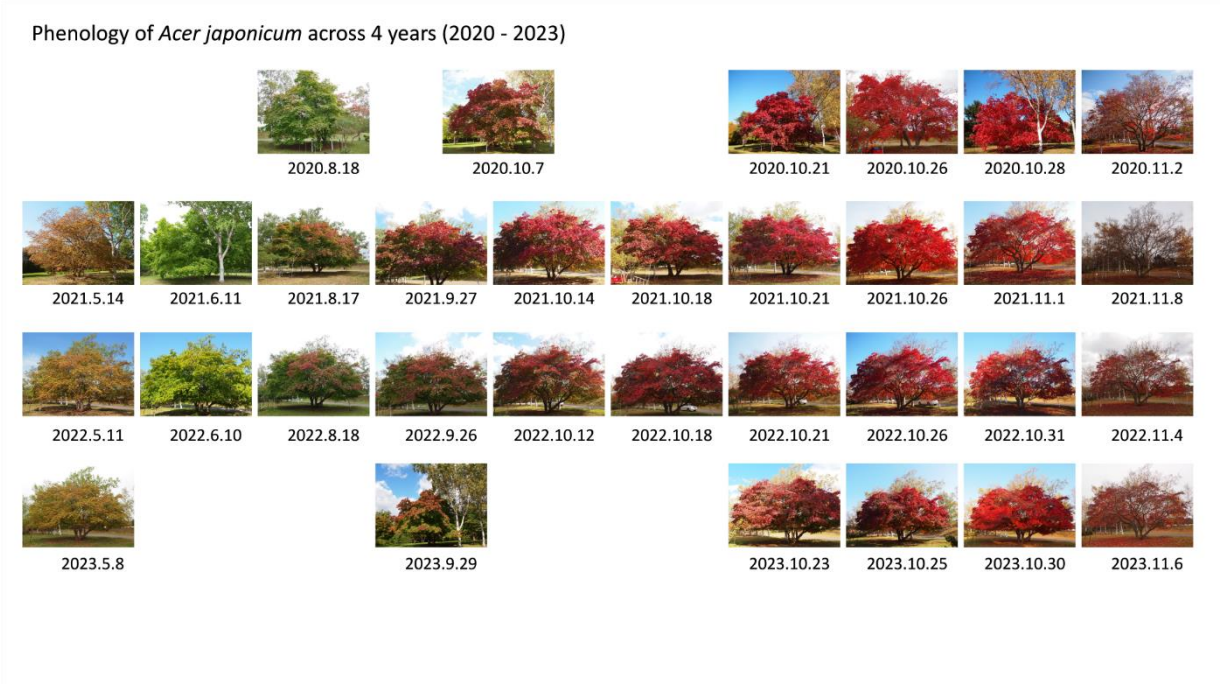
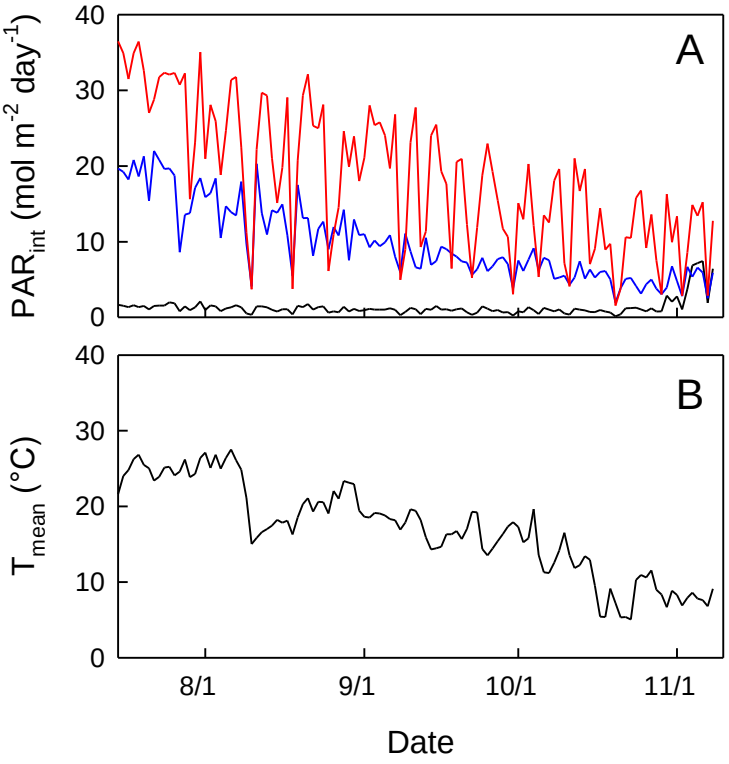
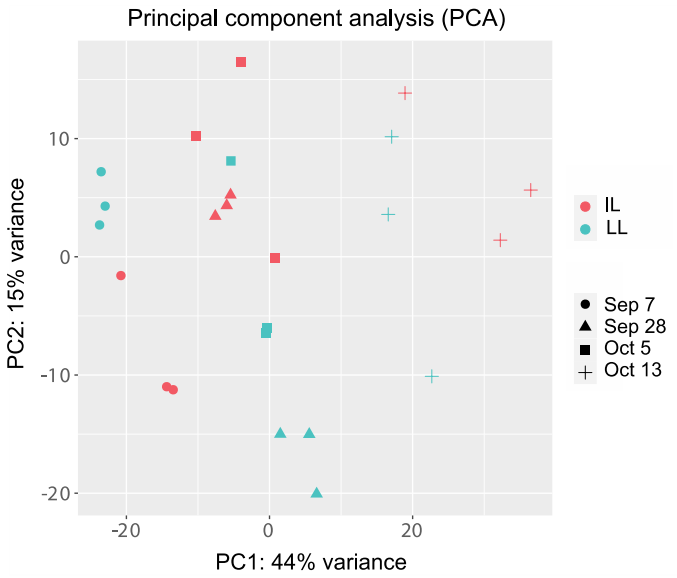
Supplementary data



Supplementary Figure S1 Phenological records of an adult tree of fullmoon maple (*Acer japonicum*) across 4 years (2020 – 2023). The adult tree (height: ≈10 m, age: 50 years old) was grown in the arboretum of Hokkaido Research Center, Forestry and Forest Products Research Institute (43.0°N, 141.4°E; 180 m a.s.l.).



Supplementary Figure S2 Seasonal changes in daily integrated photosynthetic active radiance (PAR_{int}) (A) and daily mean temperature (T_{mean}) (B) measured under the canopy of fullmoon maple, at a height of 50 cm above the ground. The figure shows fluctuations under high light at the south-faced outer-canopy (HL; red, upper seasonal change), intermediate light at north-faced outer-canopy (IL; blue, middle seasonal change), and low light condition at north-faced inner-canopy (LL; black, lower seasonal change).



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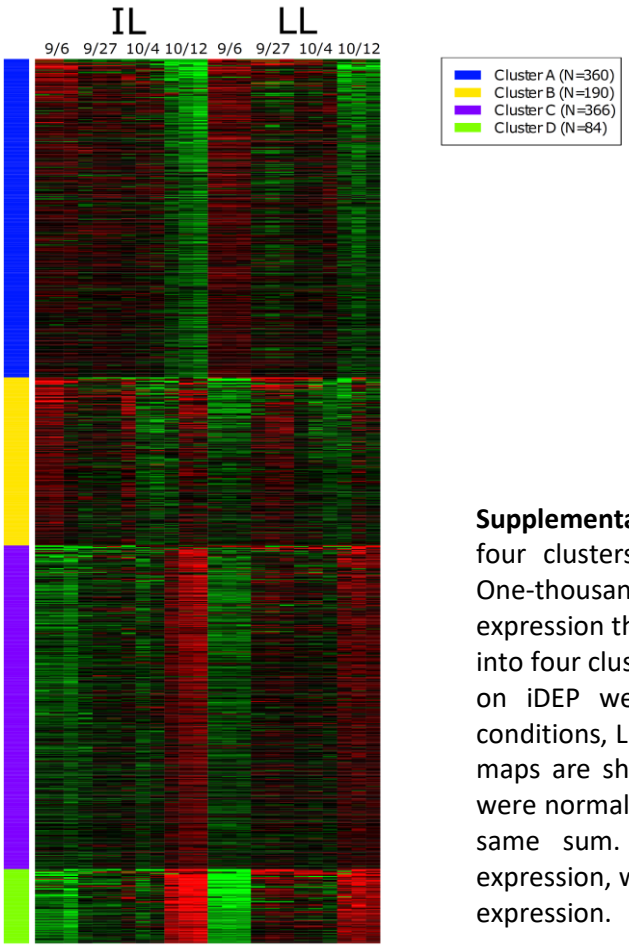
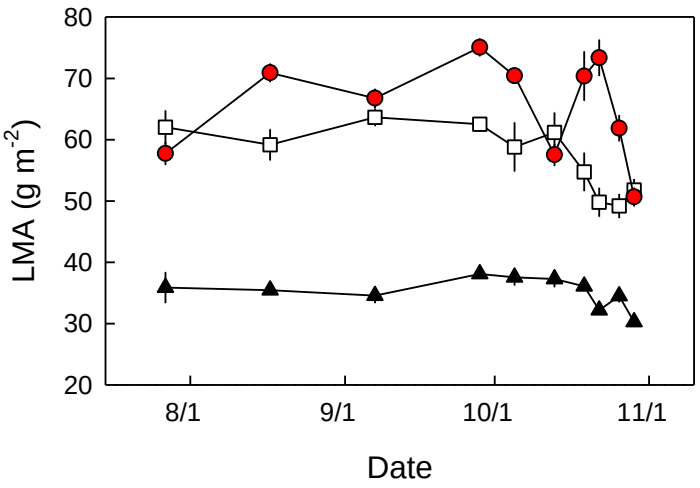
Supplementary Figure S3 Principal component analysis (PCA) of *Acer japonicum* transcriptomes.

