Study on DBH-structure of *Populus euphratica* and their spatial distribution in the lower reaches of Tarim River, northwest China

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Abstract

Combining spatial large-scale survey and selective plot investigation, we examined the distribution and diameter at breast height (DBH) of *Populus euphratica* trees in 100 hm² of the Arghan transect in the lower reaches of the Tarim River, NW China. Within 20 m of the river, the proportion of young trees with DBH<4 cm was the greatest, at 13.24 %. With increasing distance from the river, the proportion of young trees gradually dwindles. DBH distribution is simple; the proportion of trees with DBH ranging from16 to 36 cm is the greatest in the whole forest community. In addition, the further from the river, the higher the proportion of the over-mature and effete forests, with DBH > 48 cm. Within 200 m of the river are 80 % of the poplar forest of *P. euphratica* trees with high vitality, with crown density of 0-50 %. From 200 to 400 m of the river, the proportion of over-mature forests and effete forests with trees of crown density between 50 % and 75 % and lower vitality begins to increase. At more than 400 m from the river, the density of *P. euphratica* begins to decrease greatly, with the proportion < 5 %.

Keywords: DBH structure, *Populus euphratica*, Tarim River, tree distribution.
Introduction
Water is the foundation of the composition, development and stability of the oasis ecosystems and the key ecological factor in arid areas\textsuperscript{[1]}. The ecological environment in the arid areas of western China is extremely vulnerable, the contradiction between the ecological protection and economic development is increasingly extrusive during the exploitation and utilization of water resources\textsuperscript{[2]}. The Tarim River is located in Xinjiang Uyghur Autonomous region in northwest China, is the longest inland river in the country with its 1320 km mainstream, river basin has abundant natural resources yet fragile ecological environment\textsuperscript{[3]}. \textit{Populus euphratica} Oliv. is the dominant tree species in this region\textsuperscript{[4]}, it plays an indispensable role in remaining the balance of regional eco-environment, sand-fixation, regulating the oasis climate and fertile forest soil formation, considered as the natural barrier in basin and agricultural development\textsuperscript{[5]}. Recent five decades has witnessed the significant change of natural ecological environment of the river basin due to the un-rational utilization of water resource for socio-economic development activities\textsuperscript{[6]}. Especially in the lower reaches of Tarim River, \textit{P. euphratica} as the main vegetation subject for the ecosystem and ecological processes has been severely impacted by the artificial spatio-temporal variation of natural water resources and seriously degraded\textsuperscript{[7]}. With the implementation of emergency water transfer to the lower reaches of Tarim River from 2000, numbers of research activities have been carried out to evaluate the effect of water transfer on the restoration level of riparian forests\textsuperscript{[8-14]}. In this paper, based on the vast monitoring data from 2005 and 2006, through the analysis on DBH structure of \textit{P. euphratica}, reveal the transverse distribution of \textit{P. euphratica} with different DBH from the river channel and the spatial distribution of \textit{P. euphratica} by the effect of groundwater variation to provide a scientific basis for the quantitative assessment of the Tarim River ecological restoration process.

1 Study area description
The lower reaches of Tarim river refers to the part of the river from Qara village of Lopnur county to its terminal lake Tetima, with 428 km length, located between Taklimakan and Kuruk desert, 39°25′13″-41°02′36″ N; 86°32′14″-88°57′12″ E, in long narrow southeast direction, featured by continental extremely arid desert climate, with very weak ecological environment. The annual precipitation of this area is about 17-42 mm, with extreme aridity and windy weather, regarded as one of the most arid places in the China\textsuperscript{[15]}. From 1970s, the flow cutoff and lack of surface water recharge result in the decline of groundwater level, deterioration of natural vegetation which is highly rely on groundwater, large scale degradation of \textit{P. euphratica}-the dominant tree species and activation of the forest sandy land. Along the lower reaches of Tarim River distributed desert riparian vegetation with relatively simple structure, in some areas grow halophytic desert plants. Main trees are \textit{Populus euphratica}, \textit{Elaeagnus angustifolia}, main shrubs are \textit{Tamarix spp.},
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Halimodendron holodendron, Lysium ruthenicum, Phragmites communis, Poacynum hendersonii, Alhagi sparsifolia, Glycyrrhiza inflate[16,17,12].

