Performance of *Populus euphratica* in riparian forests of the Tarim River Basin, NW China: Effects of use and distance to the ground water

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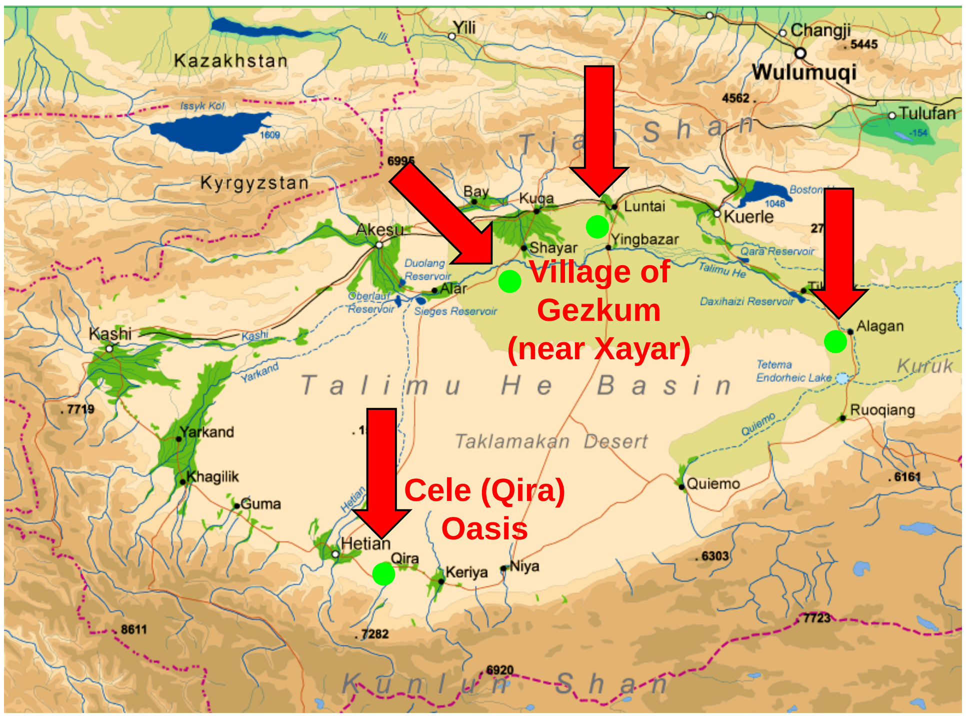
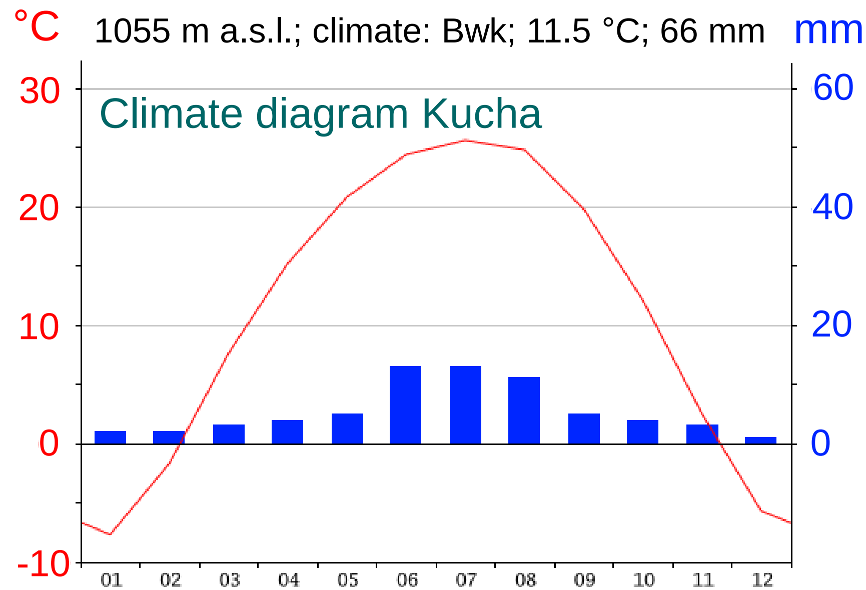
Riparian poplar forests: study sites

Use:
firewood, construction material,
wood pasture, shelter from sand drift





(http://de.climate-data.org/location/764573/)

Hyper-arid climate:

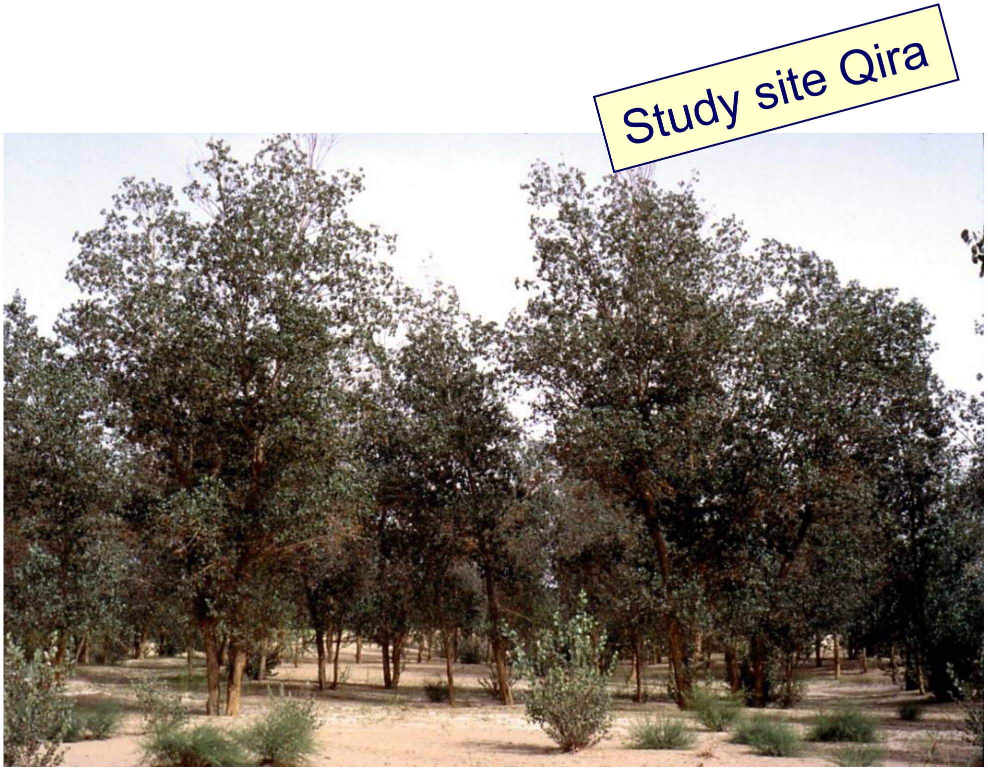
Annual precipitation: 33 – 104 mm;

