Supporting Information for the manuscript: Impact of Compound Drought-Heat Stress on Mongolian Scotch pine Growth: A Copula-Based Analysis Across Precipitation Gradients

Figure

Fig. A.1
Comparison of Resistance, Recovery, and Resilience of Mongolian Scotch Pine Growth to High-Intensity Compound Drought-Heat Events at Three Locations in Northern Greater Khingan Range).

Tables

Table A.1
Compound Drought-Heat Condition Categories Based on CDHSI
Table A.2
Optimal fitting parameters for the marginal distribution of characteristic variables of drought in each study area
Table A.3
Correlation Results Between the Compound Drought-Heat Index and PDSI as well as VPD at Sampling Points under Different Gradients. The correlations were calculated for the common period from 1958 to 2023. Double asterisks indicate values at a 99% confidence level.
Table A.4
Compound Drought-Heat Severity Index (CDHSI) Detected Using Copula Functions. Bold values indicate VDP exceeding the third quartile (Q3) or PDSI lower than the first quartile (Q1) during the 1958-2023 reference period
Table A.5
Percentage of series with a negative event year where the absolute value of the normalized growth deviation exceeds the 75% threshold.
Table A.6
Superposed Epoch Analysis (SEA) p-values for Different Lags at Three Sites.

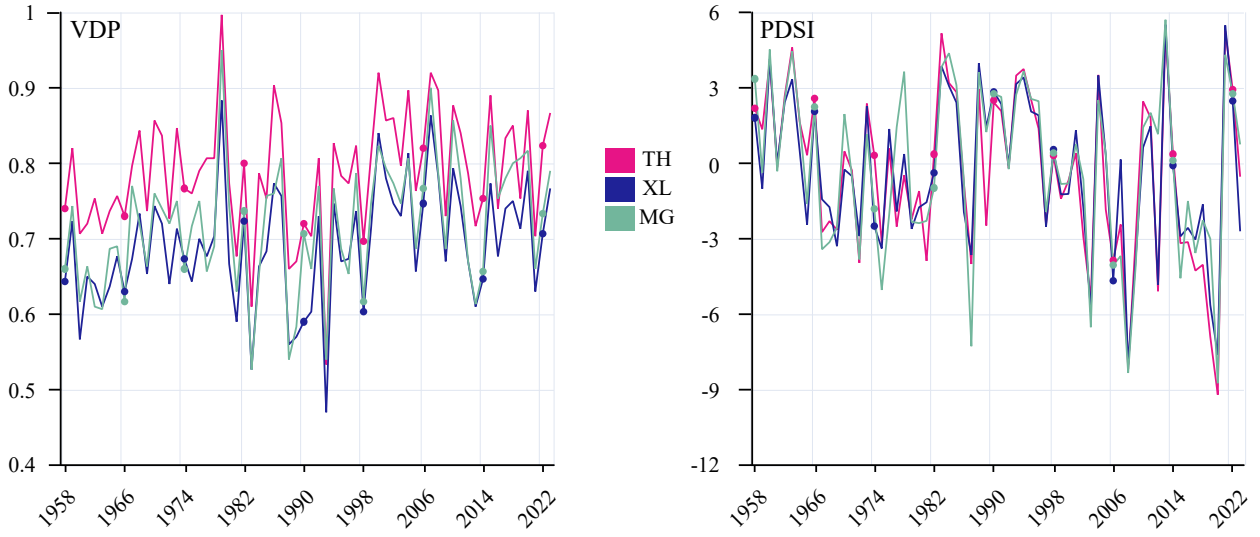

Fig. A.1: Comparison of Resistance, Recovery, and Resilience of Mongolian Scotch Pine Growth to High-Intensity Compound Drought-Heat Events at Three Locations in Northern Greater Khingan Range).

