**SUPPLEMENTARY MATERIAL**

**Supplementary Material 1. Soil properties, phylogenetic diversity and phylogenetic structure in the analyzed plots**

Table S1.1. Soil properties in the analyzed plots under the rehabilitation stages in the waste piles (WPs) and reference forest. N, P, K, Mg, B and Ca in cmolc dm-3, Na in mg dm-3.

| **Waste pile** | **Plot** | **Latitude** | **Longitude** | **pH** | **Clay** | **Sand** | **Silt** | **N** | **P** | **K** | **Mg** | **B** | **Ca** | **Na** | **H+Al** | **OM** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| WP NW2 | Initial 1 |  | . | 4.8 | 375 | 425 | 200 | 0.01 | 3.7 | 0.08 | 0.5 | 0.04 | 0.65 | 2.56 | 2.80 | 0.40 |
| Initial 2 |  |  | 6.3 | 125 | 800 | 75 | 0.02 | 31.8 | 0.05 | 0.83 | 0.05 | 0.34 | 1.79 | 1.50 | 0.46 |
| Initial 3 | -6.0300 | -50.1900 | 5.3 | 37 | 30.2 | 32.8 | 0.88 | 3.7 | 0.10 | 0.2 | <0.1 | 0.4 | 1.41 | 1.47 | 1.30 |
| Intermediate 1 | -6.0304 | -50.1920 | 5.4 | 31 | 38.8 | 30.2 | 0.41 | 3.1 | 0.10 | 0.2 | 0.07 | 0.4 | 4.54 | 2.2 | 0.80 |
| Intermediate 2 | -6.0302 | -50.1912 | 5.1 | 33 | 31.9 | 35.1 | 0.02 | 2.3 | 0.10 | 0.2 | <0.1 | 0.5 | 3.08 | 2.4 | 1.10 |
| Intermediate 3 | -6.0301 | -50.1922 | 5.2 | 41 | 30.5 | 28.5 | - | 1.2 | 0.13 | 0.6 | <0.1 | 1 | - | - | 1.50 |
| Intermediate 4 | -6.0295 | -50.1900 | 5.4 | 33 | 36.8 | 30.2 | 0.18 | 2.7 | 0.09 | 0.5 | <0.1 | 2.1 | 1.17 | 1.3 | 1.30 |
| Advanced 1 | -6.0283 | -50.1913 | 5.7 | 400 | 450 | 150 | 0.15 | 2.3 | 0.13 | 1.2 | 0.2 | 2.9 | 2.54 | 4.4 | 3.90 |
| Advanced 2 | -6.0284 | -50.1918 | 5.8 | 300 | 550 | 150 | 0.08 | 1.6 | 0.14 | 1.6 | 0.3 | 2.4 | 1.6 | 3.8 | 3.70 |
| Advanced 3 | -6.0289 | -50.1904 | 5.3 | 23 | 51.4 | 25.6 | 0.14 | 5.4 | 0.05 | 0.1 | <0.1 | 0.4 | 4.12 | 2.4 | 0.80 |
| Reference 1 | -6.0300 | -50.1971 | 4.2 | 57 | 30.1 | 12.9 | - | 2.2 | 0.15 | 0.2 | 0.6 | 0.3 | - | - | 4.20 |
| Reference 2 | -6.0301 | -50.1974 | 4.3 | 43 | 44.5 | 12.5 | - | 2.1 | 0.21 | 0.3 | 0.7 | 0.5 | - | - | 4.60 |
| Reference 3 | -6.0300 | -50.1979 | 4.3 | 31 | 55.2 | 13.8 | - | 2.5 | 0.15 | 0.2 | 0.6 | 0.1 | - | - | 4.80 |
| Reference 4 | -6.0278 | -50.1911 | 4.3 | 65 | 14 | 21 | 0.42 | 1.6 | 0.24 | 0.4 | 0.8 | 1.4 | 3.54 | 6.5 | 4.20 |
| Reference 5 | -6.0257 | -50.1916 | 4.2 | 55 | 28.4 | 16.6 | 0.43 | 2.1 | 0.24 | 0.3 | 0.8 | 0.4 | 5.49 | 9.2 | 4.60 |
| Reference 6 | -6.0258 | -50.1920 | 4 | 63 | 20.3 | 16.7 | 0.48 | 0.9 | 0.20 | 0.2 | 0.7 | 0.2 | 3.43 | 12.4 | 4.80 |
| WP NW1 | Intermediate 1 | -6.0365 | -50.1723 | 6.8 | 520 | 255 | 225 | 0.02 | 4.5 | 0.07 | 3.9 | 0.04 | 3.08 | 4.48 | 1.10 | 0.78 |
| Intermediate 2 | -6.0365 | -50.1737 | 5.7 | 395 | 505 | 100 | 0.13 | 16 | 0.11 | 1.3 | 0.18 | 2.59 | 5.46 | 1.30 | 2.67 |