Annual mean temperature: 11 °C;

Annual potential evaporation: ca. 2600 mm.

Projects: Xayar: SuMaRiO (2011 – 2015); Cele: EU INCO-DC, 1998 – 2001

Stem diameter increment: effects of stem harvest



Approx. 20-year-old stand from vegetative regeneration after clear-cutting:

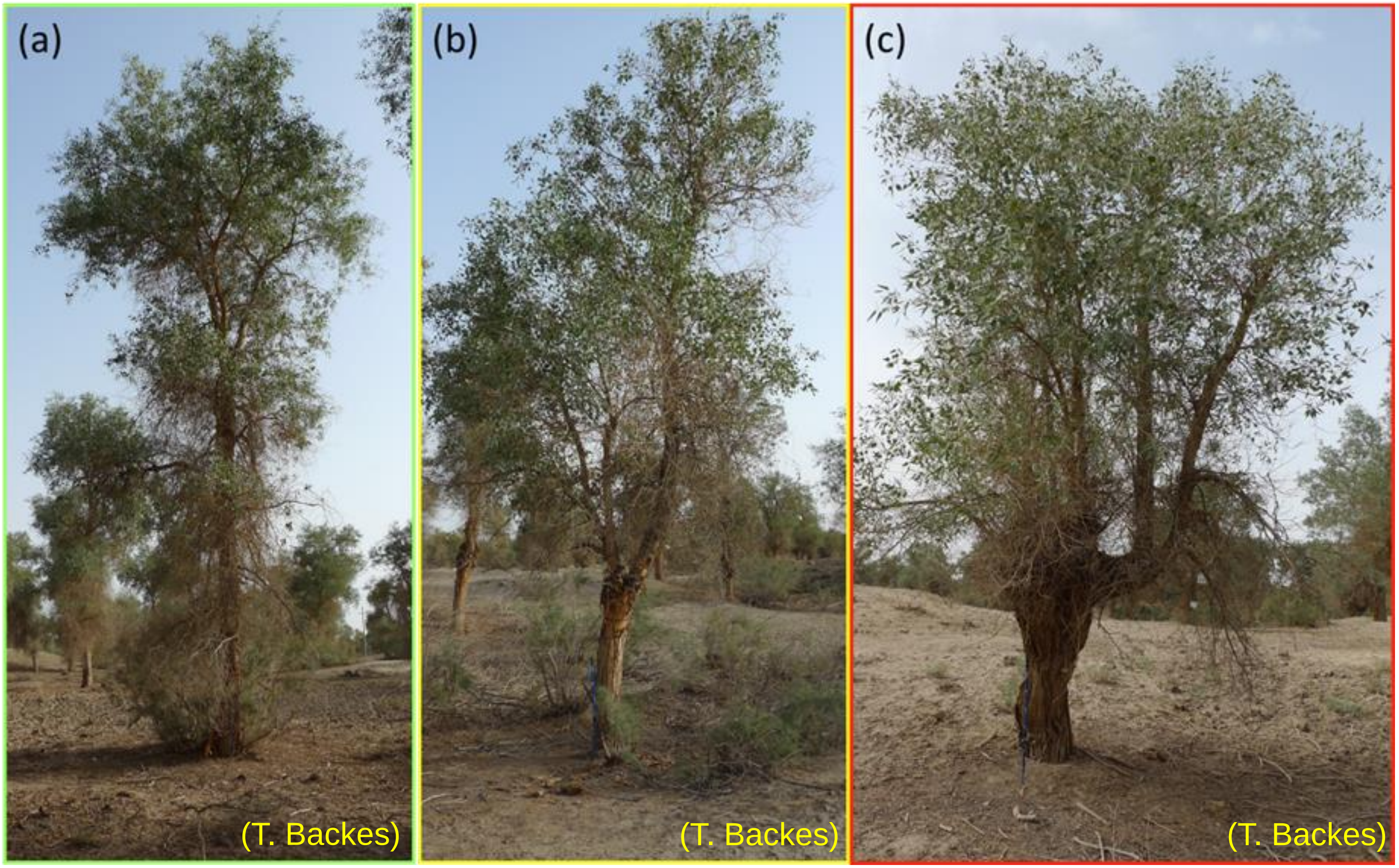
LAI: 1.9 – 2.7 m^2 m^{-2},
Stand density: 2313 – 3425 trees ha^{-1},
Basal area: 10.2 – 14.9 m^2 ha^{-1};
Above-ground tree biomass (t ha^{-1}):
No harvest: 23.7 ± 0.9; harvest: 21.2 ± 0.8

