**SUPPLEMENTAL MATERIAL for “Global response patterns of plant functional traits to combined nitrogen and phosphorus addition are governed by additive interactions”**

Evan A. Perkowski1, Alissar Cheaib1, Monika R. Kelley1, Jan Lankhorst2, Astrid Odé2, Daniil J. Scheifes2, Huiying Xu3, Keith J. Bloomfield4, Hugo J. de Boer2, Ning Dong4,5, Benjamin D. Stocker6, Karin T. Rebel2, I. Colin Prentice4, Sandy P. Harrison7, Nicholas G. Smith1

**Table S1** Summary of studies and sites included in the meta-analysis\*

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Citation** | **Site name** | **Latitude** | **Longitude** | **Elevation** | ***T*g** | ***AI*g** | ***PAR*g** | **Ecosystem type** | **Experiment type** | **N addition rate (g m-2)** | **P addition rate (g m-2)** |
| (Aerts et al., 2003) | bovenpolder | 51.85 | 5.62 | 6 | 9.6 | 1.56 | 478 | grassland | field | 10 | 5 |
| bethunepolder | 52.07 | 5.58 | 8 | 9.7 | 1.81 | 474 | grassland | field | 10 | 5 |
| (Arens et al., 2008) | pituffik | 76.55 | -68.57 | 229 | 4.2 | 0.25 | 855 | tundra | field | 5 | 2.5 |
| (Augustine et al., 2003) | mpala\_ranch | 0.28 | 37.88 | 1775 | 18.6 | 1.29 | 868 | grassland | field | 40 | 10 |
| (Aydin & Uzun, 2005) | ondokuz | 41.35 | 36.25 | 4 | 14.1 | 0.75 | 698 | grassland | field | 18 | 5.2 |
| (Bennett & Adams, 2001) | hamersley | -22.28 | 117.67 | 606 | 24.5 | 0.13 | 1078 | grassland | field | 5 | 2.5 |
| (Blanke et al., 2012) | alpflix | 46.53 | 9.65 | 2029 | 6.6 | 1.45 | 836 | grassland | field | 5 | 6 |
| (Boeye et al., 1997) | buitengoor | 51.20 | 5.17 | 36 | 10.3 | 1.46 | 481 | wetland | field | 20 | 5 |
| goorken | 51.32 | 5.12 | 27 | 10.1 | 1.51 | 480 | wetland | field | 20 | 5 |
| zwarte\_beek | 51.08 | 5.30 | 56 | 10.1 | 1.55 | 483 | wetland | field | 20 | 5 |
| (Borer et al., 2014) | sedgwick | 34.7 | -119.88 | 1122 | 12.8 | 0.49 | 883 | grassland | field | 10 | 10 |
| (Bowman et al., 1993) | niwot\_ridge | 40.06 | -105.58 | 3471 | 6.1 | 0.40 | 967 | tundra | field | 25 | 25 |
| (Bown et al., 2007) | purokohukohu | NA | NA | NA | NA | NA | NA | NA | pot | 7.14 (mM) | 0.42 (mM) |
| (Cárate-Tandalla et al., 2018) | bombuscaro | -4.12 | -78.97 | 1163 | 22.4 | 1.08 | 651 | forest | field | 5 | 1 |
| cajanuma | -4.12 | -79.18 | 2511 | 14.4 | 1.01 | 684 | forest | field | 5 | 1 |
| sanfrancisco | -3.97 | -79.18 | 2163 | 16.2 | 0.80 | 660 | forest | field | 5 | 1 |
| (Carswell et al., 2005) | okarito | -43.20 | 170.30 | NA | NA | NA | NA | NA | pot | 5 (mM) | 1.33 (mM) |
| (Chen et al., 2020) | zhifanggou | 36.74 | 109.25 | 1228 | 13.7 | 0.38 | 837 | grassland | field | 10 | 8 |

**Table S1 (cont.)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Citation** | **Site name** | **Latitude** | **Longitude** | **Elevation** | ***T*g** | ***AI*g** | ***PAR*g** | **Ecosystem type** | **Experiment type** | **N addition rate (g m-2)** | **P addition rate (g m-2)** |
| (Cleland et al., 2019) | bldr.us | 39.97 | -105.23 | 1649 | 11.0 | 0.30 | 830 | grassland | field | 10 | 10 |
| bnch.us | 44.28 | -121.97 | 1298 | 7.8 | 1.71 | 770 | grassland | field | 10 | 10 |
| bogong.au | -36.87 | 147.24 | 1567 | 7.3 | 2.09 | 797 | grassland | field | 10 | 10 |
| burrawan.au | -27.73 | 151.14 | 411 | 18.2 | 0.34 | 897 | grassland | field | 10 | 10 |
| cbgb.us | 41.79 | -93.39 | 275 | 14.1 | 0.74 | 785 | grassland | field | 10 | 10 |
| cdcr.us | 45.40 | -93.2 | 282 | 15.1 | 0.67 | 826 | grassland | field | 10 | 10 |
| cdpt.us | 41.2 | -101.63 | 1018 | 13.8 | 0.28 | 874 | grassland | field | 10 | 10 |
| cowi.ca | 48.46 | -123.38 | 24 | 10.5 | 1.91 | 561 | grassland | field | 10 | 10 |
| elliot.us | 32.88 | -117.05 | 256 | 17.7 | 0.25 | 880 | grassland | field | 10 | 10 |
| frue.ch | 47.11 | 8.54 | 972 | 7.8 | 2.13 | 617 | grassland | field | 10 | 10 |
| gilb.za | -29.28 | 30.29 | 1666 | 13.9 | 0.59 | 855 | grassland | field | 10 | 10 |
| hall.us | 36.87 | -86.7 | 201 | 13.7 | 1.27 | 709 | grassland | field | 10 | 10 |
| hart.us | 42.72 | -119.5 | 1513 | 9.5 | 0.20 | 866 | grassland | field | 10 | 10 |
| konz.us | 39.07 | -96.58 | 421 | 15.0 | 0.58 | 817 | grassland | field | 10 | 10 |
| lancaster.uk | 53.99 | -2.63 | 219 | 8.0 | 3.37 | 443 | grassland | field | 10 | 10 |
| look.us | 44.21 | -122.13 | 1481 | 6.1 | 2.72 | 673 | grassland | field | 10 | 10 |
| mtca.au | -31.78 | 117.61 | 297 | 17.7 | 0.24 | 957 | grassland | field | 10 | 10 |
| sage.us | 39.43 | -120.24 | 1968 | 8.5 | 0.53 | 977 | grassland | field | 10 | 10 |
| saline.us | 39.05 | -99.1 | 566 | 14.9 | 0.35 | 858 | grassland | field | 10 | 10 |
| sgs.us | 40.82 | -104.77 | 1654 | 11.2 | 0.22 | 860 | grassland | field | 10 | 10 |
| shps.us | 44.24 | -112.2 | 1667 | 12.2 | 0.15 | 963 | grassland | field | 10 | 10 |
| sier.us | 39.24 | -121.28 | 258 | 16.3 | 1.06 | 820 | grassland | field | 10 | 10 |
| smith.us | 48.21 | -122.62 | 56 | 10.2 | 1.08 | 562 | grassland | field | 10 | 10 |
| spin.us | 38.14 | -84.5 | 284 | 13.6 | 1.07 | 718 | grassland | field | 10 | 10 |
| summ.za | -29.81 | 30.72 | 636 | 18.2 | 0.59 | 810 | grassland | field | 10 | 10 |
| trel.us | 40.08 | -88.83 | 215 | 15.4 | 0.82 | 784 | grassland | field | 10 | 10 |
| ukul.za | -29.67 | 30.4 | 810 | 17.6 | 0.50 | 831 | grassland | field | 10 | 10 |
| unc.us | 36.01 | -79.02 | 147 | 14.9 | 0.94 | 734 | grassland | field | 10 | 10 |
| valm.ch | 46.63 | 10.37 | 2233 | 5.5 | 0.80 | 827 | grassland | field | 10 | 10 |
| (Craft et al., 1995) | everglades | 26.38 | -80.46 | 5 | 23.4 | 0.79 | 860 | grassland | field | 22.4 | 4.8 |
| (Craine et al., 2008) | pretoriuskop | -25.13 | 31.23 | 569 | 20.9 | 0.39 | 861 | grassland | field | 10 | 5 |
| letaba | -23.76 | 31.43 | 270 | 22.7 | 0.24 | 870 | grassland | field | 10 | 5 |
| makhohlola | -25.30 | 31.91 | 198 | 22.3 | 0.33 | 820 | grassland | field | 10 | 5 |
| satara | -24.40 | 31.75 | 299 | 22.0 | 0.31 | 847 | grassland | field | 10 | 5 |
| nwashitsumbe | -22.78 | 31.25 | 386 | 23.1 | 0.25 | 890 | grassland | field | 10 | 5 |
| (Crous et al., 2017) | ANUglass | NA | NA | NA | NA | NA | NA | NA | pot | 3.3 (g yr-1) | 0.153 (g yr-1) |
| (Cunha et al., 2024) | londrina | -23.32 | -51.18 | NA | NA | NA | NA | NA | pot | 8.4 | 4.5 |
| (D’Antonio & Mack, 2006) | volcanoNP | 19.1 | -155.55 | 148 | 22.8 | 0.95 | 860 | forest | field | 10 | 10 |

**Table S1 (cont.)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Citation** | **Site name** | **Latitude** | **Longitude** | **Elevation** | ***T*g** | ***AI*g** | ***PAR*g** | **Ecosystem type** | **Experiment type** | **N addition rate (g m-2)** | **P addition rate (g m-2)** |
| (Davidson et al., 2004) | fazendaVitoria | -2.98 | -47.52 | 136 | 25.9 | 1.62 | 771 | forest | field | 10 | 5 |
| (Dong et al., 2016) | baingoin | 31.43 | 90.03 | 4705 | 6.4 | 0.52 | 931 | grassland | field | 15 | 12.9 |
| (Eller et al., 2017) | flottbek | 53.56 | 9.86 | NA | NA | NA | NA | NA | pot | 1.3 (g pot-1) | 1.3 (g pot-1) |
| (Falk et al., 2010) | luneberg | 53.25 | 9.97 | 118 | 8.5 | 1.76 | 469 | grassland | field | 5 | 2 |
| (Fisher et al., 2013) | tambopata | -12.84 | -69.30 | 198 | 25.3 | 1.83 | 709 | forest | field | 2.5 | 0.5 |
| tono | -12.95 | -71.53 | 805 | 23.1 | 2.04 | 726 | forest | field | 2.5 | 0.5 |
| san\_pedro | -13.05 | -71.54 | 1511 | 20.2 | 1.68 | 674 | forest | field | 2.5 | 0.5 |
| wayqecha | -13.19 | -71.59 | 2989 | 12.9 | 0.29 | 683 | forest | field | 2.5 | 0.5 |
| (Firn et al., 2019) | bogong.au | -36.87 | 147.24 | 1567 | 7.3 | 2.09 | 797 | grassland | field | 10 | 10 |
| burrawan.au | -27.73 | 151.14 | 411 | 18.2 | 0.34 | 897 | grassland | field | 10 | 10 |
| cbgb.us | 41.79 | -93.39 | 275 | 14.1 | 0.74 | 785 | grassland | field | 10 | 10 |
| cowi.ca | 48.46 | -123.38 | 24 | 10.5 | 1.91 | 561 | grassland | field | 10 | 10 |
| elliot.us | 32.88 | -117.05 | 256 | 17.7 | 0.25 | 880 | grassland | field | 10 | 10 |
| frue.ch | 47.11 | 8.54 | 972 | 7.8 | 2.13 | 617 | grassland | field | 10 | 10 |
| gilb.za | -29.28 | 30.29 | 1666 | 13.9 | 0.59 | 855 | grassland | field | 10 | 10 |
| kiny.au | -36.20 | 143.75 | 99 | 15.5 | 0.33 | 809 | grassland | field | 10 | 10 |
| konz.us | 39.07 | -96.58 | 421 | 15.0 | 0.58 | 817 | grassland | field | 10 | 10 |
| lancaster.uk | 53.99 | -2.63 | 219 | 8.0 | 3.37 | 443 | grassland | field | 10 | 10 |
| look.us | 44.21 | -122.13 | 1481 | 6.1 | 2.72 | 673 | grassland | field | 10 | 10 |
| mcla.us | 38.86 | -122.41 | 647 | 14.0 | 1.15 | 803 | grassland | field | 10 | 10 |
| mtca.au | -31.78 | 117.61 | 297 | 17.7 | 0.24 | 957 | grassland | field | 10 | 10 |
| saline.us | 39.05 | -99.10 | 566 | 14.9 | 0.35 | 858 | grassland | field | 10 | 10 |
| sgs.us | 40.82 | -104.77 | 1654 | 11.2 | 0.22 | 860 | grassland | field | 10 | 10 |
| shps.us | 44.24 | -112.2 | 1667 | 12.2 | 0.15 | 963 | grassland | field | 10 | 10 |
| smith.us | 48.21 | -122.62 | 56 | 10.2 | 1.08 | 562 | grassland | field | 10 | 10 |
| summ.za | -29.81 | 30.72 | 636 | 18.2 | 0.59 | 810 | grassland | field | 10 | 10 |
| valm.ch | 46.63 | 10.37 | 2233 | 5.5 | 0.80 | 827 | grassland | field | 10 | 10 |
| (Fornara et al., 2013) | nash | 51.41 | -0.64 | 61 | 10.2 | 1.25 | 478 | grassland | field | 10 | 3.5 |
| (Friedrich et al., 2012) | luneberggh2 | 53.25 | 9.97 | NA | NA | NA | NA | NA | pot | 4.8 | 0.4 |
| (Frost et al., 2009) | hammersmith | 31.30 | -81.28 | 2 | 19.7 | 0.86 | 801 | wetland | field | 50 | 10 |
| (Gough & Hobbie, 2003) | toolik\_nonacidic | 68.63 | -149.72 | 726 | 6.8 | 0.52 | 592 | tundra | field | 10 | 5 |
| (Güsewell et al., 2002) | vechtplassen | 52.50 | 5.70 | -5 | 9.8 | 1.58 | 471 | wetland | field | 20 | 5 |
| (Güsewell et al., 2003) | gusewellS1 | 51.70 | 3.90 | -2 | 10.2 | 1.42 | 493 | wetland | field | 20 | 5 |
| gusewellS2 | 51.70 | 3.90 | -2 | 10.2 | 1.42 | 493 | wetland | field | 20 | 5 |
| gusewellV1 | 51.7 | 3.9 | -2 | 10.2 | 1.42 | 493 | wetland | field | 20 | 5 |
| gusewellV2 | 51.7 | 3.9 | -2 | 10.2 | 1.42 | 493 | wetland | field | 20 | 5 |
| gusewellV3 | 51.7 | 3.9 | -2 | 10.2 | 1.42 | 493 | wetland | field | 20 | 5 |
| gusewellT1 | 52.5 | 5.7 | -5 | 9.8 | 1.58 | 471 | wetland | field | 20 | 5 |
| gusewellT2 | 52.5 | 5.7 | -5 | 9.8 | 1.58 | 471 | wetland | field | 20 | 5 |

