

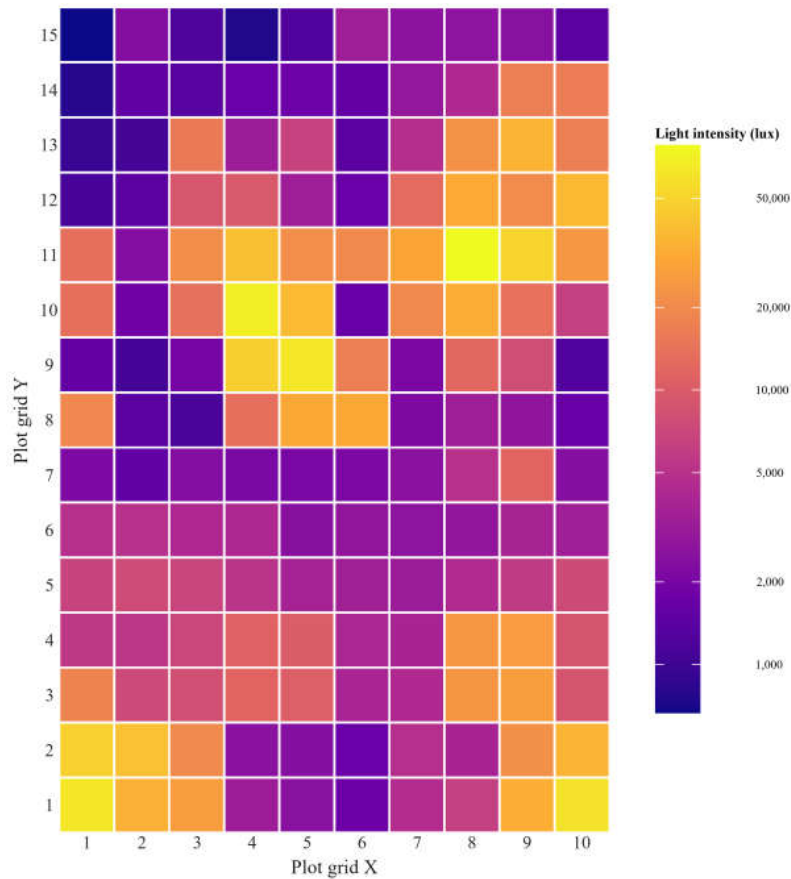


Figure S1. Spatial heatmaps of light intensity across the 6 hm² permanent plot. Values are aggregated at the 20 m × 20 m grid scale. The Mantel test, based on Euclidean distance matrices and 9,999 permutations, revealed a significant positive correlation between sapling abundance and light intensity (Mantel $r = 0.214$, $p < 0.001$). This result supports the dependence of sapling on light intensity described in Section 4.2 of the main text.

Table S1. Descriptive statistics of the environmental variables measured at the 20 m × 20 m grid scale (n = 150).

Statistics	Light intensity (lux)	Air temperature (°C)	Air humidity (%)	Aspect (°)	Slope (°)	Elevation (m)
Mean	14,842.57	29.81	32.52	146.58	21.46	1,687.89
SD	16,202.48	3.10	6.22	48.71	6.85	53.56
Min	669.40	22.46	21.32	10.00	4.00	1,578.09
Median	6,688.00	30.26	33.46	148.00	21.00	1,686.48
Max	77,606.00	34.28	44.00	312.00	42.00	1,788.76
Skewness	2.22	-0.39	-0.29	0.12	0.18	0.10
Kurtosis	4.85	-0.69	-0.86	-0.15	-0.18	-0.33

Table S2. Pearson correlation coefficients among the environmental variables (n = 150).