Harvest:
decrease in stem density to half its original value (also resulting in a more uniform stem distribution)

Treatment	**Stem diameter increment (mm)** (mean of 2 plots ± 1 SE)
Control	0.88 ± 0.06 **b**
Harvest	1.31 ± 0.09 **a**

(Data from: Gries et al. 2005, *Plant Ecology* **181**: 23–43)

Study site Xayar:
Effects of use intensity (wood harvest by pollarding)



No pollarding (tree height: 11.9 m) | Moderate pollarding (tree height: 7.3 m) | Intense pollarding (tree height: 6.4 m)

Study site Xayar:

Use intensity and tree morphology

> ANCOVA:
> Differences in cross section area-related stem hollowness independent of tree age!

Groundwater distance in all plots: 2.0 – 2.2 m

(Means ± 1 standard deviation; values with different lower-case letters are significantly different)

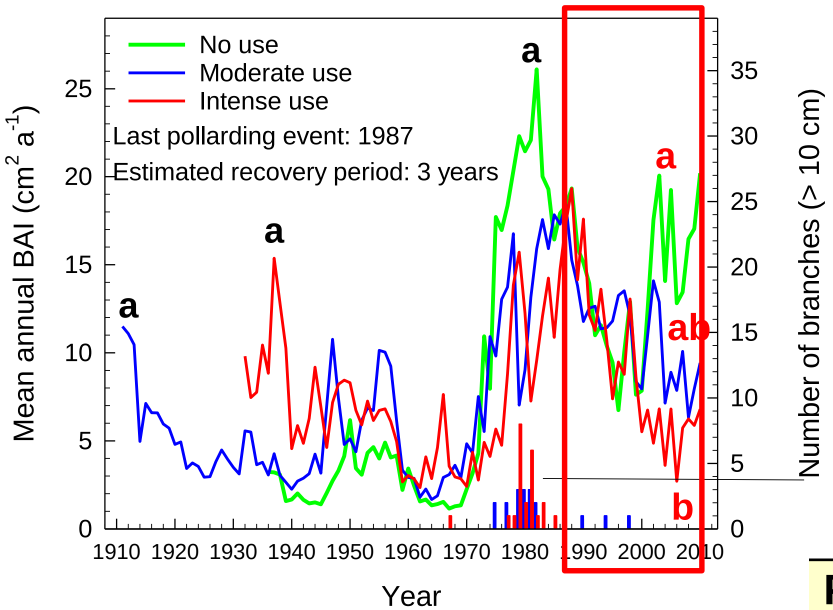
Pollarding intensity	**No Use**	**Moderate use**	**Intense use**
Tree height (m)	9.8 ± 2.1 **a**	8.2 ± 2.2 **b**	7.6 ± 1.8 **c**
Diameter at breast height (dbh) (m)	0.24 ± 0.08 **b**	0.35 ± 0.11 **a**	0.39 ± 0.14 **a**
Height:dbh	43.3 ± 10.5 **a**	25.7 ± 9.6 **b**	21.1 ± 5.9 **c**
Crown projection area	18.7 ± 8.4 **a**	11.2 ± 5.6 **b**	7.8 ± 2.7 **b**
Number secondary stems/branches per tree	1.5 ± 0.5 **b**	2.0 ± 1.0 **ab**	2.7 ± 1.1 **a**
Percentage of hollow trees	17.4	65.2	87.0
Degree of hollowness (% of radius)	3.1 ± 7.5 **b**	35.0 ± 29.9 **a**	52.3 ± 26.9 **a**
Degree of hollowness (% of stem area)	0.6 ± 1.7 **b**	20.8 ± 22.2 **a**	34.3 ± 22.6 **a**

(Data from: Lang et al. (2015), *Forest Ecology and Management* **353**: 87-96)

→ Pollarding → trees: more hollow, shorter, thicker stems, smaller crowns.

Study site Xayar: Use intensity, basal area increment, stem hollowness

Pollarding: smaller BAI (intense use, 1987-2010)



