Data Papers

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Soil invertebrates, chemistry, weather, human management, and edaphic food webs at 135 sites in The Netherlands: SIZEWEB

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Abstract. This paper provides data on the taxonomy, abundance, body size, and general feeding habits of soil invertebrates at 135 sites in the Netherlands, along with the edaphic chemical characteristics, air temperature, precipitation, atmospheric deposition, and human management practices of those sites. Sampling, monitoring, and modeling activities were performed in the framework of the Dutch Soil Quality Network. A total of 258 genera, families, and morpha of free-living soil nematodes, mites, insects, myriapods, enchytraeids, and earthworms, ranging in dry body mass >7 orders of magnitude, were identified, counted, and measured for biomass estimates. Trophic links reflecting life history were estimated from existing literature and, when possible, compared with microarthropods' carbohydrase activity. Environmental variables were collected at each site, including soil chemistry (pH, carbon, nitrogen, phosphate, cadmium, chrome, copper, lead, mercury, nickel, and zinc), atmospheric nitrogen deposition, inputs of nitrogen and phosphorus from manure, rainfall, and temperature. Prior analyses of these data are cited, and the data are released here for the first time. These data describe how strongly different types of human-induced disturbance influence the abundance–mass allometric relationships in soil biota.

Key words: Acarina; agroecosystem; allometric scaling; Annelida; atmospheric N deposition; cattle pressure; Collembola; land use; N eutrophication; Nematoda; soil nutrients; The Netherlands.

The complete data sets corresponding to abstracts published in the Data Papers section of the journal are published electronically in *Ecological Archives* at http://esapubs.org/archive (the accession number for each Data Paper is given directly beneath the title).

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INTRODUCTION

This paper provides data on the taxonomy, abundance, body size, and general feeding habits of soil invertebrates at 135 sites in the Netherlands, along with the chemical characteristics of soil, atmospheric N deposition, air temperature, precipitation, and human management practices of those sites. These data were used, for example, to investigate how soil and atmospheric chemistries influence the allometric relation between body mass and abundance (Mulder et al. 2013). The data may help forecast how human-induced environmental changes affect the occurrence, abundance, biomass, and food webs of below-ground invertebrate species.

Soil heterogeneity is largely determined by a moisture gradient providing habitat for differently shaped micro-, meso-, and macrofauna (Ghilarov 1977). The absence of a single solid, homogeneous substrate requires separate sampling protocols for the different groups of invertebrates (here, non-parasitic nematodes, mites, collembolans, enchytraeids, and earthworms). All sampling procedures are described in detail. This paper includes data only on acidic and mesic sandy soils to keep the structural variability of the soil as low as possible.

The data vary widely along a continuum from directly observed to indirectly inferred. The data most directly observed include the taxonomic identifications, the estimates of abundance of animal populations, and some chemistry measurements. The taxonomic identifications were not species-specific. In some cases, as for nematode and oligochaete juveniles or damaged arthropods, the genus could not be determined. The estimates of abundance depend on the taxonomic identifications, and moreover were subject to sampling variability. Many soil chemistry variables were directly measured from samples at the site, such as pH, soil phosphate, and heavy metals.

Indirectly estimated variables included body mass and the weather variables like temperature and precipitation. The estimates of body mass came from substituting the directly observed body length into an allometric equation that describes body wet mass as a function of length and assuming the dry body mass to be 20% of the wet mass. The accuracy of the resulting inferred weight depends on a correct taxonomic identification and on the assumption that the intercept and slope of the allometric formula, which were derived from other specimens of the taxon observed elsewhere, were on average accurate for the specimens at all the sites studied here, regardless of the soil nutrients and moisture and temperature at the site sampled. The allometric formula may have some error in describing the specimens reported here. It would be preferable in future work to measure the body mass of collected specimens directly.

The estimates of temperature and precipitation were inferred from measurements at the weather stations closest to each site and modeled via Ordinary Kriging, a widely used approach to estimating rainfall amounts as function of spatial coordinates. Most weather stations used for estimation were <1 km distant from the sites and the coverage density of 300 weather stations was very high (Haylock et al. 2008). No information is available about how closely the temperatures and precipitation at the weather stations correlate with the temperatures and precipitation at the sites. It would be desirable in future work to calibrate the inferred weather variables by measuring them directly at a sample of sites and comparing the direct measurements with those of the nearest weather stations.

Not directly observed were the inferred food webs. The uncertainty associated with the food webs compounds the uncertainty of the field sampling (rare taxa may be omitted altogether), the uncertainty of the taxonomic identifications of juveniles, and the uncertainty of the (widely made, but unsupported) assumption that if individuals belonging to one taxon eat individuals belonging to another taxon according to published studies on other locations then the first taxon consumes the second at every one of the study sites where both taxa were observed (Mulder et al. 2005*a*, 2008). This assumption posits that, when a consumer and a resource taxon are both present in the field, the consumer eats the resource regardless of the abundances of the consumer and the resource taxa, regardless of the abundances of all other taxa in the field (such as direct competitors of the consumer, including intraguild predation, and the consumers of the consumer), regardless of the chemical and physical conditions of the site, regardless of diurnal, seasonal, inter-annual, or other temporal variation, and regardless of human management practices (Table 1). In the future, it would be desirable to test this assumption (probably in mesocosms, since field testing seems impossible) by direct observations of feeding relations under different environmental conditions, perhaps using molecular markers and stable isotopes.

