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Growth rate rather than growing season length determines wood biomass in dry environments

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UQAC, CA, May 2nd 2019

Importance of wood biomass

CO_2 2.5×10^{12} kg/ year (Pan et al., 2011)

Xylem formation

(Figures from internet)

Wood biomass & Growing season

- Eddy covariance/remote sensing studies (Churkina et al., 2005; Griffis et al., 2003)

  Growing season length determines net ecosystem productivity in forests

Wood biomass & Drought

- Forest declines following severe water deficit have been observed at many sites.

Redu
spruc
temp
Valerie A.

Global Change Biology (2010) 16, 3024–3035, doi: 10.1111/j.1365-2486.2009.02147.x

Rec
sibi
CHOI

Global Change Biology (2010) 16, 771–783, doi: 10.1111/j.1365-2486.2009.01967.x

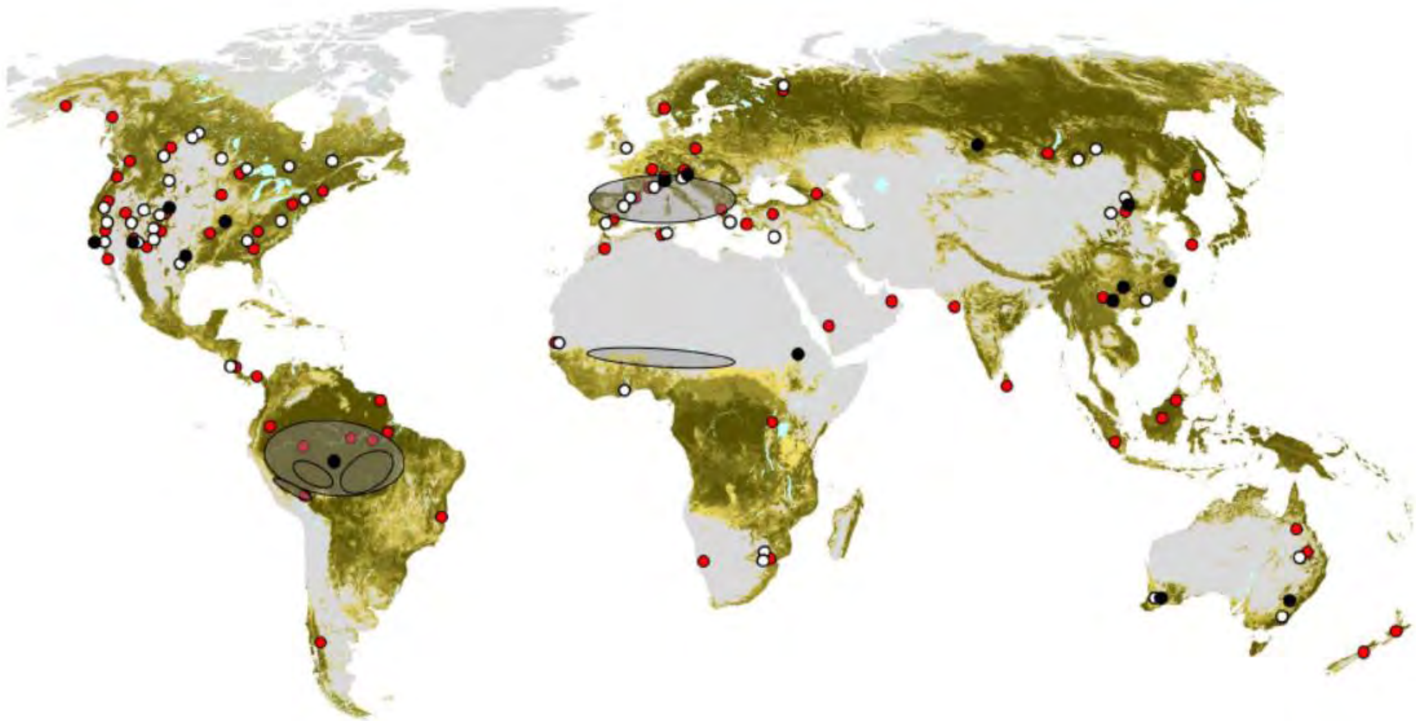
Long
by a
JIA HU

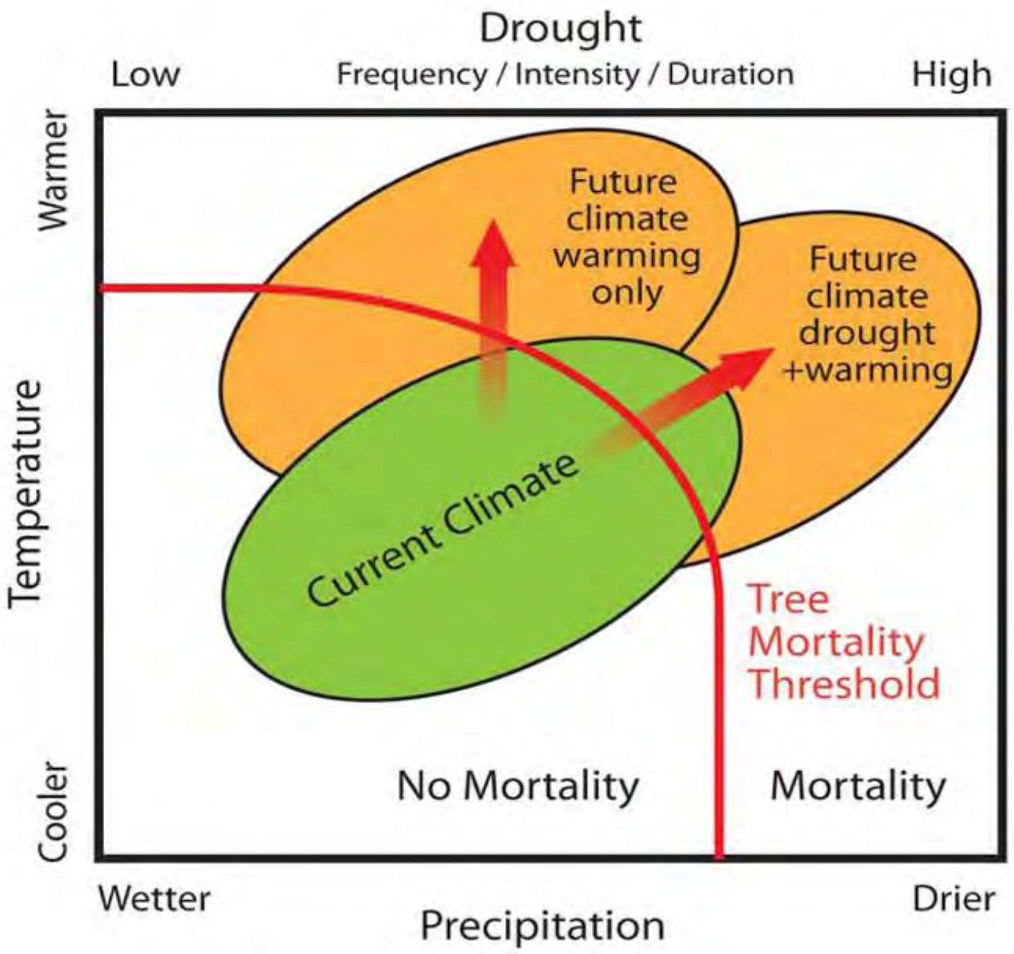
Global Change Biology (2017) 23, 2887–2902, doi: 10.1111/gcb.13595