**Table S1 (cont.)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Citation** | **Site name** | **Latitude** | **Longitude** | **Elevation** | ***T*g** | ***AI*g** | ***PAR*g** | **Ecosystem type** | **Experiment type** | **N addition rate (g m-2)** | **P addition rate (g m-2)** |
| (Güsewell et al., 2003) | gusewellW1 | 52.5 | 5.7 | -5 | 9.8 | 1.58 | 471 | wetland | field | 20 | 5 |
| gusewellW2 | 52.5 | 5.7 | -5 | 9.8 | 1.58 | 471 | wetland | field | 20 | 5 |
| gusewellW3 | 52.5 | 5.7 | -5 | 9.8 | 1.58 | 471 | wetland | field | 20 | 5 |
| gusewellW4 | 52.5 | 5.7 | -5 | 9.8 | 1.58 | 471 | wetland | field | 20 | 5 |
| (Haag, 1974) | tuktoyaktuk | 69.43 | -133.02 | 1 | 7.5 | 0.36 | 712 | tundra | field | 10 | 10 |
| (Han et al., 2011) | seefs\_sunny | 38.79 | 110.35 | 1230 | 14.2 | 0.30 | 948 | grassland | field | 10 | 10 |
| (Harrington et al., 2001) | volcanoNP | 19.10 | -155.55 | 148 | 22.8 | 0.95 | 860 | forest | field | 10 | 10 |
| naPaliKona | 22.13 | -159.63 | 1056 | 15.7 | 1.27 | 879 | forest | field | 10 | 10 |
| (Haubensak & D’Antonio, 2011) | ggnra | 37.87 | -122.52 | 87 | 14.1 | 1.18 | 793 | grassland | field | 10 | 10 |
| (He et al., 2016) | haibei | 37.62 | 101.2 | 3157 | 6.2 | 0.52 | 930 | grassland | field | 10 | 5 |
| (Herbert & Fownes, 1995) | naPaliKona | 22.13 | -159.63 | 1056 | 15.7 | 1.27 | 879 | forest | field | 10 | 10 |
| (Hersch-Green et al., 2024) | kbs.us | 42.41 | -85.39 | 289 | 13.0 | 0.86 | 739 | grassland | field | 10 | 10 |
| konz.us | 39.07 | -96.58 | 421 | 15.0 | 0.58 | 817 | grassland | field | 10 | 10 |
| spin.us | 38.14 | -84.50 | 284 | 13.6 | 1.07 | 718 | grassland | field | 10 | 10 |
| (Huff et al., 2015) | tifft | 42.87 | -78.87 | 178 | 12.5 | 0.97 | 729 | grassland | field | 10 | 8.6 |
| (Iversen et al., 2010) | undercBog | 46 | -89 | 523 | 12.1 | 0.85 | 799 | wetland | field | 6 | 2 |
| undercRichFen | 46 | -89 | 523 | 12.1 | 0.85 | 799 | wetland | field | 6 | 2 |
| (Jing et al., 2016) | haibeiAGERS | 37.6 | 101.32 | 3311 | 5.6 | 0.54 | 927 | grassland | field | 10 | 5 |
| (Ket et al., 2011) | altamaha | 31.33 | -81.47 | 6 | 19.6 | 0.85 | 795 | wetland | field | 50 | 10 |
| (Lawrence, 2001) | kembera | 0.12 | 110.5 | 133 | 26.4 | 2.15 | 773 | forest | field | 54 | 60 |
| (L. J. Li et al., 2011) | daqinggou | 42.97 | 122.35 | 249 | 16.8 | 0.41 | 912 | grassland | field | 20 | 10 |
| (J. H. Li et al., 2014) | amwelu | 34.92 | 102.88 | 3213 | 7.5 | 0.76 | 822 | grassland | field | 10 | 10 |
| (Ludwig et al., 2001) | tarangire | -3.5 | 36 | 1045 | 22.0 | 0.40 | 792 | grassland | field | 20 | 8 |
| (Lund et al., 2009) | fajemyr | 56.25 | 13.55 | 141 | 8.3 | 2.22 | 544 | wetland | field | 4 | 0.4 |
| (Mayor et al., 2014) | gigante | 9.11 | -79.84 | 83 | 26.4 | 1.38 | 939 | forest | field | 12.5 | 5 |
| (McMaster et al., 1982) | echoValley | 32.9 | 70 | 1472 | 17.2 | 0.31 | 874 | shrubland | field | 4 | 2 |
| (Mo et al., 2019) | xiaolongRS | 21.45 | 110.9 | 27 | 23.3 | 1.11 | 794 | forest | field | 10 | 10 |
| (Mo et al., 2021) | xiaoliangRS | 21.45 | 110.9 | 27 | 23.3 | 1.11 | 794 | forest | field | 10 | 10 |
| (Ngai & Jefferies, 2004) | laPerouse | 58.744 | -93.601 | 6 | 9.8 | 0.69 | 799 | wetland | field | 17 | 12 |
| (Ngatia et al., 2015) | mpala | 0 | 37 | 1852 | 16.5 | 0.52 | 852 | grassland | field | 10 | 5 |
| (Nielsen et al., 2009) | brandbjerg | 55.88 | 11.97 | 9 | 9.7 | 1.67 | 551 | grassland | field | 7.5 | 1 |
| (O’Halloran et al., 2010) | tshane | -24.17 | 21.89 | 1117 | 21.3 | 0.12 | 1067 | grassland | field | 6.7 | 3.3 |
| (Øien, 2004) | solendet | 62.67 | 11.83 | 696 | 7.1 | 1.42 | 631 | wetland | field | 12 | 3 |
| (Prystupa et al., 2004) | uniBueAi | -34.58 | -58.48 | 23 | 17.4 | 0.73 | 777 | cropland | field | 10 | 5.7 |
| (Rejmánková et al., 2008) | belize | 18.83 | -89.12 | 103 | 25.1 | 0.54 | 880 | wetland | field | 20 | 10 |
| (Ren et al., 2010) | lanzhou | 33.97 | 101.88 | 3646 | 5.7 | 0.91 | 805 | grassland | field | 10 | 20 |
| (Ries & Shugart, 2008) | pandamatenga | -18.66 | 25.5 | 1082 | 23.5 | 0.26 | 974 | grassland | field | 20 | 10 |
| (Scott et al., 2015) | ruakura | -37.78 | 175.32 | 46 | 14.2 | 1.35 | 723 | grassland | field | 10 | 3.15 |

**Table S1 (cont.)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Citation** | **Site name** | **Latitude** | **Longitude** | **Elevation** | ***T*g** | ***AI*g** | ***PAR*g** | **Ecosystem type** | **Experiment type** | **N addition rate (g m-2)** | **P addition rate (g m-2)** |
| (Shaver et al., 1998) | toolik\_inlet | 68.63 | -149.57 | 768 | 6.6 | 0.53 | 590 | tundra | field | 10 |  |
| toolik\_sag | 68.77 | -148.87 | 452 | 7.7 | 0.49 | 592 | tundra | field | 10 |  |
| (Soudzilovskaia et al., 2005) | teberda | 48.45 | 41.7 | 86 | 14.0 | 0.47 | 705 | tundra | field | 9 | 2.5 |
| (Sun et al., 2022) | shihezi | 44.33 | 86.5 | 456 | 17.1 | 0.08 | 932 | crop | field | 12 | 5 |
| (Tischer et al., 2015) | cordillera | -3.97 | -70.07 | 127 | 26.5 | 2.53 | 644 | grassland | field | 5 | 1 |
| (van Cleve & Oliver, 1982) | fairbanks | 64.83 | -147.72 | 132 | 12.3 | 0.39 | 688 | forest | field | 11.1 | 5.5 |
| (van der Hoek et al., 2004) | bennekomse | 52.02 | 5.6 | 6 | 9.8 | 1.61 | 473 | grassland | field | 20 | 4 |
| (van der Waal et al., 2011) | klaserie | -24.22 | 31.27 | 402 | 22.3 | 0.31 | 870 | grassland | field | 30 | 25 |
| (van Duren, Boeye, et al., 1997) | hasselt | 57 | 7 | 32 | 10.6 | 1.41 | 465 | grassland | field | 20 | 8 |
| (van Duren, Pegtel, et al., 1997) | drentsche | 53.08 | 6.67 | 10 | 9.0 | 1.86 | 475 | grassland | field | 20 | 8 |
| (van Wijnen & Bakker, 1999) | schiermonikoog | 53.5 | 6.17 | 6 | 9.0 | 2.08 | 475 | wetland | field | 25 | 10 |
| (Verlinden et al., 2018) | katelijne | 51.08 | 4.53 | NA | NA | NA | NA | NA | mesocosm | 9.5 | 2 |
| (Verryckt et al., 2022) | nouragues | 4.00 | -52.60 | 57 | 25.8 | 2.06 | 887 | forest | field | 12.5 | 5 |
| (Q. Wang et al., 2017) | huitong | 26.67 | 109.43 | 519 | 16.1 | 1.20 | 633 | forest | field | 20 | 5 |
| (D. Wang et al., 2018) | haibeiAMERS | 37.617 | 101.2 | 3157 | 6.2 | 0.52 | 930 | tundra | field | 10 | 5 |
| (F. C. Wang et al., 2019) | qianyanzhou | 26.70 | 105.10 | 1913 | 12.2 | 0.93 | 617 | forest | field | 10 | 5 |
| (Warren & Adams, 2002) | bullsbrook | -31.67 | 116.02 | 40 | 18.8 | 0.51 | 977 | forest | field | 2 (mM) | 0.34 (mM) |
| (Wigand et al., 2004) | nags\_creek | 41.63 | -71.32 | -16 | 12.3 | 1.17 | 710 | wetland | field | 32 | 3.2 |
| (Wright et al., 2011) | barro | 9.12 | -79.85 | 56 | 26.5 | 1.41 | 938 | forest | field | 12.5 | 5 |
| (Yang et al., 2014) | haibei | 38.297 | 101.337 | NA | NA | NA | NA | grassland | field | 10 | 5 |
| (Ye et al., 2022) | jiulianshan\_RS | 24.49 | 114.38 | 624 | 18.1 | 1.49 | 680 | forest | field | 10 | 5 |
| (Ye et al., 2023) | jiulianshan | 24.49 | 114.38 | 624 | 18.1 | 1.49 | 680 | forest | field | 10 | 5 |
| (Z. Y. Yu et al., 2009) | daqinguo | 42.97 | 122.35 | 249 | 16.8 | 0.41 | 912 | grassland | field | 20 | 10 |
| (L. Yu et al., 2015) | ewenke | 48.5 | 119.7 | 709 | 11.0 | 0.34 | 877 | grassland | field | 10 | 5 |
| (Q. Yu et al., 2022) | primary | 18.73 | 108.90 | 901 | 20.6 | 1.02 | 832 | forest | field | 10 | 10 |
| secondary | 18.74 | 108.86 | 845 | 20.9 | 1.03 | 833 | forest | field | 10 | 10 |
| (Zeng & Wang, 2015) | saihanba | 42.42 | 117.35 | 1684 | 9.7 | 0.46 | 924 | forest | field | 5 | 5 |

**\***Key: *T*g=1970-2000 growing season temperature (°C), *AI*g=growing season aridity index (unitless), *PAR*g=growing season photosynthetically active radiation (μmol m-2 s-1)

**Table S2** Meta-analytic results summarizing the effects of N, P, and N+P on traits related to leaf chemistry\*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient addition** | **k** | **Coefficient (±SE)** | **Z-value** | ***p*-value** | **95% CI range** |
| *M*area | N | 113 | **-3.536±1.613** | **-2.318** | **0.020** | **[-6.574, -0.598]** |
| P | -1.489±1.511 | -1.019 | 0.308 | [-4.305, 1.410] |
| N+P | **-5.067±1.816** | **-2.880** | **0.004** | **[-8.424, -1.686]** |
| *N*mass | N | 139 | **13.202±2.122** | **5.937** | **<0.001** | **[8.654, 17.939]** |
| P | -0.200±1.207 | -0.127 | 0.899 | [-2.469, 2.224] |
| N+P | **12.524±2.224** | **5.462** | **<0.001** | **[7.788, 17.351]** |
| *N*area | N | 87 | 13.428±4.081 | **3.164** | **0.002** | **[4.917, 22.630]** |
| P | 3.045±3.977 | 0.771 | 0.441 | [-4.591, 11.405] |
| N+P | 16.649±3.458 | **4.523** | **<0.001** | **[9.090, 24.732]** |
| *P*mass | N | 133 | -7.226±3.252 | **-2.365** | **0.018** | **[-12.716, -1.292]** |
| P | 56.674±6.823 | **6.808** | **<0.001** | **[37.713, 78.247]** |
| N+P | 44.196±5.866 | **6.387** | **<0.001** | **[28.788, 61.285]** |
| *P*area | N | 82 | -5.446±7.358 | -0.781 | 0.435 | [-17.717, 8.763] |
| P | 71.258±11.293 | **5.031** | **<0.001** | **[38.819, 111.277]** |
| N+P | 47.55±10.960 | **3.730** | **<0.001** | **[20.322, 80.941]** |
| *Leaf N:P* | N | 118 | **15.142±4.707** | **3.049** | **0.002** | **[5.127, 26.112]** |
| P | **-29.107±6.503** | **-5.476** | **<0.001** | **[-37.312, -19.828]** |
| N+P | **-18.291±4.707** | **-4.429** | **<0.001** | **[-25.323, -10.685]** |

\*Significant effects noted in bold font. Model coefficients have been transformed to percent change to mimic figures. Key: *M*area=leaf biomass per unit leaf area (g m-2); *N*mass=leaf nitrogen content per unit leaf biomass (gN g-1); *N*area=leaf nitrogen content per unit leaf area (gN m-2); *P*mass=leaf phosphorus content per unit leaf biomass (gP g-1); *P*area=leaf phosphorus content per unit leaf area (gP m-2).

