Supplementary Table 1. Carbon equivalent emitted due to maintenance and organic carbon stored or sequestered in soil. All units are tonnes carbon equivalent ha-1. ŧ

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Description** | **20-year emissions due to fertiliser use** | **20-year emissions due to fuel use for maintenance** | **20-year emissions due to irrigation** | **20-year gross organic carbon sequestration in soil** | **Net 20-year organic carbon sequestration in soil** | **Reported stored organic carbon in soil** | **Location and climate** | **References** |
| Mown lawns, low fertilizer application rate  0-20 cm depth | 4.9 | 6.7 | 10.6 | 28.2 | 5.9 |  | Southern California,  USA. MAT ≈19oC; rainfall ≈350 mm  Yr-1 | (Townsend-Small & Czimczik, 2010a, 2010b) |
| Mown lawns, high fertilizer application rate  0-20 cm depth | 26.6 | 6.7 | 10.6 | 28.2 | -15.6 |  |
| Mown lawns (average) | 1.3 | 3.8 |  |  |  | 45.8 | Across USA | (Selhorst & Lal, 2013) |
| Mown lawns  (lowest value) |  |  |  |  |  | 20.8 |
| Mown lawns  (highest value) |  |  |  |  |  | 96.3 |
| Weekly mown lawns |  | 3.4 |  |  |  |  | Massachusetts USA | (Lerman & Contosta, 2019) |
| Three-weekly mown lawns |  | 1.4 |  |  |  |  |
| Residential lawns  (no trees)  0-15 cm depth |  |  |  | 5.2 |  |  | Alabama, USA. Humid, subtropical. | (Huyler, Chappelka, Prior, & Somers, 2014) |
| Residential lawns  (no trees)  15-30 cm depth |  |  |  | -2.2 |  |  |
| Residential lawns  (no trees)  30-50 cm depth |  |  |  | 0.0 |  |  |
| Residential lawns  (no trees)  0-50 cm depth |  |  |  | 3.0 |  |  |
| Residential lawn maintenance |  | 2.8 |  |  |  |  | Florida, USA. Subtropical | (Horn, Escobedo, Hinkle, Hostetler, & Timilsina, 2015) |
| Residential tree maintenance |  | 0.04 |  |  |  |  |
| Shrub maintenance |  | 0.06 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Residential soil |  |  |  | 16.4 |  | 69.5 | Baltimore.  Temperate – warm humid summers, cold winters | (Raciti et al., 2011) |
| Forest soil |  |  |  |  |  | 54.4 |
| Grass | 2.1 | 2.9 |  |  |  |  | Chicago.  Moist, mid-continental | (Jo & McPherson, 1995) |
| Grass (high fertiliser rate) | 13.4 |  |  |  |  |  |  | (Gu, Crane, Hornberger, & Carrico, 2015) |
| Grass (low fertiliser rate) | 3.8 |  |  |  |  |  |  |
| Grass weekly mowing with push mower |  | 4.29 |  |  |  |  | Singapore. Humid, tropical. | (Velasco, Segovia, Choong, Lim, & Vargas, 2021) |
| Grass. Weekly mowing with ride-on mower |  | 1.54 |  |  |  |  |
| Grass. Assuming no carbon captured from removed clippings |  |  |  |  | -57.4 |  |
| Grass. Assuming all carbon captured from clippings (unrealistic) |  |  |  |  | 126.0 |  |
| Urban forest soil average 0-20cm |  |  |  |  |  | 54.8 | Harbin, China | (Lv et al., 2016) |
| Parkland 0-60 cm under shrubs |  |  |  |  |  | 91.5 | Helsinki, Finland. | (Lindén, Riikonen, Setälä, & Yli-Pelkonen, 2020) |
| Parkland 0-60 cm under lawn |  |  |  |  |  | 73.0 |
| Parkland 0-30 cm under shrubs un-mulched |  |  |  |  |  | 48.0 |