Also indirectly observed are the variables called farmyard Manure-N, Manure-P, and atmospheric N deposition. Each standardized livestock unit is given as the amount of cows, calves, pigs and poultry excreting 161 kg $N \cdot ha^{-1} \cdot yr^{-1}$ and 41 kg $P \cdot ha^{-1} \cdot yr^{-1}$. For example, it was supposed that 2.48 livestock units will produce 399.3 kg Manure-N and 101.7 kg Manure-P yearly. According to Table 2, these quantities were calculated yearly before sampling according to the Dutch Central Bureau of Statistics (CBS) updates. Apart from fields and forests, CBS estimated the stocking intensity (livestock units) on farms under each of the other five management practices, and the outputs of N and P from that average level of stocking intensity were imputed to each site here according to the management practice assigned to the site. The annual influx of N and P at each site from livestock was not measured directly at any site. Similarly, airborne (oxidized and reduced) N deposition was estimated at each site by bi-linear interpolation based on model calculations over one decade prior to soil sampling from data on N emissions in the grid of the European Monitoring and Evaluation Programme (EMEP, see Simpson et al., 2012). The N deposited at a site, under the weather conditions of that site, in the year of sampling of the site, was not measured. No uncertainty of the estimated N deposition was reported here. On average, the atmospheric N deposition was 15 times less

than the site-specific cattle-derived N input. Hence, uncertainties of the derived 'Total N-input' compounds were dominated by the uncertainty of 'Manure-N'. Furthermore Total N-input excluded possible additions by humans of mineral N as fertilizer, as such additions are not reported in these data. In the future, it would be desirable to calibrate inferred levels of soil N and P based on CBS and EMEP estimates against direct site-specific measurements and to measure any additions of these elements by humans.

Despite some limitations, the data offer a unique resource for investigating the influence of human management and environmental variables on soil biota.

METADATA AND DATA ARCHITECTURE

A1. Database Identity: This metadata file contains the metadata for the sites and an overall description of the data.

A2. Overall Title: SIZEWEB

B. Data Set and Metadata Identification Codes

Each data set has its own file and its own metadata documenting the data collection details and data set structure:

- `135Zoocoenoses.txt` (see Table 1 for column information)
- `135FoodWebs.txt` (see Table 2 for column information)
- `SIZEWEB Box 1.pdf` (conversion factors for enchytraeids' wet weight)
- `SIZEWEB Box 2.pdf` (inventory of soil invertebrate taxa and morpha)

METADATA CLASS I. DATA SET DESCRIPTORS

A. Data Identity

Soil invertebrates, chemistry, weather, human management, and edaphic food webs at 135 sites in The Netherlands.

B. Data Set Identification Code

http://esapubs.org/archive/ecol/E095/...

C. Data Set Description

C1. Principal Investigators:

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C2. Summary:

As part of the Dutch Soil Quality Network and in the framework of the EMEP Survey for atmospheric N deposition, we recorded soil pH, macronutrients, heavy metal concentrations, land management, and the occurrence of 258 soil invertebrate taxa (genera and families) and morpha (morphotypes) at 135 sites, along with community and environmental descriptors at each site. Of the soil invertebrates, 82.6% were identified to genus; the remainder were either assigned to families (some juveniles or damaged adults) or to morphotypes (e.g., Dauerlarvae, the nematode resting stage). These data link the chemical soil composition of agroecosystems and human-induced N deposition to the abundance of differently sized soil invertebrates.

C3. Sources of Funding:

Joel E. Cohen was supported by United States National Science Foundation grants DMS 0443803, EF-1038337 and DMS-1225529.

Christian Mulder was supported by the Scientific Advisory Committee of the Netherlands Ministry of Housing, Spatial Planning, and Environment (2004–2012), and by the BE-Basic Flagship 8 project E/607101/11/CM (2013–continuing).

D. *Key words*: *Acarina; agroecosystem; allometric scaling; Annelida; atmospheric N deposition; cattle pressure; Collembola; land use; N eutrophication; Nematoda; soil nutrients; The Netherlands.*

METADATA CLASS II. RESEARCH ORIGIN DESCRIPTORS

A. Overall Project Description

A1. Identity: Ecological Stoichiometry Project: Fitting Ecosystem Responses Across Taxocenes (FERAT). III – Invertebrata

A2. Originator: Christian Mulder

A3. Period of Study: 1999–2002

A4. Objectives: The FERAT program within the RIVM (supported by the former VROM, the Netherlands Ministry of Housing, Spatial Planning, and Environment) investigated invertebrate soil biota in differing ecosystem types from 2000 onward. The data presented here, from 1999–2002, are part of a national soil survey (Rutgers et al. 2009), the Dutch Soil Quality Network (1993–continuing).

B. Specific Subproject Description

B1. Sites Description: Data were collected in Pleistocene sandy soils at 135 sites in the Netherlands under seven different regimes of management (Fig. 1). Most sites were agroecosystems with both grasslands and croplands, making stratified sampling the best way to assess the soil biota of the entire farm. As in vegetation science (Kent and Coker 1992), 'stratification' allocates separate parts of the farm to units based on major variations in farming practices. The greater the management diversity, the more extensively the soil should be sampled, and within any uniform part of each farm the best

merging of random and systematic sampling was used. As global positioning systems (GPS) are inaccurate within few meters, the 'random walk procedure' was impossible. Hence the 'stratified random sampling' of the Zürich-Montpellier School was applied to locate the position of our soil cores (Braun-Blanquet 1928).

