Global Soil Organic Nitrogen

Andy Whitmore

Margaret Glendining, Goetz Richter and David Powlson

Soil Science Department, Rothamsted Research

John Catt, *UCL*

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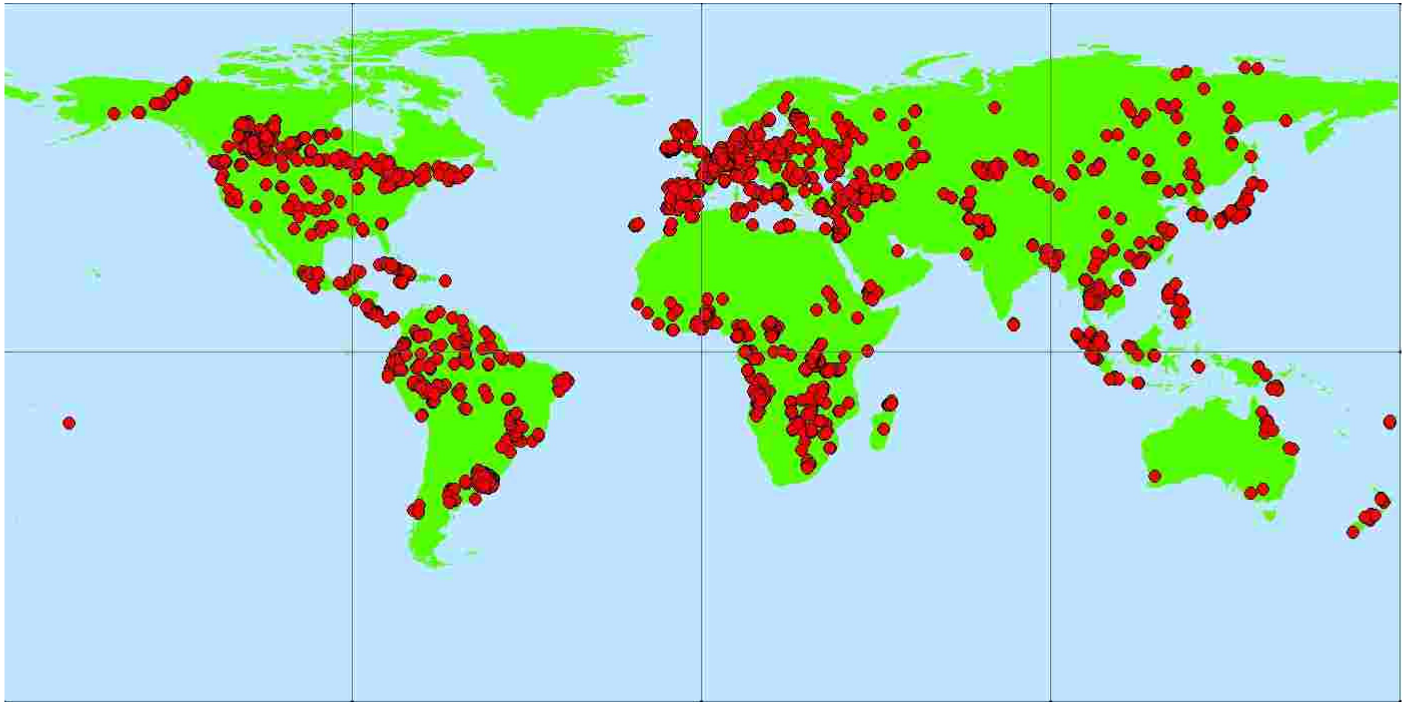
Aims

1. Create database of soil organic nitrogen from published and unpublished sources

2. Derive simple PTFs (Pedotransfer functions) to predict soil organic nitrogen from other simple measured soil and site properties

3. Derive maps of soil organic nitrogen status for use by the ecosystem modellers. QUERCC/QUEST

1) Global soil fertility dataset



Main sources: WISE 2002 (2525); Amazon(374); CanFor (700); Europe SPADBE (325); Russia (250) + others.