| Intermediate 3 | -6.0365 | -50.1737 | 6.8 | 445 | 405 | 150 | 0.02 | 26.6 | 0.08 | 1.1 | 0.08 | 2.44 | 2.31 | 1.20 | 2.75 |
| Intermediate 4 | -6.0358 | -50.1708 | 4.8 | 495 | 405 | 100 | 0.15 | 10.8 | 0.05 | 0.2 | 0.12 | 0.67 | 3.80 | 2.40 | 2.30 |
| Intermediate 5 | -6.0364 | -50.1696 | 5.6 | 470 | 355 | 175 | 0.11 | 5.8 | 0.06 | 0.8 | 0.06 | 0.94 | 4.07 | 1.80 | 1.79 |
| Intermediate 6 | -6.0362 | -50.1700 | 6.4 | 595 | 280 | 125 | 0.11 | 6.6 | 0.08 | 0.7 | 0.05 | 0.86 | 3.72 | 1.90 | 2.04 |
| WP W | Intermediate 1 | -6.0531 | -50.1808 | 5.8 | 525 | 275 | 200 | 0.03 | 4.6 | 0.15 | 2.2 | 0.14 | 3.17 | 1.21 | 2.10 | 2.09 |
| Intermediate 2 | -6.0536 | -50.1809 | 6.0 | 300 | 600 | 100 | 0.03 | 15.6 | 0.14 | 1.0 | 0.09 | 1.29 | 1.00 | 1.80 | 1.44 |
| Intermediate 3 | -6.0554 | -50.1809 | 7.0 | 325 | 525 | 150 | 0.34 | 9.1 | 0.39 | 3.3 | 0.42 | 13.5 | 12.3 | 1.70 | 7.50 |
| Intermediate 4 | -6.0597 | -50.1817 | 6.6 | 425 | 450 | 125 | 0.13 | 2.3 | 0.04 | 2.4 | 0.18 | 6.29 | 2.87 | 2.10 | 5.31 |
| Intermediate 5 | -6.0601 | -50.1815 | 6.6 | 425 | 425 | 150 | 0.01 | 6.3 | 0.11 | 1.2 | 0.10 | 2.68 | 1.63 | 1.70 | 2.54 |
| Intermediate 6 | -6.0605 | -50.1811 | 6.1 | 450 | 375 | 175 | 0.16 | 6.1 | 0.17 | 1.1 | 0.04 | 3.92 | 2.33 | 3.00 | 3.50 |
| Advanced 1 | -6.0496 | -50.1715 | 5.2 | 275 | 625 | 100 | 0.15 | 10.5 | 0.14 | 2.1 | 0.46 | 4.84 | 1.45 | 7.70 | 4.84 |
| Advanced 2 | -6.0499 | -50.1717 | 6.4 | 300 | 600 | 100 | 0.19 | 12.7 | 0.19 | 4.8 | 0.32 | 8.88 | 1.13 | 2.50 | 5.61 |
| Advanced 3 | -6.0492 | -50.1725 | 5.4 | 400 | 550 | 50.0 | 0.06 | 2.2 | 0.16 | 1.6 | 0.34 | 4.90 | 2.31 | 3.20 | 3.74 |
| WP S4 | Initial 1 | -6.0777 | -50.1586 | 6.3 | <1 | 45.1 | 54.9 | 0.04 | 3.2 | 0.22 | 13 | <0.1 | 3.3 | 2.57 | 1.50 | <0.2 |
| Initial 2 | -6.0772 | -50.1625 | 6.3 | 25 | 47.3 | 27.7 | 0.18 | 2.8 | 0.18 | 0.9 | <0.1 | 1.3 | 3.16 | 2.50 | <0.2 |
| Initial 3 | -6.0770 | -50.1639 | 5.7 | 375 | 500 | 125 | 0.07 | 4.8 | 0.18 | 2.0 | 0.14 | 2.29 | 2.06 | 2.90 | 2.53 |
| Intermediate 1 | -6.0798 | -50.1668 | 6.0 | 400 | 525 | 75 | 0.14 | 7.3 | 0.21 | 3.8 | 0.33 | 6.93 | 3.42 | 3.90 | 4.91 |
| Intermediate 2 | -6.0795 | -50.1664 | 6.2 | 325 | 600 | 75 | 0.09 | 13.9 | 0.13 | 2.3 | 0.20 | 5.94 | 2.31 | 2.90 | 4.09 |
| Intermediate 3 | -6.0789 | -50.1655 | 4.8 | 350 | 550 | 100 | 0.08 | 10.7 | 0.11 | 1.4 | 0.16 | 3.52 | 2.80 | 4.40 | 2.95 |
| Intermediate 4 | -6.0775 | -50.1604 | 5.7 | 25 | 51.2 | 23.8 | 0.23 | 8.2 | 0.18 | 1.7 | <0.1 | 1.40 | 4.13 | 3.00 | 3.10 |
| Intermediate 5 | -6.0770 | -50.1625 | 5.4 | 35 | 31.6 | 33.4 | 0.16 | 3.2 | 0.08 | 1.5 | <0.1 | 1.40 | 3.81 | 2.40 | 0.80 |