Study site Arghan (40°08′50″ N, E88°21′28″ E) is located at the cross section of two main water ways of old Tarim River and Qiwickol River in the mid-lower section of the lower Tarim River, so the vegetation coverage of this area is relatively high, restoration level of *P. euphratica* after emergency water transfer can be observed obviously.

![Fig. 1 Sketch map of the Tarim River](image-url)
2 Materials and methods
In Arghan transect, long-term monitoring plots with an area of 100 ha established (includes 100 plots of 100×100 m size). All these plots are divided into 11 fixed measuring belts according to their distance from the river bed as 0-20 m, 20-50 m, 50-100 m, 100-200 m, 200-300, 300-400 m, 400-500 m, 500-600 m, 600-800, 800-1000 m and above 1000 m which extends far to the interlaced zone of forest and desert, includes total of 5000 *P. euphratica* trees. These plots were established in August of 2005. Extensive observing on major growth parameters of *P. euphratica* such as diameter at breast height (DBH), tree height (TH), crown diameter (CD) and crown loss (CL) had been carried out and their digital photos had been taken for the systematic analysis on DBH structure and distribution of *P. euphratica*.

3 Results and discussion
Firstly, the DBH of *P. euphratica* in each measuring belts have been classified into different groups, most of the *P. euphratica*’s DBH is bigger than 72 cm so they are in categorized 18 groups each is separated by 4 cm, only a small number of *P. euphratica*’s DBH bigger than 72 cm, hence, they are classified into one group.

3.1 DBH structural feature of *P. euphratica*
After recent years of water delivering to the lower reaches of Tarim river, groundwater level raised, soil moisture content increased, so there have been developed numerous juvenile *P. euphratica* in the first measuring belt (in 20 m vicinity to the river), with the highest percentage of 13.24 %. With the increasing distance from the river, the percentage of juvenile *P. euphratica* decreases, over-matured and bad vital *P. euphratica* which has DBH of >48 cm increases, DBH distribution range becomes simple. *P. euphratica* within DBH range from 16 cm to 36 cm dominates the highest percentage (Fig. 2).
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3.2 Spatial distribution feature of *P. euphratica* forest

(A) The percentage of each DBH group of *P. euphratica* at distance 0-20 m away from the river; (B) The percentage of each group of DBH of *P. euphratica* at distance 20-50 m away from the river; (C) The percentage of each group of *P. euphratica* DBH at distance 50-100 m away from the river; (D) The percentage of each group of DBH of *P. euphratica* at distance 100-200 m away from the river; (E) The percentage of each DBH group of *P. euphratica* at distance 200-300 m away from the river; (F) The percentage of each group of DBH of *P. euphratica* at distance 300-400 m away from the river; (G) The percentage of each group of DBH of *P. euphratica* at distance 400-500 m away from the river; (H) The percentage of each group of DBH of *P. euphratica* at distance 500-600 m away from the river; (I) The percentage of each group of DBH of *P. euphratica* at distance 600-800 m away from the river; (J) The percentage of each group of DBH of *P. euphratica* at distance 800-1000 m away from the river; (K) The percentage of each group of DBH of *P. euphratica* at distance more than 1000 m away from the river.
In Arghan transect, density of the *P. euphratica* trees on two sides of the river diminishes with the increasing distance from the river, but due to the effect of topographic feature, human activity and old water ways in the middle section of the investigation plots its density rises. 80 % of *P. euphratica* are located within 200 m distance to the river, and CL of 70 % of them is between 0 %-50 %. According to the DBH structural characteristics, higher proportion of juvenile *P. euphratica* which is the decisive indicator for the steady development of *P. euphratica* community are located in the first measuring belt (0-20 m to the river) where the groundwater level and soil moisture content is higher. From 200 m-400 m of the river, the proportion of over-mature *P. euphratica* with CL between 50 %-75 % and lower vitality begins to increase. At more than 400 m from the river, due to the sharp decline of groundwater level, unable to meet the needs of growth and regeneration of *P. euphratica*, its density begins to decrease greatly, with the proportion <5 %, majority of them are with very low vitality, Fig. 3.