Soil organic matter remained low for these sandy soils, and did not vary as much among these sites as between sand and other soil types such as clay, loam, and peat (Vonk and Mulder 2013). Pine plantations were kept following traditional low-intensity agro-forestry. Other sites were cultivated actively. Organic farms, grasslands, and conventional farms were subjected to middle intensity management. Intensive and super-intensive farms were subjected to high-intensity management. Most agricultural fields were sampled during the winter after high-intensity integrated management. Organic farms were certified by the Agricultural Economics Research Institute of the Netherlands (LEI). The numbers and main characteristics of sites in each category were on average:

- 9 Mature grasslands with a suboptimal input of N, mostly fallowed pastures;
- 20 Organic farms, using compost/farmyard manure and no biocides, averaging 1.7 livestock units per hectare;
- 19 Conventional farms, using mineral fertilizers, a much smaller amount of farmyard manure, averaging 2.4 livestock units per hectare;
- 21 Intensive farms, using fertilizers, averaging 3.2 livestock units, and aiming for high yield while minimizing pesticides per hectare;
- 19 Super-intensive farms, using registered biocides and fertilizers to obtain maximum yield, averaging 5.1 livestock units per hectare;
- 28 Agricultural fields, mostly a 4-year crop rotation, pesticides only for seed dressing, minimum input of mineral fertilizers; and
- 19 Scots Pine forests, often mixed with deciduous oaks or naturalized spruces.

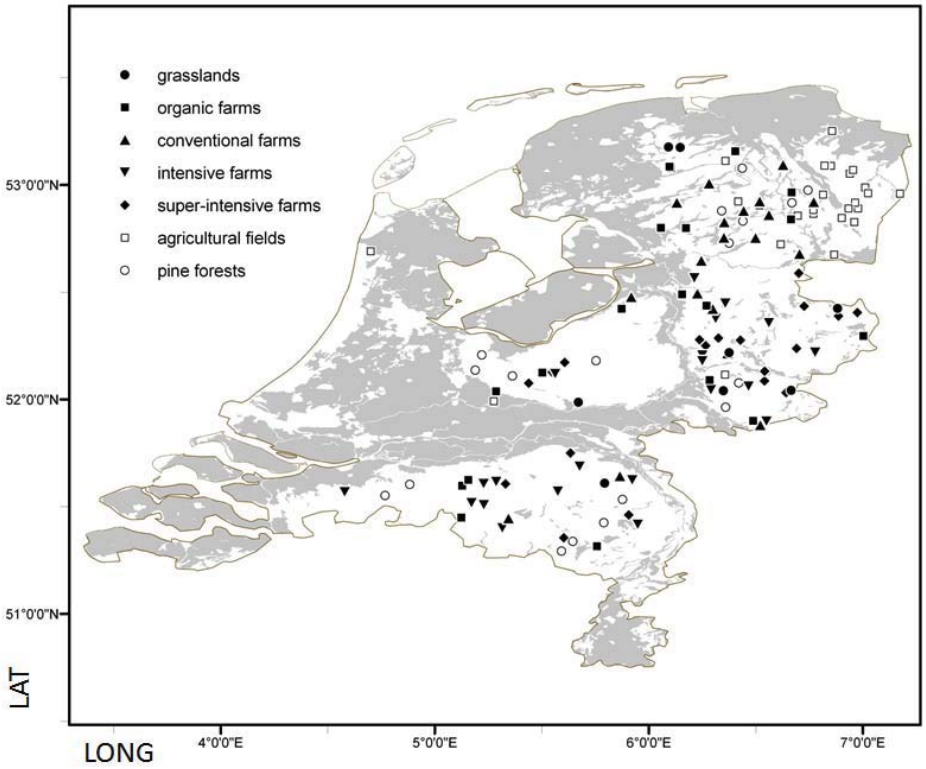

FIG. 1. Locations of the 135 investigated sites in sandy soils of the Netherlands. Some locations were too close to each other to be plotted separately. Peaty or loamy soils are shaded in gray. Figure prepared by Harm J. van Wijnen of RIVM and used with permission.

B2. Biological Data: Besides roots and living organisms, soil systems are composed of three compartments, soil particles, water, and air. In each agroecosystem, a separate sampling protocol was used for non-parasitic nematodes living in soil moisture (B2.i, wet extraction), microarthropods (B2.ii, dry extraction), enchytraeids (B2-iii, wet extraction) and earthworms (B2-iv, dry hand-sampling). As most of these invertebrates were restricted to the upper horizon(s) of the soil profile, we sampled mostly only the upper 10 cm of soil (Figure 2). Too often soil organisms are expressed as totals per surface unit (m^2 or ha) without defining the volume or depth investigated. Careful standardization is needed to allow the comparison of different food webs (Cohen et al. 1993).

B2-i Nematodes

Free-living, non-parasitic soil nematodes live and move in thin water films (Nicholas 1984, Coleman et al. 1999). To sample the nematodes of an agroecosystem (Goodell, 1982; Fig. 2A), one bulk sample was mixed from the soil randomly collected in 320 cores (diameter 2.3 × 10 cm, Fig. 2B) all over the site. Each core had a volume of ~40 cm^3, so 320 cores had a volume of ~13 L. This sample was too large for either gravimetric analysis or direct examination (ISO 2011*a*). Therefore it was mixed and subsampled. 500 g was kept in glass containers and stored at 4°C prior to funnel extraction. The extraction

from 100 g of fresh soil was performed within one week using the Oostenbrink funnel (Oostenbrink 1960) and all elutriated nematodes were collected. In two 10 mL water suspensions, all the nematode individuals were counted and approximately 150 randomly chosen specimens were identified under a light microscope while moving the counting dish slowly around. If the totals of both dishes, noted in a standard form, differed by more than 10%, one suspension was not homogenous enough to detect all nematodes and the entire procedure was repeated (ISO, 2011*a*).