Table A.1
Compound Drought-Heat Condition Categories Based on CDHSI

Category	Dry-hot condition	CDHSI
Grade 0	Abnormal	$(-0.80, -0.50]$
Grade 1	Light	$(-1.30, -0.80]$
Grade 2	Moderate	$(-1.60, -1.30]$
Grade 3	Heavy	$(-2.0, -1.60]$
Grade 4	Extreme	≤ -2

Table A.2
Optimal fitting parameters for the marginal distribution of characteristic variables of drought in each study area

Variable	Distribution & Parameters	ZZC	TH	XL
VDP	Best Fit Distribution	logistic	logistic	norm
	Fitting Parameters (location/scale or mean/sd)	0.731 / 0.050	0.792 / 0.048	0.695 / 0.087
PDSI	Best Fit Distribution	gev	norm	gev
	Fitting Parameters (mean/sd or loc /scale /shape)	-1.035/3.541/ -0.494	-0.371/3.288	-1.242/3.149/0.400

Table A.3
Correlation Results Between the Compound Drought-Heat Index and PDSI as well as VPD at Sampling Points under Different Gradients. The correlations were calculated for the common period from 1958 to 2023. Double asterisks indicate values at a 99% confidence level.

Variable	MG_CDHSI	XL_CDHSI	TH_CDHSI
VDP	-0.78**	-0.79**	-0.77**
PDSI	0.76**	0.80**	0.84**

Table A.4
Compound Drought-Heat Severity Index (CDHSI) Detected Using Copula Functions. Bold values indicate VDP exceeding the third quartile (Q3) or PDSI lower than the first quartile (Q1) during the 1958-2023 reference period.

Year	Site	CDHSI /VDP/ PDSI	VDP_Q3/ PDSI_Q1
1979	TH	-2.42 /**1.00** / -2.22	TH: 0.84 / -2.71 XL: 0.74 /-2.49 MG: 0.77 / -2.32
	XL	-2.30 / **0.88** / -2.61	
	MG	-2.49 / **0.95** / -2.33	
1987	TH	-1.63 / **0.85** / -4.00	
	XL	-1.49 / **0.76** / -3.64	
	MG	-1.67 / **0.81** / -7.27	
2000	TH	-1.70 / **0.92** / -0.69	
	XL	-1.61 / **0.75** / -1.22	
	MG	-1.73 / **0.82** / -0.80	
2003	TH	-1.70 / **0.80** / **-5.40**	
	XL	-1.62 / **0.73** / **-5.92**	
	MG	-1.73 / **0.75** / **-6.52**	
2007	TH	-1.87 / **0.92** / -2.43	
	XL	-1.73 / **0.86** / -0.15	
	MG	-1.91 / **0.90** / -3.69	
2008	TH	-2.81 / **0.90** / **-8.17**	
	XL	-2.61 / **0.78** / **-8.00**	
	MG	-2.93 / **0.79** / **-8.34**	
2015	TH	-1.74 / **0.89** / -3.18	
	XL	-1.59 / **0.77** / **-2.90**	
	MG	-1.78 / **0.85** / **-4.57**	
2018	TH	-1.61 / **0.85** / **-4.03**	
	XL	-1.48 / **0.75** / -1.63	
	MG	-1.66 / **0.80** / -2.27	
2019	TH	-2.04 / **0.75** / **-6.90**	
	XL	-2.00 / **0.71** / **-5.63**	
	MG	-2.06 / **0.81** / -3.00	

Table A.5
Percentage of series with a negative event year where the absolute value of the normalized growth deviation exceeds the 75% threshold.

Site	Series with a negative event year (%)						
	1979	1987	2000	2003	2008	2015	2019
MG	**96.3**	**83.02**	41.51	5.77	**100**	54.9	**94.12**
TH	68.42	57.14	**84.62**	38.46	69.23	**80.77**	33.33
XL	**96.88**	18.75	12.5	**84.38**	62.5	32.26	**100**

Table A.6
Superposed Epoch Analysis (SEA) p-values for Different Lags at Three Sites.

lag	p-values		
	TH	MG	XL
-4	0.209	0.451	0.059
-3	0.158	0.479	0.183
-2	0.433	0.468	0.009**
-1	0.132	0.34	0.126
0	0.013*	0.001**	0.015*
1	0.156	0.339	0.059
2	0.102	0.407	0.363
3	0.264	0.306	0.214
4	0.321	0.233	0.007**