GLOBAL DISTRIBUTION OF ROOT TURNOVER IN TERRESTRIAL ECOSYSTEMS

Summary:

Estimates of root turnover rates were calculated from measurements of live root standing crop and belowground net primary production (BNPP) compiled from the primary literature. Vegetation characteristics, soil properties, and climate conditions were associated with turnover rates to examine patterns and controls for biomes worldwide (Gill and Jackson 2000).

Based on prior analyses (Jackson et al. 1996, 1997), data were compiled from approximately 190 papers from additional journals, book chapters, technical reports, and unpublished manuscripts that included information on live root standing crop and belowground BNPP. The papers described research on every continent except Antarctica, although the majority were from North America. In the database, the plant functional type and biome coverage were most abundant for grasslands and temperate zones. Coverage in South America, Australia, and north central and eastern Asia was particularly sparse.

The data were categorized according to latitude, longitude, mean annual temperature, mean annual precipitation, maximum mean monthly temperature, minimum mean monthly temperature, soil texture, sampling method, plant age, and root diameter class, though not all information was available for every study. In cases where authors did not differentiate between live and dead biomass, we recorded total root biomass. The dominant vegetation type and the vegetation sampled (i.e., forest, grassland, shrubland, wetland) were recorded for each study. When a single paper included information for multiple vegetation types, the species within the type was averaged, and the turnover for each unique vegetation type was reported. Sites were also categorized as tropical, temperate, or high latitude. Sites that included BNPP and standing crop values for more than a single year were averaged for those years. More information and results of this study can be found in Gill and Jackson (2000).

Root turnover, in units of yr-1, is the ratio of Annual Belowground Production to Maximum Belowground Standing Crop. This approach is a modification of the model initially proposed by Dahlman and Kucera (1965). Approximately one-third of the primary literature sources reported mean rather than maximum root biomass; however, these sources did report estimates of both BNPP and root standing crop biomass. In these cases, mean root biomass was transformed to standing crop and then to maximum root standing crop using a regression model based on the relationship of mean root biomass and BNPP. This relationship was derivedusing the 20 data sets that included both mean and maximum root biomass (Gill and Jackson 2000). The 20 studies used to determine this relationship represented all biome types, and the biomass estimates spanned the range of potential mean biomass reported.

When climate variables were not reported, the CLIMATE database version 2.1 (W. Cramer, Potsdam, pers. comm.) was used to reconstruct mean climate values based on latitude and longitude coordinates.

A PDF copy of the Gill and Jackson (2000) paper is available at http://www.biology.duke.edu/jackson/np00.html.

This data set builds on the initial root data compiled by R. B. Jackson in the mid-1990s (see Jackson et al. 1996; Jackson et al. 1997). The expanded and updated data set (Gill and Jackson 2000) contains measurements for approximately 188 sites from 152 papers that were used to estimate root turnover rates for 341 site-pits. In addition, the Jackson initial data set has been expanded for studies with 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 all three data sets.

Related Archived Data Sets:

- Global Distribution of Fine Root Biomass in Terrestrial Ecosystems
- Global Distribution of Root Nutrient Concentrations in Terrestrial Ecosystems
- Global Distribution of Root Profiles in Terrestrial Ecosystems

Data Citation:

Cite this data set as follows:

Gill, R., and R. B. Jackson. 2003. Global Distribution of Root Turnover 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/661.

References:

Dahlman, R. C., and C. L. Kucera. 1965. Root productivity and turnover in native prairie. Ecology 46: 84-89.

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, 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 Biogeochemical Dynamics organized and formatted these data for long-term archive. Appendix 1 and an unpublished file were placed into a spreadsheet format and stored as ASCII tab-delimited (.txt) files. Appendix 1 and an unpublished electronic file were received from Richard A. Gill, Washington State University, Pullman, WA, in March 2002. Appendix 1 was converted from an Excel spreadsheet to a tab-delimited .txt file. A field-labeled flag was added to the file, since the original flagging method could not be transferred to a .txt file. A description of the flags can be found below. In the original Appendix, latitude and longitude were in the same column. They were split into two columns, expressed as decimal degrees, and S and W directions were given negative values and N and E were given positive values. Missing values are represented by -9999. Similarly, the unpublished Excel Spreadsheet was converted to three ASCII tab-delimited files, one for each sheet within the Excel Spreadsheet.