| Intermediate 6 | -6.0768 | -50.1635 | 6.3 | 35 | 33.2 | 31.8 | 0.05 | 2.3 | 0.17 | 0.5 | <0.1 | 0.6 | 3.51 | 1.60 | 1.60 |
| Intermediate 7 | -6.0804 | -50.1666 | 6.3 | 21 | 54.7 | 24.3 | 0.22 | 8.3 | 0.28 | 1.4 | 0.6 | 8.0 | 2.37 | 1.60 | 4.60 |
| Intermediate 8 | -6.0794 | -50.1655 | 6.9 | 325 | 550 | 125 | 0.05 | 15.8 | 0.19 | 2.9 | 0.27 | 12.5 | 2.28 | 1.80 | 4.04 |
| Intermediate 9 | -6.0798 | -50.1660 | 6.2 | 325 | 550 | 125 | 0.08 | 3.3 | 0.22 | 1.4 | 0.17 | 7.26 | 4.52 | 1.40 | 3.33 |
| Reference 1 | -6.0806 | -50.1674 | 4.4 | 67 | 8.8 | 24.2 | 0.48 | 2.2 | 0.13 | 0.5 | 0.50 | 1.70 | 3.55 | 7.8 | 4.20 |
| Reference 2 | -6.0806 | -50.1674 | 4.2 | 63 | 13.4 | 23.6 | 0.43 | 2.7 | 0.25 | 0.7 | 0.70 | 1.70 | 3.42 | 7.4 | 4.20 |
| Reference 3 | -6.0807 | -50.1672 | 4.3 | 63 | 12.9 | 24.1 | 0.54 | 2.2 | 0.20 | 0.4 | 0.5 | 1.10 | 2.44 | 7.50 | 4.60 |
| WP N1 | Initial 1 | -6.0434 | -50.1156 | 5.7 | 470 | 430 | 100 | 0.13 | 13.8 | 0.04 | 0.3 | 0.04 | 0.96 | 4.95 | 1.40 | 2.07 |
| Initial 2 | -6.0436 | -50.1155 | 6.0 | 445 | 380 | 175 | 0.07 | 11.9 | 0.03 | 0.7 | 0.02 | 0.97 | 3.69 | 1.20 | 1.07 |
| Initial 3 | -6.0439 | -50.1154 | 6.1 | 520 | 330 | 150 | 0.00 | 20 | 0.06 | 0.3 | 0.03 | 0.89 | 4.71 | 1.10 | 0.99 |
| Intermediate 1 | -6.0428 | -50.1185 | 5.8 | 420 | 430 | 150 | 0.15 | 56.8 | 0.07 | 1.1 | 0.04 | 1.79 | 6.00 | 1.30 | 1.94 |
| Intermediate 2 | -6.0426 | -50.1182 | 5.8 | 320 | 530 | 150 | 0.22 | 43.4 | 0.05 | 0.3 | 0.03 | 0.52 | 4.91 | 1.20 | 0.98 |
| Intermediate 3 | -6.0433 | -50.1194 | 6.0 | 520 | 355 | 125 | 0.06 | 75.9 | 0.06 | 0.6 | 0.04 | 1.27 | 9.40 | 1.40 | 1.64 |
| Advanced 1 | -6.0549 | -50.1219 | 5.3 | 520 | 330 | 150 | 0.16 | 4.8 | 0.10 | 2.2 | 0.10 | 0.50 | 5.74 | 1.90 | 2.21 |
| Advanced 2 | -6.0545 | -50.1223 | 5.4 | 470 | 380 | 150 | 0.22 | 4.8 | 0.07 | 4.4 | 0.11 | 2.21 | 4.86 | 2.50 | 2.60 |
| Advanced 3 | -6.0545 | -50.1223 | 5.3 | 395 | 455 | 150 | 0.04 | 13.7 | 0.09 | 2.6 | 0.09 | 1.34 | 3.89 | 1.80 | 2.54 |
| A2 | Reference 1 | -6.0982 | -50.2308 | 4.7 | 17 | 81.5 | 1.5 | 0.24 | 2.5 | 0.12 | 0.2 | 0.30 | 1.10 | 1.33 | 8.1 | 3.00 |
| Reference 2 | -6.0988 | -50.2316 | 4.8 | 17 | 75 | 8 | 0.23 | 2.6 | 0.18 | 0.3 | 0.50 | 1.50 | 1.55 | 3.3 | 4.10 |
| Reference 3 | -6.0993 | -50.2292 | 4.2 | 47 | 46 | 7 | 0.23 | 1.9 | 0.16 | 0.3 | 0.70 | 0.90 | 2.17 | 4.4 | 3.70 |
| Reference 4 | -6.0967 | -50.2270 | 4.8 | 53 | 34.7 | 12.3 | - | 2.2 | 0.20 | 0.4 | 0.80 | 2.70 | - | - | 3.90 |
| Reference 5 | -6.0978 | -50.2273 | 4.3 | 51 | 36.5 | 12.5 | - | 1.5 | 0.10 | 0.3 | 0.80 | 1.00 | - | - | 3.70 |
| Reference 6 | -6.0982 | -50.2272 | 4.3 | 61 | 27.1 | 11.9 | - | 1.8 | 0.20 | 0.5 | 1.10 | 1.90 | - | - | 4.40 |

