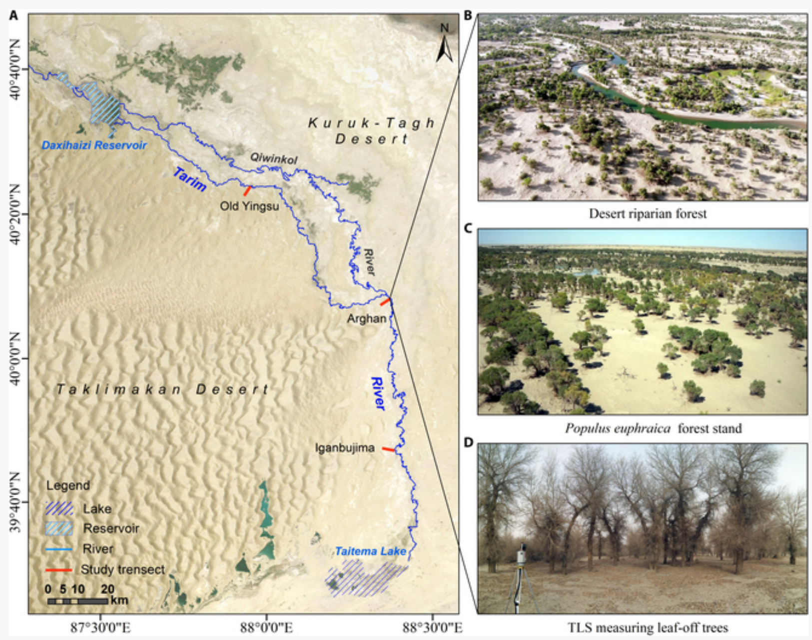
Desert poplar study advances carbon and conservation insights

GA, UNITED STATES, September 12, 2025 /EINPresswire.com/ -- Researchers have developed advanced, non-destructive models to measure the aboveground biomass and volume of Populus euphratica, a keystone tree in desert riparian forests. By combining terrestrial laser scanning (TLS) with quantitative structure modeling (QSM), the study produced more accurate estimates across both small and large trees. These models reduce errors by nearly half compared to traditional equations, providing new tools for forest conservation, carbon storage assessment, and ecosystem management in arid environments.



Study area and field photos. (A) Map of the study area showing the land use types and distribution of the ground survey transects (indicated by red lines). (B to D) Photographs of sampling sites illustrating the P. euphratica forests.

The Euphrates poplar (Populus euphratica) dominates riparian forests in arid Central Asia, where it stabilizes ecosystems, prevents desertification, and supports biodiversity. However, decades of water over-extraction and climate change have severely degraded these forests, with nearly 60% of trees in parts of the Tarim River showing signs of decline. Accurately assessing tree biomass is critical for monitoring forest health and carbon storage, yet destructive sampling is prohibited for this endangered species. Traditional biomass equations are limited by small sample sizes, particularly underestimating large trees. Based on these challenges, there is a need for nondestructive, universal methods to quantify and monitor biomass in P. euphratica forests.

A new study published on August 7, 2025, in Journal of Remote Sensing by researchers from Peking University, Xinjiang University, and the Chinese Academy of Sciences introduces a breakthrough approach to estimating biomass in Populus euphratica forests. Using terrestrial laser scanning (TLS) and quantitative structure modeling (QSM), the team addressed long-standing gaps in monitoring these endangered desert trees. This innovation replaces destructive field methods with precise 3D reconstruction, offering a vital tool for sustainable forest management in one of the world's most fragile ecosystems.

The study analyzed 177 trees along the lower Tarim River, with diameters ranging from 5 to 105 cm. New allometric equations based on TLS-QSM data achieved exceptional accuracy ($R^2 \geq 0.94$), cutting root mean square error (RMSE) by 40–50% compared to earlier models. For example, biomass estimates ranged from 3.07 to nearly 2,000 kg, while volumes spanned 0.01 to 4.25 m^3. Importantly, the new models effectively captured large trees that older equations underestimated, ensuring balanced assessments across tree sizes. Even when tree height data were unavailable, diameter-based models retained high predictive power. These findings mark a significant advance for non-invasive biomass monitoring.

Researchers employed multi-station TLS to generate dense 3D point clouds of desert poplar stands. With an average resolution of 40,000 points per square meter, they reconstructed tree structures using QSM, which models trunks and branches as nested cylinders. Volumes were converted to biomass by applying size-specific wood density data from the Tarim River region. The new equations, particularly those combining diameter at breast height and tree height ($H \cdot DBH^2$), provided the best predictive accuracy. For aboveground biomass, the model yielded an R^2 of 0.95 and an RMSE of 67.07 kg. For volume, accuracy reached $R^2 = 0.94$ with RMSE = 0.15 m^3. Compared to traditional equations developed from smaller sample sets, the new models better captured structural diversity and minimized errors for larger trees. The results provide robust foundations for regional biomass assessment and carbon accounting in desert riparian forests.

"Our work demonstrates that TLS can revolutionize biomass estimation for endangered desert trees," said Shengli Tao, corresponding author of the study. "By moving away from destructive sampling, we not only preserve these fragile ecosystems but also improve the accuracy of our measurements. These models can guide conservation, carbon management, and restoration efforts in some of the world's most threatened forests."

The team scanned desert poplar stands along a 200 km stretch of the lower Tarim River using a Riegl VZ-1000 terrestrial laser scanner. After preprocessing point clouds, individual trees were segmented and reconstructed with QSM algorithms to calculate trunk and branch volumes. Wood density data, stratified by diameter class, enabled conversion of volume to biomass. Multiple parameter tests ensured optimal reconstruction accuracy, while nonlinear regression produced new allometric equations. The models were validated against TLS-derived values, showing superior accuracy compared with existing equations.

The study's new models open opportunities for scaling biomass monitoring across regional and even global dryland forests. By integrating these equations with satellite LiDAR missions such as GEDI and ICESat-2, researchers can estimate biomass and carbon stocks at larger scales. This advancement strengthens the scientific basis for desertification control, climate change mitigation, and ecological restoration in Central Asia. In the long term, the approach could be adapted to other protected species worldwide, offering a pathway toward nondestructive, precise forest management.

References
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