

Table 2. Summary of observed variation in leaf metabolism and thermal responses across the vertical gradient and/or between sun and shade leaves

| trait | symbol | units | response | forest type(s) | reference(s)* |
|--------------------------------------------------|--------------------|---------------------------|----------------|--------------------|-----------------------|
| Stomatal conductance | | | | | |
| max stomatal conductance | $g_{s\ max}$ | $mol\ m^{-2}\ s^{-1}$ | ↑ with height | TrB, TeB, BoN | 1, 2, 4 |
| | | | ↑ with light | TrB, TeB, TeN, BoN | 8, 9, 10, 7, 4 |
| stomatal conductance limitation with temperature | g_s | $mol\ m^{-2}\ s^{-1}$ | ↑ with height | TrB, TeN | 9, 44, 5, 6, 7 |
| stomatal conductance at optimal temperature | $g_s\ at\ T_{opt}$ | $mol\ m^{-2}\ s^{-1}$ | ↑ with light | TrB, TeN | 9, 44, 7 |
| | | | ≈↑ with height | TeB | 11 |
| boundary-layer conductance | g_a | $mmol^{-2}\ s^{-1}$ | ↓ with height | TrB | 44 |
| | | | ≈↑ with light | TrB | 8 |
| | | | ↑ with height | TrB | 3 |
| | | | ↑ with height | TeN | 12 |
| | | | ↑ with light | TrB | 3 |
| | g_{bv} | mms^{-1} | ≈ with light | TeN | 12 |
| Photosynthesis | | | | | |
| maximum photosynthetic capacity | $A_{max\ area}$ | $mol\ m^{-2}\ s^{-1}$ | ↑ with height | TrB, TeB, BoN | 14, 11, 15, 4 |
| | | | ≈↓ with height | TeB | 16 |
| | | | ↑ with light | TrB, TeB, TeN, BoN | 14, 17, 18, 19, 10, 4 |
| | | | ≈ with height | TrB | 20, 21 |
| | | | ≈ with light | TrB, TeB, TeN | 20, 21, 19 |
| maximum light-saturated net photosynthesis | A_{sat} | $\mu mol\ m^{-2}\ s^{-1}$ | ↑ with height | TrB, TeB | 22, 23 |
| A_{sat} at optimum temperature | A_{opt} | $\mu mol\ m^{-2}\ s^{-1}$ | ↑ with light | TrB, TeB | 8, 23 |
| | | | ≈↑ with height | TrB, TeB | 13, 11 |
| | | | ↑ with height | TrB | 44 |
| | | | ↑ with light | TrB | 8, 13 |

| trait | symbol | units | response | forest type(s) | reference(s)* |
|---------------------------------------------------|---------------------|------------------------------------------------|--------------------------------|----------------|---------------|
| optimum temperature for photosynthesis | T_{opt} | $^{\circ}\text{C}$ | \approx with height | TrB, TeB | 24, 11, 13 |
| | | | \downarrow with height | TrB | 44 |
| | | | \approx with light | TrB, TeB | 9, 8, 11 |
| photosynthetic light compensation point | LCP | $\mu\text{mol m}^{-2}$ | \uparrow with height | TrB, TeB, TeN | 25, 16 |
| | | | \uparrow with light | TrB, TeB, TeN | 8, 17, 16 |
| maximal carboxylation rate | $V_{cmax\ area}$ | $\mu\text{mol m}^{-2}\text{s}^{-1}$ | \uparrow with height | TrB, TeB | 2, 23, 14 |
| | | | \uparrow with light | TrB, TeB, BoN | 9, 23, 14, 10 |
| | $V_{cmax\ mass}$ | $\text{nmol g}^{-1}\text{s}^{-1}$ | \approx with height | TrB, TeB | 2, 23 |
| | | | \approx with light | TrB, TeB | 2, 23 |
| | | $\text{nmolCO}_2\text{g}^{-1}\text{s}^{-1}$ | $\approx\downarrow$ with light | TeB | 26 |
| optimum temperature for V_{cmax} | $V_{cmax}(T_{opt})$ | $\mu\text{mol m}^{-2}\text{s}^{-1}$ | $\approx\uparrow$ with height | TeB | 11 |
| | | | \approx with light | TrB | 9 |
| electron transport rate | $J_{max\ area}$ | $\mu\text{mol m}^{-2}\text{s}^{-1}$ | \uparrow with height | TrB, TeB | 2, 44, 23, 14 |
| | | | \uparrow with light | TrB, TeB | 9, 23, 27, 14 |
| | $J_{max\ mass}$ | $\text{nmol g}^{-1}\text{s}^{-1}$ | \approx with height | TrB, TeB | 2, 23 |
| | | | \approx with light | TrB, TeB | 2, 23 |
| | | $\text{nmol e}^{-1}\text{g}^{-1}\text{s}^{-1}$ | $\approx\downarrow$ with light | TeB | 26 |
| optimal temperature of J_{max} | T_{optETR} | $^{\circ}\text{C}$ | \downarrow with height | TrB | 44 |
| | $J_{max}(T_{opt})$ | $\mu\text{mol m}^{-2}\text{s}^{-1}$ | \approx with light | TrB | 9 |
| photosynthetic heat tolerance | T_{50} | $^{\circ}\text{C}$ | \downarrow with height* | TrS | 31 |
| | | | $\approx\uparrow$ with light | TrB, TeB | 8, 17 |
| critical temperature beyond which Fv/Fm declines | T_{crit} | $^{\circ}\text{C}$ | | | |
| | | | $\approx\uparrow$ with light | TrB, TeB | 8 |
| high-temperature CO_2 compensation point | T_{max} | $^{\circ}\text{C}$ | \approx with height | TrB | 22 |
| | | | \approx with light | TrB | 8 |