| Parkland 0-30 cm under shrubs mulched |  |  |  |  |  | 56.0 |
| ‘Tifway’ bermudagrass. Turf farm |  |  |  | 90.2-103 |  |  | Georgia. Warm temperate continental, ppt. = 1877 mm y-1 | (Pahari, Leclerc, Zhang, Nahrawi, & Raymer, 2018) |
| Mixed Oak forest soil. 0-30cm |  |  |  |  |  | 71 | Virginia, USA. Montgomery and Roanoke Counties ppt = 1060 mm and 1044 mm, MAT = 11.9 °C and 13.2 °C, respectively | (Campbell, Seiler, Wiseman, Strahm, & Munsell, 2014) |
| Lawn soil (converted from forest). 0-30cm |  |  |  |  |  | 65 |
| Park wetland soil (0-1m depth) |  |  |  |  |  | 139.9 | Seoul Forest Park | (Bae & Ryu, 2015) |
| Mixed forest soil (0-1m depth) |  |  |  |  |  | 101.9 |
| Deciduous broadleaf forest soil (0-1m depth) |  |  |  |  |  | 72.7 |
| Evergreen needleleaf soil (0-1m depth) |  |  |  |  |  | 72.7 |
| Lawn soil (0-1m depth) |  |  |  |  |  | 37.4 |
| Bare soil (0-1m depth) |  |  |  |  |  | 15.8 |
| Urban forest (0-30 cm) |  |  |  |  |  | 89 | Auckland, Aotearoa. Moist, warm temperate. | (Weissert, Salmond, & Schwendenmann, 2016) |
| Mown grass, parkland (0-30cm) 3 of 4 sites irrigated and fertilised. |  |  |  |  |  | 108 |
| Utility lawn soil (0-20cm) (mowed every 18 days) |  |  |  |  |  | 81.1 | Uppsala, Sweden. | (Poeplau, Marstorp, Thored, & Kätterer, 2016) |
| Meadow lawn (0-20cm) (mowed 1-2 times/y) |  |  |  |  |  | 60.2 |
| Utility lawn (0-20cm) (mowed every 18 days) |  |  |  |  |  | 67.8 | Malmo, Sweden |
| Meadow lawn (0-20cm) (mowed once/y) |  |  |  |  |  | 66.5 |
| Utility lawn (0-20cm) (mowed every 18 days) |  |  |  |  |  | 73.8 | Gothenburg, Sweden |
| Meadow lawn (0-20cm) (mowed once/y) |  |  |  |  |  | 72.5 |
| Fertilised lawn (0-40 cm) |  |  |  |  | 5.96 | 29.8 (100 yr old) | Salt Lake City, USA | (Smith, Williamson, Pataki, Ehleringer, & Dennison, 2018) |
| 7-8 year old forest restoration (high success) (0-100 cm) |  |  |  |  |  | 82.9 | New York City, USA | (Downey et al., 2021) |
| 7-8 year old forest restoration (low success) (0-100 cm) |  |  |  |  |  | 37.9 |
| Park lawn C (14yrs old) (0-15 cm) | 126 \* | | |  |  | 31.5 | Shenzen and Hong Kong.  Monsoon, humid subtropical | (Kong, Shi, & Chu, 2014) |
| Park lawn D (24yrs old) (0-15 cm) | 76 \* | | |  |  | 26.2 |
| Campus lawn A (2yrs old) (0-15 cm) | 42 \* | | |  |  | 50.3 |
| Campus lawn E (2yrs old) (0-15 cm) | 44 \* | | |  |  | 14.6 |
| lawns (high sand content) (0-10 cm) |  | | | 4.2 |  | 11.5 (53.6 yr old) | Texas, USA. Cool, semiarid. | (Sapkota, Young, Coldren, Slaughter, & Longing, 2020) |
| Natural forest soil (0-60cm) |  | | |  |  | 45.5 | Kumasi, Ghana, Tropical. | (Nero, Callo-Concha, Anning, & Denich, 2017) |
| Dry urban forest (0-30 cm) |  | | |  |  | 75.7 | Hamburg | (Dorendorf, Eschenbach, Schmidt, & Jensen, 2015) |
| Wet urban forest (0-30 cm) |  | | |  |  | 144.3 |
| Urban wetland (0-30 cm) |  | | |  |  | 141.6 |
|  |  | | |  |  |  |  |  |

\* Emissions associated with mowing, fertilising, irrigation, and pesticide application. ŧ Studies of golf courses and sports fields not included.