Table S1.2. Phylogenetic diversity and structure in the analyzed plots. WP – waste pile, S – species richness, G – number of genera, F – number of families, O – number of orders, PD – phylogenetic diversity, MPDt – mean pairwise phylogenetic distance among taxa, MPDi – abundance-weighted MPD, ses.PD – standard effect size of PD, ses.MPDt – standard effect size of MPD among taxa, ses.MPDi – abundance-weighted standard effect size of MPD.

| **Waste pile** | **Plot** | **S** | **G** | **F** | **O** | **PD** | **MPDt** | **MPDi** | **ses.PD** | **ses.MPDt** | **ses.MPDi** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| WP NW2 | Initial 1 | 2 | 2 | 2 | 2 | 266.00 | 238.00 | 76.16 | 0.46521 | 0.46611 | 0.4524 |
| Initial 2 | - | - | - | - | - | - | - | - | - | - |
| Initial 3 | - | - | - | - | - | - | - | - | - | - |
| Intermediate 1 | 4 | 4 | 4 | 4 | 451.00 | 213.67 | 135.44 | -0.22953 | -0.24571 | -0.5467 |
| Intermediate 2 | 3 | 3 | 3 | 3 | 375.00 | 231.33 | 131.68 | 0.48645 | 0.45149 | 0.5578 |
| Intermediate 3 | 13 | 13 | 8 | 8 | 1157.75 | 197.67 | 174.26 | -2.39837 | -2.42944 | -1.4554 |
| Intermediate 4 | 7 | 7 | 4 | 4 | 652.00 | 190.10 | 162.24 | -2.14731 | -2.15085 | -1.1025 |
| Advanced 1 | 9 | 7 | 6 | 6 | 830.10 | 211.91 | 160.69 | -0.58278 | -0.55737 | -1.0563 |
| Advanced 2 | 7 | 5 | 5 | 5 | 639.00 | 204.00 | 157.33 | -1.09981 | -1.06489 | -0.3770 |
| Advanced 3 | 8 | 7 | 6 | 5 | 757.75 | 206.20 | 177.55 | -0.94938 | -1.03997 | -0.3224 |
| Reference 1 | 20 | 15 | 12 | 7 | 1378.43 | 222.00 | 207.62 | 0.51102 | 0.48434 | 0.4469 |
| Reference 2 | 19 | 13 | 8 | 7 | 1182.57 | 215.16 | 203.63 | -0.52429 | -0.47784 | 0.2721 |
| Reference 3 | 10 | 9 | 9 | 7 | 987.60 | 230.02 | 201.36 | 1.08984 | 1.09806 | 1.1294 |
| Reference 4 | 17 | 17 | 14 | 8 | 1519.48 | 224.17 | 203.15 | 0.70557 | 0.68412 | 0.5817 |
| Reference 5 | 24 | 22 | 16 | 12 | 1901.39 | 230.08 | 214.69 | 1.88309 | 1.88429 | 1.2431 |
| Reference 6 | 33 | 27 | 18 | 12 | 2323.58 | 222.37 | 213.17 | 0.73062 | 0.77837 | 0.7365 |
| WP NW1 | Intermediate 1 | 4 | 3 | 2 | 2 | 357.50 | 169.83 | 115.20 | -2.4247 | -2.2747 | -2.7268 |
| Intermediate 2 | 7 | 6 | 3 | 3 | 599.60 | 181.44 | 128.47 | -2.8280 | -2.9263 | -3.2122 |
| Intermediate 3 | 1 | 1 | 1 | 1 | 147.00 | NA | NA | NA | NA | NA |
| Intermediate 4 | 9 | 8 | 3 | 3 | 691.20 | 171.73 | 110.42 | -4.1159 | -4.3299 | -4.1049 |
| Intermediate 5 | 8 | 8 | 5 | 5 | 761.00 | 197.79 | 128.70 | -1.6664 | -1.7292 | -3.4850 |
| Intermediate 6 | 12 | 8 | 4 | 4 | 824.25 | 163.65 | 122.93 | -5.7681 | -5.5666 | -4.1681 |
| WP W | Intermediate 1 | 2 | 2 | 2 | 2 | 256.00 | 218.00 | 85.26 | -0.0315 | 0.0698 | -0.1489 |
| Intermediate 2 | 1 | 1 | 1 | 1 | 147.00 | NA | NA | NA | NA | NA |
| Intermediate 3 | 2 | 2 | 2 | 2 | 256.00 | 218.00 | 81.75 | 0.0120 | -0.0408 | -0.0360 |
| Intermediate 4 | 6 | 6 | 1 | 1 | 452.00 | 122.00 | 95.86 | -6.4872 | -6.4837 | -5.8577 |
| Intermediate 5 | 3 | 3 | 2 | 2 | 317.00 | 186.00 | 93.43 | -1.1970 | -1.1024 | -0.9043 |