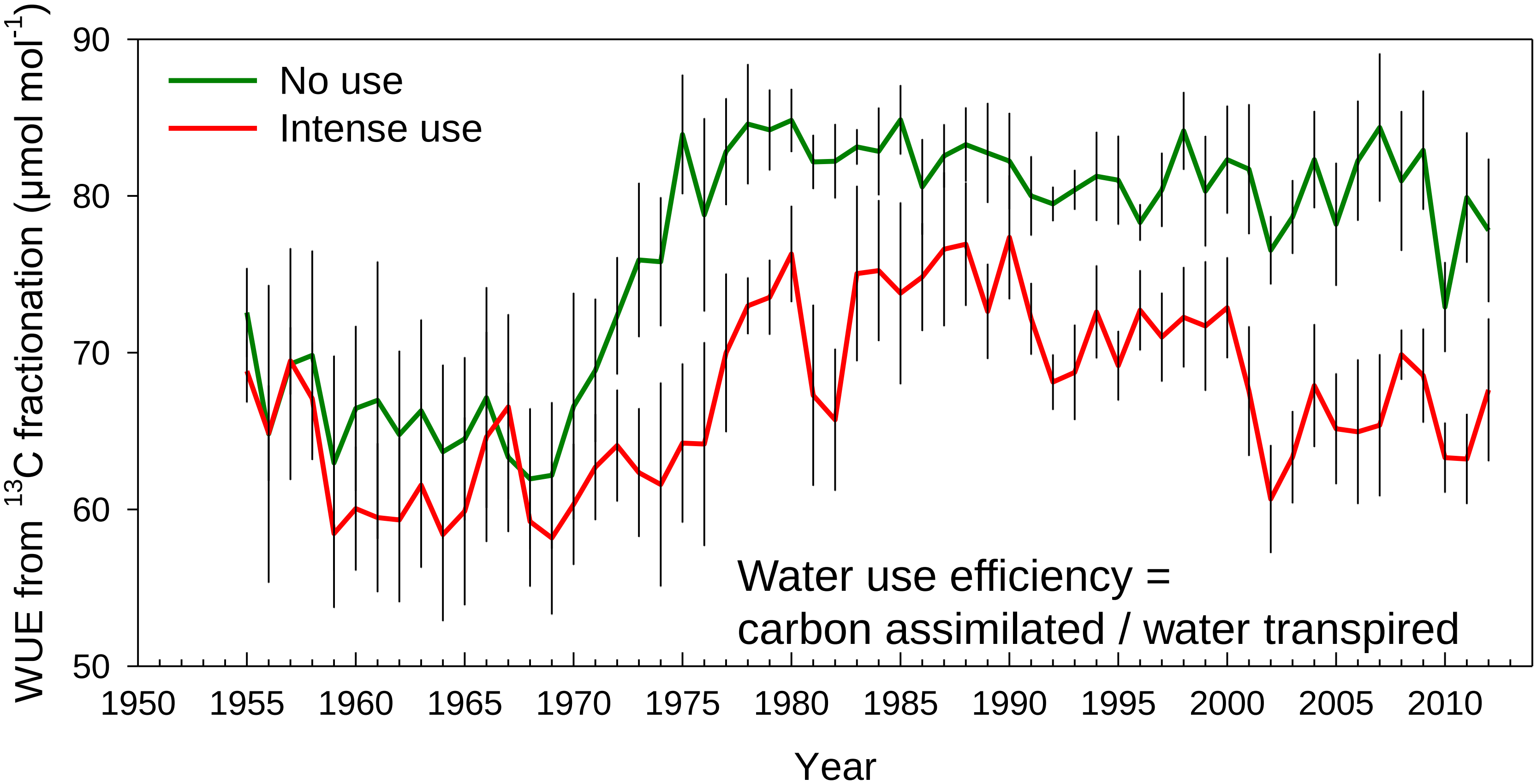
→ Intensely pollarded trees bear a higher risk of critically reduced stability.

Critical threshold of stability in hollow trees:

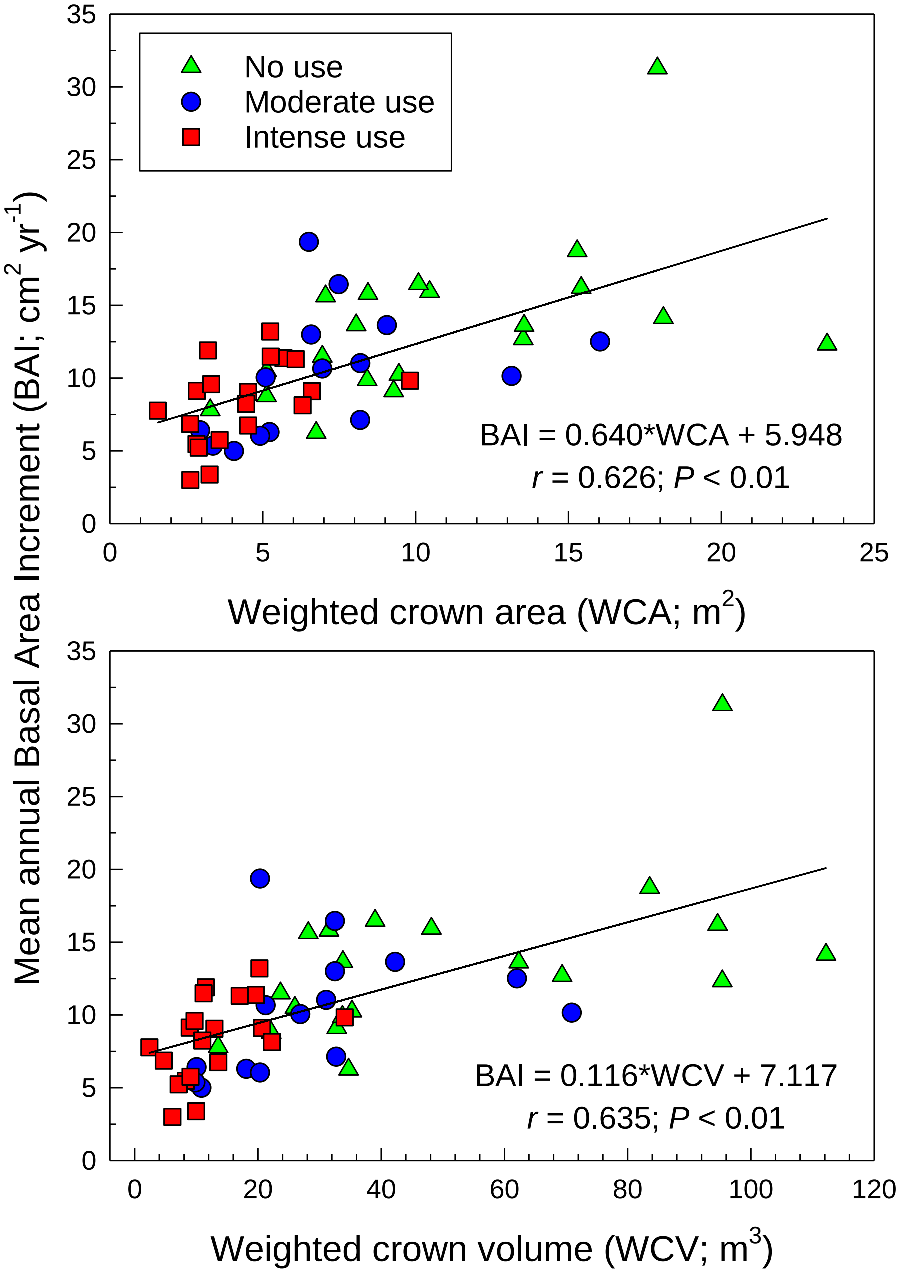
Stem wall thickness *t* / cross section radius *R* < 0.3.

