Supplementary information to the paper

Sediment Source Fingerprinting and its Control Strategies of the Lakes in Jiuzhaigou World Natural Heritage Site

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Supplementary Table S1. Basic parameters of the lakes in Jiuzhaigou Valley World Natural Heritage Site.

Lake	Altitude (m)	Length (m)	Width (m)	Depth (m)	Degree of earthquake impact
Rhino Lake	2301	2000	225	17	Less impact
Arrow Bamboo Lake	2629	1184	144–268	5–10	Heavier impact

Data source: Jiuzhaigou official website (https://www.jiuzhai.com/).

Supplementary results. Factor characteristics of potential sediment sources of lakes

Particle size characteristics

Soil physical properties are important indices for identifying sediment sources, and soil particle size has been widely used in fingerprint identification analysis [48]. The grain size distribution in different source areas of Arrow Bamboo and Rhino lakes was primarily composed of silt and sand, and the proportion of clay particles was the lowest (2.5–9.8%). The proportion of sand was highest on the forest side and that of silt was highest on the highway side (Fig. S1). The proportion of particle size in the sediments of the two lakes was between that of the forest-side and roadside soils (except for the proportion of clay particles in Arrow Bamboo Lake (Fig. S1), indicating that different sources contributed to lake sediments.
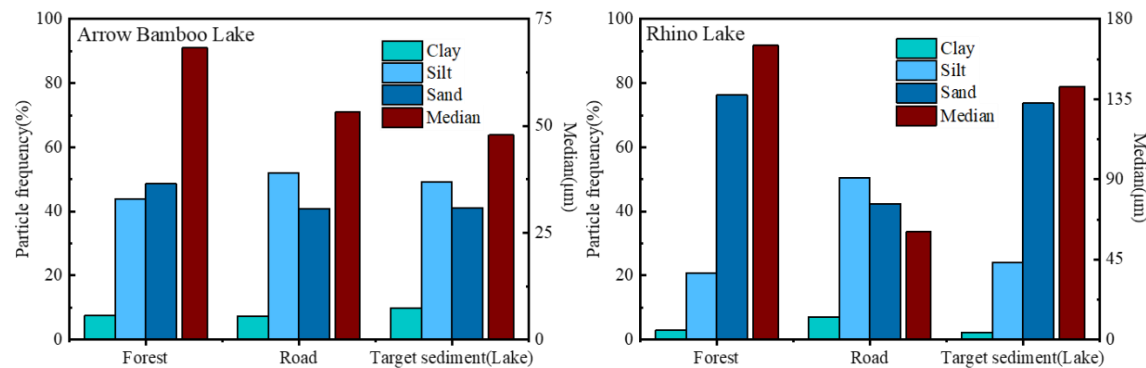

Supplementary Figure S1 Particle size distribution of different origins in Arrow Bamboo and Rhino lakes

Nutrient elements

Soil C, N, and P are essential nutrients and elements for plant growth, important components of soil nutrients, and important indicators of soil characteristics. For example, the usual concentrations of total organic carbon (TOC) and TN decrease with increasing soil depth [53] and can be used to distinguish sediments from surface and subsoil erosion processes [15]. The contents of TC, TN, and TP in the sediment and surrounding soil of Rhino Lake were typically higher than those of Arrow Bamboo Lake, especially in the soil on the forest side (except for the contents of TC and TN on the road-side, Fig. S2). This indicates that the aquatic vegetation of Rhino Lake grows better and the degree of damage to the mountains and roads on both sides is less, while the source of earthquake damage in or around Arrow Bamboo Lake was greater, and the nutrient content was correspondingly lower.