PCA of the RNA-Seq data showed that the transcriptomes of the same date and light conditions were similar to each other except for those of Oct 5, for which IL and LL samples showed a mixed distribution. PC1 explained a 44% variance of gene expression and appears to reflect developmental progress or senescence. The results indicate that the overall pattern of gene expression in individual leaves is under strong influence by developmental progression. PC2 explained a 15% variance of gene expression. For PC2, the samples from Sep 7 (LL), Sep 28 (IL), Oct 5 (IL) and Oct 13 (IL) were similar to each other, those from Sep 7 (IL) and Sep 28 (LL) seemed to form another group, and the rest of the samples showed intermediate distribution. Thus, PC2 explains the gene expression in which IL and LL show alternating patterns, which seemed correlated with anthocyanin biosynthesis (see Supplementary Fig. S4 below). Clear differences between IL and LL samples indicate that the light conditions also influenced the global transcriptional profiles. However, PC2 indicates that light conditions may have affected the transcriptome in combination with other factors such as development.

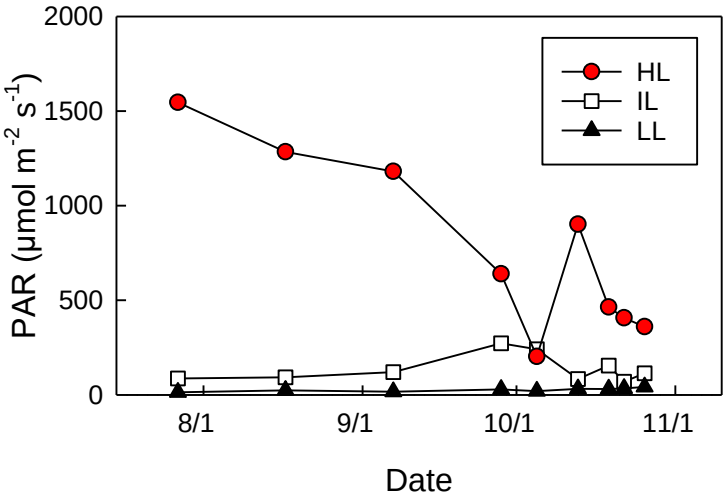


Supplementary Figure S4 k-means clustering shows four clusters of *Acer japonicum* transcriptomes. One-thousand genes, which showed higher expression than remaining genes, were categorized into four clusters based on their expression profiles on iDEP web application. IL: intermediate-light conditions, LL: low-light conditions. Above the heat maps are shown the dates of sampling. The data were normalized so that the rows (genes) have the same sum. Red color indicates an increased expression, while green color indicates a decreased expression.

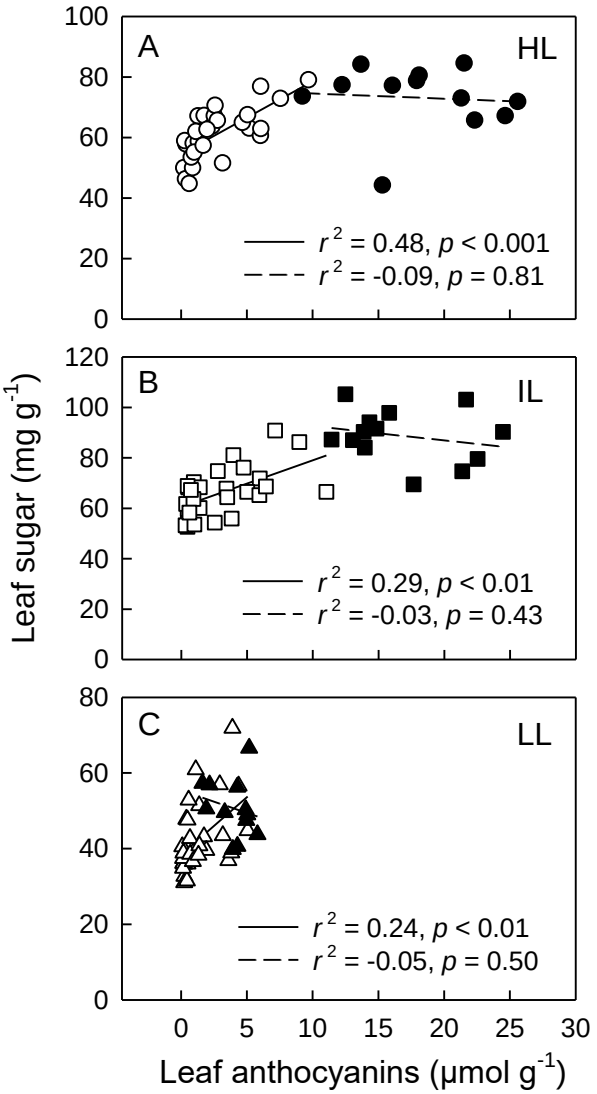
The transcriptomes were further analyzed by k-means clustering (Ge *et al.*, 2018), and the top 1,000 highly expressed genes were grouped into four clusters based on the similarities in their expression profiles (Clusters A to D). The genes grouped in Cluster A showed the highest expression on 7 Sep, with a gradual decrease toward 13 Oct. This cluster was represented by photosynthesis-related genes (Supplementary Table S1). The genes in Cluster B showed distinct expression profiles between IL and LL conditions. Under IL conditions, the expression of Cluster B genes was high on 7 Sep, once decreased on 27 Sep and 5 Oct, and again increased on 13 Oct. In contrast, Cluster B genes showed the highest expression on 27 Sep under LL conditions. Genes involved in the secondary metabolism including those for flavonoid biosynthesis were enriched in Cluster B (Supplementary Table S1 and Supplementary Dataset S2). The gene expression profiles of those categorized in Cluster C and D were similar to each other, while those in Cluster D showed larger changes in gene expression than those in Cluster C. Most of the Cluster C genes were related to various transport activities, which indicates that the transport activities were increasing during developmental leaf senescence. In Cluster D, three genes categorized in stomata opening were enriched, which include plasma membrane ATPase (*Arabidopsis* At2g18960 homolog), a Psb29 homolog likely involved in the maintenance of thylakoid membrane (Keren *et al.*, 2005), and protein phosphatase 2 involved in abscisic acid signaling (Leung *et al.*, 1997). This finding may indicate that cellular responses during developmental leaf senescence overlap with drought responses. Cluster D also contains the three key enzymes in chlorophyll breakdown, including chlorophyll magnesium dechelatase (alternatively called SGR), pheophytinase (PPH), and pheophorbide *a* oxygenase (PaO) (Supplementary Dataset S2). Thus, Cluster D also represents senescence-related metabolism.



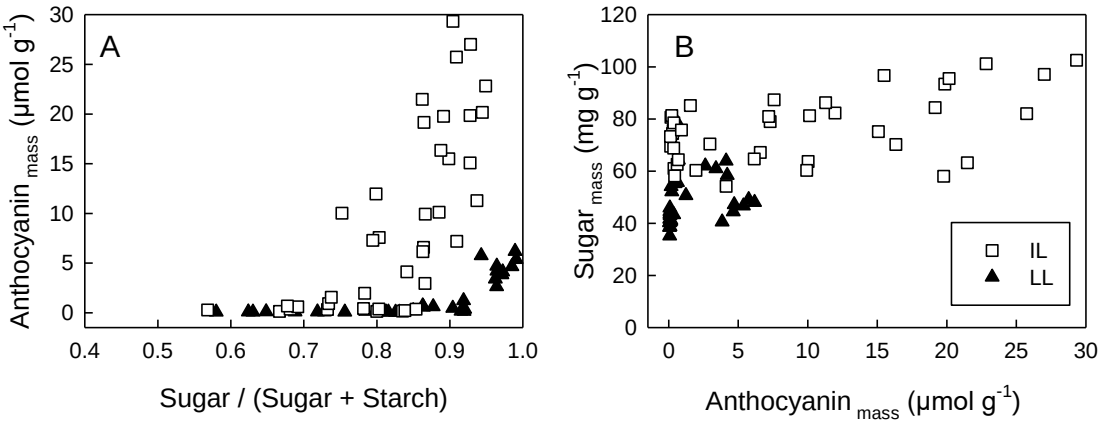
Supplementary Figure S5 Seasonal changes in leaf mass per area (LMA) in leaves grown under high light at the south-faced outer-canopy (HL, red circles), intermediate light at north-faced outer-canopy (IL, open rectangles), and low light at north-faced inner-canopy (LL, black closed triangles) of an adult tree of fullmoon maple. Values are means ± SE (n=4).