Pollarding intensity	Number of trees with *t/R* < 0.3
None	0
Moderate	0
High	8 out of 23 (35%)

Calculation of water use efficiency (WUE) from tree-ring carbon isotope ratios ($\delta^{13}C$)



! Lower WUE in intensely used trees
→ indicative of compensatory growth due to increased rates of photosynthesis.

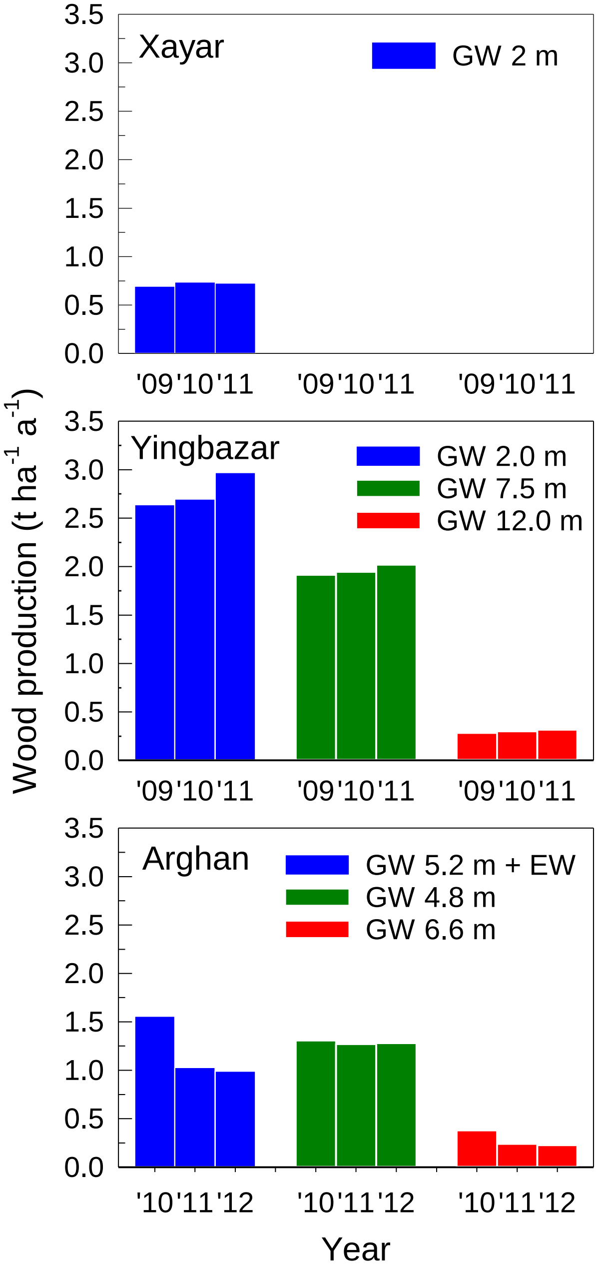


Application of crown morphology measurements: assessing stem growth increment

Mean annual basal area increment (BAI), 1911 – 2011:

Crown projection area and crown volume weighted by the ratio of vertical crown extension to total tree height

→ **Aim:**
Combination with remote sensing techniques at a landscape level.



Populus euphratica: wood production along a gradient of groundwater depths

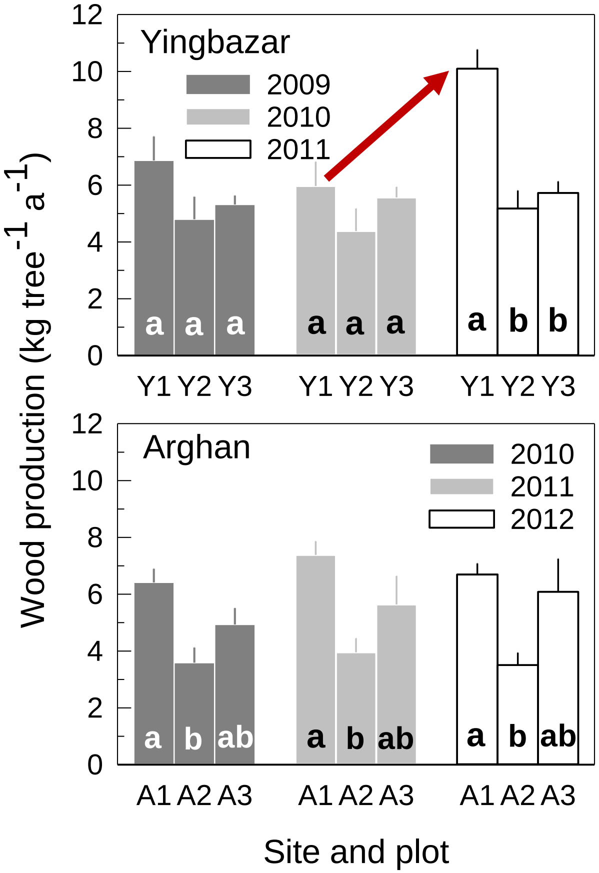
Wood production calculated using tree-ring analyses and allometric regressions adopted from Chen & Li (1984), *For. Sci. Technol. Xinjiang* **3**: 8-16