**Table S3** Meta-analytic results summarizing the effects of N, P, and N+P on traits related to leaf photosynthesis

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient addition** | **k** | **Coefficient (±SE)** | **Z-value** | ***p*-value** | **95% CI range** |
| *A*sat | N | 85 | *11.405±6.716* | *1.659* | *0.097* | *[-1.882, 26.491]* |
| P | 9.527±7.358 | 1.284 | 0.199 | [-4.687, 25.734] |
| N+P | **27.89±9.527** | **2.702** | **0.007** | **[7.037, 52.806]** |
| *V*cmax | N | 42 | 0.702±9.746 | 0.078 | 0.938 | [-16.054, 20.925] |
| P | 12.187±7.466 | 1.607 | 0.108 | [-2.469, 29.175] |
| N+P | *17.821±8.872* | *1.937* | *0.053* | *[-0.200, 39.236]* |
| *J*max | N | 40 | 9.527±6.290 | 1.502 | 0.133 | [-2.761, 23.368] |
| P | **19.363±8.220** | **2.248** | **0.025** | **[2.327, 39.375]** |
| N+P | **29.823±2.737** | **9.601** | **<0.001** | **[23.121, 37.026]** |
| *J*max:*V*cmax | N | 32 | *0.300±0.200* | *1.695* | *0.090* | *[0.000, 0.702]* |
| P | 0.000±0.200 | -0.298 | 0.766 | [-0.399, 0.300] |
| N+P | **1.207±0.200** | **5.291** | **<0.001** | **[0.702, 1.613]** |
| *PNUE* | N | 61 | 7.358±10.738 | 0.698 | 0.486 | [-12.015, 30.996] |
| P | 18.057±12.075 | 1.463 | 0.144 | [-5.446, 47.403] |
| N+P | 20.322±18.887 | 1.704 | 0.283 | [-14.187, 68.877] |
| *PPUE* | N | 62 | *24.857±12.187* | *1.933* | *0.053* | *[-0.300, 56.361]* |
| P | -17.963±17.000 | -1.255 | 0.210 | [-39.710, 11.739] |
| N+P | -2.955±17.234 | -0.191 | 0.849 | [-28.894, 32.445] |

\*Significant effects noted in bold font, marginal effects noted in italic font. Model coefficients have been transformed to percent change to mimic figures. Key: *A*sat=light-saturated net photosynthesis rate (μmol m-2 s-1); *V*cmax=maximum rate of Rubisco carboxylation (μmol m-2 s-1); *J*max=maximum rate of electron transport for RuBP regeneration (μmol m-2 s-1); *J*max:*V*cmax=ratio of the maximum rate of electron transport for RuBP regeneration to the maximum rate of Rubisco carboxylation (unitless); *PNUE*=photosynthetic nitrogen use efficiency (μmol gN-1 s-1); *PPUE*=photosynthetic phosphorus use efficiency (μmol gP-1 s-1)

**Table S4** Meta-analytic results summarizing the effects of N, P, and N+P on whole-plant traits

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient addition** | **k** | **Coefficient (±SE)** | **Z-value** | ***p*-value** | **95% CI range** |
| *Total biomass* | N | 42 | 3.458±5.443 | 0.643 | 0.520 | [-6.761, 14.912] |
| P | **16.766±8.004** | **2.007** | **0.045** | **[0.401, 35.934]** |
| N+P | **46.082±8.112** | **4.871** | **<0.001** | **[25.358, 70.063]** |
| *Aboveground biomass* | N | 125 | **38.542±3.769** | **8.753** | **<0.001** | **[28.788, 49.033]** |
| P | **21.046±3.355** | **5.741** | **<0.001** | **[13.428, 29.305]** |
| N+P | **87.199±4.917** | **13.106** | **<0.001** | **[70.404, 105.649]** |
| *Belowground biomass* | N | 63 | -1.489±7.251 | -0.218 | 0.828 | [-14.015, 12.862] |
| P | 3.252±4.394 | 0.745 | 0.456 | [-5.162, 12.412] |
| N+P | 10.628±7.681 | 1.358 | 0.174 | [-4.400, 27.762] |
| *Root mass fraction* | N | 37 | **-14.615±4.812** | **3.400** | **<0.001** | **[-22.120, -6.480]** |
| P | *-6.761±3.873* | *-1.828* | *0.068* | *[-13.498, 0.501]* |
| N+P | **-13.757±4.707** | **-3.252** | **0.001** | **[-21.101, -5.729]** |
| *Root:shoot ratio* | N | 40 | **-28.894±9.417** | **-3.802** | **<0.001** | **[-40.310, -15.211]** |
| P | **-20.308±10.738** | **-2.226** | **0.026** | **[-34.688, -2.664]** |
| N+P | **-33.035±12.075** | **-3.517** | **<0.001** | **[-46.474, -16.306]** |

\*Significant effects noted in bold font, marginal effects noted in italic font. Model coefficients have been transformed to percent change to mimic figures.

**Table S5** Climate moderator effects on leaf nutrient responses to nutrient addition\*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient** | **Moderator** | **Coef. (±SE)** | **Z-value** | ***p*-value** | **95% CI** |
| *M*area | n | *T*g | 0.140±0.301 | 0.464 | 0.643 | [-0.439, 0.723] |
| *AI*g | 3.811±2.470 | 1.530 | 0.126 | [-1.045, 8.904] |
| *PAR*g | 0.000±0.020 | -0.258 | 0.796 | [-0.040, 0.030] |
| p | *T*g | 0.371±0.250 | 1.450 | 0.147 | [-0.130, 0.874] |
| ***AI*g** | **5.001±2.112** | **2.329** | **0.020** | **[0.773, 9.396]** |
| *PAR*g | 0.020±0.010 | 1.476 | 0.140 | [-0.010, 0.040] |
| np | *Tg* | *0.592±0.311* | *1.873* | *0.061* | *[-0.030, 1.207]* |
| ***AI*g** | **7.918±2.716** | **2.841** | **0.005** | **[2.388, 13.746]** |
| *PAR*g | 0.020±0.020 | 1.211 | 0.226 | [-0.010, 0.060] |
| *N*mass | n | ***T*g** | **-0.668±0.260** | **-2.536** | **0.011** | **[-1.173, -0.150]** |
| ***AIg*** | **-5.465±2.922** | **-1.951** | **0.050** | **[-10.649, 0.030]** |
| *PAR*g | -0.010±0.020 | -0.577 | 0.564 | [-0.040, 0.020] |
| p | *T*g | 0.160±0.220 | 0.721 | 0.471 | [-0.270, 0.592] |
| *AI*g | -2.039±2.562 | -0.814 | 0.416 | [-6.770, 2.932] |
| *PAR*g | -0.010±0.010 | -0.449 | 0.653 | [-0.040, 0.020] |
| np | ***Tg*** | **-0.688±0.301** | **-2.287** | **0.022** | **[-1.272, -0.100]** |
| *AI*g | -3.911±3.365 | -1.204 | 0.229 | [-9.950, 2.542] |
| *PAR*g | -0.010±0.020 | -0.740 | 0.459 | [-0.050, 0.020] |
| *N*area | n | *Tg* | *-1.232±0.642* | *-1.943* | *0.052* | *[-2.459, 0.010]* |
| *AIg* | *-11.006±6.545* | *-1.838* | *0.066* | *[-21.408, 0.773]* |
| *PAR*g | 0.000±0.030 | -0.015 | 0.988 | [-0.070, 0.070] |
| p | *T*g | 0.040±0.521 | 0.071 | 0.944 | [-0.985, 1.066] |
| *AI*g | 1.877±4.571 | 0.417 | 0.677 | [-6.658, 11.204] |
| *PAR*g | 0.010±0.030 | 0.456 | 0.649 | [-0.050, 0.070] |
| np | *Tg* | -0.419±0.431 | -0.962 | 0.336 | [-1.252, 0.431] |
| *AI*g | -2.362±3.676 | -0.662 | 0.508 | [-9.026, 4.791] |
| *PAR*g | 0.020±0.030 | 0.741 | 0.459 | [-0.030, 0.070] |
| *P*mass | n | *T*g | 0.461±0.501 | 0.916 | 0.360 | [-0.519, 1.450] |
| *AI*g | 3.811±5.411 | 0.710 | 0.478 | [-6.378, 15.108] |
| *PAR*g | -0.050±0.030 | -1.616 | 0.106 | [-0.110, 0.010] |
| p | ***T*g** | **-2.127±1.056** | **-2.053** | **0.040** | **[-4.113, -0.100]** |
| *AIg* | *-16.423±11.004* | *-1.717* | *0.086* | *[-31.894, 2.562]* |
| *PAR*g | 0.100±0.060 | 1.629 | 0.103 | [-0.020, 0.220] |
| np | ***Tg*** | **-2.284±0.944** | **-2.454** | **0.014** | **[-4.077, -0.469]** |
| *AI*g | -8.415±9.757 | -0.944 | 0.345 | [-23.700, 9.922] |
| ***PAR*g** | **0.110±0.050** | **2.018** | **0.044** | **[0.000, 0.220]** |

**Table S5 (cont.)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient** | **Moderator** | **Coef. (±SE)** | **Z-value** | ***p*-value** | **95% CI** |
| *P*area | n | *T*g | 0.763±0.844 | 0.896 | 0.370 | [-0.896, 2.439] |
| *AI*g | -6.16±7.455 | -0.884 | 0.377 | [-18.486, 8.037] |
| *PAR*g | -0.080±0.050 | -1.653 | 0.098 | [-0.180, 0.010] |
| p | *Tg* | *-2.829±1.562* | *-1.856* | *0.064* | *[-5.739, 0.160]* |
| *AI*g | -15.659±12.930 | -1.400 | 0.162 | [-33.549, 7.047] |
| *PAR*g | 0.130±0.080 | 1.524 | 0.127 | [-0.040, 0.290] |
| np | *Tg* | -1.646±1.806 | -0.930 | 0.352 | [-5.039, 1.857] |
| *AI*g | -14.290±15.246 | -1.087 | 0.277 | [-35.092, 13.179] |
| ***PAR*g** | **0.190±0.090** | **2.034** | **0.042** | **[0.010, 0.381]** |
| *Leaf N:P* | n | ***T*g** | **-1.479±0.451** | **-3.307** | **0.001** | **[-2.352, -0.608]** |
| *AI*g | *-7.230±4.112* | *-1.881* | *0.060* | *[-14.333, 0.321]* |
| *PAR*g | 0.030±0.030 | 1.054 | 0.292 | [-0.020, 0.080] |
| p | ***T*g** | **2.153±0.834** | **2.560** | **0.011** | **[0.501, 3.832]** |
| ***AI*g** | **16.428±7.616** | **2.072** | **0.038** | **[0.823, 34.461]** |
| *PAR*g | -0.050±0.050 | -0.964 | 0.335 | [-0.140, 0.050] |
| np | *Tg* | 0.934±0.793 | 1.180 | 0.238 | [-0.608, 2.501] |
| *AI*g | 8.981±7.122 | 1.250 | 0.211 | [-4.772, 24.732] |
| ***PAR*g** | **-0.100±0.0500** | **-2.068** | **0.039** | **[-0.190, 0.000]** |

\*Trait acronyms are as defined in Fig. 2. Model coefficients and 95% confidence interval ranges have been transformed to percent change to mimic figures. Rows where *p*-values are less than 0.05 are noted in bold font and *p*-values where 0.5<*p*<0.1 are noted in italic font. Key: *T*g=mean growing season temperature (°C), *AI*g=mean growing season aridity index (unitless), *PAR*g=mean growing season photosynthetically active radiation (μmol m-2 s-1)