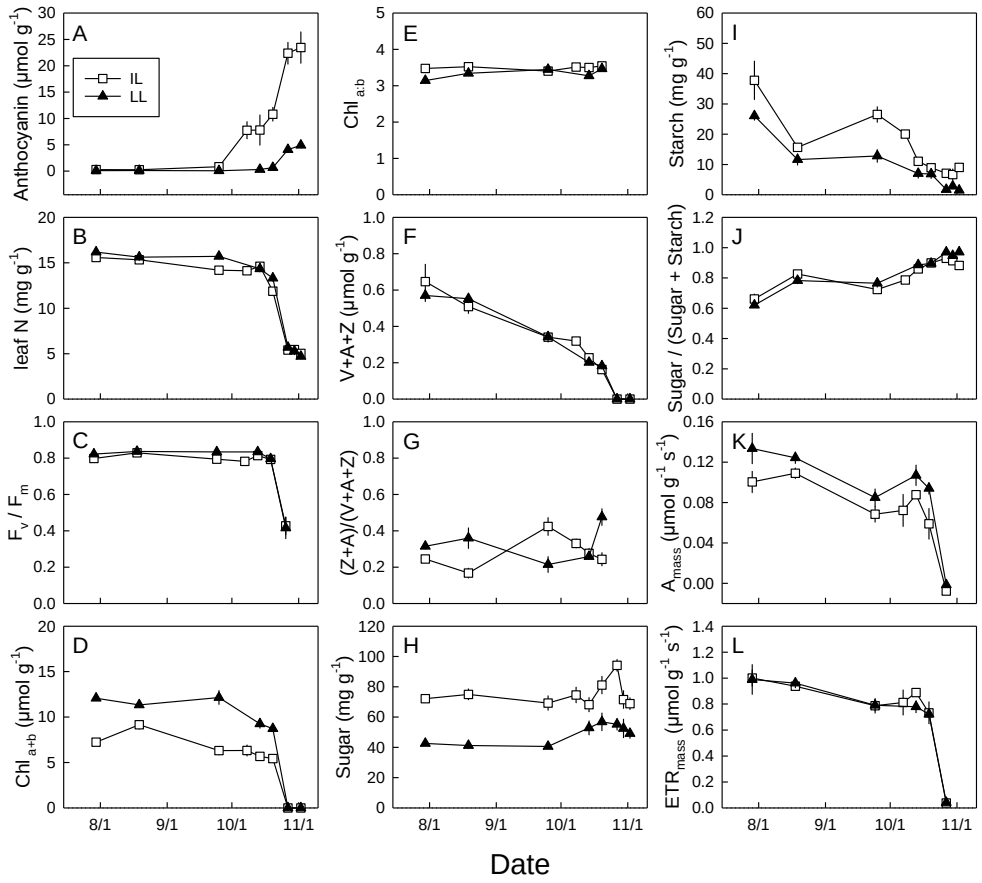
Supplementary Figure S6 Seasonal changes in mean PAR for 1 h before leaf sampling for leaves grown at the south-faced outer-canopy (red circles, HL), north-faced outer-canopy (open rectangles, IL), and north-faced inner-canopy (black closed triangles, LL) of an adult tree of fullmoon maple. Leaves were sampled on 27 Jul, 17 Aug, 7 Sep, 28 Sep, 5 Oct, 13 Oct, 19 Oct, 22 Oct, 26 Oct, and 29 Oct.



Supplementary Figure S7 Relationship between leaf anthocyanin and sugar contents in leaves grown at the south-faced outer-canopy (A), north-faced outer-canopy (B), and north-faced inner-canopy (C) of an adult tree of fullmoon maple. Open symbols indicate leaves sampled from 27 Jul to 19 Oct before leaf N resorption, while closed symbols indicate leaves sampled from 22 to 29 Oct during leaf N resorption. Linear regression analysis was conducted for each group (solid lines: 27 Jul to 19 Oct, dashed lines: 22 to 29 Oct).

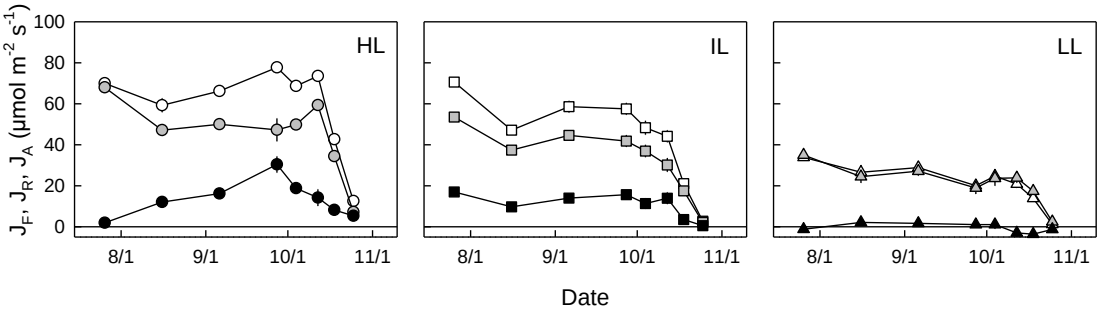


Supplementary Figure S8 Relationships between the ratio of sugar to sugar plus starch [Sugar/(Sugar+Starch)] and $Anthocyanin_{mass}$ (A), and between $Anthocyanin_{mass}$ and $Sugar_{mass}$ (B), in leaves grown at north-faced outer-canopy (open rectangles, IL) and north-faced inner-canopy (black closed triangle, LL) of an adult tree of fullmoon maple in 2020.

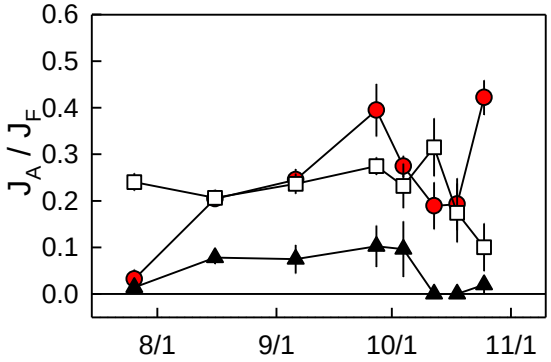


Supplementary Figure S9 Seasonal changes in 2020. Observations were made for dry mass-based leaf anthocyanin content (A), leaf N content (B), F_v/F_m (C), total chlorophyll content (D), the ratio of chlorophyll a to b (E), xanthophyll pigment pool size (V+A+Z) (F), conversion state of xanthophyll cycle [(Z+A)/(V+A+Z)], leaf sugar content (H), leaf starch content (I), the ratio of sugar to (sugar + starch) [Sugar/(Sugar + Starch)] (J), net photosynthetic rate (A_{mass}) (K), and electron transport rate (ETR_{mass}) (L) in leaves grown under intermediate light at north-faced outer-canopy (open rectangles, IL), and low light at north-faced inner-canopy (black closed triangles, LL) of an adult tree of fullmoon maple. Values are means ± SE (n=4-6).

Note: Data of LL leaves sampled on 8 Oct were excluded because girdling caused by insects was observed on the specific branch where the leaves were attached, after measurements. Comparing between the values on 8 Oct, and pre- (25 Sep) and post-values (14 Oct), higher anthocyanin content (2.70 ± 0.28 μmol g^{-1}), lower chlorophyll content (7.40 ± 0.34 μmol g^{-1}), higher sugar (81.7 ± 3.9 mg g^{-1}) and starch content (45.8 ± 3.9 mg g^{-1}), and lower photosynthetic activity (A_{mass}: 0.0080 ± 0.0018 μmol g^{-1} s^{-1}, and ETR_{mass}: 0.281 ± 0.022 μmol g^{-1} s^{-1}) were observed in these leaves (n=5).