Due to the size of the bulk sample, it was not possible to estimate directly the gravimetric moisture for the 320 microsites; hence we went to an indirect mathematical calculation. Assuming 1 m3 of dry sand weighs 1,500 kg, the topsoil weighs ≥ 150 kg. The topsoil will weigh more han the equivalent volume of dry sand if it contains moisture. Free-living soil nematodes live in soil moisture. The average water content was 17.7% by weight in three previous soil systems (Mulder et al. 2005*a*). Assuming the same percentage of soil moisture, we estimated that the upper 10 cm under a surface of 1 m² in the field contained 26.5 kg of water, where 26.5 = 17.7 × 150 / 100. Therefore we multiplied the number of counted nematodes recovered by wet extraction by this 26.5 conversion factor. The body mass averages were estimated with 90% confidence intervals using the 5th to the 95th percentiles of the body sizes of 2187 nematode specimens belonging to the collection of the Laboratory for Soil and Crop Research (BLGG AgroXpertus, Wageningen) as upgraded in 2004 (Mulder et al. 2005*b*). These reference values at the genus level are not the same as those from the life-history trait database at the individual level by Mulder and Vonk (2011), which included nematode species from many more locations and soil types (Mulder et al. 2012, Vonk et al. 2013).

FIG. 2. Sampling methods used in the field. The sod was never removed and the cores were either collected to form a bulk sample (as for nematodes, A and B) or collected in layers (D and E). For microarthropods, the upper three 2.5-cm rings was gently separated in the field (D), but for enchytraeids, all six 2.5-cm rings were kept together (E). Soil macrosamples were collected with a spade and hand sorted in the laboratory (C and F, respectively). Soil samples of one site are shown at the RIVM, Bilthoven, The Netherlands, prior to treatment (G).

B2-ii Microarthropods

Five soil samples were collected in the field using a split-tube corer: four of them were analyzed and one was kept as a reserve sample. Soil cores were placed in plastic tubes, transported to the laboratory and kept there at 4°C. In 1999 we followed the recommendations of ISO (2011*b*) for a depth of 5 cm, using plastic tubes of 5.8 cm diameter with caps for storing the soil samples (Schouten et al., 2002). From 2000 onwards, we used plastic tubes of 15 cm depth with six 2.5-cm high rings to avoid mechanical compression of the soil. After the sample was taken, the corer was opened in the field and the three upper 2.5-cm rings were separated by cutting (Fig. 2D). We focused only on the rings containing the upper 7.5 cm of soil. The sod was never removed because microarthropods inhabit litter. In the field most of the plant leaves were gently cut with a knife. The final soil sample (part of the sod + litter + mineral soil) was as close as possible to our 10 cm depth standard.

Mites and insects were extracted within a few days by increasing heat and desiccation as repellents (Berlese 1905, Tullgren 1917, Macfayden 1963). Two samples were placed on six discs (twice three 2.5-cm rings) in a funnel (Tullgren 1917), and temperature in the upper part of the funnel was increased by incandescent Philips "Classic Christmas" bulbs of 60 W and kept at 5°C in the lower part for one week. Temperature at the upper air–soil interface was raised in two steps: the first step was at 50 Volts (T = 28°C), the second step at 75–80 Volts (T = 45°C). Living organisms moved downwards to escape the heat, dropped through the funnel and collected in a bottle with 70% ethanol. This method is supposed to recover only actively moving microarthropods, as it does not extract quiescent stages, carcasses and animals enclosed in plant debris (ISO, 2011*b*), but it remains the most widely used approach (Macfayden, 1963). Slides were made more transparent with lactic acid 10% (Grandjean 1949, Gisin 1960). All microarthropods were counted and identified by light microscopy at a magnification of 200–1000× and assigned to feeding guilds on the basis of their carbohydrase activity (Mulder et al. 2009).

The abundance values for a 1-m² area were derived from the sampled surface. Each of the cores used had a surface of 26.42 cm², implying that all living microarthropods were sampled from a total volume of 1056.80 cm^3 (4 × 26.42 cm² × 10 cm)

and a total surface of 105.68 cm². In both cases, the conversion factor to 1 m² surface or 1 m² × 0.1 m volume was 94.63. The microarthropods' average masses were estimated from size and shape values of specimens belonging to the Functional Diversity ALTERRA-Wageningen collection (the former DLO-Instituut voor Bos- en Natuuronderzoek collection), and not from the specimens collected from the field.

B2-iii Enchytraeids

Almost all enchytraeids are known to be concentrated in the upper 6 cm of a soil profile. Although enchytraeids can show an aggregated distribution pattern under adverse conditions, their dispersal (escaping desiccation and moving toward fresh organic matter) remains confined within this range (O'Connor 1955, Dash 1990). In loose sand like the soil of our agroecosystems, the layer with soil organic matter is very thin. Hence, we may consider enchytraeids as inhabiting the upper 10 cm of sandy soils (Wim Didden, *personal communication* 2004). As in the case of the microarthropods (B2-ii), tubes were used, starting with thin Perspex and continuing with thicker PVC. Six soil samples were collected using a split-tube corer with six 2.5-cm rings, i.e., 6 × 2.5 = 15 cm depth (Fig. 2E). In the field, each core was carefully sliced horizontally by cutting the sod at the upper part of the sample and by gently removing the soil attached at the bottom, keeping the soil sampled in the rings undamaged. The lower part of the soil core was marked with a tape for easy recognition during the field work and after return to the laboratory (Fig. 2G). Soil enchytraeids can be damaged easily and therefore the soil core stored in plastic tubes with caps was always kept vertically. All the soil cores were always treated as intact cores to prevent damage.