Data File: Root_turnover_Appendix_1.txt (site characteristics, n=188 sites)

Variables
Climatic Type
Vegetation Type
Location [state/city/region]
Country
Latitude [decimal degrees]
Longitude [decimal degrees]
Mean Annual Temperature [deg C]
Mean Annual Precipitation [mm]
Root Collection Method
BNPP Calculation Method
Root Type Description
Fine Root Size Description
Root Turnover [yr^-1]
Flag

1 - Turnover=Annual Belowground Production/Maximum Belowground Standing Crop 2 - Turnover=BNPP/(0.45*BNPP+Mean Root Biomass) 3 - Turnover=BNPP/Initial Root Mass 4 - Turnover=BNPP/Mean Root Biomass
Species
Reference

Example Data Records:

Row Climate Vegetation Type Location Country latitude longitude Mean Annual Temperature (°C) Mean Annual Precipitation (mm) Root Collection Method BNPP Calculation Method Root Type Fine Root Size Root Turnover Flag Species Reference

1 TROPICAL Mixed Forest Himalaya India 30.25 78.42 15.3 1710 Monolith sum delta biomasumsum Fine -9999 0.443 (0.394-0.492) 1 "Quercus leucotrichophora, Pinus roxburhii" Sah et al. 1994

2 TROPICAL Savanna Kaimur Range India 24.32 82.98 24.3 1000 Monolith Allometry Total -9999 0.073 1 -9999 Singh et al. 1991

Data Files: Root_turnover_graminoids.txt, Root_turnover_shrubs.txt, Root_turnover_trees.txt

[3 data files for 3 major plant types (Graminoids, shrubs, and trees) for a total of 341 site-vegetation combinations]

	Variables, Units, and Descriptions
Col. 1	Author(s) last names
Col. 2	Citation; full citation available in the manuscript
Col. 3	Site Name (reported in paper)
Col. 4	Latitude [decimal degrees; + numbers North; - numbers South]
Col. 5	Longitude [decimal degrees; + numbers East; - numbers West]
Col. 6	Elevation [m] Only recorded when value was reported in manuscript
Col. 7	Ecotype (Categories include Subarctic/Alpine, Temperate, Tropical and Grassland, Savanna, Wetland, Forest, Shrubland).
Col. 8	Species (names reported from literature)
Col. 9	Life form (Grass/Graminoid, shrub, tree)
Col 10	Treatment (Narrative column that describes what treatments were imposed; Blank values indicate unreported treatments)
Col. 11	Stand age (Used only in Forest)
Col. 12	Soils Information (Categorical column indicating whether there are soils data available

	in the paper)
Col. 13	Sand [%]
Col. 14	Clay [%]
Col. 15	Classification (Soil series/classification reported in paper)
Col. 16	Description (Narrative description of the soil from the paper)
Col. 17	Comments (My/authors comments about the soils data)
Col. 18	%C [% Carbon content of the soil]
Col. 19	%N [% Nitrogen content of the soil]
Col. 20	pH [soil ph – unitless]
Col. 21	Multiple Depths (Categorical Data; X indicates that root dynamics were measured at multiple depths)
Col. 22	Increment (Depth increment measured)
Col. 23	N-availability [kg N] [ha^-1] [yr^-1]
Col. 24	Reported Mean Annual Temperature [°C]
Col. 25	Reported Maximum Average Monthly Temperature [°C]
Col. 26	Reported Minimum Average Monthly Temperature [°C]
Col. 27	Reported Annual Precipitation [mm]. These values may represent either site averages or the amount received in the year that measurements were made.
Col. 28	Actual Weather or Mean. Whether the Mean Annual Temperature used was reported or calculated using Max-Min weather measurements
Col. 29	DB Temperature [°C]. Mean Annual Temperature determined using CLIMATE DB and reported Lat/Lon
Col. 30	DB Max Monthly Temperature [°C]. Maximum Average Monthly Temperature determined using CLIMATE DB and reported Lat/Lon
Col. 31	DB Min Monthly Temperature [°C]. Minimum Average Monthly Temperature determined using CLIMATE DB and reported Lat/Lon
Col. 32	DB Precipitation [mm]. Mean annual precipitation determined using CLIMATE DB and reported Lat/Lon
Col. 33	Temperature [°C]. Mean annual temperature used in calculations (used reported data preferentially to CLIMATE DB temperature)
Col. 34	Max Monthly Temperature [°C]. Maximum Average Monthly Temperature used in calculations (used reported data preferentially to CLIMATE DB temperature)
Col. 35	Minimum Monthly Temperature [°C]. Minimum Average Monthly Temperature used in calculations (used reported data preferentially to CLIMATE DB temperature)
Col. 36	Precipitation [mm]. Annual precipitation used in calculations (used reported data preferentially to CLIMATE DB temperature)
Cols. 37-45	X indicates the method used in calculating BNPP or root turnover. Ten methods include - Maxima-Minima. Coring - Maxima-Minima. Monolith - C Pool Dilution