Drought causes reduced growth of trembling aspen in western Canada

LEI CHEN[1,2], JIAN-GUO HUANG[1,3], SYED ASHRAFUL ALAM[1,4], LIHONG ZHAI[1], ANDRIA DAWSON[5], KENNETH J. STADT[6] and PHILIP G. COMEAU[7]

Wood biomass & Drought

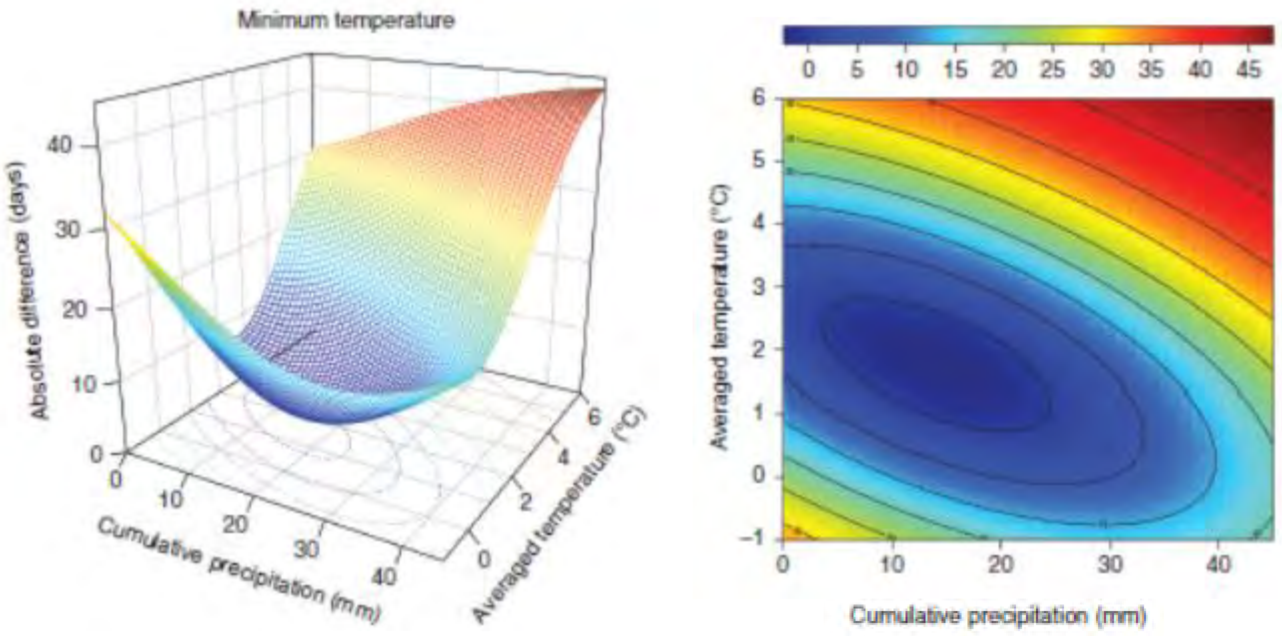




(Allen et al., 2010, 2015)

Wood biomass & Drought

- In arid environments, water availability is a driver of xylogenesis onset and ending.



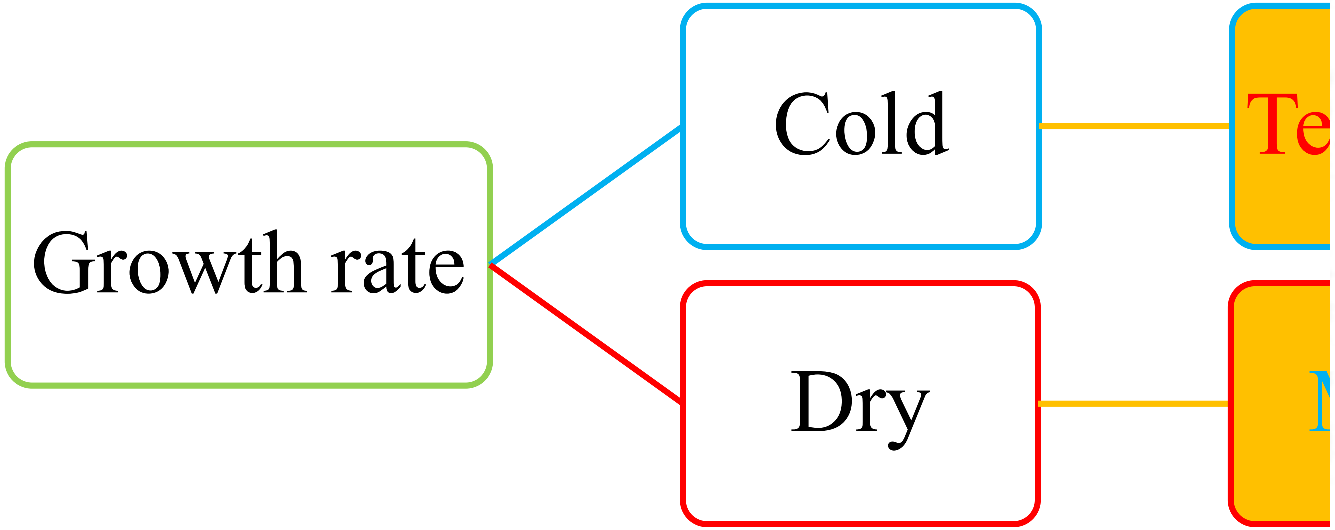
(Ren et al., 2018)