Brazil *Cooper et al* (5500) kept for validation

Topsoil (not litter layers) 3300 sites %N

Dataset Problems & Solutions

Problems

- Incomplete data set, no source has measured all properties at all sites
- Patchy geographic distribution
- Several different soil order classification systems
- Soil order information not always available (eg Russia)
- Different definitions of ‘clay’ from different sources

Solutions

- Extract sub-sets to analyse individual properties.
- Key regions are well covered
- Translated to FAO 1974 legend (DSMW) expert advice
- Devised PTF based on other measured soil properties
- No solution – unable to use this data.

Existing PTFs in literature

- **Total soil %N**:

1. Soil organic C most important explaining 70+% of variance in %N.
2. Soil %clay and %silt important via effect on %C
3. Land use history (arable, grassland, forest) via effect on %C
4. Soil order

2) Development of PTFs to predict soil total %N

Used Multiple Linear Regression techniques to predict soil %N from other properties from soil fertility dataset:

- <u>Site properties</u>: latitude, altitude, land use, region, aspect, slope, soil type …

- <u>Soil properties</u>: organic %C, pH, C:N, exchangeable cations, CEC, % clay, % sand …

- Max data set of 3306 topsoil samples, sub-sets to look at particular effects

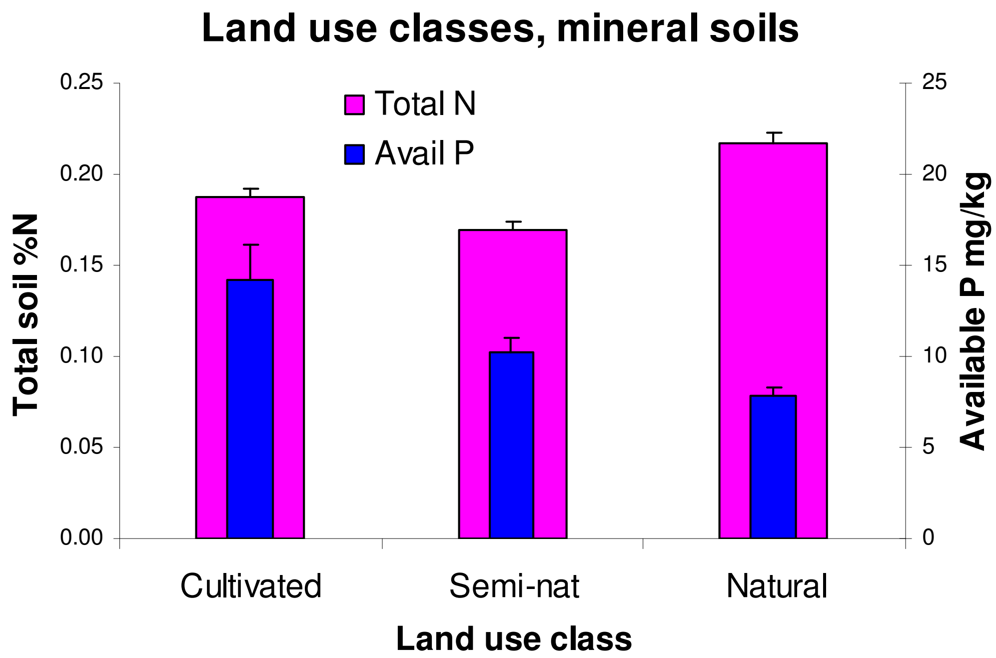
Effect of land use class

- **Natural** (native forest, native grassland etc)
- **Semi-natural** (planted forest, extensive grassland etc)
- **Cultivated** (intensive agriculture, including grassland where fertilizer would be applied)

