



## Ecosystem health assessment of the Liao River Basin upstream region based on ecosystem services



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### ABSTRACT

The upstream region of the Liao River Basin is the ecotone of agriculture–animal husbandry in northern China, whose ecosystem is relatively fragile. In recent years, the ecosystem structure, quality, and function in this region has been affected by anthropogenic and natural disturbances, including ecological protection, conservation measures and regional climate change. The ecological functions of the upstream region and western headwaters of the river are vital for sustaining a healthy ecosystem of the whole basin. Previous assessments of the ecosystem health focused on the inner construction and integrity, and less on the ecosystem processes and function. However, we consider that a healthy and balanced ecosystem needs inner integrity and stabilization in process and construction, and the capacity to perform essential ecosystem functions in a larger spatiotemporal scale. In this study, we developed the VOR model to the VORS model via the introduction of ecosystem services, established the assessment framework containing V (Vigor: net primary production [NPP]), O (Organization: area proportion of nature ecosystem, Shannon Diversity Index [SHDI], Contagion Index [CONTAG]), R (Resilience: ecology elasticity), and S (Service: water conservation, soil conservation). These seven indices formed four criterion layers. The upstream region was divided into four subregions according to sub-basins extracted by a digital elevation model. Finally, we conducted a comprehensive assessment of ecosystem health and variations for this region, based on the results of the “Ecosystem Survey and Assessment of Liao River Basin (2000–2010)”. We made three major conclusions. First, the VORS model could significantly improve the recognition of ecosystem health assessments by also evaluating ecosystem services. The new assessment model used ecosystem states and process connotations to comprehensively assess ecosystem health. Second, from 2000 to 2010, ecosystem health in the upstream region improved as a whole, mainly due to improvements in ecosystem vigor driven mainly by local climate change. The O and R indices were relatively stable. The ecosystem service indices showed strong spatial heterogeneity in the region, and changed little in this period. Finally, there were significant spatial differences in ecosystem health in this region. In general, the west regions were better than the east, ecosystem health of regions in descending order is as follows: Laoha River sub-basin > Xiliao River sub-basin, and Xila Mulun River sub-basin > Xinkai River sub-basin. Moreover, improvements in ecosystem health were greater in the mainstream sub-basins than in the branch sub-basins. Thus, the eastern regions are key areas for ecosystem health conservation, and ecosystem service is the principal constraint for local ecosystem health. Therefore, conservation of main ecosystem service capacity can drive improvements to ecosystem health.

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### 1. Introduction

Research on ecosystem health assessment (EHA) and management has gained increasing attention in recent years. Such studies have gained significance because they facilitate environmental management, played increasingly important function of support and reference [1]. There are different concepts of ecosystem health, of which the mainstream and more accepted concepts have been described by Costanza

and Rapprot, respectively. Costanza proposed that system organization, resilience and vigor, as well as the absence of signs of ecosystem distress are necessity for healthy ecosystem [2]. On the other hand, Rapprot defined a healthy ecosystem as one that is stable and sustainable such that it maintains its organization and autonomy over time and its resilience to stress [3].

At present, there are three main scales of EHAs from a macro-perspective: a single ecosystem, a landscape/regional ecosystem, and a global nature ecosystem. There are differences between the research objectives for different scaling; the regional ecological system is a more basic ecosystem-type, and the assessment of regional ecosystem