| Intermediate 6 | 6 | 6 | 4 | 4 | 612.10 | 210.87 | 154.80 | -0.5212 | -0.5686 | -0.8935 |
| Advanced 1 | 4 | 4 | 3 | 3 | 411.00 | 190.33 | 48.47 | -1.3977 | -1.3598 | -2.1092 |
| Advanced 2 | 3 | 3 | 1 | 1 | 269.00 | 122.00 | 15.42 | -3.7762 | -3.5077 | -2.9134 |
| Advanced 3 | 9 | 9 | 7 | 7 | 847.60 | 227.47 | 142.51 | 0.7629 | 0.8241 | 1.2603 |
| WP S4 | Initial 1 | 1 | 1 | 1 | 1 | 147.00 | NA | NA | NA | NA | NA |
| Initial 2 | 5 | 4 | 2 | 2 | 398.50 | 146.30 | 41.38 | -4.1322 | -3.9676 | -3.9980 |
| Initial 3 | 5 | 4 | 3 | 3 | 456.50 | 185.10 | 74.01 | -2.0071 | -1.9338 | -1.8441 |
| Intermediate 1 | 1 | 1 | 1 | 1 | 147.00 | NA | NA | NA | NA | NA |
| Intermediate 2 | 6 | 6 | 6 | 5 | 633.35 | 220.77 | 154.56 | 0.1751 | 0.1515 | 0.8448 |
| Intermediate 3 | 4 | 4 | 4 | 4 | 485.10 | 235.77 | 163.30 | 0.8264 | 0.8675 | 1.1160 |
| Intermediate 4 | 8 | 7 | 7 | 6 | 805.10 | 220.62 | 182.23 | 0.2245 | 0.1243 | 0.2539 |
| Intermediate 5 | 10 | 9 | 5 | 5 | 806.10 | 194.48 | 151.42 | -2.2057 | -2.3162 | -2.2899 |
| Intermediate 6 | 8 | 6 | 6 | 6 | 702.25 | 204.95 | 169.23 | -1.0851 | -1.0775 | -0.8890 |
| Intermediate 7 | 5 | 5 | 3 | 3 | 477.00 | 183.20 | 123.93 | -1.9831 | -1.9887 | -0.0799 |
| Intermediate 8 | 4 | 4 | 2 | 2 | 368.00 | 160.00 | 69.20 | -2.7716 | -2.8118 | -1.0543 |
| Intermediate 9 | 3 | 2 | 2 | 2 | 276.50 | 152.33 | 67.94 | -2.6023 | -2.4239 | -1.3875 |
| Reference 1 | 23 | 21 | 16 | 12 | 1890.60 | 225.14 | 212.52 | 1.1043 | 1.0703 | 0.9652 |
| Reference 2 | 17 | 16 | 9 | 7 | 1260.63 | 200.65 | 187.15 | -2.4025 | -2.4058 | -2.3162 |
| Reference 3 | 20 | 19 | 14 | 11 | 1700.50 | 221.84 | 212.20 | 0.4796 | 0.4655 | 0.9157 |
| WP N1 | Initial 1 | 1 | 1 | 1 | 1 | 147.00 | NA | 40.00 | NA | NA | -3.2958 |
| Initial 2 | 1 | 1 | 1 | 1 | 147.00 | NA | NA | NA | NA | NA |
| Initial 3 | 2 | 2 | 1 | 1 | 187.00 | 80.00 | NA | -3.1882 | -3.3572 | NA |
| Intermediate 1 | 5 | 5 | 4 | 4 | 556.10 | 231.28 | 115.55 | 0.7120 | 0.7708 | -3.7852 |
| Intermediate 2 | 8 | 7 | 5 | 5 | 756.60 | 212.23 | 151.54 | -0.5211 | -0.5685 | -2.7257 |
| Intermediate 3 | 5 | 4 | 2 | 2 | 418.50 | 162.30 | 161.30 | -3.3367 | -2.9903 | -0.0238 |
| Advanced 1 | 11 | 11 | 7 | 6 | 1010.60 | 216.62 | 177.14 | -0.1961 | -0.1902 | 1.3523 |
| Advanced 2 | 4 | 3 | 3 | 3 | 374.00 | 184.67 | 116.68 | -1.6497 | -1.6345 | -0.5826 |
| Advanced 3 | 8 | 7 | 6 | 6 | 767.35 | 211.94 | 180.82 | -0.5775 | -0.5418 | -0.9321 |
| A2 | Reference 1 | 23 | 22 | 14 | 9 | 1797.22 | 215.35 | 202.20 | -0.5016 | -0.5569 | -0.0934 |
| Reference 2 | 27 | 22 | 19 | 10 | 1988.68 | 221.36 | 213.73 | 0.4758 | 0.4230 | 1.3202 |
| Reference 3 | 24 | 21 | 16 | 12 | 2039.49 | 227.15 | 214.73 | 1.3995 | 1.4536 | 1.1338 |
| Reference 4 | 31 | 30 | 21 | 11 | 2412.93 | 222.84 | 208.86 | 0.7685 | 0.7624 | 0.0443 |
| Reference 5 | 20 | 20 | 15 | 9 | 1732.98 | 220.50 | 204.03 | 0.3475 | 0.3231 | 0.8875 |
| Reference 6 | 25 | 20 | 14 | 9 | 1807.85 | 217.18 | 199.30 | -0.2271 | -0.2671 | -0.3065 |