	Light intensity	Air temperature	Air humidity	Aspect	Slope	Elevation
Light intensity	1.000					
Air temperature	0.264	1.000				

Air humidity	-0.322	-0.588***	1.000			
Slope aspect	0.016	-0.019	-0.043	1.000		
Slope angle	0.071	-0.112	0.020	0.009	1.000	
Elevation	0.196*	0.316***	-0.351***	0.003	0.127	1.000

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table S3. Statistical metrics of PCA based on elevation, air temperature, and air humidity

Variables	PC1	PC2	PC3
Elevation	0.749	-0.261	-0.609
Air humidity	0.647	0.484	0.589
Air temperature	0.141	-0.836	0.531
Eigenvalue	1.430	1.271	0.299
Variance explained (%)	47.670	42.365	9.965
Cumulative (%)	47.670	90.035	100

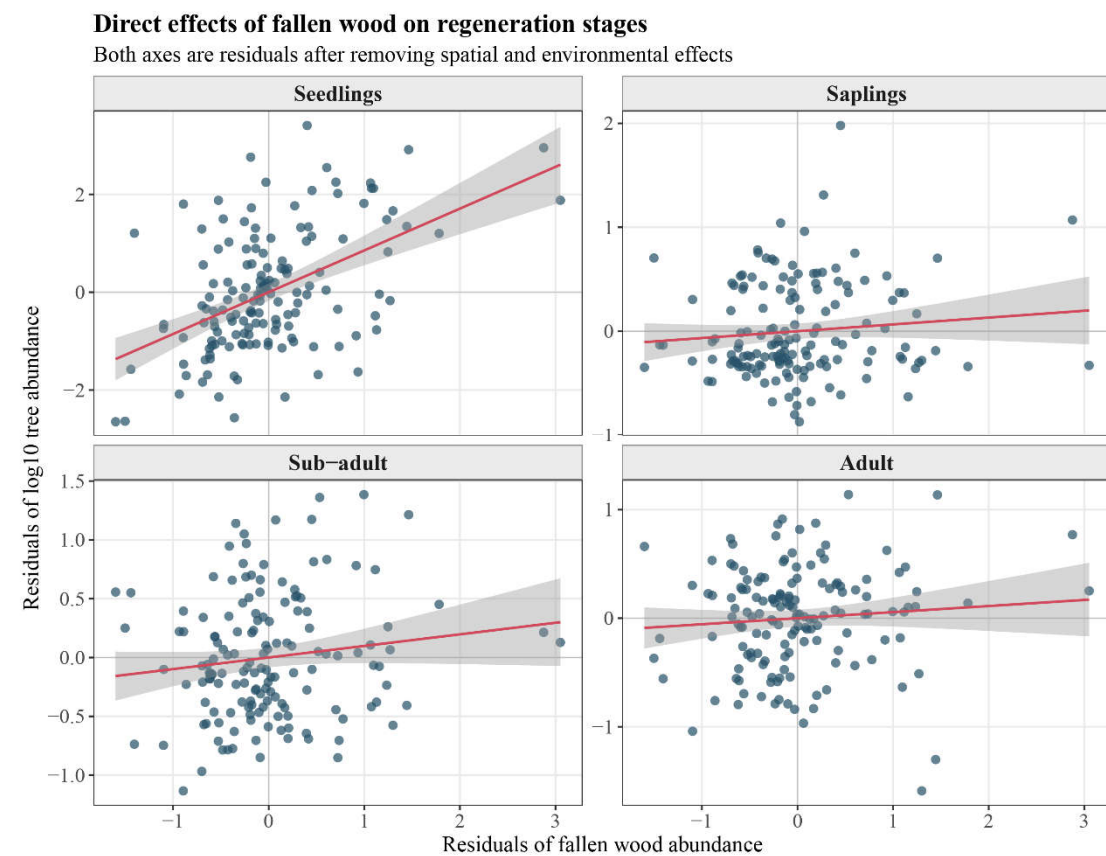


Figure S2. Partial regression analysis of *Picea schrenkiana* abundance against fallen wood abundance across different ontogenetic stages, based on 150 grid cells, after controlling for environmental heterogeneity and spatial autocorrelation. Red lines indicate fitted relationships with 95% confidence intervals (shaded). Significant positive correlations were observed for seedlings ($p < 0.001$) and adults ($p < 0.05$), whereas saplings and sub-adults showed no significant relationship ($p > 0.05$). These results quantitatively support the ontogenetic shift in dependence on fallen woods described in Section 4.2 of the main text.

