GLOBAL DISTRIBUTION OF FINE ROOT BIOMASS IN TERRESTRIAL ECOSYSTEMS

Summary:

A global data set of root biomass, rooting profiles, and nutrient concentrations in roots was compiled from the primary literature and used to study distributions of root properties. This data set consists of ninety estimates of live and total fine root biomass associated with Table 1 published in Jackson et al. (1977). Expanded data on rooting profiles and nutrients are available in other data sets; however, these data represent a unique tabulation of fine root measurements.

Understanding and predicting ecosystem functioning (e.g., carbon and water fluxes) and the role of soils in carbon storage requires an accurate assessment of plant rooting distributions. Here, in a comprehensive literature synthesis, we analyze rooting patterns for terrestrial biomes and compare distributions for various plant functional groups.

We first compiled a database of approximately 250 references that were useful for the project (see Appendix 1; additional references cited in the text but not found in Appendix 1 are included in the "Literature Cited" section). These references were found in journals, book chapters, reports, and unpublished manuscripts and include data from all continents except Antarctica. The oldest references date from early 20th Century (e.g., Cannon 1911; Price 1911; Weaver 1919), and several recent publications provided numerous references (e.g., Richards 1986; Rundel and Nobel 1991; Stone and Kalisz 1991). A reference was included in the analysis of root depth distributions if root samples were taken to at least 50 cm in at least three soil increments. Approximately 80 references met these criteria (see Appendix 2), and many included multiple sites per study. Additional studies in the database were used for biomass estimates and root/shoot ratios (see below). In some cases a given study supplied data for several species at a given location and these data were combined into one ecosystem estimate.

For each study we noted the location, latitude and longitude, annual precipitation, soil type or texture, type of roots measured (e.g., fine vs. total, live vs. dead), sampling method, and depth of sampling (see Appendix 2). Where possible, the data were analyzed as cumulative root biomass (kg m-2, soil surface-area basis), root density (kg m-3), and cumulative root fraction (the proportion of roots from the soil surface to a given depth in the soil). Where root biomass data were unavailable (e.g., data presented as root length or number of intersections), a study was included only in the analysis of cumulative root distributions. The data from each reference were separated into 11 biomes: boreal forest, crops, deserts, sclerophyllous shrubland/forest, temperate coniferous forest, temperate deciduous forest, temperate grassland, tropical deciduous forest, tropical evergreen forest, tropical grassland/savanna, and tundra.

The initial data set (Jackson et al. 1996) was expanded to examine distributions of root budgets (Jackson et al. 1997). Measurements were selected from over 300 field studies. Results from the analysis showed that calculated root surface area is almost always greater than leaf area, more than an order of magnitude so in grasslands. The average C:N:P ratio in living fine roots is 450:11:1, and global fine root carbon is more than 5% of the magnitude of all carbon contained

in the atmosphere. Assuming conservatively that fine roots turn over once per year, they represent 33% of global annual net primary productivity.

A PDF copy of the Jackson et al (1996) paper is available at http://www.biology.duke.edu/jackson/oecol96c.pdf, and a PDF copy of the Jackson et al. (1997) paper is available on-line at http://www.biology.duke.edu/jackson/PNAS97.htm.

This data set has been expanded and updated over the years to estimate root turnover rates (data for approximately 341 site-vegetation combinations for 188 site from 152 papers in Gill and Jackson 2000); studies of root nutrient concentrations (data for approximately 372 site-pit-depths from 57 papers in Gordon and Jackson 2000); and rooting depth (data for approximately 298 sites with 565 profiles in Schenk and Jackson 2002). The three recent papers include most of the data contained in the initial root data set; however, some observations may have been excluded because of more stringent selection criteria. Many of the source papers provided data for the three recent rooting papers and users are encouraged to review the three recent data sets. The file described below that provides estimates of both live and total fine root biomass for approximately 100 sites is unique to the collection of four data sets of root characteristics developed by Jackson and his collaborators.

Related Archived Data Sets:

- Global Distribution of Root Profiles in Terrestrial Ecosystems
- Global Distribution of Root Nutrient Concentrations in Terrestrial Ecosystems
- Global Distribution of Root Turnover in Terrestrial Ecosystems

Data Citation:

Cite this data set as follows:

Jackson, R. B., H. A. Mooney, and E.-D. Schulze. 2003. Global Distribution of Fine Root Biomass in Terrestrial Ecosystems. Data set. Available on-line [http://www.daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. doi:10.3334/ORNLDAAC/658.