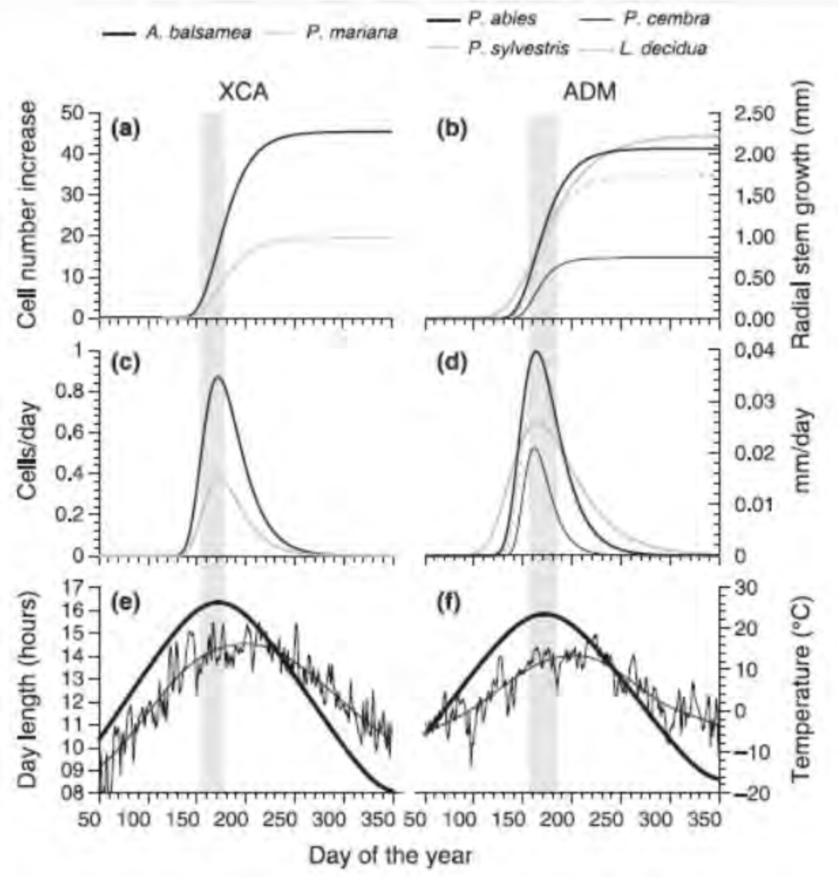
	30 days		
Pre-onse			
	VWC32	Dew	
Onset	−0.86***	0.97***	
$DateR_{max}$	−0.91***	0.92***	
r_{90}			
TrachNur	0.46**	−0.68***	
Duration	0.45**	−0.78***	
Pre-endir			
	VWC17	SoilT	Dew
Ending	−0.90***	−0.61**	
$DateR_{max}$			0.77***
r_{90}	0.51*		
TrachNur		−0.42*	−0.7***
Duration	−0.52*		−0.7***

(Ziaco et al., 2018)

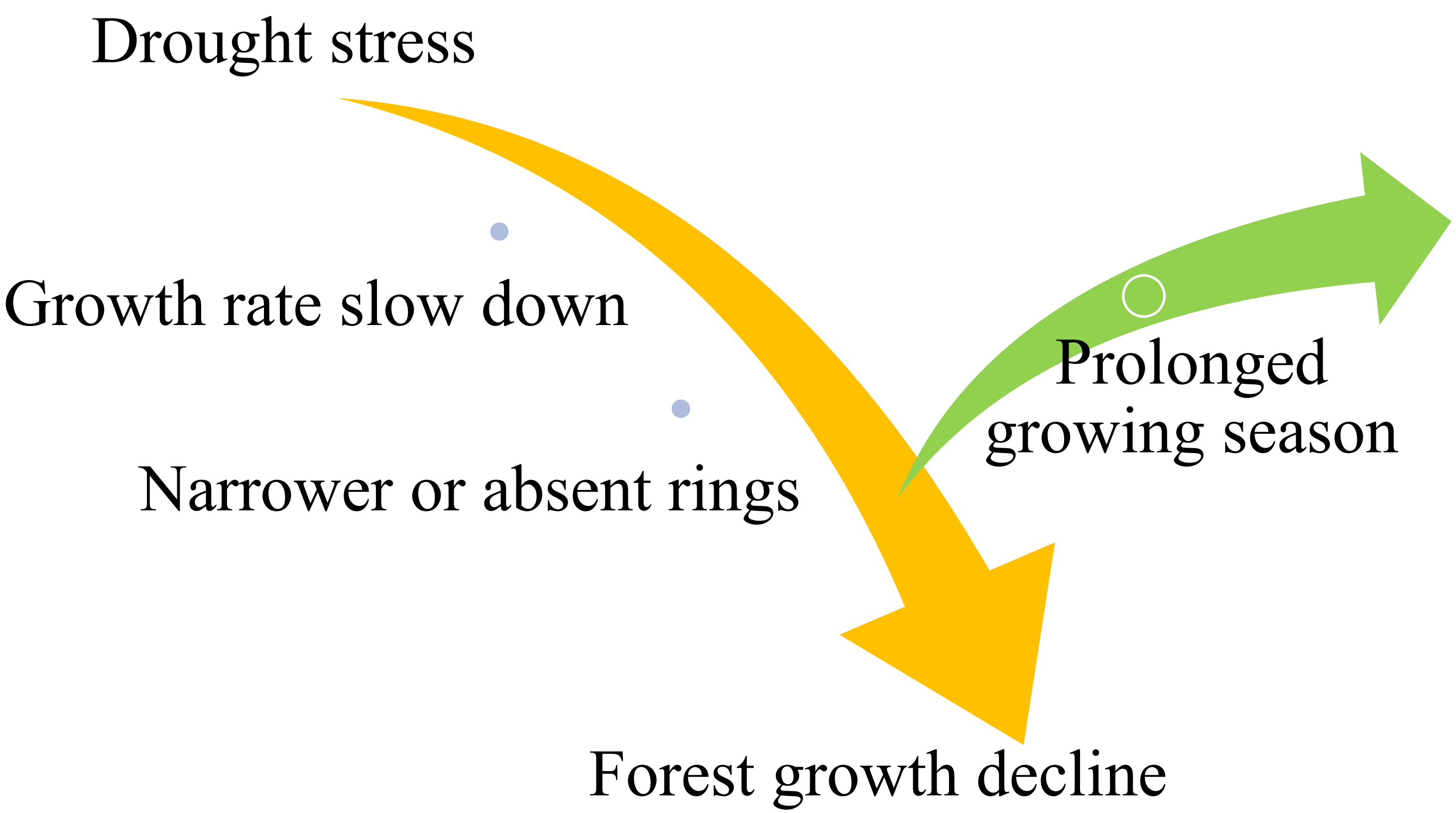
Wood biomass & Growth rate

- Growth rate is an important factor involved in fo





Wood biomass & Growth rate



Our Hypothesis

Wood production under moisture-limited conditions is mainly determined by growth rate, rather than by growing season length.

