|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | trait  Table 2. Summary of observed variation in leaf metabolism and thermal responses across the vertical gradient and/or between sun and shade leaves | symbol | units | response | forest type(s) | reference(s) | | **Stomatal conductance**  max stomatal conductance | *gs max* | *mol m² 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 | *gs* | *mol m-2 s-1* | ↑ with height | TrB, TeN | 9, 5, 6, 7 | |  |  |  | ↑ with light | TrB, TeN | 9, 7 | | stomatal conductance at optimal temperature | *gs at Topt* | *mol m-2 s-1* | ≈↑ with height | TeB | 11 | |  |  |  | ≈↑ with light | TrB | 8 | | boundary-layer conductance | *ga* | *mmol-2 s-1* | ↑ with height | TrB | 3 | |  | *gbV* | *mms-1* | ↑ with height | TeN | 12 | |  |  |  | ↑ with light | TrB | 3 | |  | *gbV* | *mms-1* | ≈ with light | TeN | 12 | | **Photosynthesis** |  |  |  |  |  | | maximum photosynthetic capacity | *Amax area* | *mol m-2 s-1* | ↑ with height | TrB, TeB, BoN | 14, 11, 15, 4 | |  |  |  | ≈↓ with height | TeB F.sylvatica | 16 | |  |  |  | ↑ with light | TrB, TeB, TeN, BoN | 14, 17, 18, 19, 10, 4 | |  | *Amax mass* | *nmol g-1 s-1* | ≈ with height | TrB | 20, 21 | |  |  |  | ≈ with light | TrB, TeB, TeN | 20, 21, 19 | | maximum light-saturated net photosynthesis | *Asat* | *µmol m-2s-1* | ↑ with height | TrB, TeB | 22, 23 | |  |  |  | ↑ with light | TrB, TeB | 8, 23 | | Asat at optimum temperature | *Aopt* | *µmol m-2s-1* | ≈↑ with height | TrB, TeB | 13, 11 | |  |  |  | ↑ with light | TrB | 8, 13 | | optimum temperature for photosynthesis | *Topt* | *˚C* | ≈ with height | TrB, TeB | 24, 11, 13 | |  |  |  | ≈ with light | TrB, TeB | 9, 8, 11 | | photosynthetic light compensation point | *LCP* | *µmol m-2* | ↑ with height | TrB, TeB, TeN | 25, 16 | |  |  |  | ↑ with light | TrB, TeB, TeN | 8, 17, 16 | | maximal carboxylation rate | *Vcmax area* | *µmol m-2s-1* | ↑ with height | TrB, TeB | 2, 23, 14 | |  |  |  | ↑ with light | TrB, TeB, BoN | 9, 23, 14, 10 | |  | *Vcmax mass* | *nmol g-1 s-1* | ≈ with height | TrB, TeB | 2, 23 | |  |  |  | ≈ with light | TrB, TeB | 2, 23 | |  |  | *nmolCO2 g-1 s-1* | ≈↓ with light | TeB | 26 | | *Vcmax* at optimum temperature | *Vcmax (Topt)* | *µ mol m-2 s-1* | ≈↑ with height | TeB | 11 | |  |  |  | ≈ with light | TrB | 9 | | electron transport rate | *Jmax area* | *µmolm-2s-1* | ↑ with height | TrB, TeB | 2, 23, 14 | |  |  |  | ↑ with light | TrB, TeB | 9, 23, 27, 14 | |  | *Jmax mass* | *nmol g-1s-1* | ≈ with height | TrB, TeB | 2, 23 | |  |  |  | ≈ with light | TrB, TeB | 2, 23 | |  |  | *nmol e-1g-1s-1* | ≈↓ with light | TeB | 26 | | *Jmax* at optimal temperature | *Jmax(Topt)* | *µmolm-2s-1* | ≈ with light | TrB | 9 | | photosynthetic heat tolerance | T50 | *˚C* | ↓ with height\* | TrS | 31 | |  |  |  | ≈↑ with light | TrB, TeB | 8, 17 | | critical temperature beyond which Fv/Fm declines | *Tcrit* | *˚C* |  |  |  | |  |  |  | ≈↑ with light | TrB, TeB | 8 | | high-temperature CO2 compensation point | Tmax | *˚C* | ≈ with height | TrB | 22 | |  |  |  | ≈ with light | TrB | 8 | | **Respiration** |  |  |  |  |  | | respiration rate at 25 ˚C | *R* | *µmolCO2*  *m-2s-1* | ↑ with height | TrB, TeB, TeN | 32, 33, 34 | |  |  | *µmol CO2 kg-1 s-1* | ≈ with height | TrB, TeB, TeN | 32, 33 | |  |  |  | ↑ with light | TrB, TeN | 32, 34, | | dark respiration | *Rdark a* | *µmol m-2 s-1* | ↑ with height | TrB, TeB, BoN | 22, 14, 35, 23, 43 | |  |  |  | ↑ with light | TrB, TeB, TeN, BoN | 22, 14, 23, 17, 10, 43 | |  | *Rdark m* | *nmol g-1s-1* | ≈↑ with height | TrB | 2, 36 | |  |  |  | ≈ with light | TrB | 2, 36 | | dark respiration at reference T | *Rdark (Tref)* | *µmol m-2s-1* | ↑ with height | TrB, TeB, TeN | 22, 14, 35, 33 | |  |  | *µmol (kg leaf) -1s-1* | ↑ with height | TrB, TeB, TeN | 22, 14, 35, 33 | |  |  | *µmol (kg N)*  *-1s-1* | ↑ with height | TeB,TeN | 35, 33 | |  |  | *µmol m-2s-1* | ↑ with light | TrB, TeB | 22, 8, 35 | | temperature sensitivity of Rdark | *Q10* | *˚C-1* | ≈ with height | TrB, TeB, TeN | 22, 35, 34 | |  |  | *˚C-1* | ≈ ↑ with height | TeB, TeN | 37, 33 | |  |  |  | ≈ ↓ with light | TrB, TeB, TeN | 22, 35, 34 | |  |  |  | ↑ with light | TeB | 37 | | light respiration | *RL* | *µmol m-2s-1* | ↑ with height | TrB | 22 | |  |  |  | ↑ with light | TrB | 22 | | activation energy of respiration | *E0* | *kJ mol-1K-1* | ≈ with height | TrB, TeB, TeN | 22, 38, 33 | |  |  |  | ≈ with light | TrB | 22, 8 | | **VOC production** |  |  |  |  |  | | isoprene emission rate  (in emitting species) | *I* | *nmol m-2s-1* | ↑ with height | TeB | 37, 39 | |  |  |  | ↑with light | TeB | 40, 37, 41 | | monoterpenoid emissions | *MT* | *µg m-2s-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.** Marenco 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.** Rijkerse 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