**Supplementary Material 2. Species mixes frequently planted for waste pile rehabilitation in the Carajás National Forest**

Table S2. Commercial and native species mixes planted for waste pile rehabilitation in 2017

|  |  |
| --- | --- |
| Family | Species |
| *Commercial species* | |
| Asteraceae | *Helianthus annus* L. |
| Brassicaceae | *Raphanus sativus* L. |
| Fabaceae | *Crotalaria spectabilis* Roth |
| Fabaceae | *Cajanus cajan* (L.) Huth |
| Fabaceae | *Stylosanthes guianensis* (Aubl.) Sw. |
| Poaceae | *Avena sativa* L. |
| Poaceae | *Cenchrus americanus* (L.) Morrone |
| *Native species* | |
| Anacardiaceae | *Spondias mombin* L. |
| Annonaceae | *Guatteria olivacea* R.E.Fr. |
| Apocynaceae | *Aspidosperma spruceanum* Benth. ex Müll. Arg. |
| Arecaceae | *Euterpe oleracea* Mart. |
| Arecaceae | *Lepidaploa arenaria* (Mart. ex DC.) H. Rob. |
| Arecaceae | *Mauritia flexuosa* L. f. |
| Arecaceae | *Oenocarpus bacaba* Mart. |
| Arecaceae | *Socratea exorrhiza* (Mart.) H. Wendl. |
| Bignoniaceae | *Handroanthus ochraceus* (Cham.) Mattos |
| Bignoniaceae | *Tabebuia roseoalba* (Ridl.) Sandwith |
| Cannabaceae | *Trema micrantha* (L.) Blume |
| Caryocaraceae | *Caryocar villosum* (Aubl.) Pers. |
| Clusiaceae | *Garcinia gardneriana* (Planch. & Triana) Zappi |
| Combretaceae | *Buchenavia parvifolia* Ducke |
| Combretaceae | *Terminalia amazonia* (J.F. Gmel.) Exell |
| Ebenaceae | *Diospyros guianensis* (Aubl.) Gürke |
| Elaeocarpaceae | *Sloanea grandiflora* Sm. |
| Fabaceae | *Apuleia leiocarpa* (Vogel) J.F. Macbr*.* |
| Fabaceae | *Aeschynomene americana* L. |
| Fabaceae | *Balizia pedicellaris* (DC.) Barneby & J.W. Grimes |
| Fabaceae | *Bauhinia longipedicellata* Ducke |
| Fabaceae | *Bauhinia platypetala* Burch. ex Benth*.* |
| Fabaceae | *Bauhinia rufa* (Bong.) Steud. |
| Fabaceae | *Bauhinia ungulata* L. |
| Fabaceae | *Bowdichia nitida* Spruce ex Benth*.* |
| Fabaceae | *Caesalpinia ferrea* Mart. ex Tul. |
| Fabaceae | *Cassia spruceana* Benth*.* |
| Fabaceae | *Chloroleucon acacioides* (Ducke) Barneby & J.W. Grimes |
| Fabaceae | *Copaifera duckei* Dwyer |
| Fabaceae | *Copaifera martii* Hayne |
| Fabaceae | *Crotalaria lanceolata* E. Mey*.* |
| Fabaceae | *Crotalaria maypurensis* Kunth |
| Fabaceae | *Dialium guianense* (Aubl.) Sandwith |
| Fabaceae | *Enterolobium maximum* Ducke |
| Fabaceae | *Enterolobium schomburgkii* (Benth.) Benth. |
| Fabaceae | *Hymenaea courbaril* L. |
| Fabaceae | *Hymenaea reticulata* Ducke |
| Fabaceae | *Machaerium acutifolium* Vogel |
| Fabaceae | *Mimosa pudica* L. |
| Fabaceae | *Ormosia fastigiata* Tul. |
| Fabaceae | *Ormosia stipularis* Ducke |
| Fabaceae | *Parkia pendula* (Willd.) Benth. ex Walp*.* |
| Fabaceae | *Parkia platycephala* Benth. |
| Fabaceae | *Platypodium elegans* Vogel |
| Fabaceae | *Platymiscium ulei* Harms |
| Fabaceae | *Piptadenia gonoacantha* (Mart.) J.F. Macbr. |
| Fabaceae | *Samanea tubulosa* (Benth.) Barneby & J.W. Grimes |
| Fabaceae | *Senegalia multipinnata* (Ducke) Seigler & Ebinger |
| Fabaceae | *Senna occidentalis* (L.) Link |
| Fabaceae | *Senna reticulata* (Willd.) H.S. Irwin & Barneby |
| Fabaceae | *Senna silvestris* (Vell.) H.S. Irwin & Barneby |
| Fabaceae | *Schizolobium parahyba var. amazonicum* (Huber ex Ducke) Barneby |
| Fabaceae | *Stryphnodendron racemiferum* (Ducke) W.A. Rodrigues |
| Fabaceae | *Tachigali vulgaris* L.F. Gomes da Silva & H.C. Lima |
| Humiriaceae | *Sacoglottis guianensis* Benth. |
| Hypericaceae | *Vismia baccifera* (L.) Triana & Planch. |
| Hypericaceae | *Vismia latifolia* (Aubl.) Choisy |
| Lecythidaceae | *Eschweilera coriacea* (DC.) S.A. Mori |
| Malpighiaceae | *Byrsonima poeppigiana* A. Juss. |
| Malvaceae | *Apeiba echinata* Gaertn. |
| Malvaceae | *Ceiba pentandra* (L.) Gaertn. |
| Malvaceae | *Guazuma ulmifolia* Lam. |
| Meliaceae | *Cedrela fissilis* Vell. |
| Meliaceae | *Cedrela odorata* L. |
| Meliaceae | *Guarea guidonia* (L.) Sleumer |
| Moraceae | *Bagassa guianensis* Aubl*.* |
| Moraceae | *Ficus insipida* Willd*.* |
| Myrtaceae | *Campomanesia xanthocarpa* Mart. ex O. Berg |
| Myrtaceae | *Eugenia omissa* McVaugh |
| Myrtaceae | *Eugenia flavescens* DC. |
| Myrtaceae | *Myrcia tomentosa* (Aubl.) DC. |
| Opiliaceae | *Agonandra brasiliensis* Miers ex Benth. & Hook. f. |
| Rubiaceae | *Spermacoce verticillata* L. |
| Rutaceae | *Pilocarpus microphyllus* Stapf ex Wardlew. |
| Rutaceae | *Zanthoxylum rhoifolium* Lam. |
| Sapotaceae | *Pouteria manaosensis* (Aubrév. & Pellegr.) T.D. Penn*.* |
| Solanaceae | *Solanum crinitum* Lam. |
| Solanaceae | *Solanum viarum* Dunal |
| Urticaceae | *Cecropia purpurascens* C.C. Berg |
| Verbenaceae | *Lippia origanoides* Kunth |