Site and plot	X1	Y1	Y2	Y3	A1	A2	A3
Tree age (years)	30	26	28	77	46	37	52
Stand density (trees ha $^{-1}$)	121	467	378	67	166	257	59

Yingbazar, Arghan: variances among years are largest in plots with largest water supply

→ **Lower productivity of stands at larger distances (> 7 m) to the water table!**

Populus euphratica: wood production of mature trees (60 – 99 years) along a gradient of groundwater depths

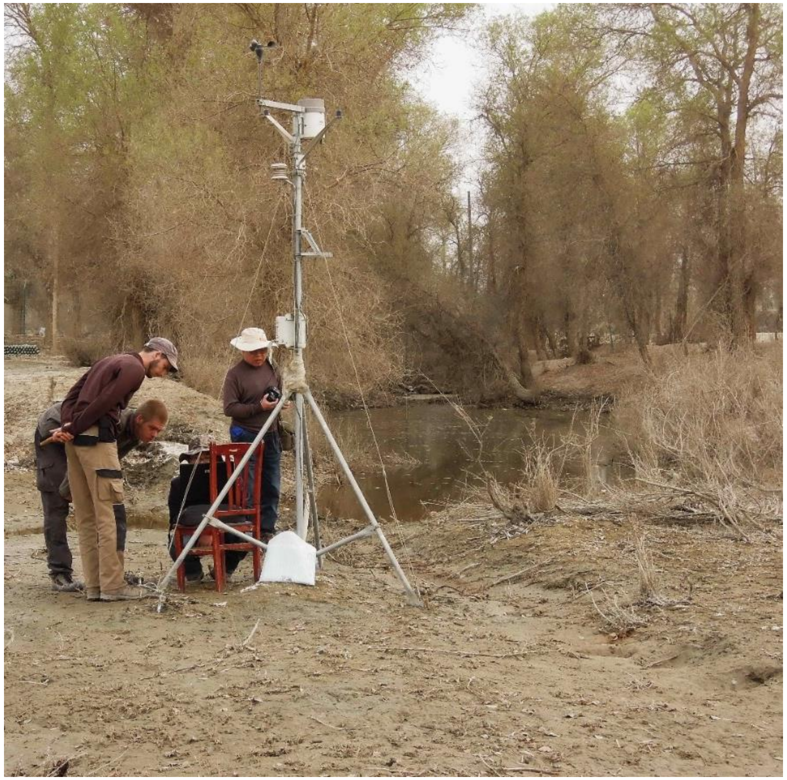


Plots with same letters do not differ significantly within a given year

Year preceding tree-growth assessment	2008	2009	2010
Tarim River run-off, Yingbazar (million m^3) (Yu Yang, TU Munich; MIKE HYDRO)	813	284	**3467**

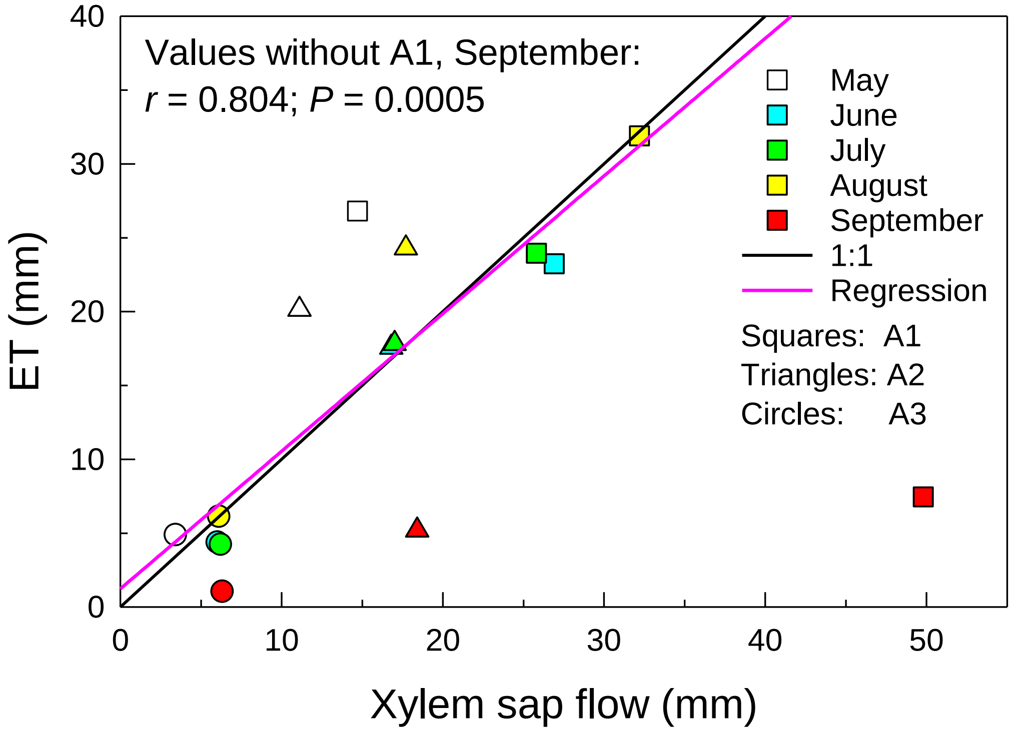
→ **Mature trees growing at relatively large distances to the ground water do not necessarily exhibit lower rates of wood production!**