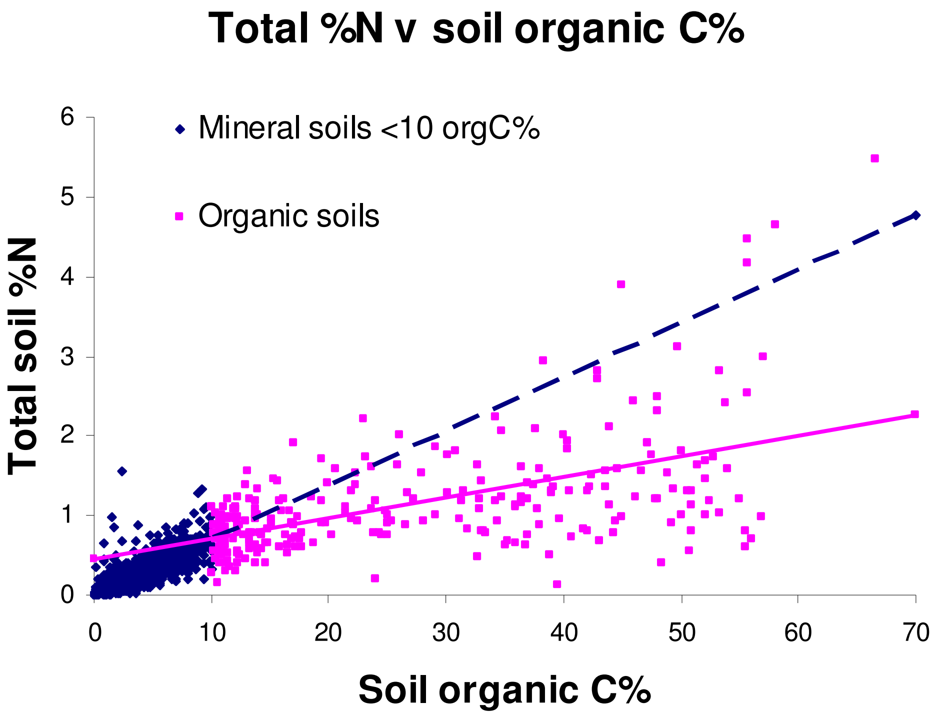
- Interaction between land use and data source/ location/ soil

- Total N analysis include all

- Available P analysis exclude cultivated



Effect of soil organic %C



Mineral soils <10% organic C

Organic soils >10% organic C

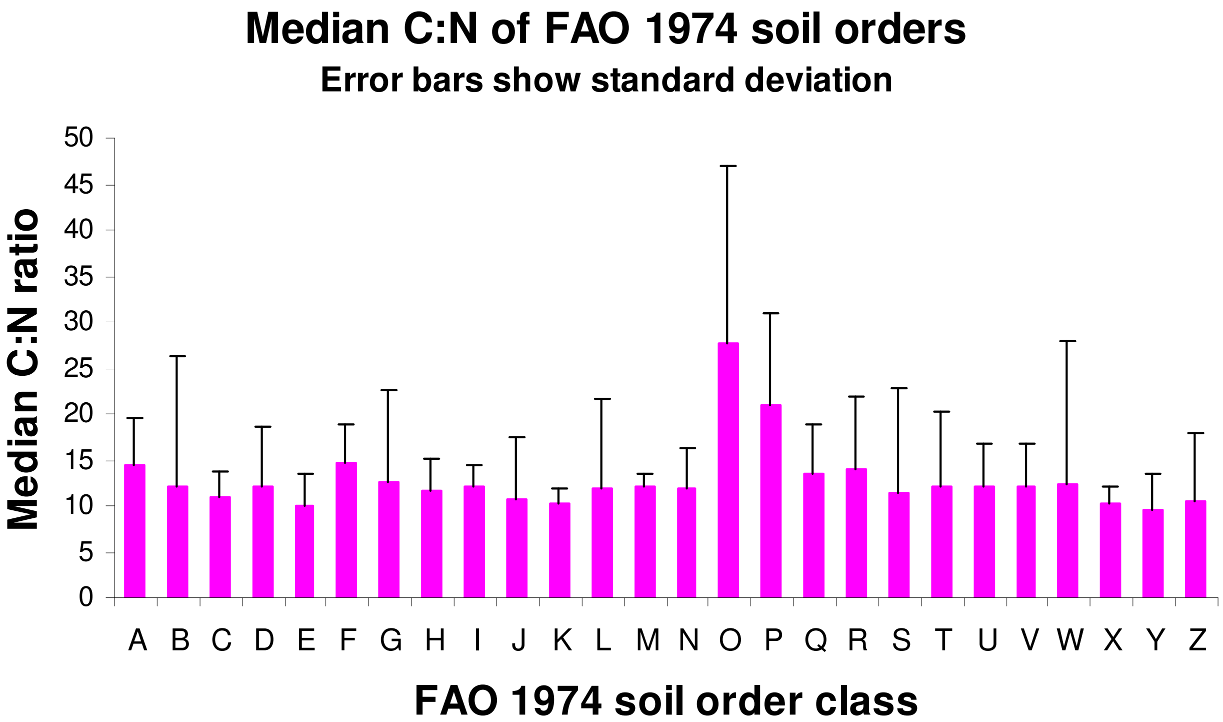
Regression analysis	**OrgC%**	**+ org/min**
% variance explained	68.9	73.0
RMS	0.0404	0.0351
number	3306	3306
Significance	<0.001	<0.001