**Fig. 3 Growth distribution of *P. euphratica* (S: crown density)**

### 3.2.1 Impact of groundwater level on *P. euphratica* distribution

In the lower reaches of Tarim River, soil salinization does not happen through the strong salt accumulation process when the groundwater depth is higher than 3 m. Under the condition of groundwater depth which is lower than 4.5 m, trees and shrubs grow normally, and desertification does not happen. Considering the current situation of water shortage and main vegetation types (mainly *P. euphratica* and *Tamarix* spp.) in this region, the most reasonable groundwater depth range remains between 3.5 and 5.0 m\[^{10,18}\], excess of this range cause the weakening of *P. euphratica* growth and its eventual death\[^{19}\]. Monitoring data of groundwater wells in this region showed that the groundwater level decreases with the increasing distance from the river. Fig. 4:
Groundwater depth of this region is about 6 m, besides it increases with the increasing distance from the river, vitality of *P. euphratica* diminishes with this trend, most of the *P. euphratica* at farthest sites from the river are with lower vitality because of the lower groundwater level which is not favorable for maintaining the growth of riparian vegetation.

### 3.2.2 Impact of human activity on *P. euphratica* spatial distribution

Recent years, as the result of ecological water transferring, *P. euphratica* trees on two sides of the river are growing at good vitality, besides, juvenile *P. euphratica* in this area occupies the biggest proportion, forest growth exhibited good trend. In some areas where with intensive human activity, with the increase of agricultural land, surface water and reduce of groundwater recharge, groundwater level declines, in addition, *P. euphratica* community severely damaged due to the deforestation activity, so the over-mature *P. euphratica* forest community with bad vitality dominated this region. From the beginning of water transferring since 2000, in order to reach the water successfully to the Tetima lake, Tarim River administration bureau implemented several projects to channel off water ways, this impacted the spatial distribution of *P. euphratica* forest to some degree.
4 Conclusions
Through the above analysis on DBH structure and distribution characteristics of *P. euphratica* forest, it can be concluded that:

1. In the lower reaches of Tarim River, different vitality and number of *P. euphratica* located correspondingly to the distance from the river, in the river vicinity area, the number of *P. euphratica* are greater and with good vitality, while at far sites from the river, density and vitality of the *P. euphratica* forest diminishes, most of them are old-mature and dead. But in the whole study area, *P. euphratica* with DBH<36 cm dominates the highest proportion, this indicates that the *P. euphratica* community is at steady developing stage.

2. The influencing factors of *P. euphratica* spatial distribution are groundwater depth, old water ways and human activity, among these, groundwater depth is the most decisive one, with the increasing distance from the river, groundwater level decreases and resulting in the diminishing vitality and density of *P. euphratica* forest.

3. After 8 years of water transferring, *P. euphratica* community in the vicinity area to the river channel recovered at certain degree, this mainly due to the raised groundwater level after recharged by the transferred water, but the *P. euphratica* community at far sites from river are with low regeneration capacity, most of the are over-mature and with lower vitality.

Related studies showed that, *P. euphratica* has drought resistance characteristics, but its seed has very low vitality and without hibernation feature. In natural condition, *P. euphratica* seed loses its vitality after 30 days; for generation it has to be placed in the soil which has higher moisture content\[^{20}\].

This study found out that with the increasing distance from the river, vitality of *P. euphratica* decreases. In the mean time, during field investigation we noticed that human pasture activity severely damaged the *P. euphratica* young seedlings. Thus, continuing with water transferring, create a water body at certain surface in the far sites from river, strengthen the conservation measurements and stop pasturing activity in order to guarantee the healthy growth of *P. euphratica* young seedlings. At the same time, decrease human activity and develop other non-agricultural industry to reduce groundwater exploitation in this area.

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References