Study regions

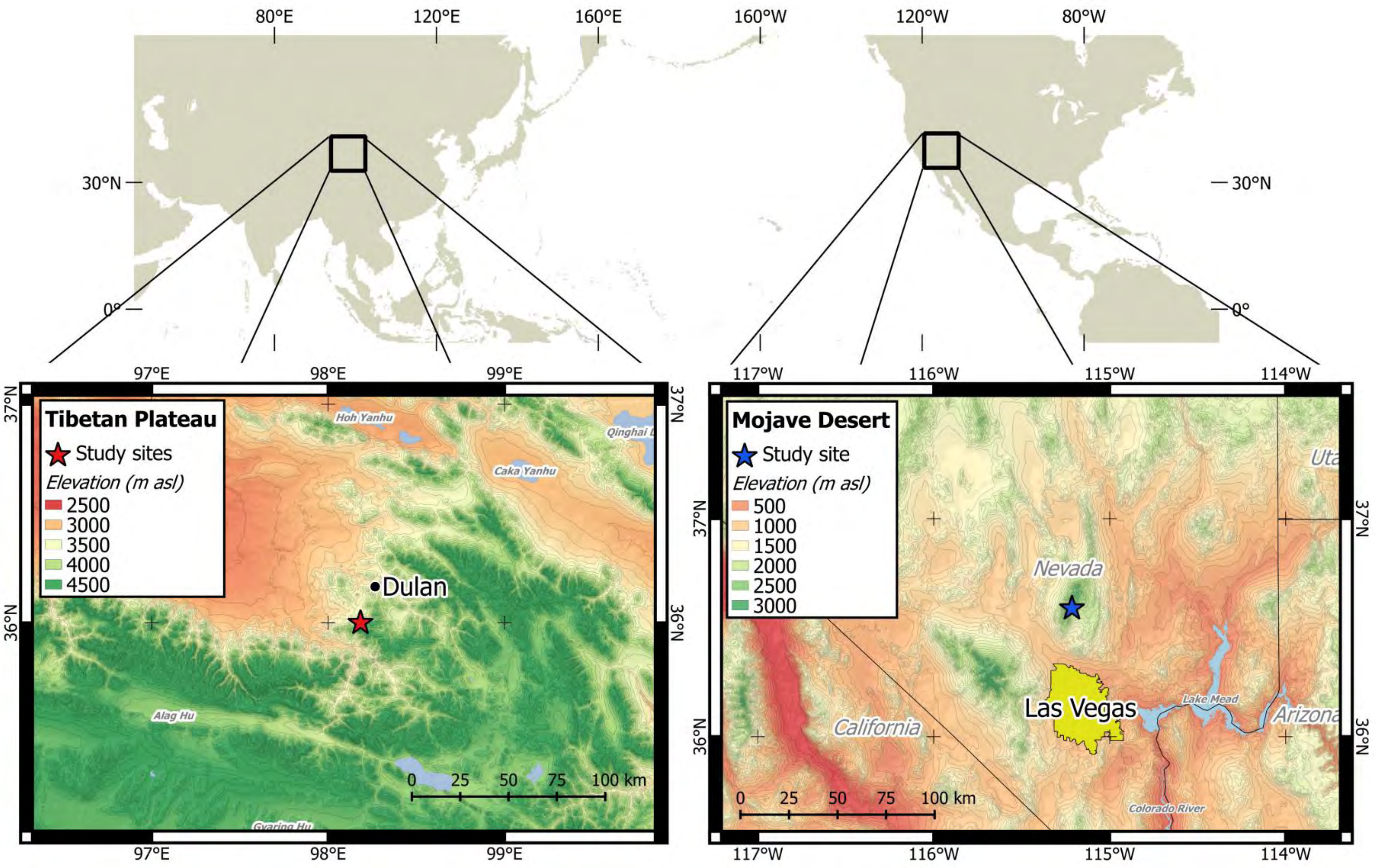


Fig. 1. Geographical location of the study sites in the Tibetan Plateau and in the Mojave Desert.

Study sites-Tibetan Plateau

(Ren et al., 2015)

Species: Qilian juniper

(*Juniperus przewalskii*)

Climate (2009-2014):

Upper: -1.49ºC, 433mm

Lower: 0.04ºC, 364mm

Study sites- Mojave Desert

(Ziaco et al., 2018)

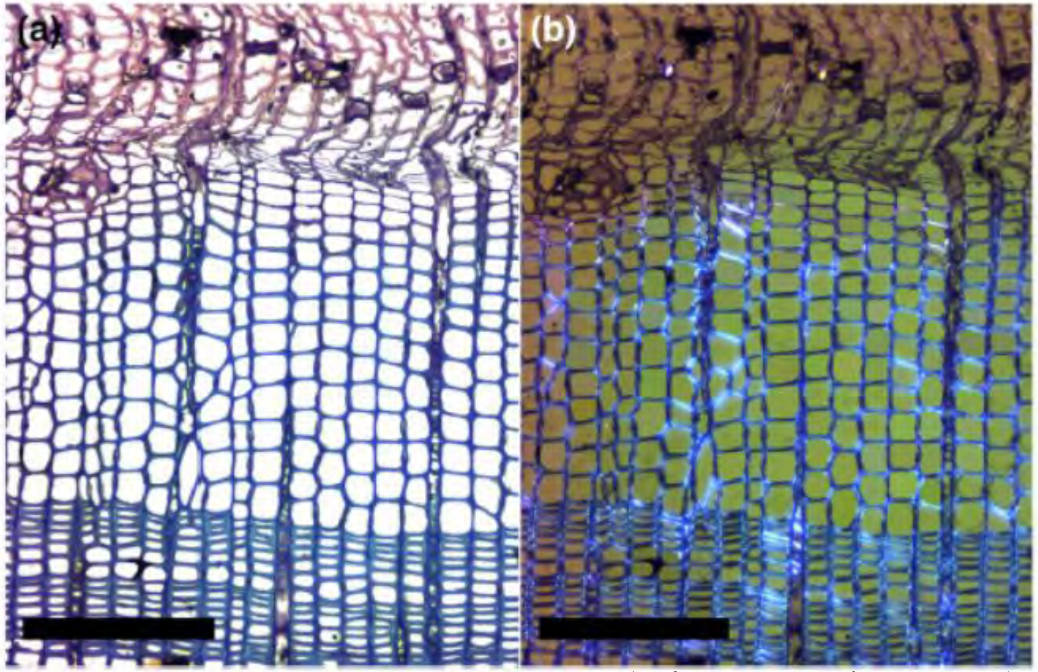
Species: Ponderosa pine

(*Pinus ponderosa*)