| trait | symbol | units | response | forest type(s) | reference(s)* |
|----------------------------------------------|-------------------------------------|-------------------------------------------------------------------|---------------------------------------------------|----------------------------------|------------------------------------------|
| Respiration | | | | | |
| respiration rate at 25 °C | R | $\mu\text{molCO}_2 \text{ m}^{-2}\text{s}^{-1}$ | ↑ with height | TrB, TeB, TeN | 44, 32, 33, 34 |
| | | $\mu\text{mol CO}_2 \text{ kg}^{-1} \text{ s}^{-1}$ | ≈ with height | TrB, TeB, TeN | 32, 33 |
| dark respiration | $R_{\text{dark } a}$ | $\mu\text{mol m}^{-2} \text{ s}^{-1}$ | ↑ with light ↑ with height | TrB, TeN TrB, TeB, BoN | 32, 34, 22, 14, 35, 23, 43 |
| | $R_{\text{dark } m}$ | $\text{nmol g}^{-1}\text{s}^{-1}$ | ↑ with light ≈ ↑ with height ≈ with light | TrB, TeB, TeN, BoN TrB | 22, 14, 23, 17, 10, 43 2, 36 2, 36 |
| dark respiration at reference T | $R_{\text{dark } (T_{\text{ref}})}$ | $\mu\text{mol m}^{-2}\text{s}^{-1}$ | ↑ with height | TrB, TeB, TeN | 22, 14, 35, 33 |
| | | $\mu\text{mol (kg leaf)}^{-1} \text{ s}^{-1}$ | ↑ with height | TrB, TeB, TeN | 22, 14, 35, 33 |
| | | $\mu\text{mol (kg N)}^{-1} \text{ s}^{-1}$ | ↑ with height | TeB, TeN | 35, 33 |
| temperature sensitivity of R_{dark} | Q_{10} | $\mu\text{mol m}^{-2}\text{s}^{-1} \text{ }^{\circ}\text{C}^{-1}$ | ↑ with light ≈ with height | TrB, TeB TrB, TeB, TeN | 22, 8, 35. 22, 44, 35, 34 |
| | | $^{\circ}\text{C}^{-1}$ | ≈ ↑ with height ≈ ↓ with light ↑ with light | TeB, TeN TrB, TeB, TeN TeB | 37, 33 22, 35, 34 37 |
| light respiration | R_L | $\mu\text{mol m}^{-2}\text{s}^{-1}$ | ↑ with height ↑ with light | TrB TrB | 22 22 |
| activation energy of respiration | E_0 | $\text{kJ mol}^{-1}\text{K}^{-1}$ | ≈ with height | TrB, TeB, TeN | 22, 38, 33 |
| | | | ≈ with light | TrB | 22, 8 |
| VOC production | | | | | |
| isoprene emission rate (in emitting species) | I | $\text{nmol m}^{-2}\text{s}^{-1}$ | ↑ with height | TeB | 37, 39 |
| | | | ↑ with light | TeB | 40, 37, 41 |
| monoterpenoid emissions | MT | $\mu\text{g m}^{-2}\text{s}^{-1}$ | ↓ with height | TeB | 42 |
| | | | ↓ with light | TeB | 42 |

1. Kafuti et al. 2020; 2. Van Wittenberghe et al. 2012; 3. Roberts et al. 1990; 4. Dang et al. 1997; 5. Marengo et al. 2017; 6. Ambrose et al. 2015; 7. Zweifel et al. 2001; 8. Slot et al. 2019; 9. Hernandez et al. 2020; 10. Urban et al. 2007; 11. Carter and Cavaleri 2018; 12. Martin et al. 1999; 13. Mau et al. 2018; 14. Kosugi et al. 2012; 15. Niinemets et al. 2015; 16. Bachofen et al. 2020; 17. Hamerlynck and Knapp 1994; 18. Coble et al. 2017; 19. Wyka et al. 2012; 20. Rijkse et al. 2000; 21. Ishida et al. 1999; 22. Weerasinghe et al. 2014; 23. Scartazza et al. 2016; 24. Miller et al. 2021; 25. Harris and Medina 2013; 26. Legner et al.

2014; **27.** Kitao et al. 2012; **28.** Fauset et al. 2018; **29.** Rey-Sanchez et al. 2016; **30.** Muller et al. 2021; **31.** Curtis et al. 2019; **32.** Mier et al. 2001; **33.** Turnbull et al. 2003; **34.** Araki et al. 2017; **35.** Bolstad et al. 1999; **36.** Kenzo et al. 2015; **37.** Harley et al. 1996; **38.** Xu and Griffin 2006; **39.** Harley et al. 1997; **40.** Niinemets and Sun, 2014; **41.** Sharkey and Monson, 2014; **42.** Saimpraga et al. 2013; **43.** Atherton et al. 2017; **44.** Carter et al. 2021