Each sample was crumbled into a sieve hung in a bowl filled to the edge with water, and kept at 10–15°C. To avoid any possible loss of juveniles which would otherwise remain in the wet soil, 60 W bulbs were carefully located above the sample (Jänsch et al. 2005). Heat was increased gradually and enchytraeids escaped downwards. After completing the extraction, all enchytraeids were recovered, identified, measured and their life-history (adults, juveniles, and/or regenerating parts) recorded. Assuming for each soil sample the radius of 3 cm (Schouten et al. 2000), the conversion factor to a surface of 1 m² soil was 58.95 (100 × 100 / (6 × π 32) = 10,000 cm² / 169.65 cm² = 58.95).

Data were stored in DBASE files according to a species and gender specific six-digit code, and automatically upgraded as soon as taxonomical changes occurred. In contrast to the other taxonomical groups, all individuals were observed and their fresh body mass was evaluated by a combination of size and shape metrics (SIZEWEB Box 1.pdf) and expert judgment by Wim Didden for all the organic farms of 2002. Little is known about the feeding strategy of enchytraeids due to their different diets during their juvenile and adult stages. Such life-history traits demand expert judgment.

B2-iv Earthworms

Six soil samples were collected in the field with a spade (Fig. 2C) and kept at 4°C until sorting. We used samples of 20 cm × 20 cm × 15 cm (length by width by depth) because the depth of the soil sample had to match the vertical distribution of the earthworms (Coleman et al. 1999). Larger earthworms were collected with plastic gloves (Fig. 2F) and small ones with forceps. After hand sorting, all recovered earthworms were killed in 70% ethanol and weighed together. Then earthworms were assigned to life stages (juveniles or adults) and identified. Dry body mass estimates were derived from some cohorts monitored in captivity at the RIVM. As all earthworms were recovered in the laboratory from six soil samples, the total volume sampled was 6 × 20 × 20 × 15 × 36,000 cm^3, each with volume 6,000 cm^3 (Schouten et al., 2002). A surface of 1 m² including the sod had a volume of 100 × 100 × 15 × 150,000 cm^3. Therefore the conversion factor from the sample to a standard volume was 4.17 (150,000 cm^3 / 36,000 cm^3 = 4.17).

B3. Environmental Data: Chemical parameters (soil pH, nutrients, heavy metals) were measured at the RIVM (Schouten et al. 2003, Mol et al. 2012). Temperatures and rainfall were calculated as described in Table 2 according to the date of sampling using data from the nearest weather stations (mostly within 1 km). Airborne N deposition was derived from the EMEP MSC-W atmospheric transport model (Simpson et al. 2012). Cattle-derived N and P were derived from the regular survey of farming management and livestock units of the CBS (www.cbs.nl). See METADATA CLASS IV. DATA STRUCTURAL DESCRIPTORS).

B4. Taxonomy: Genera are consistent with literature (`SIZEWEB Box 2.pdf`). To avoid incorrect taxonomical identification, the spelling and identification of taxa were randomly checked. In addition, in EXCEL 2007 the function "Data: *Remove Duplicates*" was applied to remove double entries. Corrections were made based on the original datasheets (DBASE and EXCEL) and/or lab notes. Suspect identifications were corrected by lumping taxa or were ignored.

B5. Allometric Relationships: As explained in **B2**, the sample sizes for populations of mites, insects, and oligochaetes were small for certain variables. Horizontal lines appeared when log(*N*) was plotted as a function of log(*M*) because estimates were derived from only 1, 2, or 3 individuals belonging to the same rare genus and populations of rare genera had the same log(*N*) value. On average, 36.29% of the variation of log(*N*) was explained by the variation in log(*M*) over all 135 sites. The average (over sites) of the linear correlation coefficient was –0.58. Several metrics were calculated for each web (Table 1): the numbers of nodes and literature-derived possible trophic links (the references used to establish these possible trophic relationships were published Open Access as Supplementary Tables in Mulder et al. 2008 and Mulder and Elser 2009), and the average of the possible lengths of the distances between each couple of trophically related genera, measuring the Manhattan square-block distance between the consumer and the resource when they are plotted on [x=log(*M*), y=log(*N*)] as in Cohen et al. (2009). Each node was defined as the maximal set of organisms that eat the same kinds of resource and are consumed by the same kinds of consumers, i.e., the "trophic species" *sensu* Cohen 1994, and is identified here by its "Trophic ID" (`135FoodWebs.txt` and Table 2).

B6. Deviations from Theory: Statistical analyses to test the assumptions of ordinary least-squares linear regression of y as a linear combination of x and a constant used the Matlab function [h,p]=regression_assumption_tester(x,y,alpha), based on joint work by Joel E. Cohen and Daniel C. Reuman. The arguments x and y are columns of the same length and the argument alpha is the desired confidence level. The argument x is replaced by its rescaled equivalent (x - mean(x))/max(abs (x-mean(x))). We used:

1) An *F* test to see if the quadratic term in a regression of y as a linear combination of x², x and a constant explains a significant amount of variance, or if the coefficient is significantly non-zero.