Derived soil order C:N ratio

- Data sub-set sites with FAO 1974 soil orders

- N = 3058

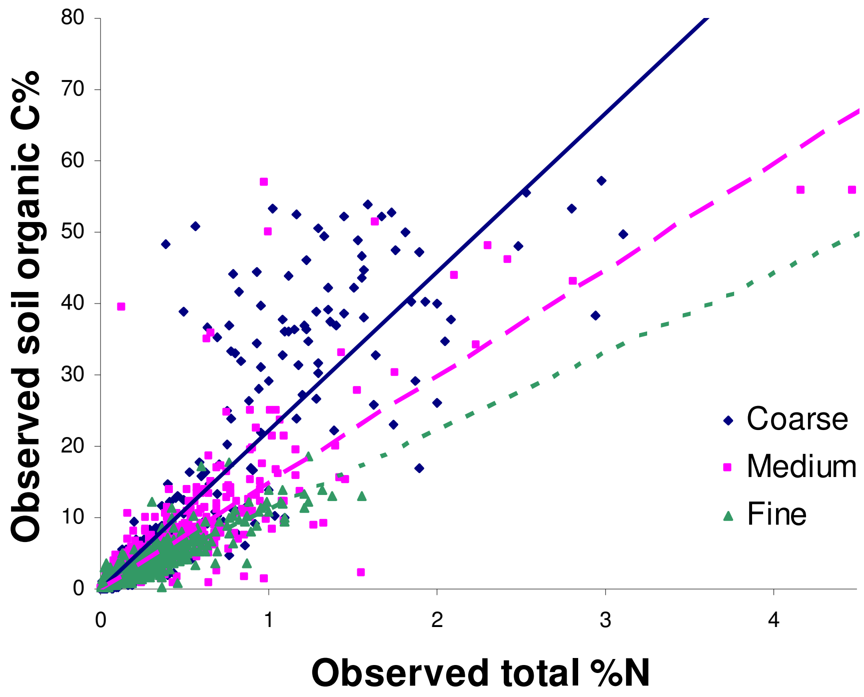
- Where less than 20 values used mean for mineral soils



