the diversity evenness, patch density and human disturbance indices all decreased. Different aspects of road development had different negative consequences for the environment. In Lancang River Valley, forests were most affected by road network development, although there were also negative affects for grassland, farmland or shrub land and these differences varied by type of road. The greatest effects for forests were observed near high-level roads, while the greatest effects for farmland occurred near the low-level roads. Scenario analysis showed that the fractal dimension index, patch numbers, and average patch area of ecosystems decreased with development of road network density. The ecological risk analysis showed that various type roads cause different risk levels and that road density has a positive relationship with regional ecological risk level at county scale. Also, different ecological risk level exists in different level roads. Full road network data (density, level) should be considered to avoid the underestimate of the ecological effects.

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1. Introduction

The expansion and extension of road networks bring out many ecological effects (Li et al., 2003). This development of road networks in China is larger than many other construction projects in China, and research shows that roads and the area adjacent to those road construction zones cover 15–20% of American total geography land (Forman, 2000). The ecology of road construction is also a frontier in ecology research (Forman, 2004; Li et al., 2003; Zong et al., 2003). While there are preliminary studies on the effects of road construction on public health and ecosystems (Saunders et al., 2002; Merrill et

al., 1999; Forman et al., 2000; Forman and Deblinger, 2000; Hansen and Clewenger, 2005), few have been examined at an ecosystem-wide level (Liu et al., 2005; Hawbaker and Radeloff, 2004). The direct and indirect influences of roads on ecological processes vary widely from plant community to landscape level (Hawbaker and Radeloff, 2004; Schweitzer, 2005). On a large scale, these influences are multiplied by the density of road networks and mainly result in landscape pattern change in the road effect zone (Hawbaker et al., 2005; Hladnik, 2005).

Road development is a primary cause of habitat fragmentation, as construction removes original land cover, thus creating edge habitat. Roads alter landscape structure and

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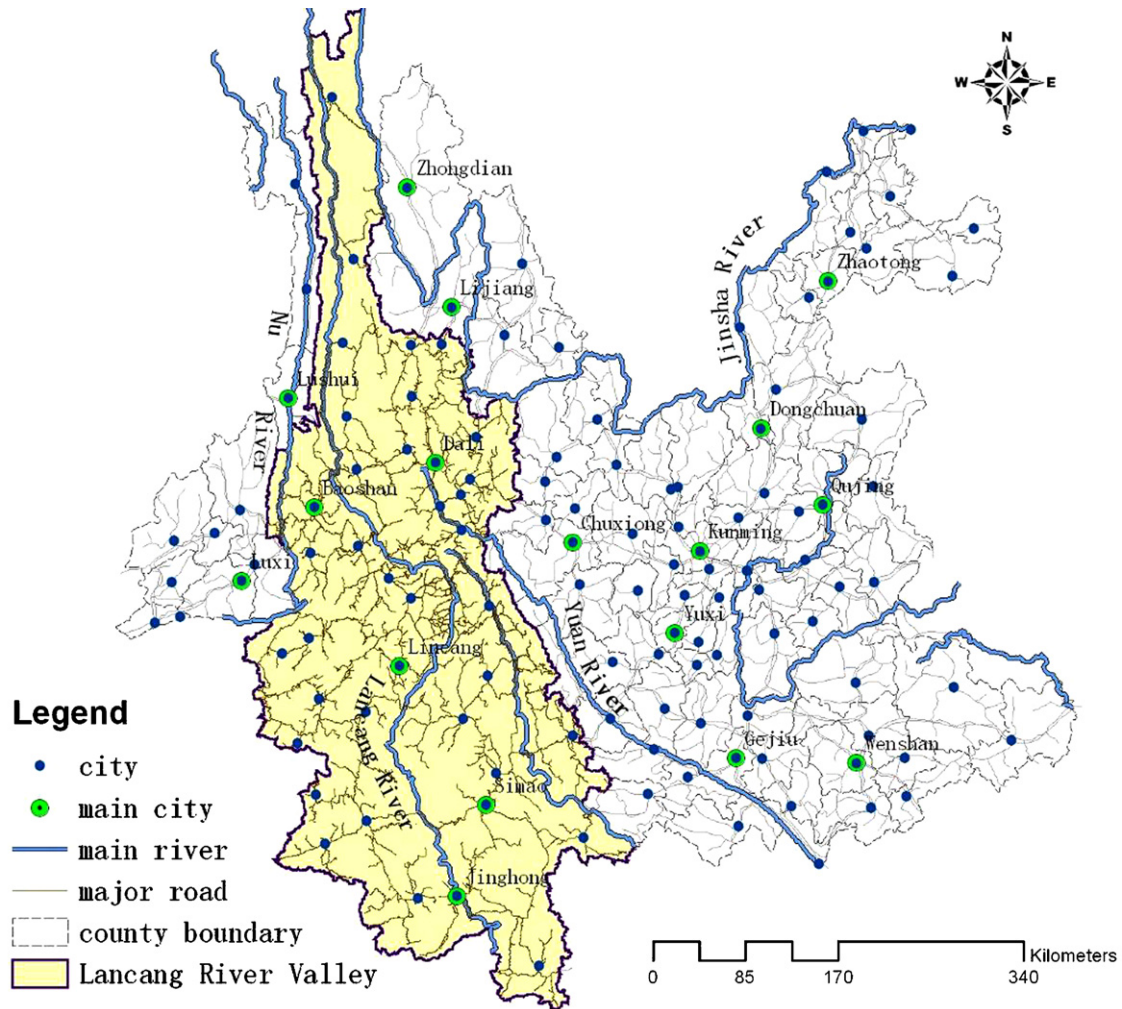


Fig. 1 – Location of Lancang River Valley in Yunnan province.

function and provide easy and feasible access for humans. The ecological results of road construction are primarily seen on the change and succession of landscape elements within the specific zone. Road establishment alters the landscape pattern, but the road itself is restricted by the landscape it is constructed within. As the indirect ecological effects of road construction and maintenance are difficult to predict and assess, researchers have become concerned about the potential and accumulative effects of roads on the physical and ecological landscape (Liu et al., 2005). It is useful to explore the relationships between landscape fragmentation and road networks for assessing the potential ecological risk level of roads, which may help estimate the scope of those ecological effects and lead to more ecologically and economically sensitive management of the road and its surrounding ecosystems (Li et al., 2004; Zhang et al., 2002). While many studies focus on the concept and framework the ecological effects particular to road construction and road use, few case studies are reported in China (Liu et al., 2005).

Currently, China is rapidly constructing new roads. In 2005, the total length of highways in China reached 193×10^4 km, including 4.1×10^4 km of expressways and 133.69×10^4 km of

county-town highways. Highways have been established in about 99.5% of towns and 92.3% of the villages in China. To realize the modernization of its transportation network, China's national road construction plan call for 200×10^4 highway kilometers, including 6.5×10^4 km of expressway by 2010; by 2050, the plan calls for 400×10^4 km of highways. As China continues to develop her western provinces, many high-level roads have been constructed in Yunnan Province to help connect western China to Southeast Asia. As highways account for more than 93% of the total transportation routes in Yunnan, road networks may be one of the largest single factors influencing ecosystems. Due to the unique ecological characteristics of the natural environment in Yunnan and the very important ecological important status of Lancang River Valley as a part of the Longitudinal Range Gorge Region in Yunnan Province, research on the ecological effects of road networks will have significant practical application in the region (Liu et al., 2005). In this paper, the Lancang River Valley was selected as an example to quantify the landscape pattern affected by road construction and to assess the ecological effect on regional ecosystem using a risk analysis method.

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