**Supplementary Material 3: Results of nodesig analysis**

Table S3. Results of ‘nodesig’ analysis (i.e., lineages over- and underrepresented compared with random expectations) for waste piles in different rehabilitation stages in Carajás.

|  |  |  |  |
| --- | --- | --- | --- |
| Rehabilitation stage | Node name | Rank | Nodesig outcome |
| Initial | Nitrogen fixing | 991 | Overrepresented |
| Fabaceae | 991 | Overrepresented |
| Bauhinia | 992 | Overrepresented |
| Lamids to Campanulids | 977 | Overrepresented |
| Asterales to Paracryphiales | 993 | Overrepresented |
| Asteraceae | 995 | Overrepresented |
| Intermediate | Nitrogen fixing | 999 | Overrepresented |
| Fabaceae | 996 | Overrepresented |
| Mimosa | 999 | Overrepresented |
| Cecropia | 976 | Overrepresented |
| Vismia | 974 | Overrepresented |
| Kirkiaceae to Rutaceae | 1 | Underrepresented |
| Sapindaceae to Rutaceae | 0 | Underrepresented |
| Myrtaceae to Vochysiaceae | 0 | Underrepresented |
| Polemoniaceae to Ericaceae | 0 | Underrepresented |
| Magnoliales to Laurales | 0 | Underrepresented |
| Advanced | Mimosa | 998 | Overrepresented |
| Bonnetiaceae to Podostemaceae | 994 | Overrepresented |
| Vismia | 997 | Underrepresented |
| Sapindaceae to Rutaceae | 0 | Underrepresented |
| Reference | Nitrogen fixing | 9 | Underrepresented |
| Fabaceae | 18 | Underrepresented |
| Bauhinia | 1 | Underrepresented |
| Senna | 0 | Underrepresented |
| Parkia | 0 | Underrepresented |
| Malpighiaceae | 2 | Underrepresented |
| Rutaceae | 989 | Overrepresented |
| Sphaerosepalaceae to Malvaceae | 7 | Underrepresented |
| Neea | 988 | Overrepresented |
| Asteraceae | 0 | Underrepresented |
| Solanum | 0 | Underrepresented |

**Supplementary Material 4: Influence of a lack of phylogenetic resolution on the outcomes of phylogenetic diversity and structure**

Diagrama, Desenho técnico

Descrição gerada automaticamente

Fig. S1. Correlation coefficients and slope values of regression lines between metrics of phylogenetic diversity and community structure among completely resolved and unresolved phylogenies. PD - phylogenetic diversity, ses.PD - *s*tandard effect size of PD, MPDt - mean pairwise phylogenetic distance among taxa, ses.MPDt - *s*tandard effect size of MPD among taxa, MPDi – abundance-weighted MPD, ses.MPDi – abundance-weighted *s*tandard effect size of MPD.