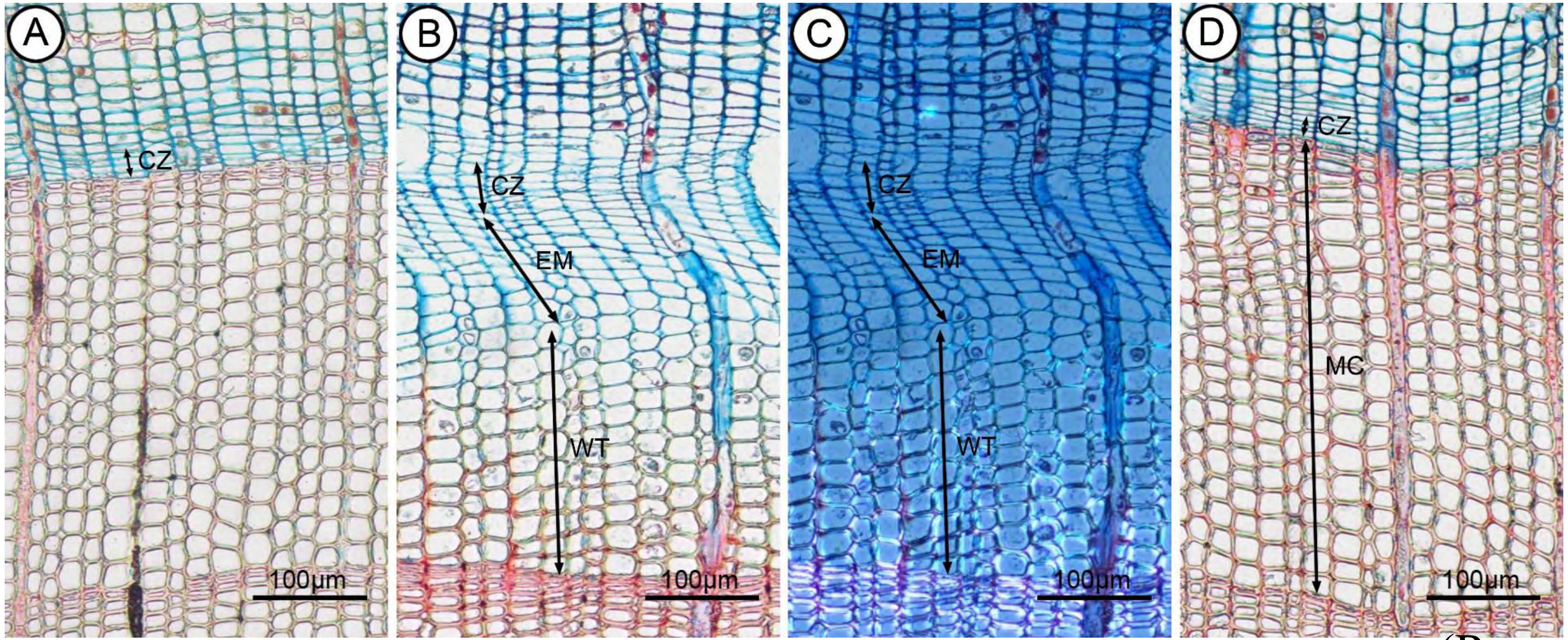
Climate (2011-2016):

10.2ºC, 338mm

Wood production data



(Ziaco et al., 2018)



(Ren et al., 2015)

Statistical analysis

- A simple physical model (Rathgeber et al., 2011)

the period of xylem cell production

$$N_{cell} = f(r_m \times D_{cell})$$

Sensitivity analysis

the final radial number of tracheids

the rate of xylem cell production

- Linear mixed models

  wood formation & climate factors

Characteristics of wood production

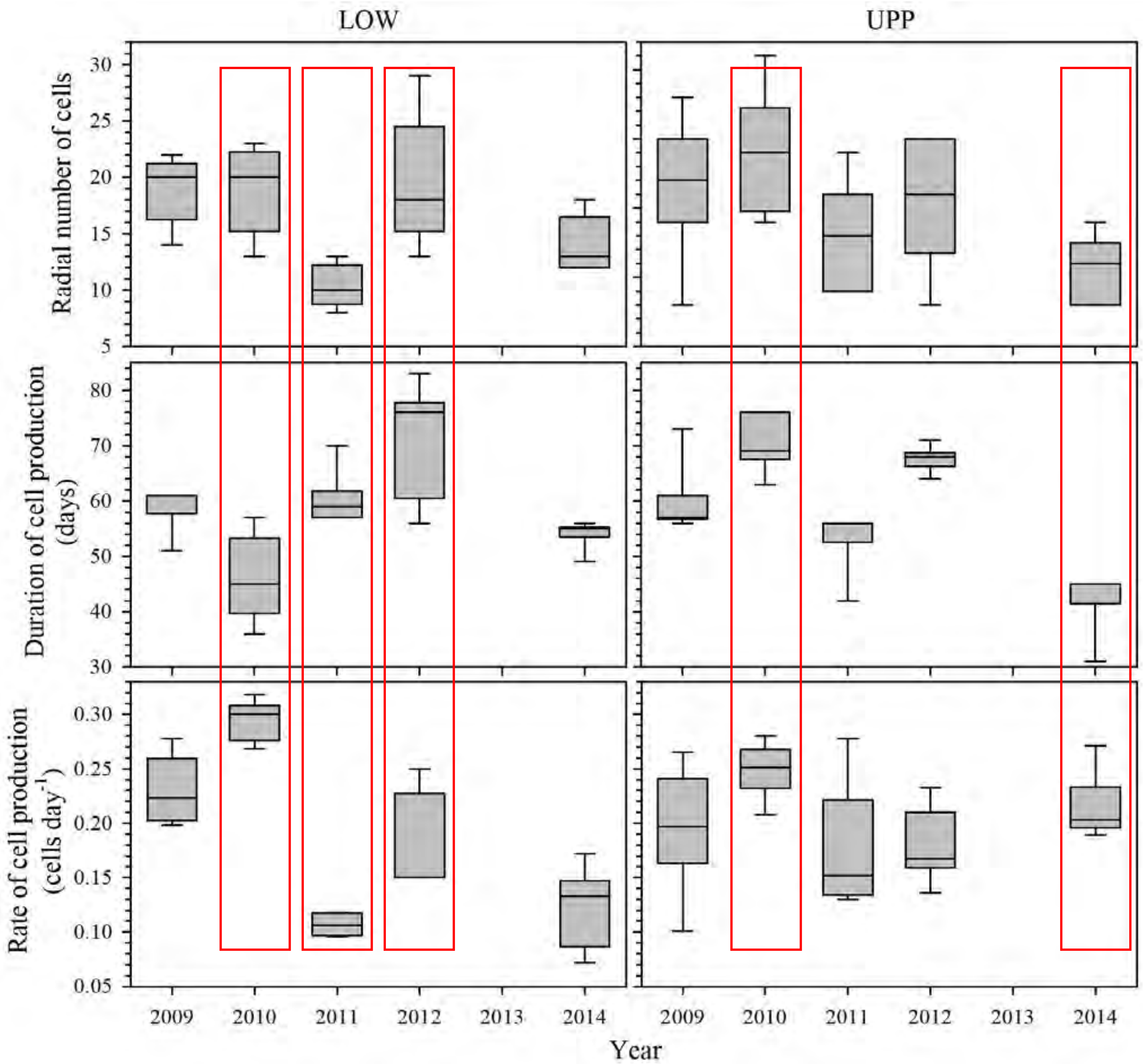


Fig. 2. Radial number of xylem cells, duration of xylem production and rate of xylem production in *Juniperus przewalskii* recorded in 2009–2014 at the lower (LOW) and upper (UPP) treelines.