**Table S6** Climate moderator effects on whole-plant responses to nutrient addition

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient** | **Moderator** | **Coef. (±SE)** | **Z-value** | ***p*-value** | **95% CI** |
| *Total biomass* | n | *Tg* | *-2.635±1.390* | *-1.927* | *0.054* | *[-5.238, 0.050]* |
| *AI*g | 1.187±9.68 | 0.128 | 0.899 | [-15.574, 21.276] |
| *PAR*g | 0.050±0.050 | 0.989 | 0.323 | [-0.050, 0.140] |
| p | *Tg* | *-2.156±1.268* | *-1.731* | *0.084* | *[-4.544, 0.290]* |
| *AI*g | -4.849±8.535 | -0.607 | 0.544 | [-18.958, 11.706] |
| *PAR*g | 0.040±0.050 | 0.744 | 0.457 | [-0.060, 0.130] |
| np | *Tg* | *-2.790±1.572* | *-1.813* | *0.070* | *[-5.710, 0.230]* |
| *AI*g | -14.922±12.975 | -1.325 | 0.185 | [-33.008, 8.058] |
| *PAR*g | 0.000±0.060 | -0.072 | 0.943 | [-0.130, 0.120] |
| *Aboveground biomass* | n | *T*g | -0.359±0.652 | -0.560 | 0.576 | [-1.627, 0.914] |
| *AI*g | 8.535±7.262 | 1.168 | 0.243 | [-5.399, 24.533] |
| *PAR*g | 0.020±0.030 | 0.569 | 0.569 | [-0.040, 0.070] |
| p | *T*g | -0.130±0.713 | -0.189 | 0.850 | [-1.518, 1.268] |
| *AIg* | *14.935±7.767* | *1.860* | *0.063* | *[-0.747, 33.096]* |
| *PAR*g | 0.040±0.030 | 1.330 | 0.184 | [-0.020, 0.100] |
| np | *Tg* | -1.252±0.975 | -1.299 | 0.194 | [-3.101, 0.642] |
| *AI*g | -7.642±11.160 | -0.751 | 0.453 | [-24.949, 13.644] |
| *PAR*g | -0.030±0.040 | -0.697 | 0.486 | [-0.110, 0.050] |
| *Belowground biomass* | n | *T*g | -0.300±0.904 | -0.328 | 0.743 | [-2.049, 1.481] |
| *AI*g | 17.621±10.749 | 1.590 | 0.112 | [-3.709, 43.692] |
| *PAR*g | 0.070±0.050 | 1.443 | 0.149 | [-0.030, 0.170] |
| p | *T*g | 0.050±0.773 | 0.069 | 0.945 | [-1.449, 1.572] |
| *AI*g | -2.887±8.828 | -0.346 | 0.729 | [-17.717, 14.625] |
| *PAR*g | 0.030±0.040 | 0.610 | 0.542 | [-0.060, 0.110] |
| np | *Tg* | -0.916±1.015 | -0.912 | 0.362 | [-2.849, 1.066] |
| *AI*g | 15.373±12.187 | 1.244 | 0.214 | [-7.900, 44.528] |
| ***PAR*g** | **0.120±0.060** | **2.202** | **0.028** | **[0.010, 0.230]** |
| *Root mass fraction* | n | *T*g | -0.638±1.369 | -0.469 | 0.639 | [-3.246, 2.051] |
| *AI*g | 12.131±11.204 | 1.078 | 0.281 | [-8.935, 38.085] |
| *PARg* | *0.120±0.060* | *1.889* | *0.059* | *[0.000, 0.240]* |
| p | *T*g | -0.965±1.045 | -0.930 | 0.353 | [-2.955, 1.076] |
| *AI*g | -8.011±8.709 | -1.000 | 0.317 | [-21.902, 8.350] |
| *PAR*g | 0.030±0.050 | 0.540 | 0.589 | [-0.070, 0.130] |
| np | *Tg* | 0.120±1.390 | 0.089 | 0.929 | [-2.537, 2.860] |
| *AI*g | 13.224±11.438 | 1.147 | 0.252 | [-8.433, 39.990] |
| *PAR*g | 0.080±0.060 | 1.328 | 0.184 | [-0.040, 0.200] |

**Table S6 (cont.)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient** | **Moderator** | **Coef. (±SE)** | **Z-value** | ***p*-value** | **95% CI** |
| *Root:shoot* | n | *T*g | -1.025±2.819 | -0.371 | 0.711 | [-6.265, 4.509] |
| *AI*g | 3.655±28.044 | 0.145 | 0.885 | [-36.148, 68.270] |
| *PAR*g | 0.110±0.130 | 0.841 | 0.401 | [-0.140, 0.361] |
| p | *T*g | -3.969±2.891 | -1.422 | 0.155 | [-9.190, 1.542] |
| ***AI*g** | **-41.128±27.852** | **-2.156** | **0.031** | **[-63.625, -4.706]** |
| *PAR*g | -0.080±0.140 | -0.602 | 0.547 | [-0.349, 0.190] |
| np | *Tg* | -0.419±3.686 | -0.116 | 0.908 | [-7.226, 6.897] |
| *AI*g | -0.618±37.713 | -0.019 | 0.985 | [-46.916, 86.060] |
| *PAR*g | 0.040±0.170 | 0.227 | 0.821 | [-0.300, 0.381] |

\*Trait acronyms are as defined in Fig. 2. Model coefficients and 95% confidence interval ranges have been transformed to percent change to mimic figures. Rows where *p*-values are less than 0.05 are noted in bold font and *p*-values where 0.5<*p*<0.1 are noted in italic font. Key: *T*g=mean growing season temperature (°C), *AI*g=mean growing season aridity index (unitless), *PAR*g=mean growing season photosynthetically active radiation (μmol m-2 s-1)

**Table S7** N2-fixer moderator effects on leaf nutrient responses to nutrient addition\*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient** | **Moderator** | **Coef.** | **Z-value** | ***p*-value** | **95% CI** |
| *M*area | n | *non-fixer* | **-4.305** | **3.508** | **<0.001** | **[-7.873, -0.698]** |
| *N2-fixer* | **13.428** | **[2.737, 25.107]** |
| p | *non-fixer* | **-0.698** | **-4.584** | **<0.001** | **[-4.209, 2.840]** |
| *N2-fixer* | **-15.718** | **[-21.886, -9.063]** |
| np | *non-fixer* | **-4.972** | **3.015** | **0.003** | **[-8.057, -1.882]** |
| *N2-fixer* | **7.681** | **[-0.995, 17.117]** |
| *N*mass | n | *non-fixer* | **16.532** | **-4.498** | **<0.001** | **[11.182, 22.018]** |
| *N2-fixer* | **-3.052** | **[-11.219, 5.760]** |
| p | *non-fixer* | **-0.598** | **3.454** | **0.001** | **[-3.149, 2.020]** |
| *N2-fixer* | **12.187** | **[4.917, 19.842]** |
| np | *non-fixer* | **14.683** | **-2.258** | **0.024** | **[9.308, 20.322]** |
| *N2-fixer* | **2.532** | **[-7.318, 13.542]** |
| *N*area | n | *non-fixer* | 13.088 | 1.423 | 0.155 | [4.394, 22.385] |
| *N2-fixer* | 20.563 | [7.466, 35.256] |
| p | *non-fixer* | *2.429* | *1.836* | *0.066* | *[-5.351, 10.738]* |
| *N2-fixer* | *11.516* | *[-0.598, 25.107]* |
| np | *non-fixer* | 16.532 | 0.615 | 0.539 | [8.981, 24.608] |
| *N2-fixer* | 20.202 | [7.037, 34.851] |
| *P*mass | n | *non-fixer* | **-8.972** | **2.595** | **0.009** | **[-14.956, -2.566]** |
| *N2-fixer* | **4.185** | **[-7.133, 17.000]** |
| p | *non-fixer* | **55.893** | **5.376** | **<0.001** | **[34.716, 80.219]** |
| *N2-fixer* | **100.973** | **[70.063, 137.501]** |
| np | *non-fixer* | **43.190** | **2.021** | **0.043** | **[25.986, 62.580]** |
| *N2-fixer* | **67.197** | **[38.265, 102.182]** |
| *P*area | n | *non-fixer* | **-8.057** | **7.716** | **<0.001** | **[-20.547, 6.396]** |
| *N2-fixer* | **37.163** | **[15.258, 63.068]** |
| p | *non-fixer* | **68.371** | **3.46** | **0.001** | **[36.479, 107.716]** |
| *N2-fixer* | **101.778** | **[60.480, 153.958]** |
| np | *non-fixer* | **45.936** | **3.819** | **<0.001** | **[19.006, 78.961]** |
| *N2-fixer* | **85.151** | **[46.375, 134.199]** |
| *Leaf N:P* | n | *non-fixer* | **19.363** | **-5.375** | **<0.001** | **[7.788, 32.313]** |
| *N2-fixer* | **-8.881** | **[-20.626, 4.603]** |
| p | *non-fixer* | -31.065 | -1.638 | 0.101 | [-40.190, -20.547] |
| *N2-fixer* | -36.365 | [-46.206, -24.723] |
| np | *non-fixer* | **-18.045** | **-8.141** | **<0.001** | **[-26.948, -8.057]** |
| *N2-fixer* | **-46.900** | **[-54.388, -38.245]** |

\*Significant effects noted in bold font. Model coefficients and 95% confidence interval ranges have been transformed to percent change to mimic figures. Key: *M*area=leaf biomass per unit leaf area (g m-2); *N*mass=leaf nitrogen content per unit leaf biomass (gN g-1); *N*area=leaf nitrogen content per unit leaf area (gN m-2); *P*mass=leaf phosphorus content per unit leaf biomass (gP g-1); *P*area=leaf phosphorus content per unit leaf area (gP m-2)

**Table S8** N2-fixer moderator effects on leaf photosynthetic responses to nutrient addition

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient** | **Moderator** | **Coef.** | **Z-value** | ***p*-value** | **95% CI** |
| *A*sat | n | *non-fixer* | **8.329** | **2.441** | **0.015** | **[-4.877, 23.368]** |
| *N2-fixer* | **19.602** | **[3.252, 38.542]** |
| p | *non-fixer* | **4.603** | **8.152** | **<0.001** | **[-10.952, 22.875]** |
| *N2-fixer* | **51.589** | **[26.617, 81.303]** |
| np | *non-fixer* | **30.474** | **-3.930** | **<0.001** | **[7.788, 57.775]** |
| *N2-fixer* | **11.405** | **[-8.972, 36.479]** |
| *V*cmax | n | *non-fixer* | **7.144** | **-3.879** | **<0.001** | **[-4.591, 20.202]** |
| *N2-fixer* | **-25.248** | **[-37.998, -9.968]** |
| p | *non-fixer* | **15.373** | **-2.309** | **0.021** | **[1.308, 31.521]** |
| *N2-fixer* | **-5.541** | **[-22.120, 14.454]** |
| np | *non-fixer* | **28.531** | **-4.918** | **<0.001** | **[14.683, 44.196]** |
| *N2-fixer* | **-17.634** | **[-31.477, -0.995]** |
| *J*max | n | *non-fixer* | **13.088** | **-2.001** | **0.045** | **[2.840, 24.483]** |
| *N2-fixer* | **-3.825** | **[-17.387, 12.075]** |
| p | *non-fixer* | 19.125 | 0.218 | 0.828 | [1.715, 39.515] |
| *N2-fixer* | 21.531 | [-2.664, 51.740] |
| np | *non-fixer* | **34.178** | **-4.209** | **<0.001** | **[27.634, 41.058]** |
| *N2-fixer* | **-9.063** | **[-23.662, 8.220]** |
| *PNUE* | n | *non-fixer* | 7.466 | -0.209 | 0.834 | [-12.015, 31.128] |
| *N2-fixer* | 6.609 | [-13.411, 31.390] |
| p | *non-fixer* | **11.963** | **8.293** | **<0.001** | **[-11.041, 40.917]** |
| *N2-fixer* | **66.363** | **[30.474, 112.336]** |
| np | *non-fixer* | **22.753** | **-5.056** | **<0.001** | **[-13.498, 74.368]** |
| *N2-fixer* | **-6.200** | **[-34.754, 34.851]** |
| *PPUE* | n | *non-fixer* | **33.643** | **-7.223** | **<0.001** | **[0.300, 78.069]** |
| *N2-fixer* | **-24.346** | **[-44.899, 3.873]** |
| p | *non-fixer* | *-19.587* | *1.825* | *0.068* | *[-41.667, 10.738]* |
| *N2-fixer* | *-3.052* | *[-32.699, 39.794]* |
| np | *non-fixer* | **4.498** | **-6.616** | **<0.001** | **[-26.288, 48.290]** |
| *N2-fixer* | **-39.770** | **[-58.687, -12.190]** |

\*Significant effects noted in bold font. Model coefficients and 95% confidence interval ranges have been transformed to percent change to mimic figures. Key:

**Table S9** Mycorrhizal acquisition strategy moderator effects on leaf nutrient responses to nutrient addition\*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient** | **Moderator** | **Coef.** | **Z-value** | ***p*-value** | **95% CI** |
| *M*area | n | *mining* | **1.106** | **-2.472** | **0.013** | **[-3.921, 6.290]** |
| *scavenging* | **-4.496** | **[-7.688, -1.094]** |
| p | *mining* | 0.300 | -1.026 | 0.305 | [-4.113, 5.022] |
| *scavenging* | -1.784 | [-4.877, 1.410] |
| np | *mining* | **-14.871** | **4.265** | **<0.001** | **[-20.308, -8.972]** |
| *scavenging* | **-2.955** | **[-6.947, 1.207]** |
| *N*mass | n | *mining* | 16.067 | -0.561 | 0.575 | [9.199, 23.491] |
| *scavenging* | 14.683 | [9.527, 20.081] |
| p | *mining* | -1.686 | 1.077 | 0.281 | [-6.293, 3.252] |
| *scavenging* | 0.803 | [-1.686, 3.355] |
| np | *mining* | 17.117 | -1.041 | 0.298 | [8.981, 25.86] |
| *scavenging* | 13.428 | [8.329, 18.887] |
| *N*area | n | *mining* | **4.289** | **2.231** | **0.026** | **[-6.387, 16.300]** |
| *scavenging* | **14.339** | **[5.548, 23.738]** |
| p | *mining* | 4.707 | -0.429 | 0.668 | [-5.541, 15.951] |
| *scavenging* | 2.942 | [-4.687, 11.071] |
| np | *mining* | 17.351 | -0.162 | 0.872 | [6.396, 29.434] |
| *scavenging* | 16.532 | [8.981, 24.732] |
| *P*mass | n | *mining* | **-20.308** | **6.069** | **<0.001** | **[-26.288, -13.843]** |
| *scavenging* | **-6.387** | **[-12.103, -0.300]** |
| p | *mining* | **123.67** | **-6.408** | **<0.001** | **[89.080, 164.323]** |
| *scavenging* | **54.496** | **[35.391, 76.297]** |
| np | *mining* | **29.823** | **3.544** | **<0.001** | **[12.637, 49.631]** |
| *scavenging* | **46.375** | **[28.660, 66.529]** |
| *P*area | n | *mining* | -4.591 | -0.129 | 0.897 | [-20.943, 15.027] |
| *scavenging* | -5.446 | [-17.799, 8.654] |
| p | *mining* | **194.763** | **-8.585** | **<0.001** | **[126.144, 284.203]** |
| *scavenging* | **60.159** | **[26.617, 102.587]** |
| np | *mining* | 50.381 | -0.294 | 0.769 | [18.412, 90.980] |
| *scavenging* | 47.108 | [19.961, 80.579] |
| *Leaf N:P* | n | *mining* | *5.654* | *1.930* | *0.054* | *[-8.698, 22.262]* |
| *scavenging* | *19.125* | *[8.004, 31.390]* |
| p | *mining* | **-49.338** | **4.918** | **<0.001** | **[-58.355, -38.430]** |
| *scavenging* | **-29.813** | **[-39.890, -18.045]** |
| np | *mining* | **-31.340** | **2.851** | **0.004** | **[-41.257, -19.748]** |
| *scavenging* | **-18.454** | **[-27.312, -8.515]** |

\*Significant effects noted in bold font. Model coefficients and 95% confidence interval ranges have been transformed to percent change to mimic figures. Key: *M*area=leaf biomass per unit leaf area (g m-2); *N*mass=leaf nitrogen content per unit leaf biomass (gN g-1); *N*area=leaf nitrogen content per unit leaf area (gN m-2); *P*mass=leaf phosphorus content per unit leaf biomass (gP g-1); *P*area=leaf phosphorus content per unit leaf area (gP m-2)

**Table S10** Mycorrhizal acquisition strategy moderator effects on leaf nutrient responses to nutrient addition

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient** | **Moderator** | **Coef.** | **Z-value** | ***p*-value** | **95% CI** |
| *A*sat | n | *mining* | **-12.366** | **4.872** | **<0.001** | **[-26.582, 4.603]** |
| *scavenging* | **15.604** | **[-0.797, 34.851]** |
| p | *mining* | 10.960 | -0.35 | 0.726 | [-6.293, 31.390] |
| *scavenging* | 8.763 | [-6.012, 25.986] |
| np | *mining* | **8.654** | **3.613** | **<0.001** | **[-12.278, 34.582]** |
| *scavenging* | **32.843** | **[9.199, 61.446]** |
| *V*cmax | n | *mining* | **-18.045** | **5.064** | **<0.001** | **[-35.144, 3.666]** |
| *scavenging* | **9.417** | **[-12.366, 36.752]** |
| p | *mining* | 12.750 | -0.108 | 0.914 | [-4.209, 32.711] |
| *scavenging* | 12.075 | [-3.052, 29.563] |
| np | *mining* | **2.634** | **3.199** | **0.001** | **[-17.963, 28.531]** |
| *scavenging* | **22.998** | **[-0.300, 51.740]** |
| *J*max | n | *mining* | **-5.446** | **4.278** | **<0.001** | **[-19.908, 11.628]** |
| *scavenging* | **19.602** | **[2.429, 39.654]** |
| p | *mining* | 20.322 | -0.171 | 0.864 | [0.803, 43.476] |
| *scavenging* | 19.125 | [1.511, 39.934] |
| np | *mining* | **10.076** | **3.302** | **0.001** | **[-6.947, 30.213]** |
| *scavenging* | **32.711** | **[13.769, 54.651]** |
| *PNUE* | n | *mining* | **-10.774** | **3.705** | **<0.001** | **[-28.965, 12.075]** |
| *scavenging* | **10.849** | **[-9.787, 36.343]** |
| p | *mining* | 17.704 | 0.063 | 0.950 | [-7.411, 49.631] |
| *scavenging* | 18.175 | [-5.541, 47.698] |
| np | *mining* | 24.483 | -0.665 | 0.506 | [-12.628, 77.181] |
| *scavenging* | 19.722 | [-14.700, 68.203] |
| *PPUE* | n | *mining* | **0.602** | **2.991** | **0.003** | **[-24.195, 33.643]** |
| *scavenging* | **28.018** | **[0.100, 63.722]** |
| p | *mining* | **-45.990** | **5.130** | **<0.001** | **[-63.175, -20.785]** |
| *scavenging* | **-12.190** | **[-37.998, 24.359]** |
| np | *mining* | **-18.860** | **2.182** | **0.029** | **[-43.221, 15.835]** |
| *scavenging* | **-0.797** | **[-27.819, 36.479]** |

\*Significant effects noted in bold font. Model coefficients and 95% confidence interval ranges have been transformed to percent change to mimic figures. Key:

**Table S11** Photosynthetic pathway moderator effects on leaf nutrient responses to nutrient addition\*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient** | **Moderator** | **Coef.** | **Z-value** | ***p*-value** | **95% CI** |
| *M*area | n | *C3* | **-0.896** | **-3.662** | **<0.001** | **[-4.209, 2.532]** |
| *C4* | **-11.839** | **[-16.723, -6.667]** |
| p | *C3* | -2.274 | 1.628 | 0.104 | [-5.351, 1.005] |
| *C4* | 1.918 | [-3.052, 7.144] |
| np | *C3* | **-1.882** | **-4.699** | **<0.001** | **[-5.918, 2.224]** |
| *C4* | **-15.802** | **[-21.101, -10.058]** |
| *N*mass | n | *C3* | **12.524** | **2.643** | **0.008** | **[7.358, 18.057]** |
| *C4* | **27.507** | **[16.532, 39.654]** |
| p | *C3* | *0.000* | *1.645* | *0.100* | *[-2.371, 2.429]* |
| *C4* | *5.548* | *[-0.797, 12.187]* |
| np | *C3* | **11.405** | **3.123** | **0.002** | **[6.078, 17.000]** |
| *C4* | **28.018** | **[17.234, 39.794]** |
| *N*area | n | *C3* | **15.835** | **-2.084** | **0.037** | **[6.609, 25.860]** |
| *C4* | **5.971** | **[-4.400, 17.468]** |
| p | *C3* | 2.942 | 0.119 | 0.905 | [-4.972, 11.516] |
| *C4* | 3.458 | [-6.293, 14.339] |
| np | *C3* | **21.774** | **-6.916** | **<0.001** | **[11.628, 32.843]** |
| *C4* | **-5.162** | **[-14.444, 5.127]** |
| *P*mass | n | *C3* | -9.063 | 1.260 | 0.208 | [-15.634, -2.078] |
| *C4* | 1.613 | [-14.358, 20.563] |
| p | *C3* | **66.696** | **-2.884** | **0.004** | **[42.618, 94.838]** |
| *C4* | **19.483** | **[-7.226, 53.726]** |
| np | *C3* | 44.340 | 0.124 | 0.901 | [26.998, 64.050] |
| *C4* | 46.375 | [15.835, 84.966] |
| *P*area | n | *C3* | -5.918 | 0.435 | 0.664 | [-18.372, 8.437] |
| *C4* | -2.274 | [-20.228, 19.722] |
| p | *C3* | 72.979 | -0.683 | 0.494 | [39.515, 114.470] |
| *C4* | 61.931 | [23.986, 111.488] |
| np | *C3* | **52.653** | **-2.518** | **0.012** | **[22.507, 90.218]** |
| *C4* | **22.262** | **[-5.918, 59.042]** |
| *Leaf N:P* | n | *C3* | 17.468 | 0.152 | 0.879 | [6.078, 29.953] |
| *C4* | 18.649 | [1.005, 39.515] |
| p | *C3* | -31.202 | -0.417 | 0.676 | [-40.310, -20.705] |
| *C4* | -33.369 | [-45.228, -18.942] |
| np | *C3* | -20.626 | 1.132 | 0.258 | [-29.461, -10.774] |
| *C4* | -12.716 | [-27.819, 5.548] |

\*Significant effects noted in bold font. Model coefficients and 95% confidence interval ranges have been transformed to percent change to mimic figures. Key: *M*area=leaf biomass per unit leaf area (g m-2); *N*mass=leaf nitrogen content per unit leaf biomass (gN g-1); *N*area=leaf nitrogen content per unit leaf area (gN m-2); *P*mass=leaf phosphorus content per unit leaf biomass (gP g-1); *P*area=leaf phosphorus content per unit leaf area (gP m-2)

**Table S12** Photosynthetic pathway moderator effects on leaf photosynthetic responses to nutrient addition

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient** | **Moderator** | **Coef.** | **Z-value** | ***p*-value** | **95% CI** |
| *A*sat | n | *C3* | **-13.064** | **-5.745** | **<0.001** | **[-2.469, 27.634]** |
| *C4* | **11.963** | **[-25.696, 1.613]** |
| p | *C3* | **-15.549** | **-6.632** | **<0.001** | **[-3.536, 30.083]** |
| *C4* | **27.890** | **[-28.538, -0.100]** |
| np | *C3* | 31.39 | 0.764 | 0.445 | [6.078, 54.188] |
| *C4* | 0.702 | [7.896, 60.159] |
| *V*cmax | n | *C3* | 8.546 | 0.464 | 0.643 | [-16.138, 20.804] |
| *C4* | 12.412 | [-24.648, 56.361] |
| p | *C3* | -2.274 | -1.365 | 0.172 | [-2.078, 29.175] |
| *C4* | 17.939 | [-23.203, 24.359] |
| np | *C3* | 17.351 | -0.058 | 0.954 | [-0.200, 39.236] |
| *C4* | 9.527 | [-5.824, 46.228] |
| *J*max | n | *C3* | 12.412 | 0.145 | 0.885 | [-2.761, 23.244] |
| *C4* | 19.602 | [-22.508, 62.905] |
| p | *C3* | 1.410 | -1.509 | 0.131 | [2.737, 39.236] |
| *C4* | 29.175 | [-21.730, 31.521] |
| np | *C3* | 26.744 | -0.220 | 0.826 | [20.925, 37.988] |
| *C4* | 6.930 | [6.716, 50.531] |
| *PNUE* | n | *C3* | **27.762** | **3.900** | **<0.001** | **[-12.453, 30.474]** |
| *C4* | **18.887** | **[2.737, 58.883]** |
| p | *C3* | **-20.388** | **-8.214** | **<0.001** | **[-4.782, 48.587]** |
| *C4* | **18.649** | **[-37.500, 1.410]** |
| np | *C3* | **45.645** | **4.406** | **<0.001** | **[-15.126, 65.699]** |
| *C4* | **24.483** | **[3.149, 105.649]** |
| *PPUE* | n | *C3* | 34.986 | 0.986 | 0.324 | [-0.399, 55.582] |
| *C4* | -17.634 | [2.840, 77.358] |
| p | *C3* | -28.609 | -1.231 | 0.218 | [-39.286, 11.851] |
| *C4* | -3.825 | [-51.032, 4.081] |
| np | *C3* | **51.589** | **4.535** | **<0.001** | **[-29.602, 31.390]** |
| *C4* | **-13.064** | **[5.022, 118.803]** |

\*Significant effects noted in bold font. Model coefficients and 95% confidence interval ranges have been transformed to percent change to mimic figures. Key:

**Table S13** Meta-analytic results summarizing the interaction effect on leaf nutrient, leaf photosynthetic, and whole-plant traits