2) The Jarque-Bera test of normality on the residuals from the standard linear regression of y on x and a constant (Jarque and Bera 1987), implemented in Matlab by the function 'jbtest'.

3) The Lilliefors test of normality on the residuals from the same regression (Lilliefors 1967), implemented in Matlab by the function 'lillietest'.

4) An *F* test to see if the linear and quadratic terms are needed in a regression of abs(r) (the absolute values of the residuals from a standard linear regression of y against x and a constant) against $\hat{y}^2$, $\hat{y}$ and a constant, where $\hat{y}$ is the value of y predicted by the regression result of y on x and a constant.

5) The Durbin-Watson test for serial independence of residuals (Durbin and Watson 1950, 1951), implemented in Matlab by the function 'dwatson.m' as modified by Kanzler (1998, rev. 2005).

6) The truncated Pareto distribution was compared to two alternatives, a quadratic generalization of the truncated Pareto distribution and a truncated log-normal distribution, which is often used to characterize body mass distributions (Reuman et al. 2008, where Appendices S2 and S3 give details of maximum likelihood estimation and numerical methods). If we could not reject the hypothesis that the individual size distribution was truncated at 1% level, the food web passed the test.

Results of site-specific tests of allometric theory (1 = pass, 0 = fail, 1% level of significance) are shown in Table 1 and in the file `135Zoocoenoses.txt`.

METADATA CLASS III. DATA SET STATUS AND ACCESSIBILITY

A. Status

A1. Latest Updates:

30 August 2004 (the faunal records lumped at genus level)

2 November 2006 (descriptors and elemental predictors)

3 June 2013 (atmospheric deposition and trace elements)

A2. Latest Archive Date:

30 September 2013

A3. Metadata Status:

The metadata are now complete and up to date.

A4. Data Verification:

Every entry was compared to existing records for sandy soils. Soil abiotic predictors (pH, C, Cd, Cr, Cu, Hg, Ni, Pb, and Zn) were systematically compared with the values reported in geological maps (Mol et al. 2012) and data were periodically checked by people using the same database who found oddities or outliers. Biological records were randomly checked after each update. Questions on particular entries were answered by referring to the original hard-copy datasheets and DBASE and EXCEL data files. Inconsistent taxonomy (epilobous/tanylobous earthworms in ID 139), incomplete data (microarthropods in ID 174), missing records (ID 195 only) and undocumented choices (IDs 233–242) were omitted. Information outside the normal operating range was checked and compared to the original data sheets.

B. Accessibility

B1. Storage Location and Medium: (Ecological Society of America Data Archives [Ecological Archives], URL published in the 2014 volume of its *Ecology* journal).

B2. Contact Person: Christian Mulder, Centre for Sustainability, Environment and Health (DMG), National Institute for Public Health and the Environment (RIVM), 3720BA Bilthoven, The Netherlands. e-mail: christian.mulder@rivm.nl

B3. Data Set Ownership: These data are generated and provided for public use as part of a larger monitoring program conducted by the Centre for Sustainability, Environment and Health (DMG) at the RIVM, the National Institute for Public Health and the Environment, 3720BA Bilthoven, The Netherlands.

B4. Proprietary Restrictions: None. We request that other authors notify Joel E. Cohen and Christian Mulder of future publications using this database. This courtesy will allow us to document the use of these data.

B5. Copyright and Access Rights: No copyright restrictions, royalty-free access.

B6. Citation: Please cite these data as: Cohen, J. E., and Mulder, C. (2014).

Soil invertebrates, chemistry, weather, human management, and edaphic food webs at 135 sites in The Netherlands: SIZEWEB. *Ecology* **95**.

B7. Costs: None.

METADATA CLASS IV. DATA STRUCTURAL DESCRIPTORS

A. Data Set Files

1 - SYNOPSIS

1a. Identity: 135Zoocoenoses.txt

1b. Size: 136 rows (including header), 106 Kb.

1c. Format and Storage Mode: ASCII text, tab delimited. No compression scheme used.

1d. Header Information: The header of the `135Zoocoenoses.txt` file lists the variables defined in Table 1.

1e. Row Information: Each row in this data set characterizes the results of the field survey in each location and summarizes the allometry computed for the edaphic food web (see `SIZEWEB Box 2.pdf` and `135FoodWebs.txt` for complete information).

1f. Alphanumeric Attributes: Mixed.

2 – COMPLETE DATA SET

2a. Identity: `135FoodWebs.txt`

2b. Size: 7326 rows (including header), 1.29 Mb.

2c. Format and Storage Mode: ASCII text, tab delimited. No compression scheme used.

2d. Header Information: The header of the `135FoodWebs.txt` file lists the variables defined in Table 2.

2e. Row Information: Each row records the information on one population of soil invertebrates and the corresponding physical and chemical information for the site where this population was sampled.

2f. Alphanumeric Attributes: Mixed.

2g. Authentication Procedures: For the data file `135FoodWebs.txt`, the average of all the Log(Abundance) values must equal 3.36 (log individuals m-2), and also the average of all the Log(Biomass) values must be equal to 3.36 (log µg dry weight m-2). The sum for all 135 sites of all the Log(*N*), Log(*M*) and Log(*B*) entries in the three allometric descriptors in the columns G, H, and I must equal 49,323.69.

3 – BOX 1

3a. Identity: `SIZEWEB Box 1.pdf`

3b. Size: 11 Kb.

3c. Format and Storage Mode: PDF Version 1.5 (Acrobat 6.x). No tagged PDF.