Rate *vs.* duration of wood production

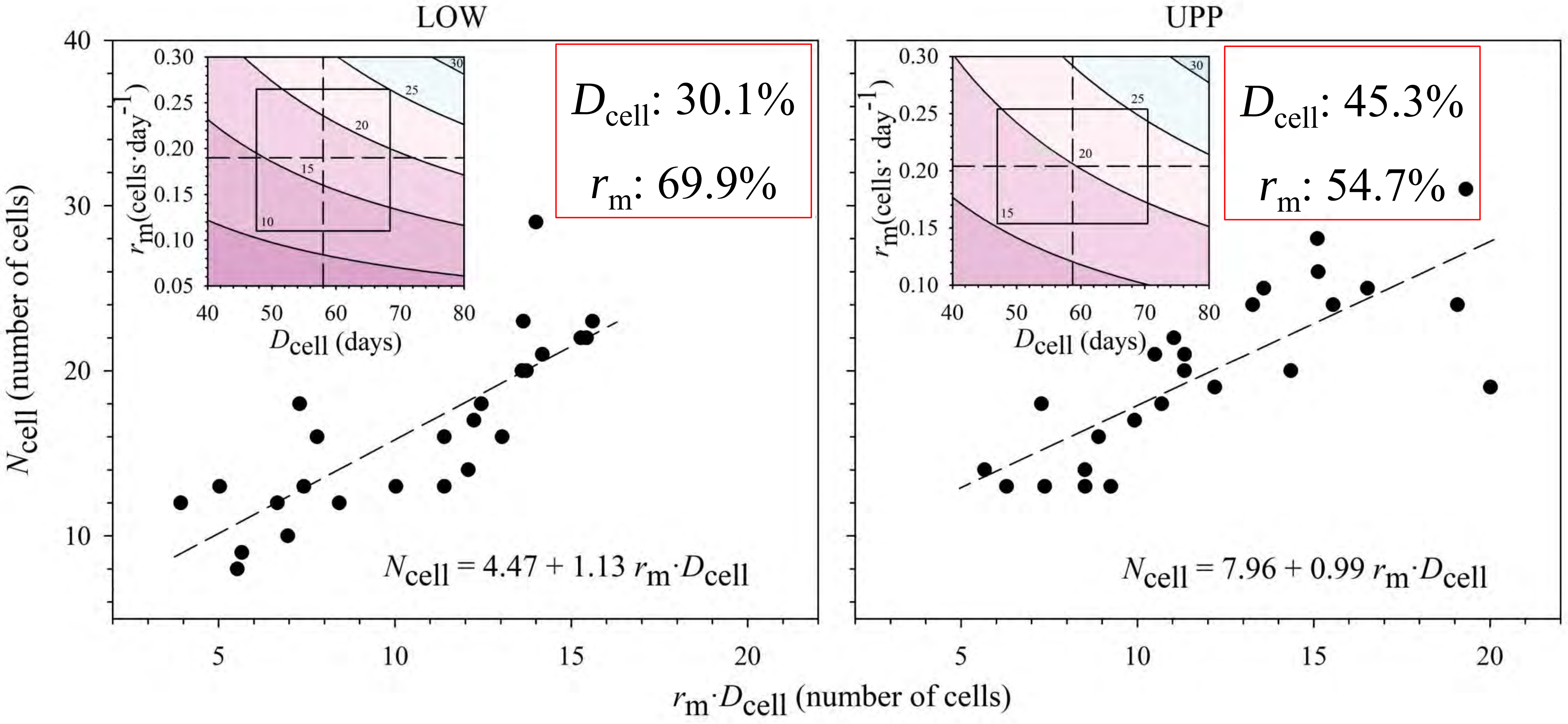
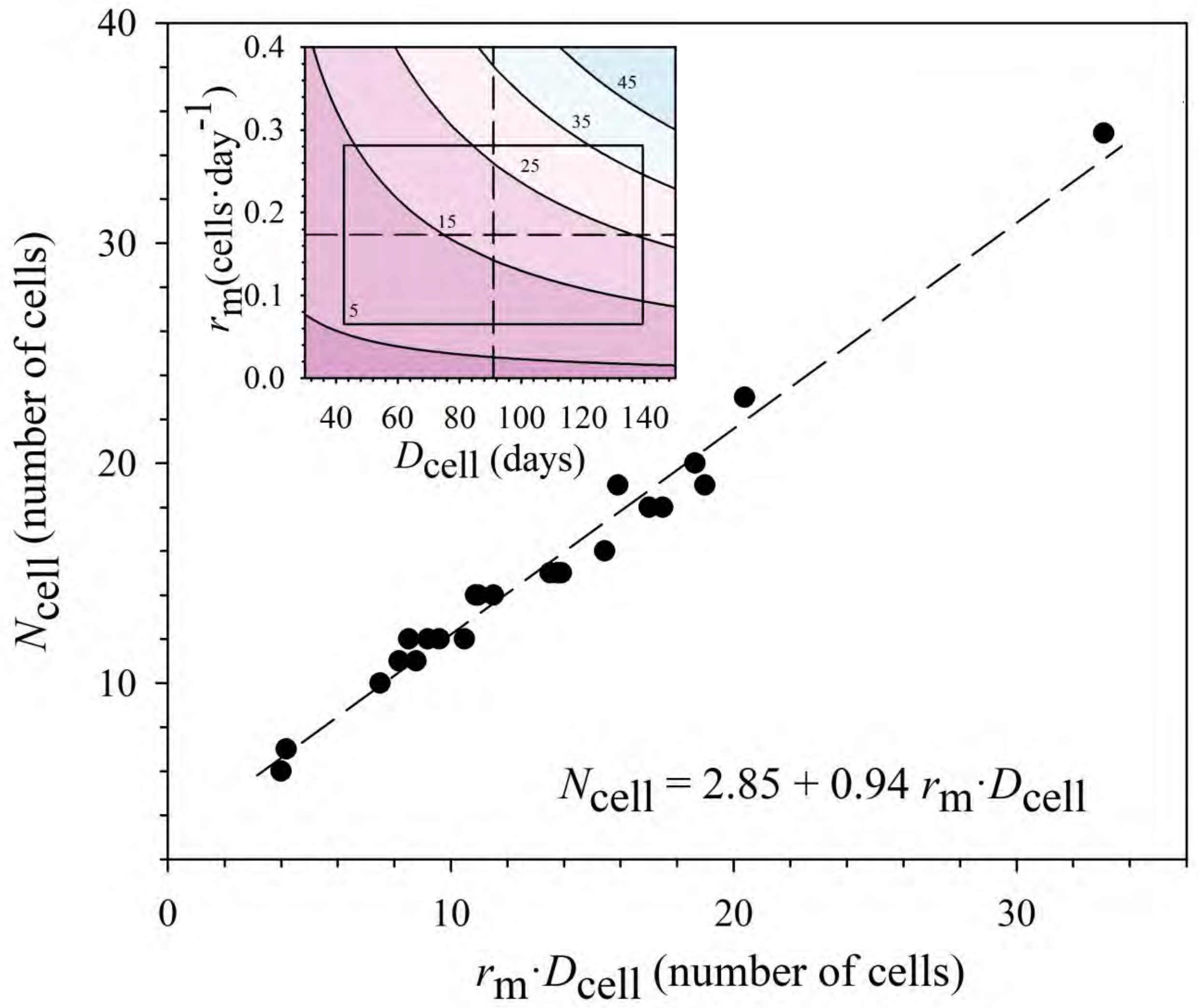


Fig. 3. The simple physical model of the total number of xylem cells (N_{cell}), the period of xylem cell production (D_{cell}) and the xylem growth rate (r_m) in *Juniperus przewalskii* as well as the sensitivity analysis of the physical model at the lower (LOW) and upper (UPP) treelines.