Relationship sap flow / Penman-Monteith: Arghan site, 2013



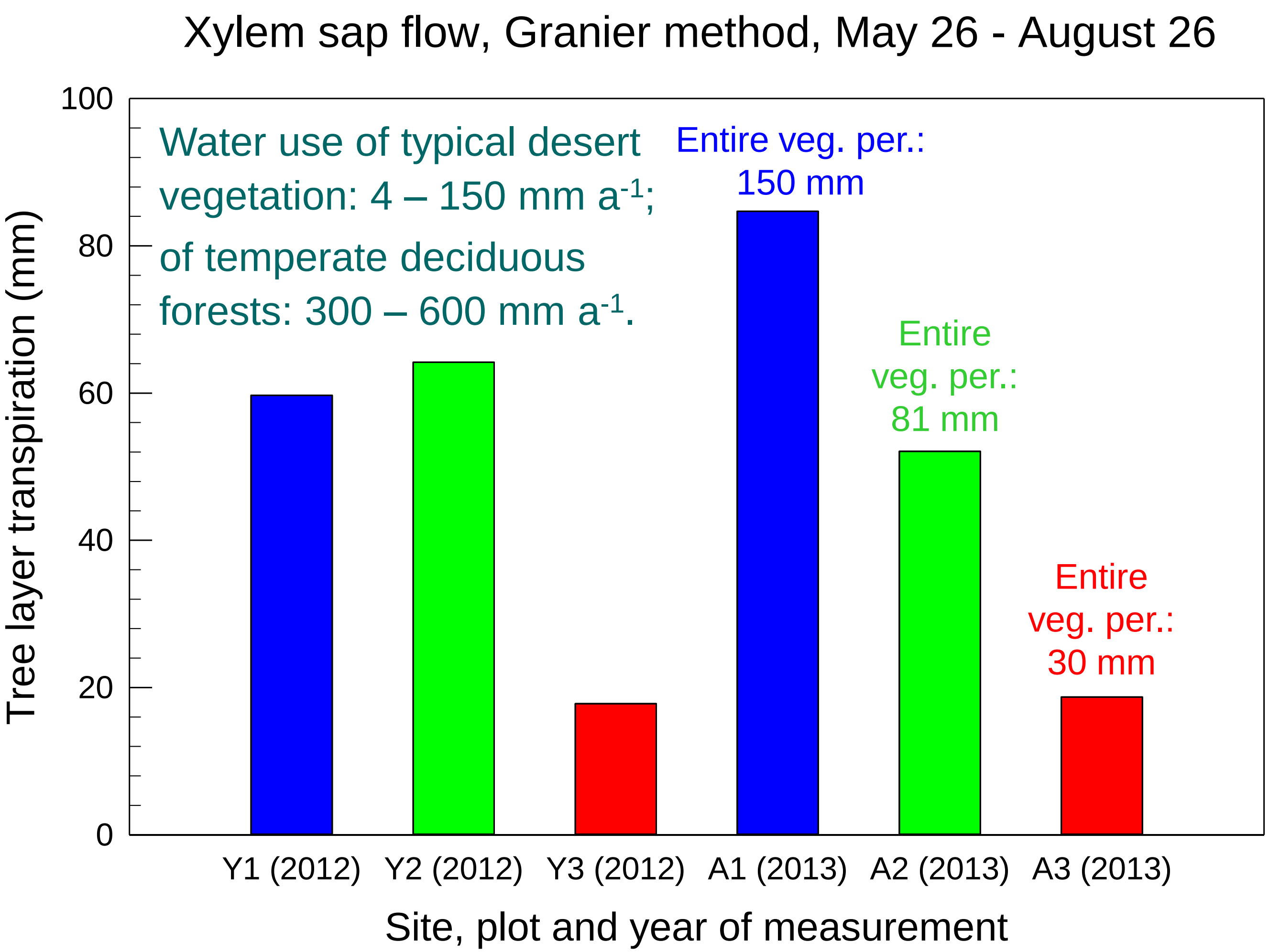
Installation of climate stations at the study sites Xayar, Yingbazar, Arghan

(operated by the Institute of Ecology and Geography, CAS)



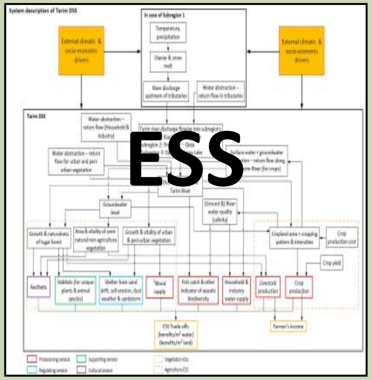
→ **Reasonable consistency between sap flow measurements and Penman-Monteith approach.**

Water use, May - August

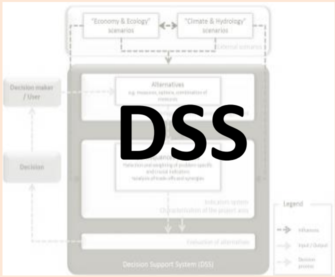


→ Water use decreases with increasing distance to the ground water (and an increase in tree age and decrease in stand density).

Research contribution to Ecosystem Services (ESS) in the Tarim Basin and the contribution to the SuMaRiO-Decision Support System (DSS)



- Poplar wood is a renewable resource; its **use through pollarding** in stands growing at short distances to the groundwater should be permitted as Euphrates poplar has a high regeneration potential after moderate intensities of pollarding.
- With increasing distance to the groundwater, the **extent of supporting and provisioning ES (wood production) decreases** at the stand level (but not necessarily at the tree level).
- At large distances to the groundwater, the extent of ESS will decline due to a **dwindling regeneration capability** of the trees.