Supplementary Figure S10 Seasonal changes in total electron flow estimated with chlorophyll fluorescence (J_F = ETR, open symbols), which estimated from Rubisco carboxylation and photorespiration based on Rubisco kinetics (J_R, grey symbols), and alternative electron flow (J_A, closed symbols) estimated as $J_A = J_F - J_R$ in HL (circles), IL (rectangles), and LL leaves (triangles) of *A. japonicum*. Values indicate means ± SE (n=4).



Supplementary Figure S11 Seasonal changes in the ratio of J_A to J_F in HL (red circles), IL (open rectangles), and LL leaves (closed triangles) of *A. japonicum*. Values indicate means ± SE (n=4). J_A/J_F was set to 0 when J_A had a negative value.

Supplementary Table S1 Representative metabolic pathways enriched in k-means clustering.

Cluster	P values	No of Genes	Pathways
A	1.28E-08	28	Photosynthesis
A	1.20E-07	18	Photosynthesis, light reaction
A	1.03E-05	17	Electron transport chain
A	2.00E-05	31	Generation of precursor metabolites and energy
A	0.00156972	34	Small molecule biosynthetic process
A	0.0059441	72	Response to abiotic stimulus
B	3.10E-05	14	Secondary metabolic process
B	0.0001529	9	Detoxification
B	0.00080103	10	Response to toxic substance
B	0.00080103	9	Phenylpropanoid metabolic process
B	0.00180125	5	Toxin metabolic process
B	0.00419419	32	Transmembrane transport
C	3.58E-08	67	Transmembrane transport
C	0.00025389	41	Ion transport
C	0.00301831	20	Metal ion transport
C	0.00360087	40	Lipid metabolic process
C	0.00508498	36	Cellular lipid metabolic process
C	0.00546383	19	Anion transport
C	0.00579501	31	Ion transmembrane transport
C	0.00579501	25	Inorganic ion transmembrane transport
C	0.00694276	26	Cation transport
D	0.00941617	3	Stomatal opening

Top 1,000 genes whose expression were higher than those of the remaining genes were clustered by k-means clustering on iDEP (Supplementary Fig. S4).

Supplementary Table S2 Results of Tukey-Kramer multiple comparison test of dry mass- and area-based leaf anthocyanin content, leaf N content, and F_v/F_m in leaves of a fullmoon maple tree among dates, or among light conditions (high light: HL, intermediate light: IL, and low light: LL).

		Date									
	Light	27 Jul	17Aug	7 Sep	28 Sep	5 Oct	13 Oct	19 Oct	22 Oct	26 Oct	29 Oct
$Anthocyanin_{mass}$ ($\mu mol\ g^{-1}$)	HL	0.30 ^{f,A} ± 0.03	0.80 ^{f,A} ± 0.07	1.19 ^{f,A} ± 0.08	2.46 ^{ef,A} ± 0.29	2.26 ^{ef,AB} ± 0.26	5.49 $^{de,\ AB}$ ± 0.34	7.09 ^{d,A} ± 1.01	12.80 ^{c,A} ± 1.43	18.21 ^{b,A} ± 1.27	23.46 ^{a,A} ± 1.00
	IL	0.46 ^{b,A} ± 0.04	0.71 ^{b,A} ± 0.16	1.06 ^{b,A} ± 0.22	2.78 ^{b,A} ± 1.29	3.07 ^{b,A} ± 0.24	6.49 ^{b,A} ± 1.57	6.82 ^{b,A} ± 0.88	14.86 ^{a,A} ± 2.32	19.04 ^{a,A} ± 2.61	15.12 ^{a,B} ± 1.02
	LL	0.29 ^{cd,A} ± 0.07	0.27 ^{cd,B} ± 0.06	0.14 ^{d,B} ± 0.02	0.59 ^{cd,A} ± 0.09	1.33 ^{bcd,B} ± 0.22	1.82 ^{bcd,B} ± 0.71	3.46 ^{ab,A} ± 0.99	2.69 ^{ac,B} ± 0.79	4.43 ^{a,B} ± 0.42	4.73 ^{a,C} ± 0.41
$Anthocyanin_{area}$ ($mmol\ m^{-2}$)	HL	0.017 ^{d,B} ± 0.002	0.057 ^{cd,A} ± 0.005	0.079 ^{cd,A} ± 0.006	0.186 ^{cd,A} ± 0.025	0.160 ^{cd,A} ± 0.02	0.316 ^{bc,AB} ± 0.021	0.503 ^{b,A} ± 0.088	0.939 ^{a,A} ± 0.117	1.119 ^{a,A} ± 0.048	1.190 ^{a,A} ± 0.071
	IL	0.028 ^{d,A} ± 0.003	0.042 ^{cd,A} ± 0.01	0.068 ^{cd,A} ± 0.014	0.177 ^{cd,A} ± 0.083	0.181 ^{cd,A} ± 0.02	0.401 ^{bc,A} ± 0.109	0.374 ^{cd,AB} ± 0.057	0.756 ^{ab,A} ± 0.158	0.902 ^{a,A} ± 0.089	0.78 ^{a,B} ± 0.04
	LL	0.010 ^{c,B} ± 0.002	0.010 ^{c,B} ± 0.002	0.005 ^{c,B} ± 0.001	0.022 ^{c,A} ± 0.003	0.049 ^{bc,B} ± 0.007	0.071 ^{ac,B} ± 0.031	0.124 ^{ab,B} ± 0.035	0.087 ^{ac,B} ± 0.026	0.153 ^{a,B} ± 0.013	0.143 ^{a,C} ± 0.012
N_{mass} ($mg\ g^{-1}$)	HL	18.5 ^{a,A} ± 0.4	15.7 ^{cd,A} ± 0.3	16.3 ^{bc,B} ± 0.1	16.5 ^{bc,A} ± 0.2	15.3 ^{cd,B} ± 0.2	17.1 ^{ab,A} ± 0.4	14.5 ^{d,B} ± 0.4	12.1 ^{e,A} ± 0.5	6.3 ^{f,AB} ± 0.1	4.7 ^{g,B} ± 0.1
	IL	18.1 ^{a,A} ± 0.2	16.0 ^{b,A} ± 0.6	16.3 ^{ab,B} ± 0.2	16.3 ^{ab,A} ± 0.2	16.1 ^{b,B} ± 0,2	14.6 ^{bc,B} ± 0.7	13.5 ^{c,B} ± 0.2	10.9 ^{d,A} ± 0.7	5.5 ^{e,B} ± 0.4	5.2 ^{e,A} ± 0.1
	LL	17.8 ^{a,A} ± 0.9	17.1 ^{a,A} ± 0.5	18.1 ^{a,A} ± 0.1	16.8 ^{a,A} ± 0.5	17.4 ^{a,A} ± 0.4	17.3 ^{a,A} ± 0.6	16.0 ^{a,A} ± 0.2	12.1 ^{b,A} ± 0.3	6.9 ^{c,A} ± 0.3	4.3 ^{d,B} ± 0.0
N_{area} ($g\ m^{-2}$)	HL	1.07 ^{b,A} ± 0.04	1.11 ^{ab,A} ± 0.01	1.09 ^{b,A} ± 0.03	1.24 ^{a,A} ± 0.04	1.08 ^{b,A} ± 0.01	0.98 ^{bc,A} ± 0.01	1.02 ^{b,A} ± 0.06	0.88 ^{c,A} ± 0.02	0.39 ^{d,A} ± 0.02	0.24 ^{e,A} ± 0.00
	IL	1.12 ^{a,A} ± 0.04	0.94 ^{ab,B} ± 0.01	1.04 ^{ab,A} ± 0.03	1.02 ^{ab,B} ± 0.02	0.95 ^{ab,A} ± 0.06	0.89 ^{bc,A} ± 0.05	0.74 ^{c,B} ± 0.04	0.54 ^{d,B} ± 0.05	0.27 ^{e,B} ± 0.03	0.27 ^{e,A} ± 0.02
	LL	0.63 ^{a,B} ± 0.01	0.61 ^{a,C} ± 0.02	0.63 ^{a,B} ± 0.03	0.63 ^{a,C} ± 0.03	0.65 ^{a,B} ± 0.03	0.64 ^{a,B} ± 0.00	0.58 ^{a,B} ± 0.02	0.39 ^{b,C} ± 0.01	0.24 ^{c,B} ± 0.02	0.13 ^{d,B} ± 0.00
F_v/F_m	HL	0.79 ^{ab,B} ± 0.01	0.78 ^{ab,A} ± 0.01	0.78 ^{ab,B} ± 0.00	0.79 ^{ab,A} ± 0.00	0.82 ^{a,A} ± 0.00	0.79 ^{ab,A} ± 0.01	0.70 ^{c,B} ± 0.01	0.74 ^{bc,B} ± 0.01	0.53 ^{d,A} ± 0.04	–
	IL	0.79 ^{a,B} ± 0..01	0.78 ^{a,A} ± 0.01	0.80 ^{a,B} ± 0.01	0.81 ^{a,A} ± 0.01	0.82 ^{a,A} ± 0.00	0.79 ^{a,A} ± 0.01	0.73 ^{a,AB} ± 0.01	0.73 ^{a,B} ± 0.02	0.41 ^{b,A} ± 0.07	–
	LL	0.84 ^{a,A} ± 0.00	0.81 ^{a,A} ± 0.02	0.84 ^{a,A} ± 0.01	0.81 ^{a,A} ± 0.02	0.83 ^{a,A} ± 0.01	0.80 ^{a,A} ± 0.01	0.77 ^{a,A} ± 0.01	0.80 ^{a,A} ± 0.01	0.53 ^{b,A} ± 0.05	–
ABS_{LED}	HL	0.842 ^{a,A} ± 0.015	0.819 ^{a,A} ± 0.011	0.814 ^{a,A} ± 0.011	0.812 ^{a,A} ± 0.01	0.811 ^{a,A} ± 0.002	0.825 ^{a,A} ± 0.002	0.819 ^{a,A} ± 0.013	0.810 ^{a,A} ± 0.009	0.560 ^{b,A} ± 0.014	0.563 ^{b,A} ± 0.007
	IL	0.867 ^{a,A} ± 0.019	0.848 ^{a,A} ± 0.009	0.831 ^{a,A} ± 0.011	0.821 ^{ab,A} ± 0.005	0.831 ^{a,A} ± 0.014	0.820 ^{ab,A} ± 0.01	0.796 ^{ab,A} ± 0.013	0.691 ^{b,B} ± 0.046	0.309 ^{c,B} ± 0.033	0.500 ^{d,A} ± 0.059
	LL	0.839 ^{a,A} ± 0.005	0.839 ^{a,A} ± 0.006	0.847 ^{a,A} ± 0.007	0.826 ^{a,A} ± 0.01	0.827 ^{a,A} ± 0.009	0.812 ^{a,A} ± 0.013	0.803 ^{a,A} ± 0.006	0.653 ^{b,B} ± 0.023	0.156 ^{c,C} ± 0.053	0.108 ^{c,B} ± 0.007