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Trait** | **k** | **Coefficient (±SE)** | **Z-value** | ***p*-value** | **95% CI range** |
| *M*area | 88 | -3.729±8.654 | -0.459 | 0.646 | [-18.209, 13.315] |
| *N*mass | 139 | 2.634±6.396 | 0.423 | 0.672 | [-9.154, 16.067] |
| *N*area | 87 | -4.972±18.530 | -0.297 | 0.766 | [-31.887, 32.711] |
| *Pmass* | *133* | *-11.219±6.930* | *-1.781* | *0.075* | [-22.042, 1.207] |
| *P*area | 82 | -9.335±19.722 | -0.545 | 0.586 | [-36.237, 28.917] |
| ***Leaf N:P*** | **118** | **-39.950±20.322** | **-2.763** | **0.006** | **[-58.189, -13.757]** |
| *A*sat | 85 | 19.722±28.146 | 0.727 | 0.467 | [-26.288, 94.449] |
| *V*cmax | 42 | 16.766±30.474 | 0.584 | 0.560 | [-30.650, 96.600] |
| *J*max | 40 | 15.373±34.178 | 0.486 | 0.627 | [-35.144, 105.238] |
| *J*max:*V*cmax | 32 | 9.199±12.187 | 0.761 | 0.447 | [-12.890, 36.752] |
| *PNUE* | 61 | 15.373±49.332 | 0.356 | 0.722 | [-47.429, 153.198] |
| *PPUE* | 62 | -10.952±29.434 | -0.448 | 0.654 | [-46.313, 47.846] |
| *Total biomass* | 42 | 14.339±10.96 | 1.289 | 0.197 | [-6.761, 40.074] |
| ***Aboveground biomass*** | **125** | **19.961±7.788** | **2.418** | **0.016** | **[3.562, 39.097]** |
| *Belowground biomass* | 63 | 3.977±9.417 | 0.429 | 0.668 | [-12.890, 24.110] |
| *Root mass fraction* | 40 | 13.655±14.912 | 0.920 | 0.358 | [-13.498, 49.332] |
| *Root:shoot ratio* | 37 | 12.975±13.769 | 0.940 | 0.347 | [-12.366, 45.499] |

\*Significant effects noted in bold font, marginal effects noted in italic font. Model coefficients and 95% confidence interval ranges have been transformed to percent change to mimic figures. Key: *M*area=leaf biomass per unit leaf area (g m-2); *N*mass=leaf nitrogen content per unit leaf biomass (gN g-1); *N*area=leaf nitrogen content per unit leaf area (gN m-2); *P*mass=leaf phosphorus content per unit leaf biomass (gP g-1); *P*area=leaf phosphorus content per unit leaf area (gP m-2); leaf N:P=ratio of leaf nitrogen content per unit leaf biomass to leaf phosphorus content per unit leaf biomass (unitless); *A*sat=light-saturated net photosynthesis rate (μmol m-2 s-1); *V*cmax=maximum rate of Rubisco carboxylation (μmol m-2 s-1); *J*max=maximum rate of electron transport for RuBP regeneration (μmol m-2 s-1); *J*max:*V*cmax=ratio of the maximum rate of electron transport for RuBP regeneration to the maximum rate of Rubisco carboxylation (unitless); *PNUE*=photosynthetic nitrogen use efficiency (μmol gN-1 s-1); *PPUE*=photosynthetic phosphorus use efficiency (μmol gP-1 s-1)

**Table S14** Climate moderator effects on interaction effect sizes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Trait** | **Moderator** | **Coef. (±SE)** | **Z-value** | ***p*-value** | **95% CI** |
| *M*area | *T*g | 1.129±1.999 | 0.567 | 0.571 | [-2.720, 5.130] |
| *AI*g | -12.651±24.676 | -0.613 | 0.540 | [-43.307, 34.583] |
| *PAR*g | -0.027±0.157 | -0.174 | 0.862 | [-0.335, 0.281] |
| *N*mass | *T*g | -0.030±1.090 | -0.027 | 0.978 | [-2.131, 2.117] |
| *AI*g | 9.808±17.231 | 0.589 | 0.556 | [-19.589, 49.953] |
| *PAR*g | 0.021±0.085 | 0.241 | 0.809 | [-0.146, 0.187] |
| *N*area | *T*g | 1.728±2.044 | 0.847 | 0.397 | [-2.227, 5.844] |
| *AIg* | 7.688±25.313 | 0.328 | 0.743 | [-30.801, 67.585] |
| *PAR*g | 0.057±0.144 | 0.394 | 0.693 | [-0.224, 0.338] |
| *P*mass | *T*g | 0.398±1.238 | 0.323 | 0.747 | [-1.993, 2.848] |
| *AI*g | 22.294±17.721 | 1.234 | 0.217 | [-11.174, 68.374] |
| *PAR*g | 0.065±0.090 | 0.721 | 0.471 | [-0.112, 0.242] |
| *P*area | *T*g | 0.924±2.694 | 0.346 | 0.729 | [-4.199, 6.322] |
| ***AI*g** | 28.181±28.488 | 0.990 | 0.322 | [-21.574, 109.502] |
| ***PAR*g** | 0.202±0.161 | 1.254 | 0.210 | [-0.114, 0.519] |
| *Leaf N:P* | ***T*g** | **4.008±1.846** | **2.148** | **0.032** | **[0.344, 7.805]** |
| *AI*g | 21.666±18.488 | 1.156 | 0.248 | [-12.749, 69.654] |
| ***PAR*g** | **-0.291±0.113** | **-2.574** | **0.010** | **[-0.511, -0.069]** |
| *Total biomass* | *T*g | 3.995±3.738 | 1.067 | 0.286 | [-3.223, 11.752] |
| *AI*g | -2.789±21.811 | -0.143 | 0.886 | [-33.966, 43.106] |
| *PAR*g | -0.042±0.112 | -0.371 | 0.710 | [-0.261, 0.178] |
| *Aboveground biomass* | ***T*g** | **-2.965±1.500** | **-2.021** | **0.043** | **[-5.756, -0.091]** |
| ***AI*g** | **-32.187±18.025** | **-2.344** | **0.019** | **[-50.995, -6.162]** |
| *PAR*g | -0.092±0.069 | -1.345 | 0.178 | [-0.226, 0.042] |
| *Belowground biomass* | *T*g | -1.448±1.676 | -0.878 | 0.380 | [-4.607, 1.815] |
| *AI*g | -6.037±20.485 | -0.334 | 0.738 | [-34.787, 35.388] |
| *PAR*g | 0.032±0.091 | 0.347 | 0.728 | [-0.147, 0.210] |
| *Root mass fraction* | *T*g | 1.315±4.651 | 0.287 | 0.774 | [-7.322, 10.756] |
| *AI*g | 29.968±50.352 | 0.643 | 0.520 | [-41.560, 189.045] |
| *PAR*g | -0.089±0.218 | -0.41 | 0.682 | [-0.514, 0.338] |
| *Root:shoot* | *T*g | -0.762±4.277 | -0.183 | 0.855 | [-8.583, 7.728] |
| *AI*g | 7.988±49.877 | 0.190 | 0.849 | [-51.141, 138.675] |
| *PAR*g | -0.102±0.208 | -0.490 | 0.624 | [-0.508, 0.306] |

**Table S15** N2-fixer moderator effects on interaction effect sizes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Trait** | **Moderator** | **Coefficient** | **Z-value** | ***p*-value** | **95% CI** |
| *M*area | *non-fixer* | -2.699 | -0.562 | 0.574 | [-17.671, 14.997] |
| *N2-fixer* | -19.934 | [-58.628, 54.950] |
| *N*mass | *non-fixer* | 1.881 | -0.297 | 0.766 | [-10.735, 16.279] |
| *N2-fixer* | -5.154 | [-39.708, 49.203] |
| *N*area | *non-fixer* | -5.596 | 0.282 | 0.778 | [-32.038, 31.134] |
| *N2-fixer* | 3.962 | [-50.914, 120.187] |
| *P*mass | *non-fixer* | -12.926 | 0.734 | 0.463 | [-24.362, 0.240] |
| *N2-fixer* | 6.595 | [-36.698, 79.499] |
| *P*area | *non-fixer* | -11.243 | 0.979 | 0.327 | [-34.769, 20.768] |
| *N2-fixer* | 30.457 | [-42.939, 198.259] |
| *Leaf N:P* | *non-fixer* | -42.317 | 0.675 | 0.500 | [-61.841, -12.802] |
| *N2-fixer* | -22.786 | [-71.325, 107.913] |
| *A*sat | *non-fixer* | 21.196 | -0.151 | 0.880 | [-24.956, 95.731] |
| *N2-fixer* | 12.994 | [-63.351, 248.376] |
| *V*cmax | *non-fixer* | 16.419 | 0.097 | 0.922 | [-30.962, 96.315] |
| *N2-fixer* | 20.838 | [-50.927, 197.553] |
| *J*max | *non-fixer* | 17.757 | -0.626 | 0.531 | [-35.268, 114.217] |
| *N2-fixer* | -7.04 | [-63.840, 138.978] |
| *PNUE* | *non-fixer* | 17.524 | -0.632 | 0.527 | [-46.805, 159.643] |
| *N2-fixer* | -16.543 | [-81.838, 283.489] |
| *PPUE* | *non-fixer* | -11.031 | 0.056 | 0.956 | [-46.564, 48.131] |
| *N2-fixer* | -8.575 | [-69.902, 177.712] |

**Table S16** Mycorrhizal acquisition strategy moderator effects on interaction effect sizes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Trait** | **Moderator** | **Coefficient** | **Z-value** | ***p*-value** | **95% CI** |
| *M*area | *mining* | **-36.479** | **2.386** | **0.017** | [-56.424, -7.405] |
| *scavenging* | **5.492** | [-11.699, 26.030] |
| *N*mass | *mining* | *40.604* | *-1.945* | *0.052* | *[-1.294, 100.284]* |
| *scavenging* | *-3.476* | *[-15.745, 10.580]* |
| *N*area | *mining* | -17.018 | 0.648 | 0.517 | [-54.840, 52.482] |
| *scavenging* | -1.925 | [-27.768, 33.164] |
| *P*mass | *mining* | *-34.049* | *1.759* | *0.079* | *[-53.628, -6.202]* |
| *scavenging* | *-7.097* | *[-19.825, 7.652]* |
| *P*area | *mining* | **-44.204** | **2.511** | **0.012** | **[-69.318, 1.465]** |
| *scavenging* | **3.021** | **[-27.030, 45.447]** |
| *Leaf N:P* | *mining* | *-60.625* | *1.655* | *0.098* | *[-81.232, -17.391]* |
| *scavenging* | *-37.282* | *[-56.349, -9.886]* |
| *A*sat | *mining* | 33.522 | -0.313 | 0.754 | [-47.574, 240.059] |
| *scavenging* | 18.799 | [-25.606, 89.709] |
| *V*cmax | *mining* | **68.145** | **-2.082** | **0.037** | **[-2.636, 190.384]** |
| *scavenging* | **2.337** | **[-31.565, 53.033]** |
| *J*max | *mining* | **65.695** | **-2.044** | **0.041** | **[-9.184, 202.312]** |
| *scavenging* | **0.490** | **[-35.796, 57.284]** |
| *PNUE* | *mining* | 41.970 | -0.521 | 0.602 | [-63.857, 457.667] |
| *scavenging* | 10.442 | [-47.347, 131.661] |
| *PPUE* | *mining* | -26.107 | 0.587 | 0.557 | [-71.673, 92.755] |
| *scavenging* | -7.860 | [-43.254, 49.611] |

**Table S17** Photosynthetic pathway moderator effects on interaction effect sizes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Trait** | **Moderator** | **Coefficient** | **Z-value** | ***p*-value** | **95% CI** |
| *M*area | *C3* | -6.255 | 0.789 | 0.430 | [-21.149, 11.453] |
| *C4* | 13.258 | [-26.833, 75.316] |
| *N*mass | *C3* | 2.811 | -0.979 | 0.327 | [-9.747, 17.115] |
| *C4* | -22.930 | [-56.059, 35.176] |
| *N*area | *C3* | -5.264 | 0.105 | 0.917 | [-34.130, 36.251] |
| *C4* | -2.194 | [-45.042, 74.058] |
| *P*mass | *C3* | -13.664 | 1.220 | 0.222 | [-24.986, -0.634] |
| *C4* | 21.728 | [-28.617, 107.581] |
| *P*area | *C3* | -8.417 | -0.321 | 0.748 | [-37.193, 33.543] |
| *C4* | -17.251 | [-55.835, 55.041] |
| *Leaf N:P* | *C3* | -42.510 | 0.583 | 0.560 | [-61.888, -13.280] |
| *C4* | -30.847 | [-65.953, 40.457] |
| *A*sat | *C3* | 20.634 | 0.093 | 0.926 | [-26.267, 97.369] |
| *C4* | 25.310 | [-48.628, 205.663] |
| *V*cmax | *C3* | 15.774 | 0.363 | 0.716 | [-30.687, 93.379] |
| *C4* | 38.080 | [-54.130, 315.655] |
| *J*max | *C3* | 14.038 | 0.442 | 0.659 | [-35.231, 100.786] |
| *C4* | 40.423 | [-54.273, 331.225] |
| *PNUE* | *C3* | 13.526 | 0.763 | 0.445 | [-47.326, 144.675] |
| *C4* | 80.291 | [-63.878, 799.865] |
| *PPUE* | *C3* | -11.821 | 0.484 | 0.629 | [-46.982, 46.659] |
| *C4* | 12.026 | [-65.074, 259.323] |

**References**

Aerts, R., De Caluwe, H., & Beltman, B. (2003). Is the relation between nutrient supply and biodiversity co-determined by the type of nutrient limitation? *Oikos*, *101*(3), 489–498. https://doi.org/10.1034/j.1600-0706.2003.12223.x

Arens, S. J. T., Sullivan, P. F., & Welker, J. M. (2008). Nonlinear responses to nitrogen and strong interactions with nitrogen and phosphorus additions drastically alter the structure and function of a high arctic ecosystem. *Journal of Geophysical Research: Biogeosciences*, *113*(3), 1–10. https://doi.org/10.1029/2007JG000508

Augustine, D. J., McNaughton, S. J., & Frank, D. A. (2003). Feedbacks between soil nutrients and large herbivores in a managed savanna ecosystem. *Ecological Applications*, *13*(5), 1325–1337. https://doi.org/10.1890/02-5283

Aydin, I., & Uzun, F. (2005). Nitrogen and phosphorus fertilization of rangelands affects yield, forage quality and the botanical composition. *European Journal of Agronomy*, *23*(1), 8–14. https://doi.org/10.1016/j.eja.2004.08.001