References:

Gill, R., and R. B. Jackson. 2000. Global Patterns of root turnover for terrestrial ecosystems. New Phytologist 81:275-280.

Gordon, W. S., and R. B. Jackson. 2000. Nutrient concentrations in fine roots. Ecology 81:1:275-280.

Jackson, R. B., H. A. Mooney, and E.-D. Schulze. 1997. A global budget for fine root biomass, surface area, and nutrient contents. Proceedings of the National Academy of Sciences, U.S.A. 94:7362-7366

Jackson, R. B., J. Canadell, J. R. Ehleringer, H. A. Mooney, O. E. Sala, and E.-D. Schulze. 1996. A global analysis of root distributions for terrestrial biomes. Oecologia 108:389-411.

Schenk, H. J., and R. B. Jackson. 2002. The global biogeography of roots. Ecological Monographs 72(3):311-328.

Data Format:

The Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC) for Biogeochemistry Dynamics organized and formatted these data for long-term archive. Spreadsheet files are stored as ASCII tab-delimited files. Missing values are represented by -999.

Data File: PNAS fine root biomass (99), Fine_Root_Biomass_Table_1.txt

Variables
ID
Biome
Reference
Fine root biomass (live)
Fine root biomass (total)
NPP (g m-2 yr-1)
MAP
Notes
Conversion from total to live

Example Data Records:

Biome Reference Fine root biomass (live) Fine root biomass (total) NPP (g m-2 yr-1) MAP Notes Conversion from total to live Paper
Temperate Deciduous Forest Aber et al. 1985 181 323 378 -9999 Sugar maple In Wisconsin (estimated using N budget method; <3mm) "56% live; based on Burke & Raynal, 46% live; Fahey & Hughes 67% live, McClaugherty et al. 58% live; Symbula and Day 1988 73% live; van Praag 37.8%" PNAS 1997
Temperate Deciduous Forest Burke and Raynal 1994 250 540 240 1060 (<3mm to 28 cm) "56% live; based on Burke & Raynal, 46% live; Fahey & Hughes 67% live, McClaugherty et al. 58% live; Symbula and Day 1988 73% live; van Praag 37.8%" PNAS 1997
Temperate Deciduous Forest Cox et al. 1978 476 850 675 -9999 "Liriodendron tulipfera (<5mm to 60 cm), excluded from analysis because root size is 5mm." "56% live;

based on Burke & Raynal, 46% live; Fahey & Hughes 67% live, McClaugherty et al. 58% live; Symbula and Day 1988 73% live; van Praag 37.8%"   PNAS 1997

Companion File 1: Notes on individual studies, Fine_Root_Biomass_Notes.txt
(also in .pdf and .rtf formats)

Miscellaneous notes.

Companion File 2: PNAS references (136), Fine_Root_Biomass_References.txt
(also in .pdf and .rtf formats)

Example Data Records:

References associated with the Table 1 and text in Jackson, RB, HA Mooney, E-D Schulze. 1997. A global budget for fine root biomass, surface area, and nutrient contents. Proceedings of the National Academy of Sciences, U.S.A., 94:7362-7366

1. Nadelhoffer, K. J. & Raich, J. W. (1992) Ecology 73, 1139–1147.
2. Vogt, K. A., Grier, C. C. & Vogt, D. J. (1986) Adv. Ecol. Res. 15, 303–377.
3. Hendrick, R. L. & Pregitzer, K. S. (1994) Nature (London) 361, 59–61.
4. Caldwell, M. M. & Richards, J. H. (1986) in On the Economy of Plant Form and Function, ed. Givnish, T. J. (Cambridge Univ. Press, Cambridge, U.K.), pp. 251–273.
5. Reichle, D. E., Dinger, B. E., Edwards, N. T., Harris, W. F. & Sollins, P. (1973) in Carbon and the Biosphere, eds. Woodwell, G. M. & Pecan, E. V. (U.S. Atomic Energy Commission, Brookhaven, NY), pp. 345–365.

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