There were differences in the spatial distribution of nutrient elements in the sediments of the two lakes and soils from different source areas. The TC content in the sediments of Arrow Bamboo Lake was higher than that of the forest or highway-side soil, whereas the TN content in the sediments was slightly lower than that of the forest or highway side soil. The contents of TC and TN in the sediments of Rhino Lake were as follows: soil on the road-side < lake sediment on the forest side. The TP content of sediments in both lakes was lower than that of soil on the forest or road-side (Fig. S2). This indicates that the surrounding environments of the two lakes are different, especially on the forest-side.
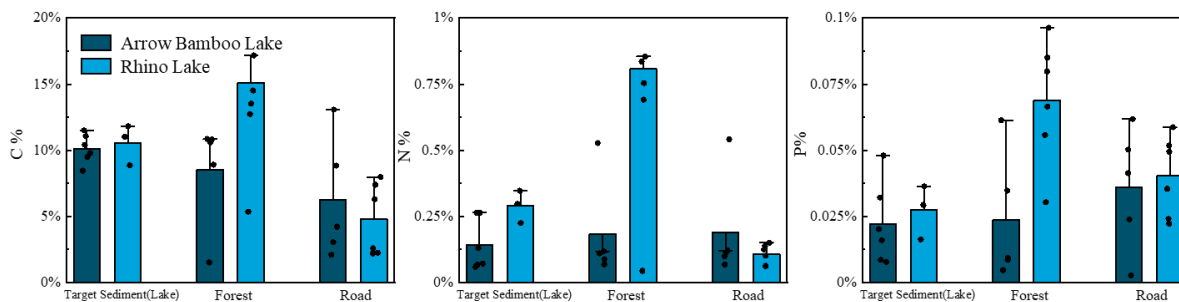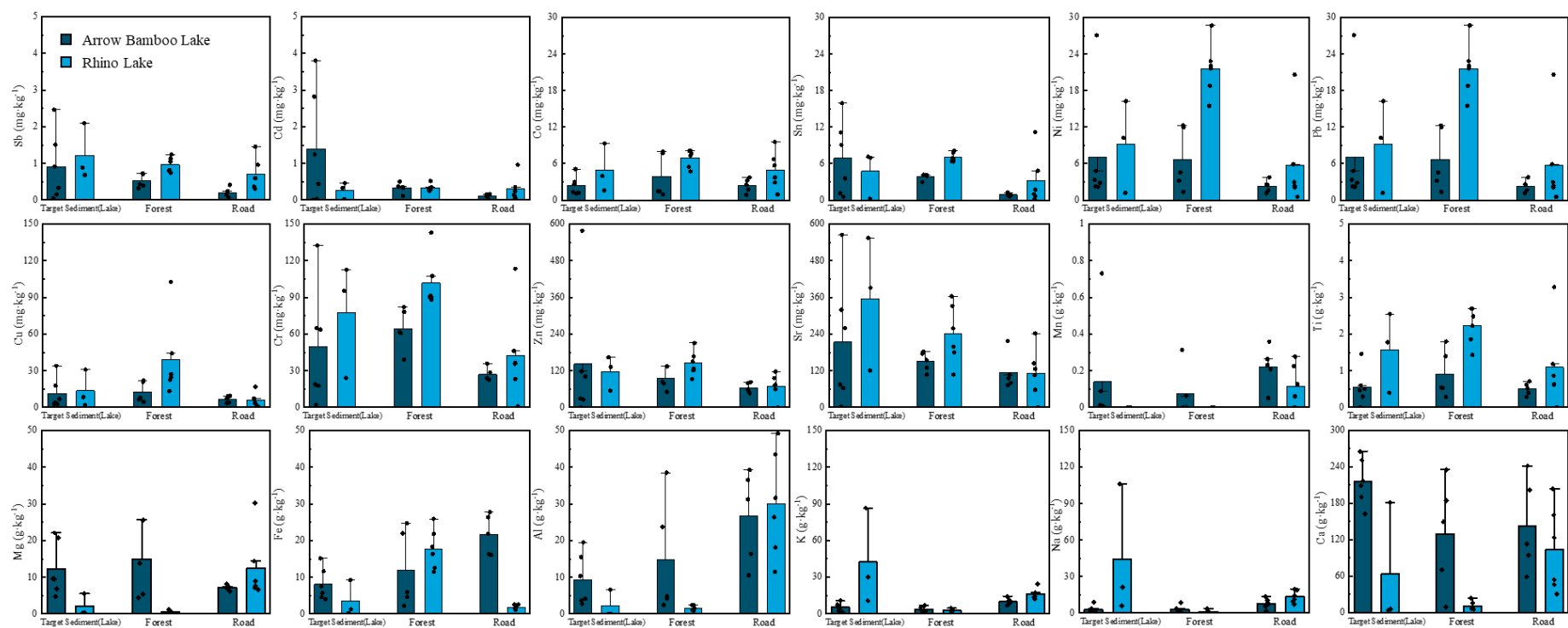

Supplementary Figure S2 Distribution of TC, TN, and TP content in different land types near Arrow Bamboo and Rhino lakes

Metal elements

Major and trace elements (including rare earth elements) are often used to identify the different spatial sources of sediments [15,49]. The contents of different metals in the sediments of the two lakes and soils from different sources can be divided into four orders of magnitude. The highest contents were Ca, Na, K, Al, Fe, Mg, and Ti in the order of g·kg^{-1}. The next highest contents were Mn, Sr, Zn, and Cr, which were in the order of 100 mg·kg^{-1}. The Cu, Pb, and N contents were in the range of 10–100 mg·kg^{-1}. Finally, the Sn, Co, Cd, and Sb contents were in the lowest order of magnitude and were distributed below 10 mg·kg^{-1} (Fig. S3). Generally, the contents of metal elements in the sediment and surrounding soil of Rhino Lake were higher than those of Arrow Bamboo Lake. This may be because Rhino Lake is located near the entrance of the scenic area, where human activities are intensive and upstream water is absorbed, which is more likely to delay the retention of various metal elements. Particularly, the contents of Al, Fe, Mn, Ca, and Mg in sediment and surrounding soil and Cd in lake sediment of Arrow Bamboo Lake were significantly higher than those of Rhino Lake, Fig. S3.

In addition, the contents of the same heavy metals in different sources of the two lakes were as follows: heavy metal content in the sediments of Rhino Lake was mainly between the content in the soil on the road-side and forest-side (including Cr, Co, Zn, Cd, Ni, Cu, Pb, Fe, Ti, Sn, Ca, Mg, and Al), or higher than those in the soil of the road-side or forest-side (including Sb, Na, K, and Sr) (except for Mn). Heavy metal content in the sediments of Arrow Bamboo Lake was typically higher than that of the roadside or the forest-side soil, including Zn, Cd, Ni, Sb, Pb, Sn, Sr, and Ca. Some of them in the lake sediments were between the soil of the roadside and forest side, such as Cr, Co, Cu, Mg, Ti, K, and Mn. Only the content of Na, Al, and Fe in the sediments was lower than that of the soil on the roadside and forest side (Fig. S3), indicating that there was a difference in metal element input between the two lakes.

Supplementary Figure S3 Distribution of heavy metal content in different land types from Arrow Bamboo and Rhino lakes.