	- N-Budget - Allometry - In-growth cores - Budget - Cohort Lifespan - Minirhizotron/Rhizotron
Col. 46	Fine Root Biomass. Reported Value of FRB (used only for Forests and Shrublands)
Col. 47	Units used in reporting fine root biomass
Col. 48	Initial (X indicates that the value of fine root biomass was determined at the beginning of the growing season)
Col. 49	Mean (X indicates that the value of fine root biomass was reported as the seasonal/annual average)
Col. 50	Maximum (X indicates that the value of fine root biomass was determined at the end of the growing season)
Col. 51	% Lignin. Percentage of biomass that is lignin for the measured roots
Col. 52	% N. Percentage of biomass that is N
Col. 53	Total Root Biomass. Mass of total root biomass
Col. 54	Units used in reporting total root biomass
Col. 55	Initial (X indicates that the value of total root biomass was determined at the beginning of the growing season)
Col. 56	Mean (X indicates that the value of total root biomass was reported as the seasonal/annual average)
Col. 57	Maximum (X indicates that the value of total root biomass was determined at the end of the growing season)
Col. 58	% Lignin [%]. Percentage of biomass that is lignin for the measured roots
Col. 59	% N [%]. Percentage of biomass that is N
Col. 60	Belowground Fine NPP (Belowground Net Primary Production for fine roots)
Col. 61	Units for belowground fine NPP
Col. 62	Belowground NPP (Belowground Net Primary Production)
Col. 63	Units for BNPP
Col. 64	Net Annual Mortality (Measure of root death)
Col. 65	Units (Units for Net Annual Mortality)
Col. 66	Aboveground Net Primary Production
Col. 67	Units (Units for ANPP)
Col. 68	Total Root Turnover Coefficient (BNPP/Total Root Biomass)
Col. 69	Coarse versus Fine (Whether the turnover coefficient was for all root biomass or just fine roots; only relevant with forests)
Col. 70	Size [mm]. Size increment used in determining the fine v. coarse distinction
Col. 80	Root turnover calculation. Root turnover calculated by converting all biomass data to maximum root biomass using the linear regression reported in Gill and Jackson 2000.

Col. 81	Comments (Notes concerning the source of data within the paper and assumptions made in calculating the data).

Example Data Records: (Root_turnover_graminoids.txt)

Author(s) Citation Site Name Latitude Longitude Elevation (m) Ecotype Species Life Form Treatment Stand Age Soils Information Sand Clay Classification Description Comments % C % N pH Multiple Depths Increment N-availability kg N/ha/yr Reported Temperature oC Rep Max Monthly Temperature Rep MIN Monthly Temp Rep Precipitation (mm) Rep Growing Season PPT Actual Weather or Mean DB Temperature oC DB Max Monthly Temperature DB MIN Monthly Temp DB Precipitation (mm) Temperature oC Max Monthly Temperature MIN Monthly Temp Precipitation (mm) Maxima-Minima: Coring Maxima-Minima: Monolith C Pool Dilution N-Budget Allometry In-growth cores Budget Cohort Lifespan Minirhizotron/Rhizotron Fine Root Biomass -9999 Units Initial Mean Maximum % Lignin % N Total Root Biomass Units Initial Mean Maximum % Lignin % N Belowground Fine NPP Units Belowground NPP Units Net Annual Mortality Units Aboveground NPP Units Total Root turnover Coef Coarse v. Fine Size (mm) Root turnover calculation Comments
"Aerts, Bakker, and De Caluwe (1992)" Biogeochemistry 15:175-190 "Edese Heide, central Netherlands" 52.02 5.5 -9999 Temperate Grassland Deschampsi flexuosa Grass None -9999 X -9999 -9999 Humus podsol -9999 -9999 -9999 -9999 4.012 -9999 -9999 -9999 -9999 -9999 -9999 -9999 -9999 -9999 8.17 16 1 700 8.17 16 1 700 X -9999 180 g/m2/yr -9999 -9999 -9999 -9999 0.960 Fine -9999 0.960 Production and turnover values from Table 2.
"Aerts, Bakker, and De Caluwe (1992)" Biogeochemistry 15:175-190 "Edese Heide, central Netherlands" 52.02 5.5 -9999 Temperate Grassland Deschampsi flexuosa Grass None -9999 X -9999 -9999 Humus podsol -9999 -9999 -9999 -9999 4.012 -9999 -9999 -9999 -9999 -9999 -9999 -9999 -9999 -9999 8.17 16 1 700 8.17 16 1 700 -9999 -9999 -9999 -9999 -9999 -9999 -9999 -9999 X -9999 0.37 m/yr -9999 -9999 -9999 -9999 0.760 Fine -9999 0.760 Production and turnover values from Table 2.

Companion File: Root_turnover_ references.txt (companion file also in .pdf and .rtf formats)

References for 152 source papers.

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