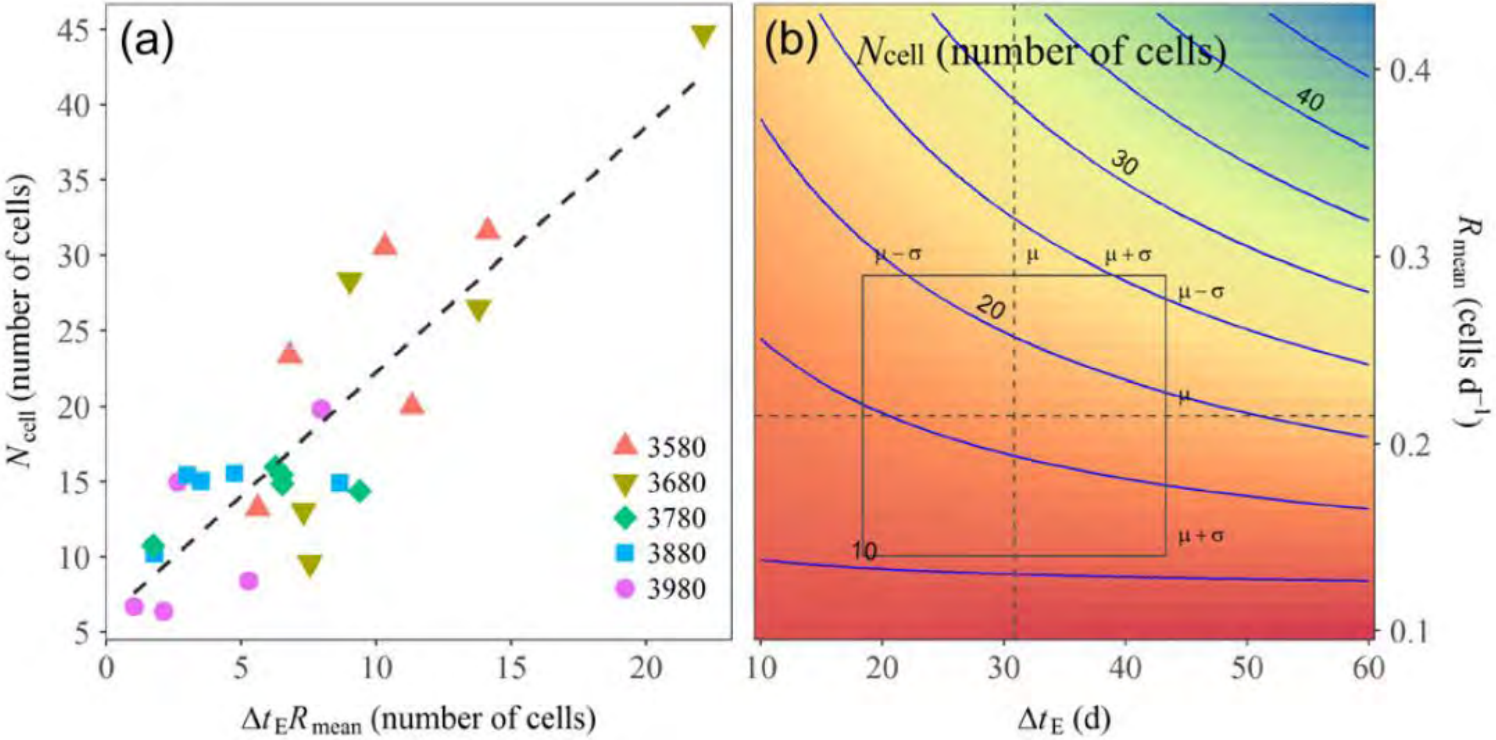
Rate *vs.* duration of wood production



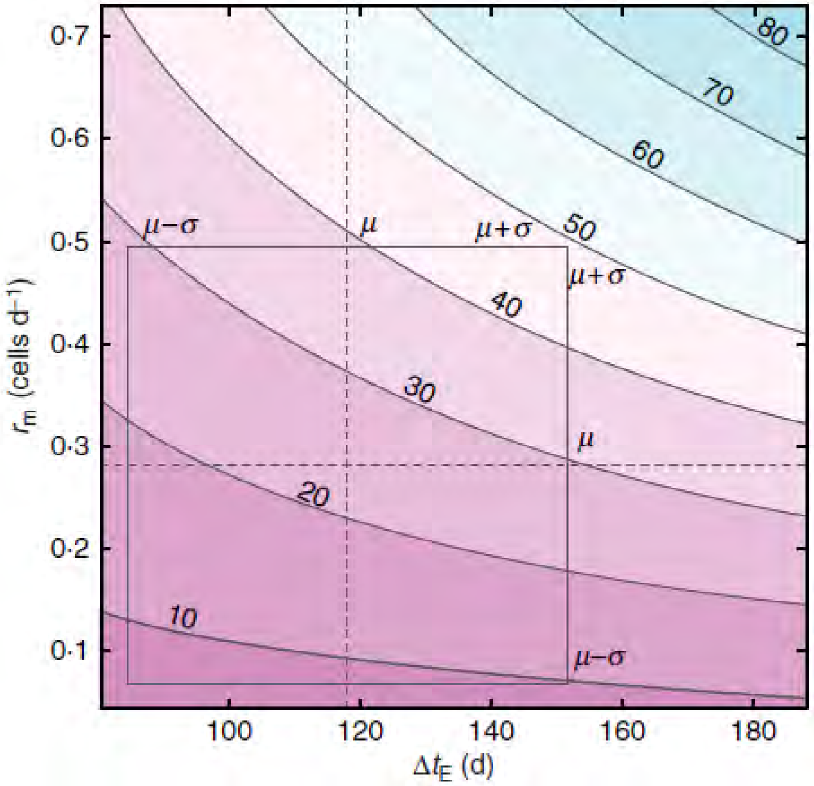
D_{cell}: 46.1%, r_m: 53.9%

Fig. 4. The simple physical model of the total number of xylem cells (N_{cell}), the period of xylem cell production (D_{cell}) and the xylem growth rate (r_m) in *Pinus ponderosa* as well as the sensitivity analysis of the physical model at the Las Vegas.