Table S4. Parameters of partial regression analysis of *P.schrenkiana* abundance against fallen wood abundance at different ontogenetic stages based on 150 grid cells.

Ontogenetic stages	Intercept	Slope	<i>p</i> values	95% CI lower limit	95% CI upper limit	<i>R</i> ²
Seedlings	0	5.125	<0.001	3.738	6.511	0.265
Saplings	0	-0.060	0.292	-0.170	0.051	0.008
Sub-adult	0	0.007	0.882	-0.084	0.098	0.0001
Adult	0	0.257	0.039	0.013	0.500	0.029

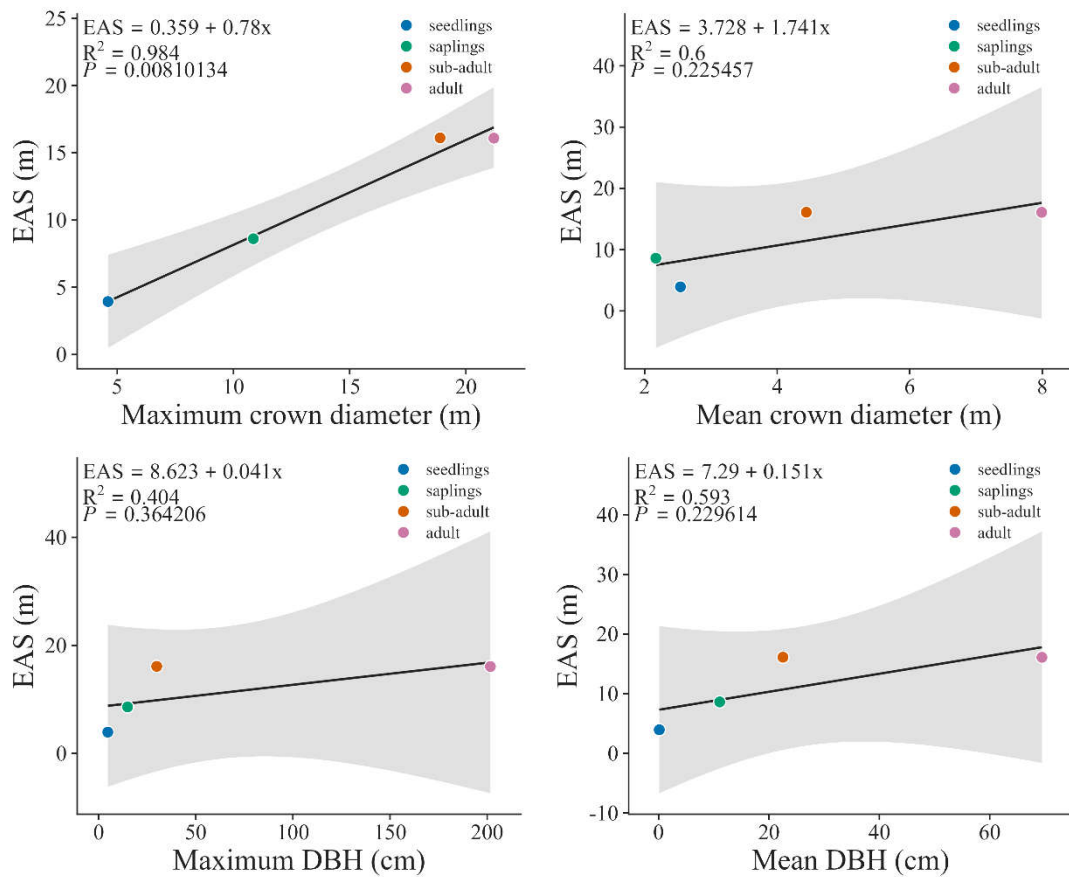


Figure S3. Regression analysis of environmental action scale (EAS) against crown width and DBH across different ontogenetic stages of *P.schrenkiana*. Solid lines represent fitted regression lines with 95% confidence intervals (shaded). This result quantitatively supports the discussion in Section 4.5 that max crown width serves as a consistent morphological reflection of EAS.