Supplementary Table 2. Carbon stored and sequestered in urban vegetation: tonnes of carbon per hectare of vegetation cover and per hectare of land. AG = above ground stems, BG = below ground roots.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Description** | **20-year carbon sequestration per hectareof cover** | **Reported stored carbon per hectareof cover** | **Reported stored carbon per hectareof land** | **Location and climate** | **References** | |
| **NATURAL FORESTS** | | | | | | |
| Natural forest |  |  | 19.8 | Barcelona, Spain | (Chaparro & Terradas, 2009) | |
| Natural forest (AG)  Natural forest (AG & BG) |  |  | 617.9  690.4 | Kumasi, Ghana, tropical. | (Nero et al., 2017) | |
| Tall natural forest (AG & BG dead and alive plus litter) |  |  | 144-360.5 (ave.=252.4) | Aotearoa NZ | (Paul, Kimberley, & Beets, 2021) | |
| **URBAN TREES CITY WIDE** | | | | | | |
| Public owned sites |  |  | 288.6 | Leicester, Britain | (Davies, Edmondson, Heinemeyer, Leake, & Gaston, 2011) | |
| Trees (AG & BG) (Location with highest stored carbon density) | 80.2 | 141.4 |  | Omaha, USA | (Nowak, Greenfield, Hoehn, & Lapoint, 2013) | |
| Trees (AG & BG) (Location with lowest stored carbon density) | 22.2 | 31.4 |  | South Dakota, USA |
| Trees (AG & BG) average across 34 cities | 41.0 | 76.9 |  | USA |
| Trees (AG & BG) average across 50 states | 61.2 |  |  |
| Riparian urban trees |  | 98.5 |  | Leipzig, Germany | (Strohbach & Haase, 2012) | |
| Urban forest |  |  | 33.4 | Barcelona, Spain | (Chaparro & Terradas, 2009) | |
| Forest Park (AG) |  |  | 166.95 | Almada, Portugal | (Mexia et al., 2018) | |
| Park grassland with a high density of trees (AG) |  |  | 156.3 |  |  | |
| Forest patches |  |  | 110.7 | Boston, USA | (Raciti, Hutyra, & Newell, 2014) | |
| Park trees (AG) |  |  | 420.0 | Kumasi, Ghana, tropical. | | (Nero et al., 2017) |
| Urban forest (AG) |  |  | 97.9 | Auckland, Aotearoa NZ | (Wang, Gao, & Schwendenmann, 2020) | |
| Urban Forest | 136.8 |  | 63.19 | Seoul, South Korea | (Lee, Kil, Jo, & Choi, 2019) | |
| Urban trees |  |  | 13.7 | Berlin, Germany | (Schreyer, Tigges, Lakes, & Churkina, 2014) | |
| Urban trees |  | 110.9 | 32.6 | Brisbane, Australia | (Mitchell et al., 2018) | |
| Parkland low density trees (105-126/ha) (AG) |  |  | 22.1 - 28.1 | Helsinki, Finland. | (Lindén et al., 2020) | |
| Urban trees |  | 54.7 | 13.5 | Meran, Italy | (Speak, Escobedo, Russo, & Zerbe, 2020) | |
| Urban forest |  |  | 8.92 | Shanghai, China | (Yao, Zhao, & Escobedo, 2017) | |
| Peri-urban forest |  |  | 9.81 |  |  | |
| Trees and shrubs | 96.0 |  |  | Chicago, USA | (Jo & McPherson, 1995) | |
| Urban trees |  |  | 4.7 - 7.2 | Korea, 3 cities | (Jo, 2002) | |
| Urban trees |  |  | 0 - 68.1 | Beijing, China | (Sun, Xie, & Zhao, 2019) | |