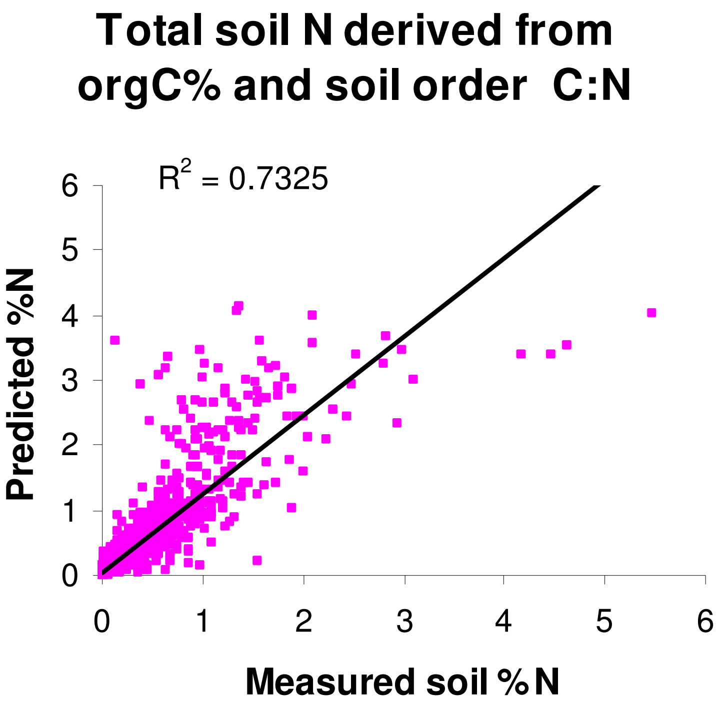
Effect of soil texture on %N

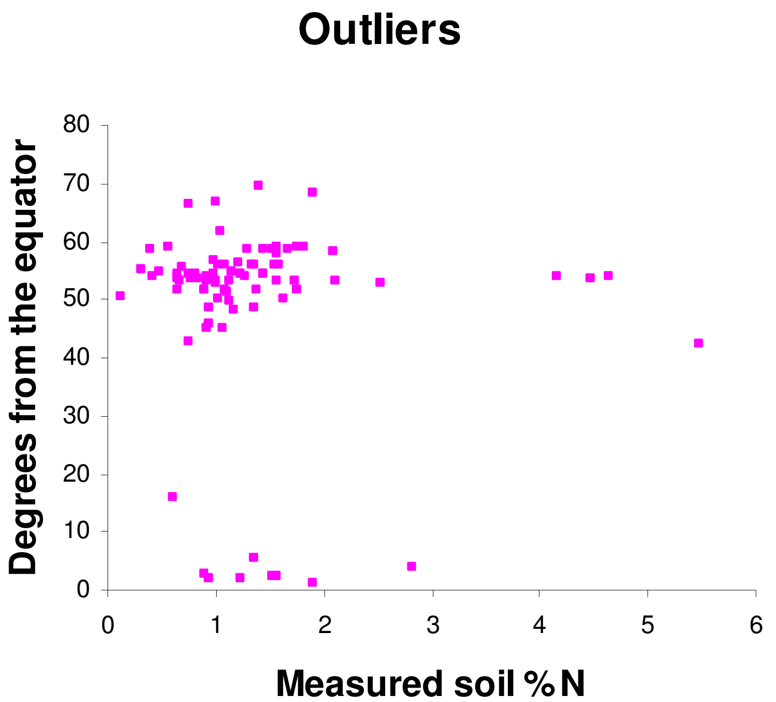
- Topsoil texture class defined by FAO:
- Class 1 **Coarse**, <15%clay and>65%sand
- Class 2 **Medium**, <35%clay
- Class 3 **Fine** >35% clay

- Including texture class as a variate improves the prediction of total soil N (<0.001). Texture class is included in the DSMW.