Significant differences ($P < 0.05$) are indicated by different small letters among dates for each light condition, and by capital letters among light conditions for each date. Values indicate means ± SE (n=4). Note: Leaf anthocyanins and N could be measured for the leaves sampled on 29 Oct, whereas F_v/F_m could not be measured, since fluorescence signals were too small because of almost no chlorophyll remained at that time.

Supplementary Table S3 Results of Tukey-Kramer multiple comparison test of leaf mass per area (LMA) in leaves of a fullmoon maple tree among dates, or among light conditions (high light: HL, intermediate light: IL, and low light: LL).

		Date									
	Light	27 Jul	17 Aug	7 Sep	28 Sep	5 Oct	13 Oct	19 Oct	22 Oct	26 Oct	29 Oct
LMA ($g\ m^{-2}$)	HL	$57.7^{cd,A}$ ± 1.9	$70.9^{ab,A}$ ± 1.5	$66.7^{ac,A}$ ± 1.6	$75.1^{a,A}$ ± 1.5	$70.4^{ab,A}$ ± 1.0	$57.5^{cd,A}$ ± 1.8	$70.4^{ab,A}$ ± 4.0	$73.4^{a,A}$ ± 3.0	$61.9^{bc,A}$ ± 2.1	$50.7^{d,A}$ ± 1.5
	IL	$62.0^{ab,A}$ ± 2.7	$59.2^{ac,B}$ ± 2.5	$63.7^{a,A}$ ± 1.4	$62.5^{a,B}$ ± 0.9	$58.8^{ac,B}$ ± 4.0	$61.2^{ab,A}$ ± 3.3	$54.7^{ac,B}$ ± 3.1	$49.8^{bc,B}$ ± 2.4	$49.2^{c,B}$ ± 2.2	$51.8^{ac,A}$ ± 1.8
	LL	$35.9^{ab,B}$ ± 2.5	$35.5^{ab,C}$ ± 0.7	$34.6^{ab,B}$ ± 1.2	$38.1^{a,C}$ ± 0.9	$37.6^{a,C}$ ± 1.3	$37.3^{a,B}$ ± 1.3	$36.1^{ab,C}$ ± 0.5	$32.2^{ab,C}$ ± 0.6	$34.5^{ab,C}$ ± 1.0	$30.3^{b,B}$ ± 0.5

Significant differences ($P < 0.05$) are indicated by different small letters among dates for each light condition, and by capital letters among light conditions for each date. Values indicate means ± SE (n=4). HL: high light at the south-faced outer-canopy; IL: intermediate light at north-faced outer-canopy; LL: low light at north-faced inner-canopy.

Supplementary Table S4 Results of Tukey-Kramer multiple comparison test of pigments in leaves of a fullmoon maple tree among dates, or among light conditions (high light: HL, intermediate light: IL, and low light: LL).

