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| |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | 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) | | max stomatal conductance | *gs max* | mol m² s-1 | ↑ with height | TrB, TeB, BoN | Kafuti et al. 2020, Van Wittenberghe et al. 2012, Roberts et al. 1990, Dang et al. 1997 | |  |  |  | ↓ with height | BoN, TrB | Ambrose et al. 2015, Marenco et al. 2017, Zeifel et al. 2001 | |  |  |  | ↑ with light | BoN, TrB, TeB | Zeifel et al. 2001, Slot et al. 2019, Hernandez et al. 2020, Urban et al. 2007 | | stomatal conductance limitation with temperature | *gs* | mol m-2 s-1 | ↑ with height | TrB, BoN | Hernandez et al. 2020, Zeifel et al. 2001 | |  |  |  | ↑ with light | BoN, TrB | Zeifel et al. 2001, Hernandez et al. 2020 | | stomatal conductance at optimal temperature | *gs at Topt* | mol m-2 s-1 | ≈ ↑ with height | TeB | Carter and Cavaleri 2018 | |  |  |  | ≈↑ with light | TrB | Slot et al. 2019 | | boundary-layer conductance | *ga* | m mol-2 s-1 | ↑ with height | TrB | Roberts et al. 1990 | |  | *gbV* | mms-1 | ↑ with height | BoN | Martin et al. 1999 | |  |  |  | ↑ with light | TrB | Roberts et al. 1990 | |  | *gbV* | mms-1 | ≈ with light | BoN | Martin et al. 1999 | | maximum photosynthetic capacity | *Amax area* | mol m-2 s-1 | ↑ with height | TeB, TrB | Carter and Cavaleri 2018, Kosugi et al. 2012, Niinemets et al. 2015, Mau et al. 2018 | |  |  |  | ≈ ↓ with height | TeB F.sylvatica | Bachofen et al. 2020 | |  |  |  | ↑ with light | TeB, TrB, BoN | Hamerlynck and Knapp 1994, Kosugi et al. 2012, Coble et al. 2017, Mau et al. 2018, Urban et al. 2007, Wyka et al. 2012 | |  | *Amax mass* | nmol g-1 s-1 | ≈ with height | TrB | Rijkerse et al. 2000, Ishida et al. 1999 | |  |  |  | ≈ with light | TeB, TrB, BoN | Wyka et al. 2013, Rijkerse et al. 2000, Ishida et al. 1999 | | maximum light-saturated net photosynthesis | *Asat* | µmol m-2s-1 | ↑ with height | TeB, TrB | Scartazza et al. 2016, Weerasinghe et al. 2014 | |  |  |  | ↑ with light | TeB, TrB | Scartazza et al. 2016, Slot et al. 2019 | | Asat at optimum temperature | *Aopt* | µmol m-2s-1 | ≈↑ with height | TeB, TrB | Carter and Cavaleri 2018, Mau et al. 2018 | |  |  |  | ↑ with light | TrB | Slot et al. 2019, Mau et al. 2018 | | optimum temperature for photosynthesis | *Topt* | ˚C | ≈ with height | TrB, TeB | Miller et al. 2021, Carter and Cavaleri 2018, Mau et al. 2018 | |  |  |  | ≈ with light | TrB, TeB | Hernandez et al. 2020, Slot et al. 2019, Carter and Cavaleri 2018 | | photosynthetic light compensation point | *LCP* | µmol m-2 | ↑ with height | TeB, BoN, TrB | Bachofen et al. 2020, Harris and Medina 2013 | |  |  |  | ↑ with light | TrB, TeB, BoN | Slot et al. 2019, Hamerlynck and Knapp, 1994, Bachofen et al. 2020 | | maximal carboxylation rate | *Vcmax area* | µmol m-2s-1 | ↑ with height | TeB, TrB | Scartazza et al. 2016, Kosugi et al. 2012, van de Weg et al. 2012 | |  |  |  | ↑ with light | TeB,TrB, BoN | Scartazza et al. 2016, Kosugi et al. 2012, Hernandez et al. 2020, Urban et al. 2007 | |  | *Vcmax mass* | nmol g-1 s-1 | ≈ with height | TrB, TeB | van de Weg et al. 2012, Scartazza et al. 2016 | |  |  |  | ≈ with light | TrB, TeB | van de Weg et al. 2012, Scartazza et al. 2016 | |  |  | nmolCO2 g-1 s-1 | ≈↓ with light | TeB | Legner et al. 2014 | | *Vcmax* at optimum temperature | *Vcmax (Topt)* | µ mol m-2 s-1 | ≈ ↑ with height | TeB | Carter and Cavaleri 2018 | |  |  |  | ≈ with light | TrB | Hernandez et al. 2020 | | electron transport rate | *Jmax area* | µmolm-2s-1 | ↑ with height | TeB, TrB | Scartazza et al. 2016, Kosugi et al. 2012 van de Weg et al. 2012 | |  |  |  | ↑ with light | TeB,TrB | Scartazza et al. 2016, Kitao et al. 2012, Kosugi et al. 2012, Hernandez et al. 2020 | |  | *Jmax mass* | nmol g-1s-1 | ≈ with height | TrB, TeB | van de Weg et al. 2012, Scartazza et al. 2016 | |  |  |  | ≈ with light | TrB, TeB | van de Weg et al. 2012, Scartazza et al. 2016 | |  |  | nmol e-1g-1s-1 | ≈ ↓ with light | TeB | Legner et al. 2014 | | *Jmax* at optimal temperature | *Jmax(Topt)* | µmolm-2s-1 | ≈ with light | TrB | Hernandez et al. 2020 | | leaf temperature | *TL* | ˚C | ↑ with height | TrB, TeB | Fauset et al. 2018, Mau et al. 2018, Ishida et al. 1999, Rey-Sanchez et al. 2016, Hamerlynck and Knapp, 1994 | |  |  |  | ↓ with height | BoN | Muller et al. 2021, Martin et al. 1999 | |  |  |  | ↑ with light | TrB, TeB | Fauset et al. 2018, Ishida et al. 1999, Rey-Sanchez et al. 2016, Miller et al. 2021, Hamerlynck and Knapp, 1994 | |  |  |  | ≈ with light | BoN | Muller et al. 2021 | | thermal time constant (in relation to increasing gs) | *Ʈ* | s | ↓ with height | TrB, TrS | Fauset et al. 2018, Curtis et al. 2019 | |  |  |  | ↓ with light | TrB | Fauset et al. 2018 | | photosynthetic heat tolerance | T50 | ˚C | ↑ with height\* | TrS | Curtis et. al, 2018 | |  |  |  | ≈ ↑ with light | TrB, TeB | Slot et al. 2019, Hamerlynck and Knapp, 1994 | | critical temperature beyond which Fv/Fm declines | *Tcrit* | ˚C |  |  |  | |  |  |  | ≈ ↑ with light | TrB, TeB | Slot et al. 2019 | | high-temperature CO2 compensation point | Tmax | ˚C | ≈ with height | TrB | Weerasinghe et al. 2014 | |  |  |  | ≈ with light | TrB | Slot et al. 2019 | | respiration rate at 25 ˚C | *R* | µmolCO2  m-2s-1 | ↑ with height | TeB, BoN, TrB | Turnbull et al. 2003, Araki et al. 2017, Mier et al. 2001 | |  |  | µmol CO2 kg-1 s-1 | ≈ with height | TeB, BoN, TrB | Turnbull et al. 2003, Mier et al. 2001 | |  |  |  | ↑ with light | BoN, TrB | Araki et al. 2017, Mier et al. 2001 | | dark respiration | *Rdark a* | µmol m-2 s-1 | ↑ with height | TrB, TeB | Weerasinghe et al. 2014, Kosugi et al. 2012, Bolstad et al. 1999, Scartazza et al. 2019 | |  |  |  | ↑ with light | TrB, TeB, BoN | Weerasinghe et al. 2014, Kosugi et al. 2012, Scartazza et al. 2019, Hamerlynck and Knapp, 1994, Urban et al. 2007 | |  | *Rdark m* | nmol g-1s-1 | ≈ ↑ with height | TrB | van de Weg et al. 2012, Kenzo et al. 2015 | |  |  |  | ≈ with light | TrB | van de Weg et al. 2012, Kenzo et al. 2015 | | dark respiration at reference T | Rdark(Tref) | µmol m-2s-1 | ↑ with height | TrB, TeB, BoN | Weerasinghe et al. 2014, Kosugi et al. 2012, Bolstad et al. 1999, Turnbull et al. 2003 | |  |  | µmol (kg leaf) -1s-1 | ↑ with height | TrB, TeB, BoN | Weerasinghe et al. 2014, Kosugi et al. 2012, Bolstad et al. 1999, Turnbull et al. 2003 | |  |  | µmol (kg N)  -1s-1 | ↑ with height | TeB, BoN | Bolstad et al. 1999, Turnbull et al. 2003 | |  |  | µmol m-2s-1 | ↑ with light | TeB, TrB | Bolstad et al. 1999, Weerasinghe et al. 2014, Slot et al. 2019 | | temperature sensitivity of Rdark | *Q10* | ˚C-1 | ≈ with height | TrB, TeB, BoN | Weerasinghe et al. 2014, Bolstad et al. 1999, Araki et al. 2017\* | |  |  | ˚C-1 | ≈ ↑ with height | TeB, BoN | Harley et al. 1996, Turnbull et al. 2003 | |  |  |  | ≈ ↓ with light | TrB, TeB, BoN | Weerasinghe et al. 2014, Bolstad et al. 1999, Araki et al. 2017\* | |  |  |  | ↑ with light | TeB | Harley et al. 1996 | | light respiration | *RL* | µmol m-2s-1 | ↑ with height | TrB | Weerasinghe et al. 2014 | |  |  |  | ↑ with light | TrB | Weerasinghe et al. 2014 | | activation energy of respiration | *E0* | kJ mol-1K-1 | ≈ with height | TrB, TeB, BoN | Weerasinghe et al. 2014, Turnbull et al. 2003, Xu and Griffin 2006 | |  |  |  | ≈ with light | TrB | Weerasinghe et sl. 2014, Slot et al. 2019 | | isoprene emission rate  (in emitting species) | *I* | nmol m-2s-1 | ↑ with height | TeB | Harley et al. 1996, Harley et al. 1997 | |  |  |  | ↑with light | TeB | Niinemets and Sun, 2014, Harley et al. 1996, Sharkey and Monson, 2014 | | monoterpenoid emissions | *MT* | µg m-2s-1 | ↓ with height | TeB | Saimpraga et al. 2013 | |  |  |  | ↓ with light | TeB | Saimpraga et al. 2013 | |