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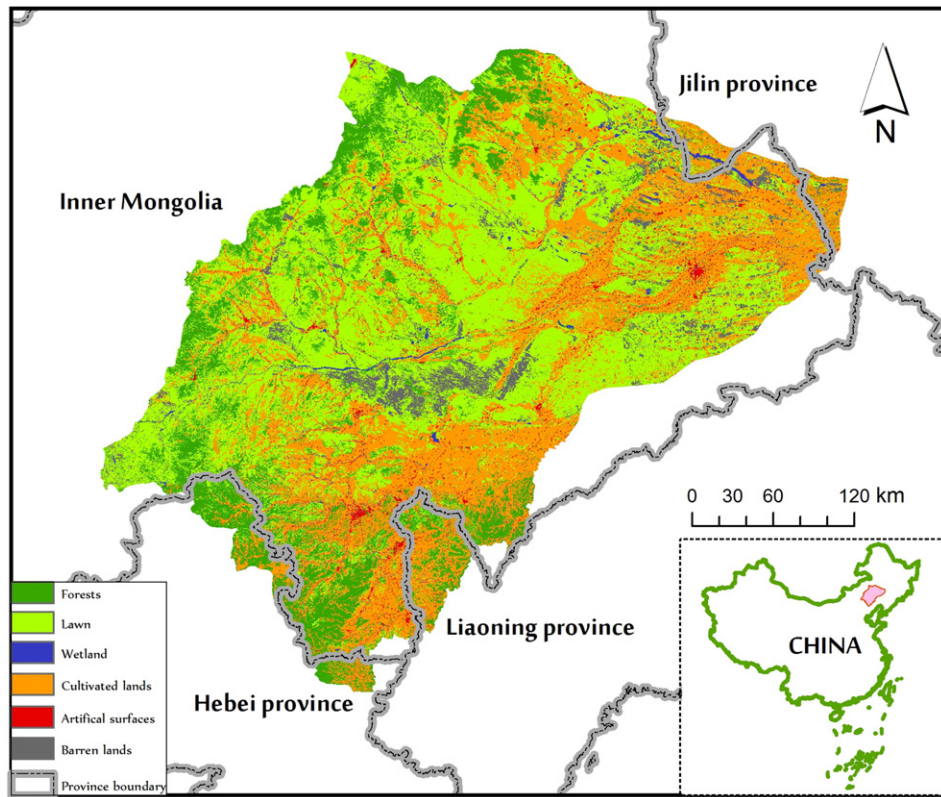


Fig. 1. Geo-location and ecosystem-type of study area.

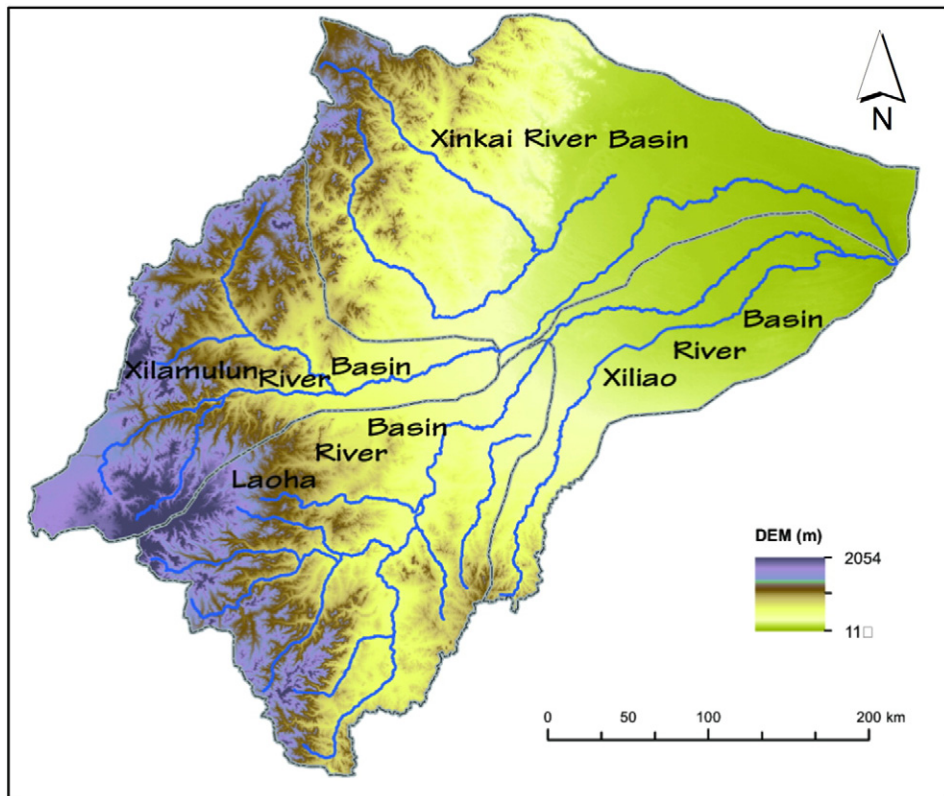


Fig. 2. Sub-basins of upstream of Liao River Basin.

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