- **Regeneration capacity** of trees **in dependence upon pollarding intensity**;
- **Growth increment** of trees and stands growing at close distances to the groundwater **in dependence upon river discharge**;
- **Wood production** and **water use** of trees and stands growing at different distances to the groundwater.

Acknowledgements:

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Thank you for your attention!

Recovery from pollarding

Index of resilience I_R:

ratio of the three-year averages of the annual BAI after and before the pollarding event;

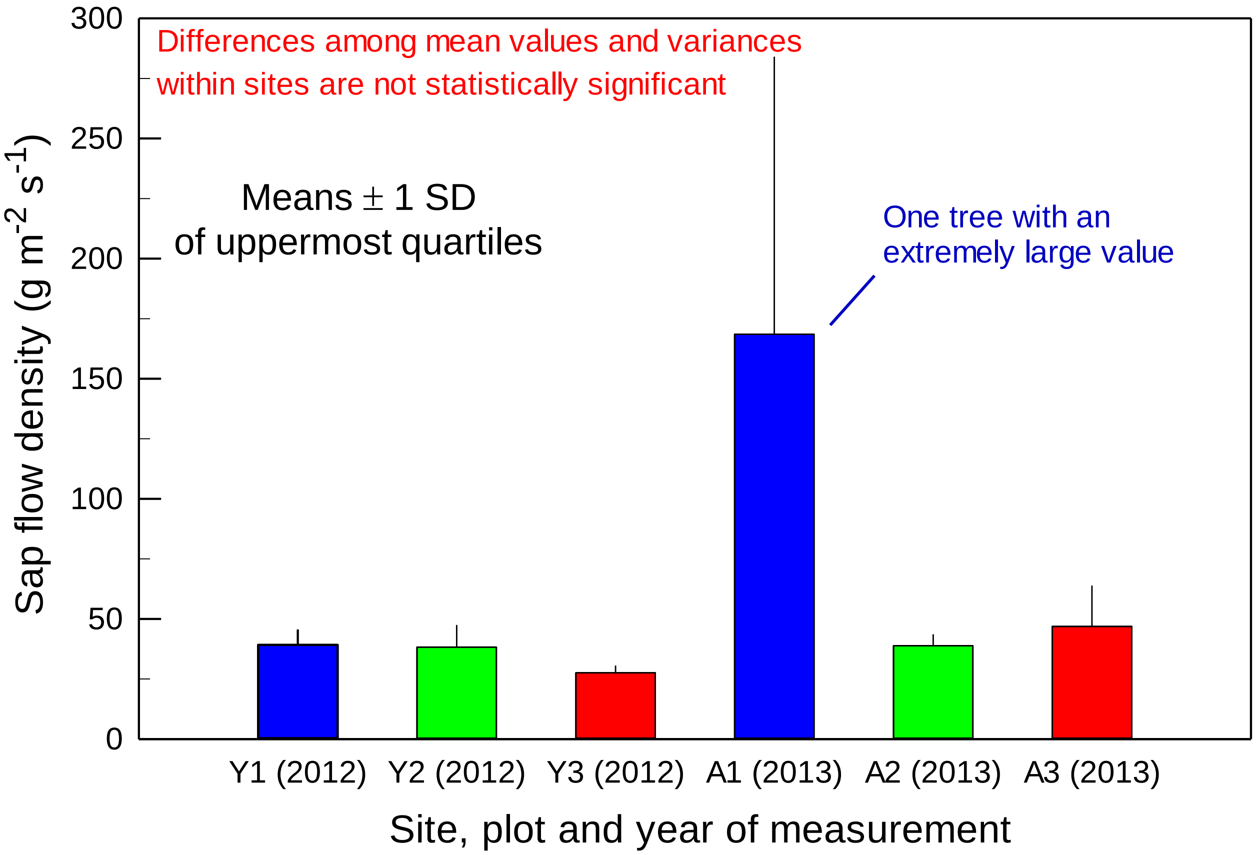
$I_R \geq 1$: full recovery or increase in growth; $I_R < 1$: decline in growth after pollarding

Pollarding intensity	**I_R** (means ± 1 standard deviation)	**Significantly different from 0?**
Moderate	0.79 ± 0.36 **a**	No
High	0.91 ± 0.40 **a**	No

→ Even intensely pollarded poplars are able to recover from pollarding.

Populus euphratica: sap flow density (sapwood)

Xylem sap flow, Granier method, May 26 - August 11



→ Differences in water use and productivity not due to limitations in water transport capacity of the stem!

Conclusions on the effects of pollarding

Pollarded trees (in particular, intensely pollarded ones) …

… exhibit distinct morphological changes;

… display reductions in the increments of tree rings and basal area;

… bear increased risk of instable stems (after intense pollarding);

… but are capable of regenerating to a certain extent (Index of resilience close to 1); compensatory responses:
- formation of secondary shoots,
- decrease in iWUE (as a consequence of higher rates of gas exchange,);

→ **Moderate intensities of pollarding seem to be sustainable.**

Conclusions on the effects of groundwater distance

"Ecological water" (Arghan site) seems to enhance stem increment growth.

With increasing distance to the groundwater level …:

- … Stands are sparser and display a reduced tree cover;
- … Trees are older, exhibit an altered morphology and a decrease in growth increment;
- … Tree increment decoupled from river run-off – relationship between river run-off and stem diameter increment significant only at small distance to groundwater (Yingbazar);

! **Redirection of water from stands close to the groundwater towards stands with larger distances to the groundwater might reduce growth in stands close to groundwater.**