Effect of soil order C:N and latitude



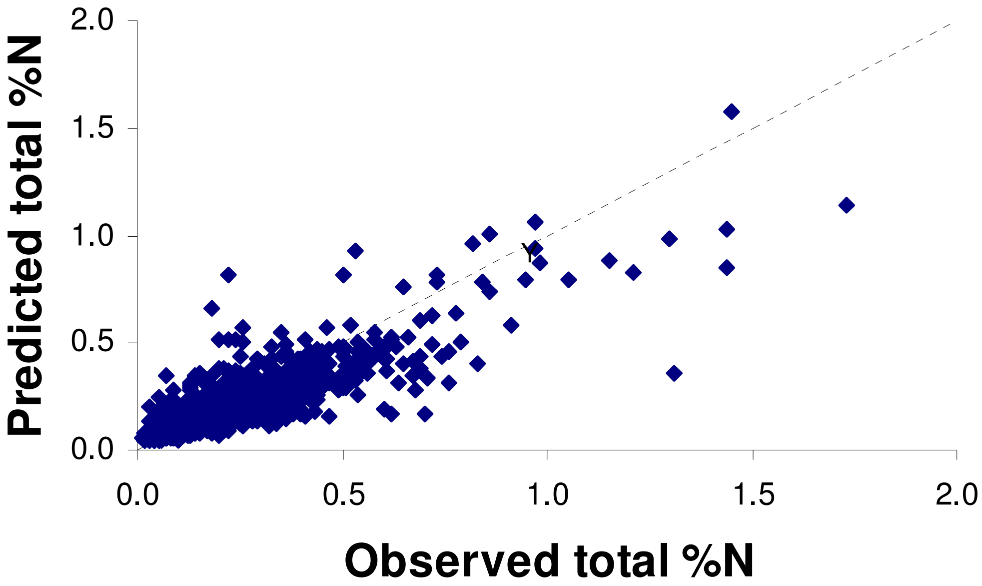


Outliers: Ob%N - Pred%N of 0.5%N or more, n=85

Total %N also has a small negative relationship with latitude

Validation of soil %N PTFs:
Brazilian database (Cooper et al, 2005)

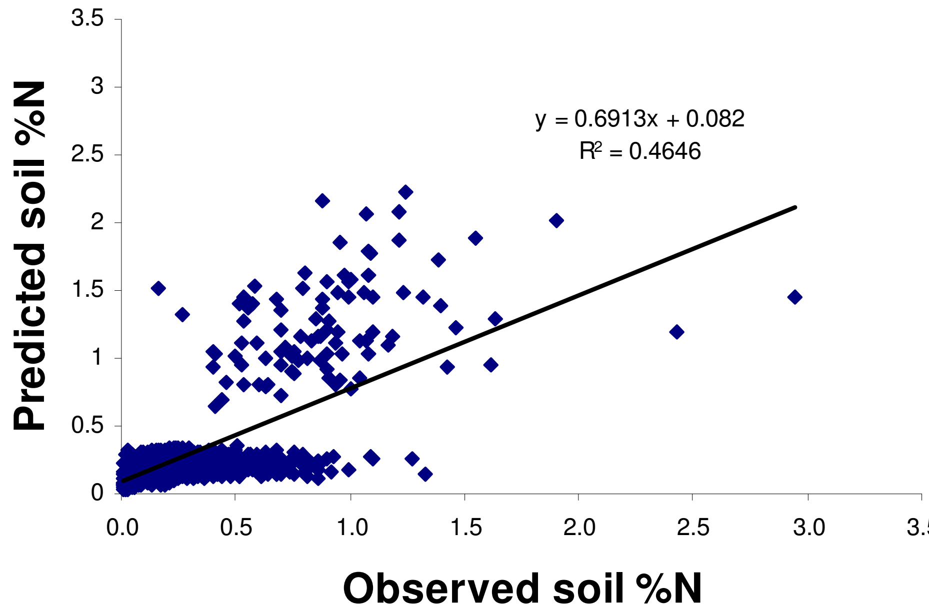
OrgC%, soil order C:N, latitude, org/min