| Trees |  |  | 31.6 | Leicester, Britain | (Davies et al., 2011) | |
| Residential |  |  | 32.8 | Boston, USA | (Raciti et al., 2014) | |
| Street trees (AG) | 50.5 |  |  | Bolzano, Italy | (Russo, Escobedo, Timilsina, & Zerbe, 2015) | |
| Cycle path trees (AG) | 30.7 |  |  |
| Urban neotropical trees (AG & BG estimated: 0.26) | 17.6 - 9.7 |  |  | Medellin, Colombia | (Reynolds, Escobedo, Clerici, & Zea-Camaño, 2017) | |
| Natural urban forest AG & BG to 10 cm depth) |  | 263.04 |  | New York, USA | (Pregitzer, Hanna, Charlop-Powers, & Bradford, 2021) | |
| Urban dry forest (AG & BG) |  |  | 123.2 | Hamburg | (Dorendorf et al., 2015) | |
| Urban wet forest (AG & BG) |  |  | 126.4 |
| Urban forest tree (AG & BG estimated) |  | 3.6 - 378.1 |  | Harbin, China | (Lv et al., 2016) | |
| Urban forest tree (AG & BG estimated) average |  | 77.1 |  |
| Forest Park (AG & BG) |  |  | 262.4 | Almada, Portugal | (Mexia et al., 2018) | |
| Park grassland with high density of trees (AG & BG) |  |  | 228.1 |  |  | |
| Park trees (AG & BG) |  |  | 474.7 | Kumasi, Ghana, tropical. | | (Nero et al., 2017) |
| **DOMESTIC GARDENS** | | | | | | |
| Domestic gardens |  |  | 7.6 | Leicester, Britain | (Davies et al., 2011) | |
| Domestic herbaceous vegetation |  |  | 1.4 |  |  | |
| Single- and semidetached house |  | 28.6 |  | Leipzig, Germany | (Strohbach & Haase, 2012) | |
| Multi-story houses |  | 63.8 |  |  |  | |
| Residential trees |  |  | 63.0 | Florida, USA | (Timilsina, Staudhammer, Escobedo, & Lawrence, 2014) | |
| Residential |  |  | 23.0 | Barcelona, Spain | (Chaparro & Terradas, 2009) | |
| **SHRUBS** | | | | | | |
| Mixed shrub species (AG) | 62.2 |  |  | New Zealand | (Kimberley, Bergin, & Beets, 2014) | |
| Urban shrubland (AG) |  |  | 30.5 | Auckland, Aotearoa NZ | (Wang et al., 2020) | |
| Planted landfill severely impacted impoverished soil (mostly early successional species). (AG & BG) | 34 | 45.9 |  | Auckland Park, Aotearoa NZ, warm temperate. | (Schwendenmann & Mitchell, 2014) | |
| Planted landfill severely impacted soil. (AG & BG + SOC 0-5 cm depth) | 53.9 | 72.7 |  |  |  | |
| Regenerating forest (AG & BG dead + alive + litter) | 12.6 | 53.6 |  | Aotearoa New Zealand | (Paul et al., 2021) | |
| Sage scrub (native) (AG & BG to 10 cm depth) |  | 43 |  | California, USA | (Wheeler et al., 2016) | |
| **MOWN GRASS** | | | | | | |
| Grass (AG) | -8.0 | 2.2 |  | Chicago, USA | (Jo & McPherson, 1995) | |
| Grass, (AG) |  | 0.8 |  | Singapore. Monsoon, tropical. | (Ng et al., 2015) | |
| Tall fescue grass (AG) |  | 2.9 |  |  | (Lilly, Jenkins, & Carroll, 2015) | |
| Tall fescue grass (BG) |  | 3.1 |  |  |
| Grass (AG) |  | 1.0 |  | Average reported from 2012 literature review | (Guertal, 2012) | |
| Grass (BG) |  | 1.4 |  |

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