3d. Header Information: Conversion factors for enchytraeids' wet mass.

4 – BOX 2

4a. Identity: `SIZEWEB Box 2.pdf`

4b. Size: 95 Kb.

4c. Format and Storage Mode: PDF Version 1.5 (Acrobat 6.x). No tagged PDF.

4d. Header Information: Inventory of soil invertebrate taxa and morpha.

B. Variable Information

TABLE 1. Column information for `135Zoocoenoses.txt` (base-10 logarithms throughout)

Variable name	Variable definition	Storage type	Range of values
Web ID	Site-specific identification number	Numeric	#95 – #138, #140 – #173, #175 – #194, #196 – #232
Description	Description of the type of ecosystem investigated (cf. Ecosystem Type ID in the last column of Table 2)	Character	
Observational Scale	Observational Scale at which the soil system was investigated and sampled across the field	Character	
First Sampling	Date (M-D-Y) of the first field investigation (most surveys took one day)	Mixed	April 20, 1999 – June 2, 2002
Taxa S	Number of Taxa recorded (overview in SIZEWEB Box 1.pdf)	Floating Point	30 – 96

Pearson's r of AMR	Correlation coefficient of log Abundance with log Body Mass	Floating Point	-0.79 – -0.09
Slope of AMR	Slope of the log Abundance-log Mass Linear Regression	Floating Point	-0.84 – -0.08
Intercept of AMR	Intercept of the log Abundance-log Mass Linear Regression	Floating Point	2.73 – 3.88
Rsquare of AMR	Significance (R^2) of the log Abundance-log Mass Linear Regression	Floating Point	0.01 – 0.63
Quadratic Coefficient	Quadratic Coefficient *F* with Squared Predictor on log Abundance-log Mass	Logical	1=pass, 0=fail
Jarque-Bera	Jarque-Bera test on residuals from log Abundance-log Mass Ordinary Least Square (OLS) regression	Logical	1=pass, 0=fail
Lilliefors	Lilliefors test on residuals from log Abundance-log Mass OLS regression	Logical	1=pass, 0=fail
Absolute Residuals	Absolute Residuals *F* with Squared Predictor on log Abundance-log Mass	Logical	1=pass, 0=fail
Durbin-Watson	Durbin-Watson test on residuals from log Abundance-log Mass OLS regression	Logical	1=pass, 0=fail
Truncated Pareto	If generalized Cumulative Distribution Function could not reject that the Individual Mass Distribution of log Abundance-log Mass is a truncated Pareto	Logical	1=pass, 0=fail
Possible Links L	Number of trophic Links as estimated by functional guilds and prey preferences derived from literature and carbohydrase activity	Floating Point	233 – 2758
Link Density	Ratio of the number of Possible Links *L* and the Number of Taxa *S*	Floating Point	7 – 32
5th TLL	5th percentile of all the trophic links' lengths (*TLL*)	Floating Point	0.27 – 0.71
Average TLL	Average of all the trophic links' lengths (*TLL*)	Floating Point	1.45 – 3.34
95th TLL	95th percentile of all the trophic links' lengths (*TLL*)	Floating Point	2.76 – 9.06
Min Log(N)	Smallest log population density recorded (minimal log individuals m^{-2})	Floating Point	0.62 – 2.10

Log(averageN)	Log of the average of all recorded population densities (log average individuals m^{-2})	Floating Point	3.26 – 4.84
Max Log(N)	Largest log population density recorded (maximal log individuals m^{-2})	Floating Point	4.15 – 6.35
Log(summedN)	Log of total m^{-2} of all the recorded soil invertebrates	Floating Point	5.05 – 6.44
Min Log(B)	Smallest log estimated biomass (µg m^{-2})	Floating Point	0.75 – 2.47
Log(averageB)	Log of average estimated biomass (µg m^{-2})	Floating Point	3.31 – 5.54
Max Log(B)	Largest log estimated biomass (µg m^{-2})	Floating Point	4.30 – 7.08
Log(summedB)	Log of total m^{-2} of the estimated biomass values for all soil invertebrates	Floating Point	4.88 – 7.24

TABLE 2. Column information for `135FoodWebs.txt` (base-10 logarithms throughout)

Variable name	**Variable definition**	**Storage type**	**Range of values**
Record ID	Site-specific identification of a single soil population	Numeric	#1 – #7325
Web ID	Site-specific edaphic web identification	Numeric	#95 – #138, #140 – #173 #175 – #194, #196 – #232
Genus/Morphon	Name of the recorded taxon (or morphon) from SIZEWEB Box 2.pdf	Character	
Feeding Preference	Dominant feeding strategy of individuals belonging to a Taxon ID	Character	
Trophic ID	Functional group according to Feeding Preference and the kind of invertebrates	Numeric	11 – 92
Taxon ID	Code of the recorded taxon	Numeric	11006 – 92138
Log(Abundance)	Log recorded numerical Abundance per square meter of all individuals belonging to a single taxon	Floating Point	0.62 – 6.35
Log(averageMass)	Log average body Mass (µg dry mass) for each taxon. This trait	Floating Point	-1.63 – 5.32