Rate *vs.* duration of wood production



(Zhang et al., 2018)



(Rathgeber et al., 2011)

Wood production *vs*. climatic variables

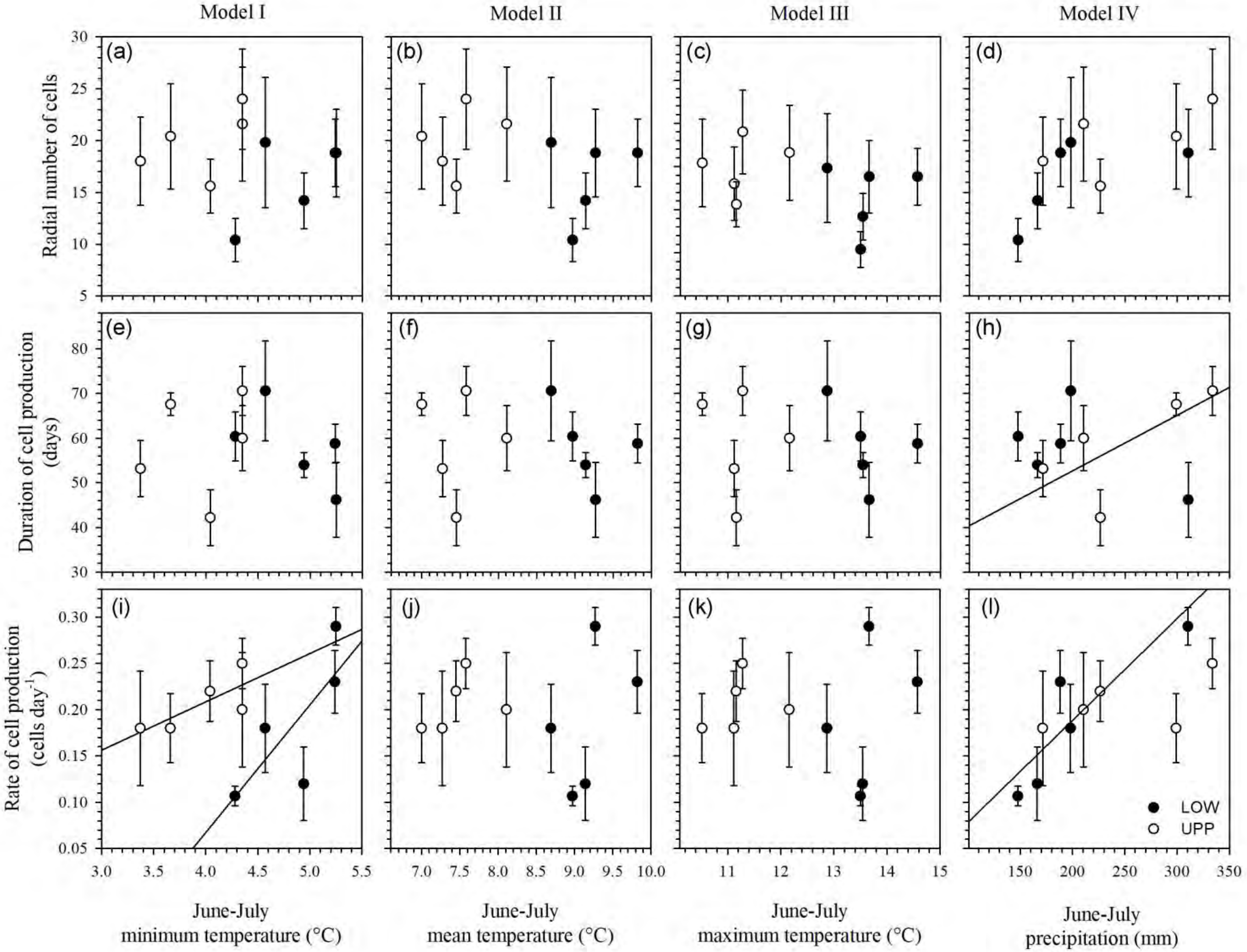


Fig. 5. Radial number of cells, duration of cell production and rate of cell production in *Juniperus przewalskii* vs. the June-July temperatures and precipitation recorded in the study years at the lower (filled dots) and upper (open dots) treelines.

Wood production *vs*. climatic variables

Table 1 Statistical parameters (*F*, significance level *P*) of linear mixed models based on radial number of cells (N_{cell}), duration of cell production (D_{cell}) and rate of cell production (r_{m}) in *Juniperus przewalskii*.

	Model I			Model II			Model III			Model IV		
	Site	T_{min}	S× T_{min}	Site	T_{mean}	S× T_{mean}	Site	T_{max}	S× T_{max}	Site	*PPT*	S× *PPT*
N_{cell}	1.09	7.58*	0.30	0.01	1.44	0.02	0.03	0.48	0.11	0.44	9.35**	0.10
D_{cell}	6.35*	0.92	6.10*	1.47	1.72	1.20	0.70	1.95	0.51	19.66**	0.88	20.77**
r_m	9.02**	25.32**	5.85**	2.48	5.08*	1.71	1.37	2.35	0.97	11.84**	38.67**	14.80**

T_{min}, June-July minimum temperature; T_{mean}, June-July mean temperature; T_{max}, June-July maximum temperature; *PPT*, June-July precipitation.

One and two asterisks indicated $P < 0.05$ and $P < 0.01$, respectively.

Conclusions

- Most variability of wood formation in conifer species under drought-prone environments is explained by the rate of xylem production rather than its duration.

- Under warmer and drier conditions, a longer growing season will not benefit xylem formation in conifers.

- Warming-induced drought may limit carbon sequestration by reducing the rate of cell production.

Co-authors

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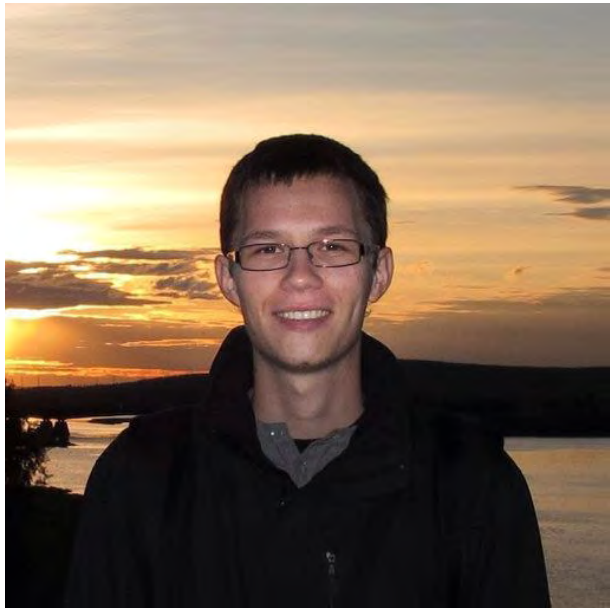
- Franco Biondi
- Peter Prislan
- Eryuan Liang

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Thank you!