# Congo's blackwater Ruki River is a major transporter of forest carbon, study shows

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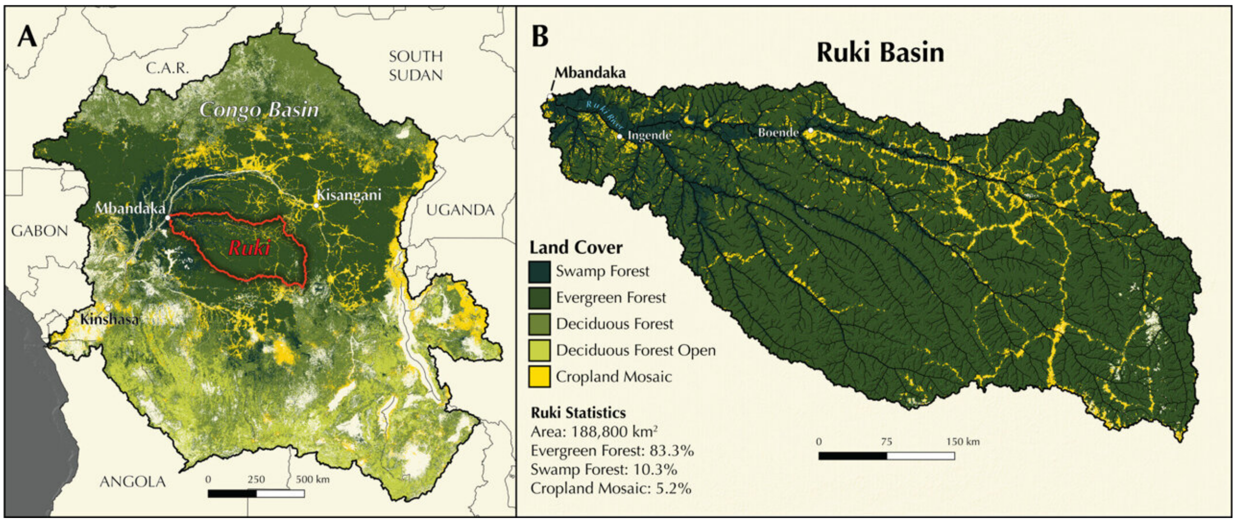


Map of the Congo Basin (A) with the Ruki sub-basin highlighted in red. Detailed map of the Ruki Basin with sampling location at Mbandaka shown in panel (B). Land-cover data sourced from ESA CCI-LC 2021 data. Credit: *Limnology and Oceanography* (2023). DOI: 10.1002/lno.12436

The Congo Basin of central Africa is well known for its network of rivers that drain a variety of landscapes, from dense tropical forests to more arid and wooded savannas. Among the Congo River's large tributaries, the Ruki is unique in its extremely dark color, which renders the water opaque below a few centimeters' depth.

This large blackwater river caught the attention of our carbon biogeochemistry research team when we visited its confluence with the Congo River at the city of Mbandaka. Mbandaka is a small city in the Democratic Republic of Congo, located about 600km upstream from Kinshasa on the Congo River. The area around Mbandaka is known as the Cuvette Centrale and is characterized by its vast low-lying topography, much of which floods during the rainy season and results in extensive swamp forests.

As we watched the placid dark water of the Ruki flow by, we wondered just how much carbon this river was transporting and where it came from. To answer these questions, we decided to measure the carbon in the Ruki for one year to account for seasonal changes.

The results of this study show that the Ruki is a major contributor of dissolved carbon to the Congo River, and that the majority of this carbon is sourced from the leaching of forest vegetation and soils. These results also suggest that the way in which calculations are made about how much carbon tropical forests accumulate might be off the mark—perhaps slightly overestimated.

These findings are important because rivers are major conduits of carbon from land to ocean and atmosphere, supplying organic matter to downstream ecosystems and carbon dioxide to the air. It is important to quantify how much carbon they are moving, where it is coming from, and where it ends up. Such accounting helps scientists understand how different ecosystems function, what role they play in the carbon cycle, and how they might respond to future or ongoing human perturbations such as climate or land-use change.

## The heart of the forest

The Ruki River lies at the center of the Congo Basin. It drains a uniquely homogeneous 188,800km$^2$ of pristine lowland and swamp forests. Since climate, vegetation, soils, geology and the concentration of human impacts vary widely across Earth's surface, it's uncommon for a watershed of this size to have such uniform land cover. There are likely no other such uniform watersheds of this size on earth.

This means we had an opportunity to pinpoint how a specific land cover influences the quantity and composition of organic material leached from decomposing plants and soils and carried by rainwater to river channels. Knowing this, we can "unmix" the signals measured in the Congo River and better ascertain the differences in carbon export between the many tributaries and land covers of the basin.

We found that Ruki supplies 20% of the dissolved carbon in the Congo River though it makes up only 5% of the Congo's watershed by area. This contribution is so high because the Ruki's water is extremely concentrated in dissolved organic matter. In fact, it is significantly richer in dissolved carbon than even the Amazon's Rio Negro ("Black River"), which is famous for its black color also stemming from high concentration of organics.

Water with very high concentrations of organic matter signals neither a good nor bad thing. It just means lots of carbon is contained in the water.

Because the Ruki watershed is so flat, rainwater drains slowly and has plenty of time to leach organic material from its dense vegetation. It's like leaving multiple bags of tea to steep in water over a long period of time.

One of the reasons we wanted to know where these organic compounds were originating from is that large areas of the Ruki are underlain by enormous tracts of peat-like soils. These organic-rich soils have accumulated over hundreds to thousands of years from the buildup of partially decomposed plant matter.

If this peat was being leached or eroded into the river, through some form of disturbance, it could be released as carbon dioxide into the atmosphere and compound the greenhouse effect, much like the unearthing and combustion of fossil fuels.

Our radiocarbon isotopic measurements of the dissolved carbon indicate that there is very little peat carbon entering the river (none of it is very old), and that the dissolved carbon is sourced instead from forest vegetation and recently formed soil.

This is good news for now, but it's something to keep an eye on if periods of drought or human activity disturb these carbon-rich peat soils.

## Balancing the forest sink

Why does it matter if the Ruki transports a large amount of carbon?

One answer is that the carbon lost from terrestrial ecosystems to rivers can determine whether forests are taking up more carbon from the atmosphere (sinks) than releasing it (source) to the atmosphere. Most assessments of the balance (carbon coming in versus carbon going out of a forest) fail to account for the carbon that moves laterally to rivers.

In the case of the Ruki, the high amount of carbon that is contained in the river per unit area of the watershed suggests that this lateral movement of carbon from the Congo's lowland forests comprises a significant proportion of the carbon balance, that is, the difference between what is coming in from photosynthesis and what is returned via respiration.

Thus, tropical forests like those around the Ruki might not accumulate quite as much carbon as we once thought. Further research is required to pin down whether this is the case. But our work on the Ruki already indicates that areas drained by such blackwater rivers may be particularly prone to carbon accounting errors like this.



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