		Date									
	Light	27 Jul	17 Aug	7 Sep	28 Sep	5 Oct	13 Oct	19 Oct	22Oct	26 Oct	29 Oct
$Chl_{a+b,mass}$ ($\mu mol\ g^{-1}$)	HL	8.03 ^{a,B} ± 0.88	4.62 ^{bc,B} ± 0.21	4.86 ^{bc,B} ± 0.28	4.33 ^{bc,B} ± 0.46	5.41 ^{b,B} ± 0.09	5.12 ^{b,B} ± 0.20	4.67 ^{bc,B} ± 0.39	3.22 ^{c,B} ± 0.09	0.76 ^{d,A} ± 0.09	0.00 $^{d,–}$ ± 0.00
	IL	8.86 ^{a,B} ± 0.22	8.47 ^{ab,B} ± 0.97	5.95 ^{bcd,B} ± 1.01	4.57 ^{de,B} ± 0.90	7.85 ^{ac,B} ± 0.42	4.59 ^{de,B} ± 0.53	5.45 ^{ce,B} ± 0.30	2.89 ^{ef,B} ± 0.40	0.15 ^{fg,B} ± 0.07	0.00 $^{g,–}$ ± 0.00
	LL	18.66 ^{a,A} ± 1.63	16.48 ^{ab,A} ± 1.48	17.85 ^{a,A} ± 0.80	10.06 ^{cd,A} ± 0.87	11.89 ^{bc,A} ± 1.11	11.64 ^{bc,A} ± 1.47	10.53 ^{cd,A} ± 1.06	6.08 ^{d,A} ± 0.67	0.61 ^{e,A} ± 0.12	0.00 $^{e,–}$ ± 0.00
$Chl_{a+b,area}$ ($\mu mol\ m^{-2}$)	HL	462 ^{a,B} ± 49	327 ^{bc,B} ± 9	323 ^{bc,B} ± 13	327 ^{bc,A} ± 41	381 ^{ab,A} ± 8	294 ^{bc,B} ± 13	328 ^{bc,A} ± 29	234 ^{c,A} ± 13	47 ^{d,A} ± 6	0 $^{d,–}$ ± 0
	IL	549 ^{a,AB} ± 24	499 ^{ab,AB} ± 57	376 ^{bcd,B} ± 59	285 ^{de,A} ± 55	458 ^{ac,A} ± 22	276 ^{de,B} ± 20	295 ^{ce,A} ± 5	143 ^{ef,B} ± 17	6 ^{f,B} ± 3	0 $^{f,–}$ ± 0
	LL	658 ^{a,A} ± 22	584 ^{ab,A} ± 51	615 ^{a,A} ± 15	404 ^{c,A} ± 32	449 ^{bc,A} ± 51	428 ^{bc,A} ± 43	381 ^{c,A} ± 42	196 ^{d,AB} ± 23	21 ^{e,B} ± 5	0 $^{e,–}$ ± 0
$Chl_{a:b}$	HL	3.92 ^{ab,A} ± 0.33	3.45 ^{b,A} ± 0.07	3.69 ^{ab,A} ± 0.17	3.78 ^{ab,A} ± 0.05	3.85 ^{ab,A} ± 0.03	4.00 ^{ab,A} ± 0.12	4.47 ^{a,A} ± 0.29	3.92 ^{ab,A} ± 0.05	4.08 ^{ab,B} ± 0.39	–
	IL	3.49 ^{bd,AB} ± 0.03	3.24 ^{d,A} ± 0.03	3.39 ^{cd,AB} ± 0.06	3.54 ^{bd,B} ± 0.05	3.49 ^{bd,B} ± 0.01	3.54 ^{bd,B} ± 0.06	3.63 ^{bc,B} ± 0.03	3.79 ^{b,A} ± 0.08	4.52 ^{a,AB} ± 0.22	–
	LL	3.08 ^{d,B} ± 0.02	3.24 ^{bd,A} ± 0.05	3.22 ^{cd,B} ± 0.01	3.26 ^{bd,C} ± 0.03	3.31 ^{bc,C} ± 0.05	3.23 ^{cd,B} ± 0.03	3.46 ^{b,B} ± 0.03	3.31 ^{bc,B} ± 0.04	5.16 ^{a,A} ± 0.09	–
$V+A+Z_{mass}$ ($\mu mol\ g^{-1}$)	HL	0.97 ^{a,A} ± 0.15	0.69 ^{bc,A} ± 0.03	0.85 ^{ab,A} ± 0.01	0.53 ^{cd,A} ± 0.03	0.40 ^{d,A} ± 0.02	0.55 ^{cd,A} ± 0.04	0.39 ^{d,A} ± 0.03	0.36 ^{d,A} ± 0.03	0.32 ^{d,A} ± 0.03	0.00 $^{e,–}$ ± 0.00
	IL	0.76 ^{a,A} ± 0.07	0.57 ^{b,A} ± 0.01	0.40 ^{c,C} ± 0.01	0.31 ^{cd,B} ± 0.05	0.37 ^{cd,A} ± 0.03	0.23 ^{d,B} ± 0.01	0.32 ^{cd,A} ± 0.01	0.24 ^{d,B} ± 0.02	0.08 ^{e,B} ± 0.02	0.00 $^{e,–}$ ± 0.00
	LL	0.70 ^{a,A} ± 0.05	0.59 ^{ab,A} ± 0.05	0.50 ^{bc,B} ± 0.02	0.41 ^{cd,AB} ± 0.02	0.33 ^{de,A} ± 0.02	0.35 ^{de,B} ± 0.03	0.30 ^{de,A} ± 0.02	0.23 ^{e,B} ± 0.02	0.08 ^{f,B} ± 0.01	0.00 $^{f,–}$ ± 0.00
$V+A+Z_{area}$ ($\mu mol\ m^{-2}$)	HL	55.9 ^{a,A} ± 8.4	49.0 ^{ab,A} ± 2.3	56.8 ^{a,A} ± 0.9	39.4 ^{bc,A} ± 2.3	28.5 ^{cd,A} ± 1.7	31.6 ^{cd,A} ± 1.6	27.4 ^{cd,A} ± 2.1	26.5 ^{cd,A} ± 2.0	19.9 ^{d,A} ± 1.2	0.0 $^{e,–}$ ± 0.0
	IL	46.6 ^{a,A} ± 4.0	33.5 ^{b,B} ± 1.4	25.4 ^{bc,B} ± 0.3	19.6 ^{ce,B} ± 3	21.5 ^{cd,B} ± 2.1	14.2 ^{de,B} ± 0.5	17.5 ^{ce,B} ± 0.6	11.6 ^{ef,B} ± 0.7	3.8 ^{fg,B} ± 0.8	0.0 $^{g,–}$ ± 0.0
	LL	24.9 ^{a,B} ± 0.6	20.8 ^{b,C} ± 1.6	17.1 ^{bc,C} ± 0.5	15.6 ^{cd,B} ± 0.7	12.5 ^{de,C} ± 1.1	12.9 ^{de,B} ± 0.7	11 ^{ef,C} ± 0.9	7.3 ^{f,B} ± 0.7	2.8 ^{g,B} ± 0.4	0.0 $^{g,–}$ ± 0.0
(Z+A)/(V+A+Z)	HL	0.94 ^{a,A} ± 0.02	0.85 ^{ab,A} ± 0.03	0.93 ^{a,A} ± 0.02	0.76 ^{bc,A} ± 0.05	0.38 ^{d,A} ± 0.03	0.80 ^{ab,A} ± 0.05	0.76 ^{bc,A} ± 0.03	0.64 ^{c,A} ± 0.02	0.77 ^{bc,A} ± 0.02	–
	IL	0.22 ^{de,B} ± 0.01	0.34 ^{cde,B} ± 0.03	0.30 ^{de,B} ± 0.04	0.39 ^{bd,B} ± 0.03	0.40 ^{bd,A} ± 0.06	0.19 ^{e,B} ± 0.02	0.51 ^{abc,B} ± 0.04	0.57 ^{ab,A} ± 0.06	0.66 ^{a,B} ± 0.02	–
	LL	0.27 ^{bcd,B} ± 0.04	0.13 ^{de,C} ± 0.01	0.18 ^{ce,C} ± 0.01	0.29 ^{bc,B} ± 0.04	0.13 ^{e,B} ± 0.02	0.28 ^{bc,B} ± 0.04	0.35 ^{b,C} ± 0.04	0.38 ^{b,B} ± 0.04	0.60 ^{a,B} ± 0.01	–

Pigments analyzed were dry mass- and area-based leaf total chlorophyll content (Chl_{a+b}), chlorophyll a to b ratio ($Chl_{a:b}$), dry mass-based xanthophyll cycle pigments content (V+A+Z), including violaxanthin (V), antheraxanthin (A), and zeaxanthin (Z), and conversion state of xanthophyll cycle [(Z+A)/(V+A+Z)]. Significant differences ($P < 0.05$) are indicated by different small letters among dates for each light condition, and by capital letters among light conditions for each date. Values indicate means ± SE (n=4). Note: Chl a:b and (Z+A)/(V+A+Z) could not be calculated on 29 Oct, since Chl_{a+b} and (V+A+Z) were not detectable (=0).

Supplementary Table S5 Results of Tukey-Kramer multiple comparison test of dry mass- and area-based leaf sugar content, leaf starch content, and ratio of sugar to [sugar + starch] in leaves of a fullmoon maple tree among dates, or among light conditions (high light: HL, intermediate light: IL, and low light: LL).