Bennett, L. T., & Adams, M. A. (2001). Response of a perennial grassland to nitrogen and phosphorus additions in sub-tropical, semi-arid Australia. *Journal of Arid Environments*, *48*(3), 289–308. https://doi.org/10.1006/jare.2000.0759

Blanke, V., Bassin, S., Volk, M., & Fuhrer, J. (2012). Nitrogen deposition effects on subalpine grassland: The role of nutrient limitations and changes in mycorrhizal abundance. *Acta Oecologica*, *45*, 57–65. https://doi.org/10.1016/j.actao.2012.09.002

Boeye, D., Verhagen, B., Van Haesebroeck, V., & Verheyen, R. F. (1997). Nutrient limitation in species‐rich lowland fens. *Journal of Vegetation Science*, *8*(3), 415–424. https://doi.org/10.2307/3237333

Borer, E. T., Seabloom, E. W., Mitchell, C. E., & Cronin, J. P. (2014). Multiple nutrients and herbivores interact to govern diversity, productivity, composition, and infection in a successional grassland. *Oikos*, *123*(2), 214–224. https://doi.org/10.1111/j.1600-0706.2013.00680.x

Bowman, W. D., Theodose, T. A., Schardt, J. C., & Conant, R. T. (1993). Constraints of Nutrient Availability on Primary Production in Two Alpine Tundra Communities. *Ecology*, *74*(7), 2085–2097. https://doi.org/10.2307/1940854

Bown, H. E., Watt, M. S., Clinton, P. W., Mason, E. G., & Richardson, B. (2007). Partititioning concurrent influences of nitrogen and phosphorus supply on photosynthetic model parameters of Pinus radiata. *Tree Physiology*, *27*(3), 335–344. https://doi.org/10.1093/treephys/27.3.335

Cárate-Tandalla, D., Camenzind, T., Leuschner, C., & Homeier, J. (2018). Contrasting species responses to continued nitrogen and phosphorus addition in tropical montane forest tree seedlings. *Biotropica*, *50*(2), 234–245. https://doi.org/10.1111/btp.12518

Carswell, F. E., Whitehead, D., Rogers, G. N. D., & Mcseveny, T. M. (2005). Plasticity in photosynthetic response to nutrient supply of seedlings from a mixed conifer-angiosperm forest. *Austral Ecology*, *30*(4), 426–434. https://doi.org/10.1111/j.1442-9993.2005.01486.x

Chen, Z. F., Xiong, P. F., Zhou, J. J., Lai, S. B., Jian C.X., Wang, Z., & Xu, B. C. (2020). Photosynthesis and nutrient-use efficiency in response to N and P addition in three dominant grassland species on the semiarid Loess Plateau. *Photosynthetica*, *58*(4), 1028–1039. https://doi.org/10.32615/ps.2020.056

Cleland, E. E., Lind, E. M., DeCrappeo, N. M., DeLorenze, E., Wilkins, R. A., Adler, P. B., Bakker, J. D., Brown, C. S., Davies, K. F., Esch, E., Firn, J., Gressard, S., Gruner, D. S., Hagenah, N., Harpole, W. S., Hautier, Y., Hobbie, S. E., Hofmockel, K. S., Kirkman, K., … Seabloom, E. W. (2019). Belowground Biomass Response to Nutrient Enrichment Depends on Light Limitation Across Globally Distributed Grasslands. *Ecosystems*, *22*(7), 1466–1477. https://doi.org/10.1007/s10021-019-00350-4

Craft, C. B., Vymazal, J., & Richardson, C. J. (1995). Response of everglades plant communities to nitrogen and phosphorus additions. *Wetlands*, *15*(3), 258–271. https://doi.org/10.1007/BF03160706

Craine, J. M., Morrow, C., & Stock, W. D. (2008). Nutrient concentration ratios and co-limitation in South African grasslands. *New Phytologist*, *179*(3), 829–836. https://doi.org/10.1111/j.1469-8137.2008.02513.x

Crous, K. Y., O’Sullivan, O. S., Zaragoza-Castells, J., Bloomfield, K. J., Negrini, A. C. A., Meir, P., Turnbull, M. H., Griffin, K. L., & Atkin, O. K. (2017). Nitrogen and phosphorus availabilities interact to modulate leaf trait scaling relationships across six plant functional types in a controlled-environment study. *New Phytologist*, *215*(3), 992–1008. https://doi.org/10.1111/nph.14591

Cunha, J. P. B. F., Pimenta, J. A., Torezan, J. M. D., de Oliveira, H. C., & Stolf-Moreira, R. (2024). Growth and physiological responses of Atlantic Forest tree seedlings to nitrogen and phosphorus addition. *Trees - Structure and Function*, *38*(4), 903–913. https://doi.org/10.1007/s00468-024-02523-8

D’Antonio, C. M., & Mack, M. C. (2006). Nutrient limitation in a fire-derived, nitrogen-rich Hawaiian grassland. *Biotropica*, *38*(4), 458–467. https://doi.org/10.1111/j.1744-7429.2006.00170.x

Davidson, E. A., Reis De Carvalho, C. J., Vieira, I. C. G., Figueiredo, R. D. O., Moutinho, P., Ishida, F. Y., Dos Santos, M. T. P., Guerrero, J. B., Kalif, K., & Sabá, R. T. (2004). Nitrogen and phosphorus limitation of biomass growth in a tropical secondary forest. *Ecological Applications*, *14*(4 SUPPL.), 150–163. https://doi.org/10.1890/01-6006

Dong, J., Cui, X., Wang, S., Wang, F., Pang, Z., Xu, N., Zhao, G., & Wang, S. (2016). Changes in biomass and quality of alpine steppe in response to N & P fertilization in the Tibetan Plateau. *PLoS ONE*, *11*(5), 1–14. https://doi.org/10.1371/journal.pone.0156146

Eller, F., Jensen, K., & Reisdorff, C. (2017). Nighttime stomatal conductance differs with nutrient availability in two temperate floodplain tree species. *Tree Physiology*, *37*(4), 428–440. https://doi.org/10.1093/treephys/tpw113

Falk, K., Friedrich, U., von Oheimb, G., Mischke, K., Merkle, K., Meyer, H., & Härdtle, W. (2010). Molinia caerulea responses to N and P fertilisation in a dry heathland ecosystem (NW-Germany). *Plant Ecology*, *209*(1), 47–56. https://doi.org/10.1007/s11258-010-9720-2

Firn, J., McGree, J. M., Harvey, E., Flores-Moreno, H., Schütz, M., Buckley, Y. M., Borer, E. T., Seabloom, E. W., La Pierre, K. J., MacDougall, A. M., Prober, S. M., Stevens, C. J., Sullivan, L. L., Porter, E., Ladouceur, E., Allen, C., Moromizato, K. H., Morgan, J. W., Harpole, W. S., … Risch, A. C. (2019). Leaf nutrients, not specific leaf area, are consistent indicators of elevated nutrient inputs. *Nature Ecology & Evolution*, *3*(3), 400–406. https://doi.org/10.1038/s41559-018-0790-1

Fisher, J. B., Malhi, Y., Torres, I. C., Metcalfe, D. B., van de Weg, M. J., Meir, P., Silva-Espejo, J. E., & Huasco, W. H. (2013). Nutrient limitation in rainforests and cloud forests along a 3,000-m elevation gradient in the Peruvian Andes. *Oecologia*, *172*(3), 889–902. https://doi.org/10.1007/s00442-012-2522-6

Fornara, D. A., Banin, L., & Crawley, M. J. (2013). Multi-nutrient vs. nitrogen-only effects on carbon sequestration in grassland soils. *Global Change Biology*, *19*(12), 3848–3857. https://doi.org/10.1111/gcb.12323

Friedrich, U., von Oheimb, G., Kriebitzsch, W. U., Schleßelmann, K., Weber, M. S., & Härdtle, W. (2012). Nitrogen deposition increases susceptibility to drought - experimental evidence with the perennial grass Molinia caerulea (L.) Moench. *Plant and Soil*, *353*(1–2), 59–71. https://doi.org/10.1007/s11104-011-1008-3

Frost, J. W., Schleicher, T., & Craft, C. (2009). Effects of nitrogen and phosphorus additions on primary production and invertebrate densities in a Georgia (USA) tidal freshwater Marsh. *Wetlands*, *29*(1), 196–203. https://doi.org/10.1672/07-79.1

Gough, L., & Hobbie, S. E. (2003). Responses of moist non-acidic arctic tundra to altered environment: Productivity, biomass, and species richness. *Oikos*, *103*(1), 204–216. https://doi.org/10.1034/j.1600-0706.2003.12363.x

Güsewell, S., Koerselman, W., & Verhoeven, J. T. A. (2002). Time-dependent effects of fertilization on plant biomass in floating fens. *Journal of Vegetation Science*, *13*(5), 705–718. https://doi.org/10.1111/j.1654-1103.2002.tb02098.x

Güsewell, S., Koerselman, W., & Verhoeven, J. T. A. (2003). Biomass N:P ratios as indicators of nutrient limitation for plant populations in wetlands. *Ecological Applications*, *13*(2), 372–384. https://doi.org/10.1890/1051-0761(2003)013[0372:BNRAIO]2.0.CO;2

Haag, R. W. (1974). Nutrient limitations to plant production in two tundra communities. *Canadian Journal of Botany*, *52*(1), 103–116.

Han, X., Tsunekawa, A., Tsubo, M., & Li, S. (2011). Aboveground biomass response to increasing nitrogen deposition on grassland on the northern Loess Plateau of China. *Acta Agriculturae Scandinavica Section B: Soil and Plant Science*, *61*(2), 112–121. https://doi.org/10.1080/09064710903544201

Harrington, R. A., Fownes, J. H., & Vitousek, P. M. (2001). Production and resource use efficiencies in N- and P-limited tropical forests: A comparison of responses to long-term fertilization. *Ecosystems*, *4*(7), 646–657. https://doi.org/10.1007/s10021-001-0034-z

Haubensak, K. A., & D’Antonio, C. M. (2011). The importance of nitrogen-fixation for an invader of a coastal California grassland. *Biological Invasions*, *13*(6), 1275–1282. https://doi.org/10.1007/s10530-010-9904-7

He, D., Xiang, X., He, J. S., Wang, C., Cao, G., Adams, J., & Chu, H. (2016). Composition of the soil fungal community is more sensitive to phosphorus than nitrogen addition in the alpine meadow on the Qinghai-Tibetan Plateau. *Biology and Fertility of Soils*, *52*(8), 1059–1072. https://doi.org/10.1007/s00374-016-1142-4

Herbert, D. A., & Fownes, J. H. (1995). Phosphorus limitation of forest leaf area and net primary production on a highly weathered soil. *Biogeochemistry*, *29*(3), 223–235. https://doi.org/10.1007/BF02186049

Hersch-Green, E. I., Fay, P. A., Hass, H. B., & Smith, N. G. (2024). Mechanistic insights into plant community responses to environmental variables: genome size, cellular nutrient investments, and metabolic tradeoffs. *New Phytologist*. https://doi.org/10.1111/nph.20374

Huff, L. M., Potts, D. L., & Hamerlynck, E. P. (2015). Ecosystem CO 2 Exchange in Response to Nitrogen and Phosphorus Addition in a Restored, Temperate Grassland. *The American Midland Naturalist*, *173*(1), 73–87. https://doi.org/10.1674/0003-0031-173.1.73

Iversen, C. M., Bridgham, S. D., & Kellogg, L. E. (2010). Scaling plant nitrogen use and uptake efficiencies in response to nutrient addition in peatlands. *Ecology*, *91*(3), 693–707. https://doi.org/10.1890/09-0064.1

Jing, X., Yang, X., Ren, F., Zhou, H., Zhu, B., & He, J. S. (2016). Neutral effect of nitrogen addition and negative effect of phosphorus addition on topsoil extracellular enzymatic activities in an alpine grassland ecosystem. *Applied Soil Ecology*, *107*, 205–213. https://doi.org/10.1016/j.apsoil.2016.06.004

Ket, W. A., Schubauer-Berigan, J. P., & Craft, C. B. (2011). Effects of five years of nitrogen and phosphorus additions on a Zizaniopsis miliacea tidal freshwater marsh. *Aquatic Botany*, *95*(1), 17–23. https://doi.org/10.1016/j.aquabot.2011.03.003

Lawrence, D. (2001). Nitrogen and phosphorus enhance growth and luxury consumption of four secondary forest tree species in Borneo. *Journal of Tropical Ecology*, *17*(6), 859–869. https://doi.org/10.1017/S0266467401001638

Li, J. H., Yang, Y. J., Li, B. W., Li, W. J., Wang, G., & Knops, J. M. H. (2014). Effects of nitrogen and phosphorus fertilization on soil carbon fractions in alpine meadows on the Qinghai-Tibetan Plateau. *PLoS ONE*, *9*(7). https://doi.org/10.1371/journal.pone.0103266

Li, L. J., Zeng, D. H., Yu, Z. Y., Fan, Z. P., Mao, R., & Peri, P. L. (2011). Foliar N/P ratio and nutrient limitation to vegetation growth on Keerqin sandy grassland of North-east China. *Grass and Forage Science*, *66*(2), 237–242. https://doi.org/10.1111/j.1365-2494.2011.00781.x

Ludwig, F., de Kroon, H., Prins, H. H. T., & Berendse, F. (2001). Effects of nutrients and shade on tree‐grass interactions in an East African savanna. *Journal of Vegetation Science*, *12*(4), 579–588. https://doi.org/10.2307/3237009