**Supplementary Material 5. Methodological details used to survey environmental variables to compute environmental rehabilitation status**

For each plot, soil samples at 0-20 cm depths were collected to measure soil organic matter. Soil gathered from 5 homogeneously distributed sampling points within the entire plot was mixed and air-dried. Soil organic matter was determined by the potassium dichromate method (Silva, 2009).

The leaf area index (LAI) was measured in the field using LAI-2200C sensors (LICOR Inc., Lincoln, NE, USA) following the manufacturer’s instructions, in which above-canopy sky conditions were continuously monitored by a sensor at a site free of vegetation, and a second sensor was used to capture two below-canopy readings in each corner and in the center of each plot, totaling 10 below-canopy readings for each plot.

To compute functional richness within each plot (Legras et al. 2018), maximum height, maximum diameter (Oliveira-Filho, 2017), wood density (Zanne et al., 2009), growth form (Jardim Botânico de Rio de Janeiro, 2020), fruit type, dispersal and pollination syndrome (Amaral et al., 2009; Barretto and Catharino, 2015; Ferraz et al., 2004; Gastauer et al., 2015; Silva et al., 2003; Vásquez and Webber, 2010) information was retrieved from public databases or the literature. Additionally, we measured petiole length, leaf length and leaf width as well as fruit length and width from herbarium exsiccate (MPEG) and computed the ratios between height and diameter, petiole and leaf length and fruit length and width. Functional richness was computed from the 15 traits using the ‘dbFD’ function of the FD package (Mouchet et al., 2010; Villéger et al., 2008).

**References**

Amaral, D.D. do, Vieira, I.C.G., Almeida, S.S. de, Salomão, R. de P., Silva, A.S.L. da, Jardim, M.A.G., 2009. Checklist da flora arbórea de remanescentes florestais da região metropolitana de Belém e valor histórico dos fragmentos, Pará, Brasil. Bol. Mus. Para. Emilio Goeldi Cienc. Nat. 4, 231–289.

Barretto, E.H.P., Catharino, E.L.M., 2015. Florestas maduras da região metropolitana de São Paulo: diversidade, composição arbórea e variação florística ao longo de um gradiente litoral-interior, Estado de São Paulo, Brasil. Hoehnea 42, 445–469.

Ferraz, I.D.K., Leal Filho, N., Imakawa, A.M., Varela, V.P., Piña-Rodrigues, F.C.M., 2004. Características básicas para um agrupamento ecológico preliminar de espécies madeireiras da floresta de terra firme da Amazônia Central. Acta Amazon. 34, 621–633.

Gastauer, M., Guerra Sobral, M.E., Meira-Neto, J.A.A., 2015. Preservation of primary forest characteristics despite fragmentation and isolation in a forest remnant from Viçosa, MG, Brazil. Revista Arvore 39. https://doi.org/10.1590/0100-67622015000600001

Legras, G., Loiseau, N., Gaertner, J.-C., 2018. Functional richness: Overview of indices and underlying concepts. Acta Oecol. 87, 34–44.

Mouchet, M.A., Villéger, S., Mason, N.W.H., Mouillot, D., 2010. Functional diversity measures: an overview of their redundancy and their ability to discriminate community assembly rules. Funct. Ecol. 24, 867–876.

Oliveira-Filho, A.T., 2017. NeoTrop Tree - Welcome [WWW Document]. NeoTrop Tree. URL http://www.neotroptree.info/(accessed 5.5.20).

Silva, A.F.D., Oliveira, R.V.D., Santos, N.R.L., Paula, A.D., 2003. Composição florística e grupos ecológicos das espécies de um trecho de floresta semidecídua submontana da Fazenda São Geraldo, Viçosa-MG. Rev. Ordem Med. 27, 311–319.

Vásquez, S.P.F., Webber, A.C., 2010. Biologia floral e polinização de *Casearia grandiflora*, Casearia. javitensis e Lindackeria paludosa (Flacourtiaceae) na região de Manaus, AM. Rev. Bras. Bot. 33, 131–141.

Villéger, S., Mason, N.W.H., Mouillot, D., 2008. New multidimensional functional diversity indices for a multifaceted framework in functional ecology. Ecology 89, 2290–2301.

Zanne, A.E., Lopez-Gonzalez, G., Coomes, D.A., Ilic, J., Jansen, S., Lewis, S.L., Miller, R.B., Swenson, N.G., Wiemann, M.C., Chave, J., 2009. Global wood density database.