		Date									
	Light	27 Jul	17 Aug	7 Sep	28 Sep	5 Oct	13 Oct	19 Oct	22 Oct	26 Oct	29 Oct
$Sugar_{mass}$ ($mg\ g^{-1}$)	HL	53.3 ^{b,A} ± 3.1	51.6 ^{b,A} ± 2.8	60.7 ^{ab,A} ± 2.5	62.5 ^{ab,A} ± 3.7	64.1 ^{ab,AB} ± 2.8	62.9 $^{ab,\ AB}$ ± 0.9	74.1 ^{a,A} ± 2.5	78.1 ^{a,B} ± 2.2	72.1 ^{a,AB} ± 9.3	69.5 ^{ab,B} ± 1.8
	IL	58.1 ^{e,A} ± 3.6	61.4 ^{de,A} ± 3.5	65.3 ^{ce,A} ± 2.1	63.4 ^{de,A} ± 3.7	65.3 ^{ce,A} ± 4.3	69.8 ^{bce,A} ± 3.8	80.5 ^{acd,A} ± 5.0	96.5 ^{a,A} ± 4.5	88.9 ^{ab,A} ± 3.2	84.6 ^{ac,A} ± 5.8
	LL	36.0 ^{ab,B} ± 1.3	33.6 ^{b,B} ± 1.4	37.9 ^{ab,B} ± 1.2	47.4 ^{ab,B} ± 3.5	47.1 ^{ab,B} ± 5.6	48.4 ^{ab,B} ± 7.9	48.3 ^{ab,B} ± 4.0	53.4 ^{a,C} ± 2.2	55.0 ^{a,B} ± 4.3	43.6 ^{ab,C} ± 2.4
$Sugar_{area}$ ($g\ m^{-2}$)	HL	3.09 ^{d,A} ± 0.27	3.66 ^{cd,A} ± 0.2	4.06 ^{bcd,A} ± 0.26	4.68 ^{ac,A} ± 0.24	4.52 ^{ac,A} ± 0.24	3.62 ^{cd,A} ± 0.14	5.21 ^{ab,A} ± 0.32	5.72 ^{a,A} ± 0.14	4.43 ^{ac,A} ± 0.54	3.53 ^{cd,A} ± 0.19
	IL	3.62 ^{a,A} ± 0.34	3.65 ^{a,A} ± 0.36	4.15 ^{a,A} ± 0.04	3.96 ^{a,A} ± 0.23	3.86 ^{a,A} ± 0.41	4.28 ^{a,A} ± 0.35	4.44 ^{a,A} ± 0.48	4.81 ^{a,B} ± 0.36	4.29 ^{a,A} ± 0.29	4.39 ^{a,A} ± 0.33
	LL	1.29 ^{a,B} ± 0.11	1.19 ^{a,B} ± 0.06	1.31 ^{a,B} ± 0.04	1.76 ^{a,B} ± 0.10	1.78 ^{a,B} ± 0.27	1.83 ^{a,B} ± 0.38	1.74 ^{a,B} ± 0.13	1.72 ^{a,C} ± 0.07	1.9 ^{a,B} ± 0.16	1.32 ^{a,B} ± 0.05
$Starch_{mass}$ ($mg\ g^{-1}$)	HL	8.5 ^{c,A} ± 1.8	39.4 ^{a,AB} ± 7.2	24.2 ^{b,A} ± 4.8	15.2 ^{bc,A} ± 0.6	7.4 ^{c,A} ± 0.4	4.2 $^{c,\ A}$ ± 0.5	6.1 ^{c,A} ± 1.3	3.1 ^{c,A} ± 0.2	1.6 ^{c,A} ± 0.3	2.0 ^{c,A} ± 0.6
	IL	13.1 ^{bc,A} ± 2.9	49.2 ^{a,A} ± 7.2	22.0 ^{b,A} ± 1.2	15.7 ^{bc,A} ± 1.5	21.4 ^{b,A} ± 5.1	9.7 ^{bc,A} ± 1.1	5.8 ^{c,A} ± 0.4	2.6 ^{c,A} ± 0.3	2.7 ^{c,A} ± 0.2	3.3 ^{c,A} ±
	LL	10.0 ^{ab,A} ± 1.4	19.7 ^{a,B} ± 2.5	8.6 ^{ab,B} ± 1.5	15.9 ^{ab,A} ± 4.9	16.3 ^{ab,A} ± 8.7	7.9 ^{ab,A} ± 5.3	3.4 ^{ab,A} ± 1.1	0.9 ^{b,B} ± 0.3	1.6 ^{b,A} ± 0.4	2.0 ^{ab,A} ± 0.8
$Starch_{area}$	HL	0.48 ^{cd,A} ± 0.09	2.79 ^{a,A} ± 0.52	1.61 ^{b,A} ± 0.3	1.14 ^{bc,A} ± 0.04	0.52 ^{cd,A} ± 0.03	0.24 ^{cd,A} ± 0.03	0.44 ^{cd,A} ± 0.11	0.23 ^{cd,A} ± 0.02	0.10 ^{d,AB} ± 0.02	0.11 ^{d,A} ± 0.03
	IL	0.82 ^{be,A} ± 0.20	2.90 ^{a,A} ± 0.42	1.40 ^{b,A} ± 0.06	0.98 ^{bd,AB} ± 0.11	1.20 ^{bc,A} ± 0.22	0.59 ^{cde,A} ± 0.05	0.31 ^{de,AB} ± 0.03	0.13 ^{e,B} ± 0.02	0.13 ^{e,A} ± 0.01	0.17 ^{e,A} ± 0.05
	LL	0.36 ^{a,A} ± 0.06	0.70 ^{a,B} ± 0.09	0.29 ^{a,B} ± 0.04	0.58 ^{a,B} ± 0.18	0.64 ^{a,A} ± 0.36	0.32 ^{a,A} ± 0.22	0.12 ^{a,B} ± 0.04	0.03 ^{a,C} ± 0.01	0.05 ^{a,B} ± 0.02	0.06 ^{a,A} ± 0.02
Sugar/ (Sugar + Starch)	HL	0.86 ^{bc,A} ± 0.03	0.58 ^{e,A} ± 0.04	0.72 ^{d,A} ± 0.04	0.80 ^{cd,A} ± 0.01	0.90 ^{ac,A} ± 0.00	0.94 ^{ab,A} ± 0.01	0.92 ^{ab,A} ± 0.02	0.96 ^{ab,B} ± 0.00	0.98 ^{a,A} ± 0.00	0.97 ^{a,A} ± 0.00
	IL	0.82 ^{bd,A} ± 0.02	0.56 ^{e,A} ± 0.04	0.75 ^{d,A} ± 0.01	0.80 ^{cd,A} ± 0.02	0.76 ^{d,A} ± 0.05	0.88 ^{abc,A} ± 0.02	0.93 ^{ab,A} ± 0.01	0.97 ^{a,AB} ± 0.00	0.97 ^{a,A} ± 0.00	0.96 ^{a,A} ± 0.01
	LL	0.78 ^{bd,A} ± 0.02	0.63 ^{d,A} ± 0.03	0.82 ^{ad,A} ± 0.03	0.77 ^{cd,A} ± 0.06	0.80 ^{ad,A} ± 0.08	0.89 ^{abc,A} ± 0.05	0.94 ^{abc,A} ± 0.02	0.98 ^{a,A} ± 0.00	0.97 ^{a,A} ± 0.01	0.96 ^{ab,A} ± 0.02

Significant differences ($P < 0.05$) are indicated by different small letters among dates for each light condition, and by capital letters among light conditions for each date. Values indicate means ± SE (n=4).

Supplementary Table S6 Results of Tukey-Kramer multiple comparison test of dry mass- and area-based net photosynthetic rate (A_{mass}, A_{area}), and electron transport rate (ETR_{mass}, ETR_{area}) in leaves of a fullmoon maple tree among dates, or among light conditions (high light: HL, intermediate light: IL, and low light: LL).

		Date							
	Light	26 Jul	16 Aug	6 Sep	27 Sep	4 Oct	12 Oct	18 Oct	25 Oct
A_{mass}	HL	0.130 ^{ab,A}	0.098 ^{cd,A}	0.109 ^{ac,A}	0.089 ^{cd,A}	0.103 ^{bcd,A}	0.138 ^{a,A}	0.075 ^{d,A}	0.020 ^{e,A}
(μmol g^{-1} s^{-1})		± 0.009	± 0.009	± 0.009	± 0.009	± 0.005	± 0.002	± 0.005	± 0.002
	IL	0.111 ^{a,A}	0.093 ^{ab,A}	0.106 ^{a,A}	0.102 ^{ab,A}	0.094 ^{ab,A}	0.074 ^{bc,B}	0.052 ^{c,B}	0.005 ^{d,B}
		± 0.111	± 0.008	± 0.003	± 0.007	± 0.008	± 0.011	± 0.004	± 0.004
	LL	0.132 ^{a,A}	0.107 ^{ac,A}	0.121 ^{ab,A}	0.073 ^{c,A}	0.091 ^{ac,A}	0.082 ^{bc,B}	0.072 ^{c,A}	0.012 ^{d,AB}
		± 0.008	± 0.014	± 0.007	± 0.012	± 0.015	± 0.009	± 0.005	± 0.004
A_{area}	HL	7.47 ^{a,A}	6.90 ^{ab,A}	7.25 ^{a,A}	6.68 ^{ab,A}	7.27 ^{a,A}	7.95 ^{a,A}	5.26 ^{b,A}	1.20 ^{c,A}
(μmol m^{-2} s^{-1})		± 0.32	± 0.48	± 0.41	± 0.57	± 0.27	± 0.23	± 0.39	± 0.09
	IL	6.86 ^{a,A}	5.44 ^{bc,A}	6.75 ^{ab,A}	6.36 ^{ab,A}	5.44 ^{bc,B}	4.40 ^{c,B}	2.80 ^{d,B}	0.21 ^{e,B}
		± 0.19	± 0.26	± 0.22	± 0.43	± 0.39	± 0.42	± 0.10	± 0.19
	LL	4.70 ^{a,B}	3.80 ^{ab,B}	4.21 ^{ab,B}	2.76 ^{b,B}	3.38 ^{ab,C}	3.03 ^{b,C}	2.59 ^{b,B}	0.41 ^{c,B}
		± 0.23	± 0.46	± 0.31	± 0.47	± 0.51	± 0.25	± 0.20	± 0.15
ETR_{mass}	HL	1.22 ^{ab,A}	0.84 ^{c,A}	1.00 ^{c,A}	1.04 ^{bc,A}	0.98 ^{c,A}	1.29 ^{a,A}	0.61 ^{d,A}	0.20 ^{e,A}
(μmol g^{-1} s^{-1})		± 0.04	± 0.06	± 0.04	± 0.03	± 0.02	± 0.07	± 0.03	± 0.02
	IL	1.14 ^{a,A}	0.80 ^{b,A}	0.92 ^{b,AB}	0.92 ^{b,A}	0.83 ^{b,AB}	0.73 ^{b,B}	0.38 ^{c,B}	0.06 ^{d,B}
		± 0.03	± 0.04	± 0.03	± 0.05	± 0.05	± 0.08	± 0.01	± 0.02
	LL	0.95 ^{a,B}	0.75 ^{ac,A}	0.83 ^{ab,B}	0.53 ^{cd,B}	0.66 ^{bc,B}	0.57 ^{bcd,B}	0.38 ^{d,B}	0.04 ^{e,B}
		± 0.04	± 0.1	± 0.03	± 0.05	± 0.08	± 0.07	± 0.01	± 0.01
ETR_{area}	HL	70 ^{ab,A}	59.3 ^{c,A}	66.3 ^{bc,A}	77.7 ^{a,A}	68.7 ^{b,A}	73.6 ^{ab,A}	42.7 ^{d,A}	12.6 ^{e,A}
(μmol m^{-2} s^{-1})		± 1.4	± 3.4	± 1.4	± 1.9	± 1.4	± 2.0	± 0.8	± 0.9
	IL	70.6 ^{a,A}	47.1 ^{cd,B}	58.6 ^{b,A}	57.6 ^{bc,B}	48.4 ^{bd,B}	44.2 ^{d,B}	21.1 ^{e,B}	2.8 ^{f,B}
		± 1.5	± 0.4	± 2.9	± 2.9	± 3.4	± 2.9	± 1.8	± 0.9
	LL	33.9 ^{a,B}	26.7 ^{ab,C}	28.9 ^{ab,B}	20.1 ^{bc,C}	24.8 ^{ab,C}	20.9 ^{bc,C}	13.9 ^{c,C}	1.3 ^{d,B}
		± 1.3	± 3.5	± 1.8	± 2.3	± 2.9	± 1.9	± 0.2	± 0.5

Significant differences ($P < 0.05$) are indicated by different small letters among dates for each light condition, and by capital letters among light conditions for each date. Values indicate means ± SE (n=4).