Lund, M., Christensen, T. R., Mastepanov, M., Lindroth, A., & Ström, L. (2009). Effects of N and P fertilization on the greenhouse gas exchange in two northern peatlands with contrasting N deposition rates. *Biogeosciences*, *6*(10), 2135–2144. https://doi.org/10.5194/bg-6-2135-2009

Mayor, J. R., Wright, S. J., & Turner, B. L. (2014). Species-specific responses of foliar nutrients to long-term nitrogen and phosphorus additions in a lowland tropical forest. *Journal of Ecology*, *102*(1), 36–44. https://doi.org/10.1111/1365-2745.12190

McMaster, G. S., Jow, W. M., & Kummerow, J. (1982). Response of Adenostoma Fasciculatum and Ceanothus Greggii Chaparral to Nutrient Additions. *The Journal of Ecology*, *70*(3), 745. https://doi.org/10.2307/2260102

Mo, Q., Li, Z., Sayer, E. J., Lambers, H., Li, Y., Zou, B., Tang, J., Heskel, M., Ding, Y., & Wang, F. (2019). Foliar phosphorus fractions reveal how tropical plants maintain photosynthetic rates despite low soil phosphorus availability. *Functional Ecology*, *33*(3), 503–513. https://doi.org/10.1111/1365-2435.13252

Mo, Q., Wang, W., Lambers, H., Chen, Y., Yu, S., Wu, C., Fan, Y., Zhou, Q., Li, Z., & Wang, F. (2021). Response of foliar mineral nutrients to long-term nitrogen and phosphorus addition in a tropical forest. *Functional Ecology*, *35*(10), 2329–2341. https://doi.org/10.1111/1365-2435.13896

Ngai, J. T., & Jefferies, R. L. (2004). Nutrient limitation of plant growth and forage quality in Arctic coastal marshes. *Journal of Ecology*, *92*(6), 1001–1010. https://doi.org/10.1111/j.0022-0477.2004.00926.x

Ngatia, L. W., Turner, B. L., Njoka, J. T., Young, T. P., & Reddy, K. R. (2015). The effects of herbivory and nutrients on plant biomass and carbon storage in Vertisols of an East African savanna. *Agriculture, Ecosystems and Environment*, *208*, 55–63. https://doi.org/10.1016/j.agee.2015.04.025

Nielsen, P. L., Andresen, L. C., Michelsen, A., Schmidt, I. K., & Kongstad, J. (2009). Seasonal variations and effects of nutrient applications on N and P and microbial biomass under two temperate heathland plants. *Applied Soil Ecology*, *42*(3), 279–287. https://doi.org/10.1016/j.apsoil.2009.05.006

O’Halloran, L. R., Shugart, H. H., Wang, L., Caylor, K. K., Ringrose, S., & Kgope, B. (2010). Nutrient limitations on aboveground grass production in four savanna types along the Kalahari Transect. *Journal of Arid Environments*, *74*(2), 284–290. https://doi.org/10.1016/j.jaridenv.2009.08.012

Øien, D. I. (2004). Nutrient limitation in boreal rich-fen vegetation: A fertilization experiment. *Applied Vegetation Science*, *7*(1), 119–132. https://doi.org/10.1111/j.1654-109X.2004.tb00602.x

Prystupa, P., Savin, R., & Slafer, G. A. (2004). Grain number and its relationship with dry matter, N and P in the spikes at heading in response to N x P fertilization in barley. *Field Crops Research*, *90*(2–3), 245–254. https://doi.org/10.1016/j.fcr.2004.03.001

Rejmánková, E., MacEk, P., & Epps, K. (2008). Wetland ecosystem changes after three years of phosphorus addition. *Wetlands*, *28*(4), 914–927. https://doi.org/10.1672/07-150.1

Ren, Z., Li, Q., Chu, C., Zhao, L., Zhang, J., Dexiecuo Ai, Yang, Y., & Wang, G. (2010). Effects of resource additions on species richness and ANPP in an alpine meadow community. *Journal of Plant Ecology*, *3*(1), 25–31. https://doi.org/10.1093/jpe/rtp034

Ries, L. P., & Shugart, H. H. (2008). Nutrient limitations on understory grass productivity and carbon assimilation in an African woodland savanna. *Journal of Arid Environments*, *72*(8), 1423–1430. https://doi.org/10.1016/j.jaridenv.2008.02.013

Scott, J. T., Lambie, S. M., Stevenson, B. A., Schipper, L. A., Parfitt, R. L., & McGill, A. C. (2015). Carbon and nitrogen leaching under high and low phosphate fertility pasture with increasing nitrogen inputs. *Agriculture, Ecosystems and Environment*, *202*, 139–147. https://doi.org/10.1016/j.agee.2014.12.021

Shaver, G. R., Johnson, L. C., Cades, D. H., Murray, G., Laundre, J. A., Rastetter, E. B., Nadelhoffer, K. J., & Giblin, A. E. (1998). Biomass and CO2 flux in wet sedge tundras: Responses to nutrients, temperature, and light. *Ecological Monographs*, *68*(1), 75–97. https://doi.org/10.1890/0012-9615(1998)068[0075:bacfiw]2.0.co;2

Soudzilovskaia, N. A., Onipchenko, V. G., Cornelissen, J. H. C., & Aerts, R. (2005). Biomass production, N:P ratio and nutrient limitation in a Caucasian alpine tundra plant community. *Journal of Vegetation Science*, *16*(4), 399–406. https://doi.org/10.1111/j.1654-1103.2005.tb02379.x

Sun, Y., Wang, X., Ma, C., & Zhang, Q. (2022). Effects of Nitrogen and Phosphorus Addition on Agronomic Characters, Photosynthetic Performance and Anatomical Structure of Alfalfa in Northern Xinjiang, China. *Agronomy*, *12*(7), 1613. https://doi.org/10.3390/agronomy12071613

Tischer, A., Werisch, M., Döbbelin, F., Camenzind, T., Rillig, M. C., Potthast, K., & Hamer, U. (2015). Above- and belowground linkages of a nitrogen and phosphorus co-limited tropical mountain pasture system – responses to nutrient enrichment. *Plant and Soil*, *391*(1–2), 333–352. https://doi.org/10.1007/s11104-015-2431-7

van Cleve, K., & Oliver, L. K. (1982). Growth response of postfire quaking aspen ( Populus tremuloides Michx.) to N, P, and K fertilization. *Canadian Journal of Forest Research*, *12*(2), 160–165. https://doi.org/10.1139/x82-024

van der Hoek, D., van Mierlo, A. J. E. M., & van Groenendael, J. M. (2004). Nutrient limitation and nutrient-driven shifts in plant species composition in a species-rich fen meadow. *Journal of Vegetation Science*, *15*(3), 389–396. https://doi.org/10.1111/j.1654-1103.2004.tb02276.x

van der Waal, C., De Kroon, H., Heitkönig, I. M. A., Skidmore, A. K., Van Langevelde, F., De Boer, W. F., Slotow, R., Grant, R. C., Peel, M. P. S., Kohi, E. M., De Knegt, H. J., & Prins, H. H. T. (2011). Scale of nutrient patchiness mediates resource partitioning between trees and grasses in a semi-arid savanna. *Journal of Ecology*, *99*(5), 1124–1133. https://doi.org/10.1111/j.1365-2745.2011.01832.x

van Duren, I. C., Boeye, D., & Grootjans, A. P. (1997). Nutrient limitations in an extant and drained poor fen: Implications for restoration. *Plant Ecology*, *133*(1), 91–100. https://doi.org/10.1023/A:1009728007279

van Duren, I. C., Pegtel, D. M., Aerts, B. A., & Inberg, J. A. (1997). Nutrient supply in undrained and drained Calthion meadows. *Journal of Vegetation Science*, *8*(6), 829–838. https://doi.org/10.2307/3237027

van Wijnen, H. J., & Bakker, J. P. (1999). Nitrogen and phosphorus limitation in a coastal barrier salt marsh: The implications for vegetation succession. *Journal of Ecology*, *87*(2), 265–272. https://doi.org/10.1046/j.1365-2745.1999.00349.x

Verlinden, M. S., Ven, A., Verbruggen, E., Janssens, I. A., Wallander, H., & Vicca, S. (2018). Favorable effect of mycorrhizae on biomass production efficiency exceeds their carbon cost in a fertilization experiment. *Ecology*, *99*(11), 2525–2534. https://doi.org/10.1002/ecy.2502

Verryckt, L. T., Vicca, S., Van Langenhove, L., Stahl, C., Asensio, D., Urbina, I., Ogaya, R., Llusià, J., Grau, O., Peguero, G., Gargallo-Garriga, A., Courtois, E. A., Margalef, O., Portillo-Estrada, M., Ciais, P., Obersteiner, M., Fuchslueger, L., Lugli, L. F., Fernandez-Garberí, P. R., … Janssens, I. A. (2022). Vertical profiles of leaf photosynthesis and leaf traits and soil nutrients in two tropical rainforests in French Guiana before and after a 3-year nitrogen and phosphorus addition experiment. *Earth System Science Data*, *14*(1), 5–18. https://doi.org/10.5194/essd-14-5-2022

Wang, D., Ling, T., Wang, P., Jing, P., Fan, J., Wang, H., & Zhang, Y. (2018). Effects of 8-year nitrogen and phosphorus treatments on the ecophysiological traits of two key species on tibetan plateau. *Frontiers in Plant Science*, *9*(September), 1–12. https://doi.org/10.3389/fpls.2018.01290

Wang, F. C., Fang, X. M., Wang, G. G., Mao, R., Lin, X. F., Wang, H., & Chen, F. S. (2019). Effects of nutrient addition on foliar phosphorus fractions and their resorption in different-aged leaves of Chinese fir in subtropical China. *Plant and Soil*, *443*(1–2), 41–54. https://doi.org/10.1007/s11104-019-04221-8

Wang, Q., Zhang, W., Sun, T., Chen, L., Pang, X., Wang, Y., & Xiao, F. (2017). N and P fertilization reduced soil autotrophic and heterotrophic respiration in a young Cunninghamia lanceolata forest. *Agricultural and Forest Meteorology*, *232*, 66–73. https://doi.org/10.1016/j.agrformet.2016.08.007

Warren, C. R., & Adams, M. A. (2002). Phosphorus affects growth and partitioning of nitrogen to Rubisco in Pinus pinaster. *Tree Physiology*, *22*(1), 11–19. https://doi.org/10.1093/treephys/22.1.11

Wigand, C., Thursby, G. B., McKinney, R. A., & Santos, A. F. (2004). Response of Spartina patens to dissolved inorganic nutrient additions in the field. *Journal of Coastal Research*, *20*(SPEC. ISS. 45), 134–149. https://doi.org/10.2112/si45-134.1

Wright, S. J., Yavitt, J. B., Wurzburger, N., Turner, B. L., Tanner, E. V. J., Sayer, E. J., Santiago, L. S., Kaspari, M., Hedin, L. O., Harms, K. E., Garcia, M. N., & Corre, M. D. (2011). Potassium, phosphorus, or nitrogen limit root allocation, tree growth, or litter production in a lowland tropical forest. *Ecology*, *92*(8), 1616–1625. https://doi.org/10.1890/10-1558.1

Yang, X., Ren, F., Zhou, H., & He, J. S. (2014). Responses of plant community biomass to nitrogen and phosphorus additions in an alpine meadow on the Qinghai-Xizang Plateau. *Chinese Journal of Plant Ecology*, *38*(2), 159–166. https://doi.org/10.3724/sp.j.1258.2014.00014

Ye, X., Bu, W., Hu, X., Liu, B., Liang, K., & Chen, F. (2023). Species divergence in seedling leaf traits and tree growth response to nitrogen and phosphorus additions in an evergreen broadleaved forest of subtropical China. *Journal of Forestry Research*, *34*(1), 137–150. https://doi.org/10.1007/s11676-021-01437-2

Ye, X., Wang, F., Hu, X., Lin, Y., Sun, R., Liang, X., & Chen, F. (2022). Experimental Approach Alters N and P Addition Effects on Leaf Traits and Growth Rate of Subtropical Schima superba (Reinw. ex Blume) Seedlings. *Forests*, *13*(2), 141. https://doi.org/10.3390/f13020141

Yu, L., Song, X. L., Zhao, J. N., Wang, H., Bai, L., & Yang, D. L. (2015). Responses of plant diversity and primary productivity to nutrient addition in a Stipa baicalensis grassland, China. *Journal of Integrative Agriculture*, *14*(10), 2099–2108. https://doi.org/10.1016/S2095-3119(14)61001-7

Yu, Q., Ni, X., Cheng, X., Ma, S., Tian, D., Zhu, B., Zhu, J., Ji, C., Tang, Z., & Fang, J. (2022). Foliar phosphorus allocation and photosynthesis reveal plants’ adaptative strategies to phosphorus limitation in tropical forests at different successional stages. *Science of the Total Environment*, *846*(May), 157456. https://doi.org/10.1016/j.scitotenv.2022.157456

Yu, Z. Y., Zeng, D. H., Jiang, F. Q., & Zhao, Q. (2009). Responses of biomass to the addition of water, nitrogen and phosphorus in Keerqin sandy grassland, Inner Mongolia, China. *Journal of Forestry Research*, *20*(1), 23–26. https://doi.org/10.1007/s11676-009-0004-4

Zeng, W., & Wang, W. (2015). Combination of nitrogen and phosphorus fertilization enhance ecosystem carbon sequestration in a nitrogen-limited temperate plantation of Northern China. *Forest Ecology and Management*, *341*, 59–66. https://doi.org/10.1016/j.foreco.2015.01.004