	was mostly kept constant across the data set, except for all enchytraeids		
Log(Biomass)	Log estimated dry Biomass (µg m^{-2}) of all individuals belonging to a single taxon	Floating Point	0.75 – 7.08
Soil pH	pH of oven-dried samples determined in potassium chloride solution (1M KCl)	Floating Point	2.8 – 6.3
C-tot	Total soil Carbon (g/kg) as 54.66% of the soil organic matter determined by thermogravimetric analysis	Floating Point	2.7 – 97.8
N-tot	Total soil Nitrogen (g/kg) determined by a titrimetric method after distillation using Kjeldahl destruction	Floating Point	1 – 6 (missing values: N/A)
Airborne N	Mean Nitrogen (kg N ha^{-1} yr^{-1}) over one decade prior to soil sampling computed in the grid of the European Monitoring and Evaluation Programme (EMEP), data according to the total N emission and deposition	Floating Point	11.9 – 38.2
Total N-input	Sum of livestock Manure-N and Airborne-N (kg ha^{-1}), excluding possible addition of mineral N (fertilizers)	Floating Point	12 – 2454
Manure-N	Mean Nitrogen (kg N_{tot} ha^{-1} yr^{-1}) excreted by cows, calves, pigs, and poultry, calculated yearly before sampling according to the Dutch Central Bureau of Statistics (CBS) updates	Floating Point	0 – 2417
Manure-P	Mean Phosphorus (kg P_{tot} ha^{-1} yr^{-1}) excreted by cows, calves, pigs, and poultry, calculated yearly before sampling according to the Dutch Central Bureau of Statistics (CBS) updates	Floating Point	0 – 615.4
P-pore water	Phosphate content (mg/L) determined after extraction at a water to soil ratio 60:1	Floating Point	1 – 113
Soil-Phosphate	Phosphate content (mg/kg dry soil) determined after acetate–lactate extraction	Floating Point	10 – 1090
Soil-Ptot	Total soil Phosphorus (mg/kg) determined by Automated Ion Analyzer after sample digestion	Floating Point	31 – 1371 (missing values: N/A)
Soil-Cd	Cadmium (mg/kg dry soil) measured by Inductively Coupled Plasma (ICP) Mass Spectrometry after sample digestion	Floating Point	0.06 – 0.75

Soil-Cr	Chrome (mg/kg dry soil) measured by Inductively Coupled Plasma (ICP) Mass Spectrometry after sample digestion	Floating Point	3.6 – 48.2
Soil-Cu	Copper (mg/kg dry soil) measured by Inductively Coupled Plasma (ICP) Mass Spectrometry after sample digestion	Floating Point	1.5 – 34.4
Soil-Hg	Mercury (mg/kg dry soil) measured by Atomic Absorption after pyrolysis	Floating Point	0.01 – 0.17
Soil-Ni	Nickel (mg/kg dry soil) measured by Inductively Coupled Plasma (ICP) Mass Spectrometry after sample digestion	Floating Point	0 – 9 (if under detection limit: <DL)
Soil-Pb	Lead (mg/kg dry soil) measured by Inductively Coupled Plasma (ICP) Mass Spectrometry after sample digestion	Floating Point	6.8 – 66.5
Soil-Zn	Zinc (mg/kg dry soil) measured by Inductively Coupled Plasma (ICP) Mass Spectrometry after sample digestion	Floating Point	3.7 – 80.4
Mean rainfall	Average of daily precipitation (mm) from the nearest weather stations of the Royal Netherlands Meteorological Institute (KNMI) calculated over the period of 21 days before sampling	Floating Point	0.2 – 7.0
Max rainfall	Maximal daily precipitation (mm) from the nearest weather stations of the Royal Netherlands Meteorological Institute (KNMI) calculated over the period of 21 days before sampling	Floating Point	2.4 – 52.4
Average-T	Average of air temperatures (°C) from the nearest weather stations of the Royal Netherlands Meteorological Institute (KNMI) calculated over the period of 21 days before sampling	Floating Point	5.0 – 22.0
Average-Tmax	Average of temperatures at noon (°C) from the nearest weather stations of the Royal Netherlands Meteorological Institute (KNMI) calculated over the period of 21 days before sampling	Floating Point	8.9 – 33.2
Location-LAT	Latitude degrees from S to N	Floating Point	51° 29′ N – 53° 25′ N
Location-LONG	Longitude degrees from E to W	Floating Point	4° 58′ E – 7° 17′ E
Vegetation cover (%)		Floating Point	0 – 100

	Percentage grass cover in open agroecosystems and tree canopy in forests (%)		
Ecosystem Type ID	Conventional (‘1’), Organic (‘2’), Intensive (‘3’), and Super-intensive farms (‘4’), Grassland (‘5’), Pine forest (‘6’), and Agricultural field (‘7’)	Numeric	1 – 7

METADATA CLASS V. SUPPLEMENTAL DESCRIPTORS

A. Data Acquisition

A1. Data Forms and Location:

Original data forms and all ACCESS XP and EXCEL 2007 and 2010 datasheets reside at the ‘Rijksinstituut voor Volksgezondheid en Milieu’ (RIVM, the Dutch National Institute for Public Health and the Environment), located at Antonie van Leeuwenhoeklaan 9, 3721MA Bilthoven, The Netherlands.

A2. Competing Interests:

The authors declare that they have no competing interests.

B. Quality Assurance/Quality Control Procedures

Data were double checked upon entry. For each site, after the complete entry of data, all the data were checked against original sources at the RIVM.

C. History of Data Set Usage

The data set is original and unpublished.

D. Publications and Results

Mulder et al. (2006, 2008, 2011*a*, 2011*b*, 2013) published results on faunal biomass distribution and trophic link lengths. Reuman et al. (2008, 2009*a*, 2009*b*) published theoretical developments and empirical tests.

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