Supplementary Table S7 Results of Tukey-Kramer multiple comparison test of area-based total electron flow estimated by chlorophyll fluorescence (J_F), electron flow consumed by Rubisco carboxylation and oxygenation (J_R), alternative electron flow (J_A), and the ratio of J_A to J_F (J_A/J_F) in leaves of a fullmoon maple tree among dates, or among light conditions (high light: HL, intermediate light: IL, and low light: LL).

		Date							
	Light	26 Jul	16 Aug	6 Sep	27 Sep	4 Oct	12 Oct	18 Oct	25 Oct
J_F	HL	70.0 ^{ab,A}	59.3 ^{c,A}	66.3 ^{bc,A}	77.7 ^{a,A}	68.7 ^{b,A}	73.6 ^{ab,A}	42.7 ^{d,A}	12.6 ^{e,A}
(μmol m^{-2} s^{-1})		± 1.4	± 3.4	± 1.4	± 1.9	± 1.4	± 2.0	± 0.8	± 0.9
	IL	70.6 ^{a,A}	47.1 ^{cd,B}	58.6 ^{b,A}	57.6 ^{bc,B}	48.4 ^{bd,B}	44.2 ^{d,B}	21.1 ^{e,B}	2.8 ^{f,B}
		± 1.5	± 0.4	± 2.9	± 2.9	± 3.4	± 2.9	± 1.8	± 0.9
	LL	33.9 ^{a,B}	26.7 ^{ab,C}	28.9 ^{ab,B}	20.1 ^{bc,C}	24.8 ^{ab,C}	20.9 ^{bc,C}	13.9 ^{c,C}	1.3 ^{d,B}
		± 1.3	± 3.5	± 1.8	± 2.3	± 2.9	± 1.9	± 0.2	± 0.5
J_R	HL	68.0 ^{a,A}	47.2 ^{bc,A}	50.1 ^{c,A}	47.3 ^{bc,A}	49.8 ^{c,A}	59.4 ^{ac,A}	34.5 ^{b,A}	7.2 ^{d,A}
(μmol m^{-2} s^{-1})		± 2.6	± 2.8	± 2.4	± 5.6	± 1.5	± 2.1	± 2.5	± 0.4
	IL	53.6 ^{a,B}	37.4 ^{bc,B}	44.6 ^{ab,A}	41.9 ^{b,A}	37.0 ^{bc,B}	30.2 ^{c,B}	17.5 ^{d,B}	2.2 ^{e,B}
		± 1.4	± 0.8	± 1.5	± 2.9	± 3.0	± 3.4	± 0.6	± 1.0
	LL	35.1 ^{a,C}	24.5 ^{ab,C}	27.2 ^{ab,B}	19.0 ^{b,B}	23.7 ^{ab,C}	23.9 ^{ab,B}	17.5 ^{b,B}	2.5 ^{c,B}
		± 1.6	± 3.1	± 2.2	± 2.9	± 3.6	± 2.4	± 1.5	± 0.8
J_A	HL	2.0 ^{d,B}	12.1 ^{cd,A}	16.2 ^{bc,A}	30.4 ^{a,A}	18.9 ^{c,A}	14.2 ^{bc,A}	8.2 ^{cd,A}	5.4 ^{bd,A}
(μmol m^{-2} s^{-1})		± 1.5	± 0.8	± 1.3	± 4.0	± 1.7	± 4.1	± 2.4	± 0.7
	IL	17.0 ^{a,A}	9.7 ^{ab,A}	14.0 ^{a,A}	15.7 ^{a,B}	11.4 ^{ab,A}	14.0 ^{a,A}	3.5 ^{bc,AB}	0.6 ^{c,B}
		± 1.5	± 0.8	± 1.8	± 0.9	± 2.5	± 2.9	± 1.9	± 0.2
	LL	-1.1 ^{a,B}	2.2 ^{a,B}	1.7 ^{a,B}	1.1 ^{a,C}	1.1 ^{a,B}	-3.0 ^{a,B}	-3.6 ^{a,B}	-1.2 ^{a,B}
		± 1.3	± 0.6	± 1.3	± 1.4	± 2.0	± 2.1	± 1.5	± 0.7
J_A/J_F	HL	0.03 ^{c,B}	0.20 ^{bc,A}	0.25 ^{ab,A}	0.39 ^{a,A}	0.27 ^{ab,A}	0.19 ^{bc,A}	0.19 ^{bc,A}	0.42 ^{a,A}
		± 0.02	± 0.01	± 0.02	± 0.06	± 0.02	± 0.05	± 0.06	± 0.04
	IL	0.24 ^{ab,A}	0.21 ^{ab,A}	0.24 ^{ab,A}	0.27 ^{ab,A}	0.23 ^{ab,A}	0.31 ^{a,A}	0.17 ^{ab,AB}	0.10 ^{b,B}
		± 0.02	± 0.02	± 0.02	± 0.02	± 0.05	± 0.06	± 0.06	± 0.05
	LL	0.01 ^{a,B}	0.08 ^{a,B}	0.07 ^{a,B}	0.10 ^{a,B}	0.10 ^{a,A}	0.00 ^{a,B}	0.00 ^{a,B}	0.02 ^{a,B}
		± 0.01	± 0.01	± 0.03	± 0.04	± 0.06	± 0.00	± 0.00	± 0.02

J_A/J_F was set to 0 when J_A had a negative value. Significant differences ($P < 0.05$) are indicated by different small letters among dates for each light condition, and by capital letters among light conditions for each date. Values indicate means ± SE (n=4).

Supplementary Protocol S1 *Estimation of alternative electron flow*

To estimate the contribution of anthocyanin synthesis to consuming excessive energy, we investigated seasonal changes in alternative electron flow consumed by other than Rubisco carboxylation and oxygenation in HL, IL, and LL leaves. Electron flow estimated on the basis of chlorophyll fluorescence (J_F) was considered as total electron flow. We considered the difference between J_F and electron flow consumed by Rubisco carboxylation and oxygenation (J_R) as alternative electron flow (J_A); $J_A = J_F - J_R$ (Laisk *et al.*, 2006).

J_F was equal to ETR in the main text, estimated as J_F = ETR = ABS × light intensity × YII × 0.5 (Demmig-Adams *et al.*, 1996). J_R was derived from Rubisco kinetics, light-saturated net photosynthetic rate (A), and intercellular CO_2 concentration (C_i) on the assumption that J_R is limited by NADPH consumption (Farquhar & von Caemmerer, 1982; von Caemmerer, 2000) as $J_R = \frac{8\,\Gamma^* + 4\,C_i}{C_i - \Gamma^*}(A + R_d)$, where Γ^* is the C_i-based apparent photosynthetic compensation point determined for tobacco plant (*Nicotiana tabacum* L.) (Bernacchi *et al.*, 2001), and R_d is respiration rate under light. R_d was estimated from an empirical model; R_d = [0.5 – 0.05 ln(PFD)] R_n (R_n: respiration rate under dark) according to (Lloyd *et al.*, 1995). As we did not measure R_n of *A. japonicum*, we estimated R_n of *A. japonicum* from a common dry mass-based respiration rate ($R_{n.mass}$, 0.0138 μmol g^{-1} s^{-1}) for *Betula platyphylla* var. *japonica* (n=11), and *Fagus crenata* (n=7), as R_n (μmol m^{-2} s^{-1}) = $R_{n.mass}$ (μmol g^{-1} s^{-1}) x LMA (g m^{-2}). Temperature-dependency on Γ^* and R_d was also taken into account (Bernacchi *et al.*, 2001). Although there might be an inevitable uncertainty in estimating J_R accurately because of many assumptions on the parameters not directly measured, such as C_i-based Γ^* and R_d. However, we believe that assessments of seasonal trends in electron flows and for a relative comparison among leaves grown under different light conditions would be possible.

References in Supplementary data

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