RMSE = 0.0632

3648 data points, Omitting sites with C:N<3 or >100

C) Predicting total %N without knowledge of soil organic C%

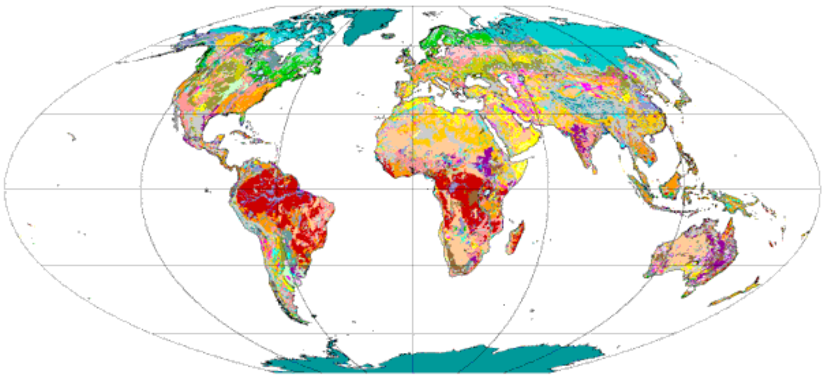


Model 1: pH, %clay, %sand, latitude, org/min

- 49% variance explained
- RMS = 0.0250
- N = 2365

3) Deriving maps of soil %N

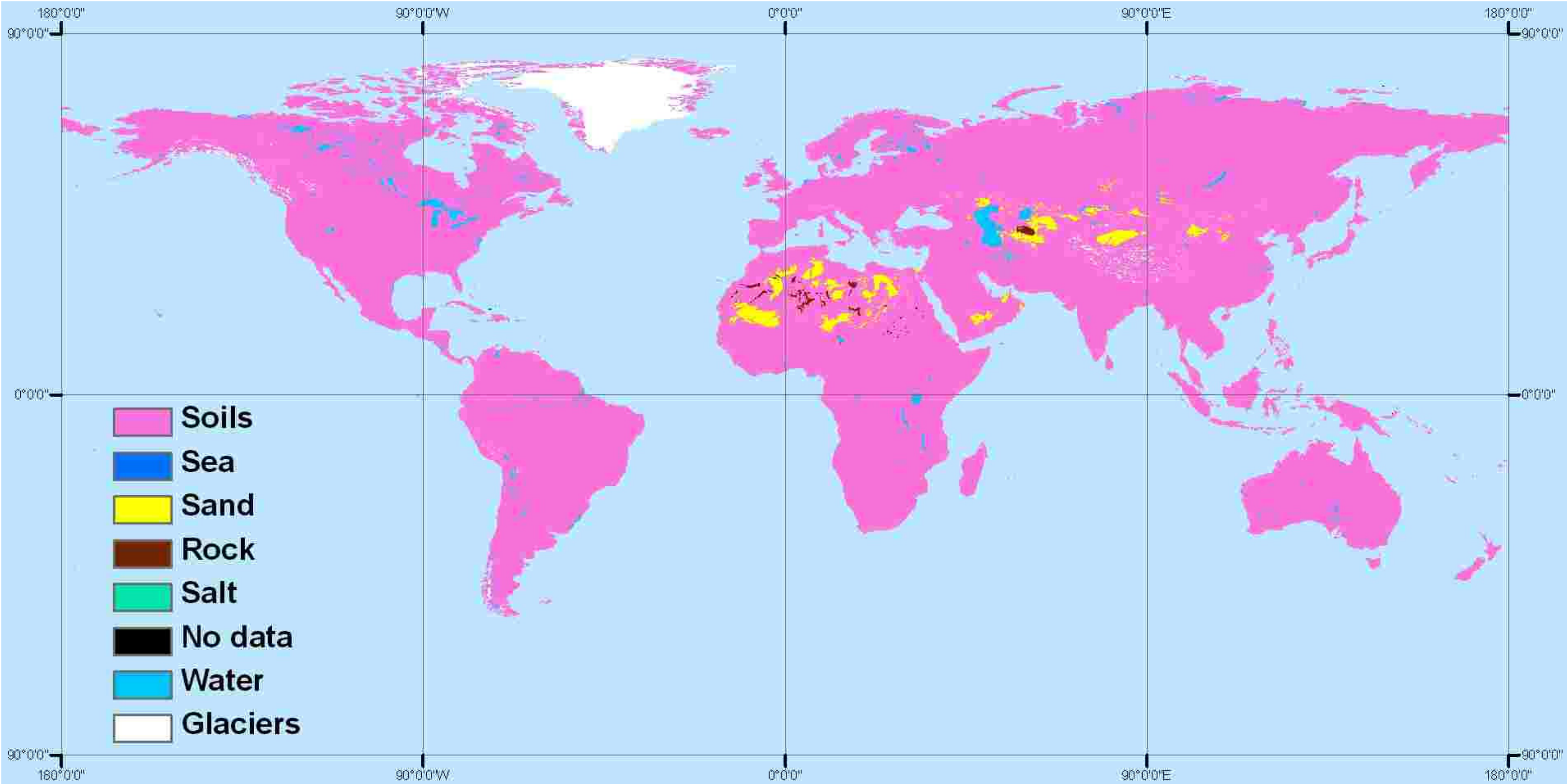
Based on the Digital Soil Map of the World, DSMW (FAO 1995)



FAO 1974 legend:

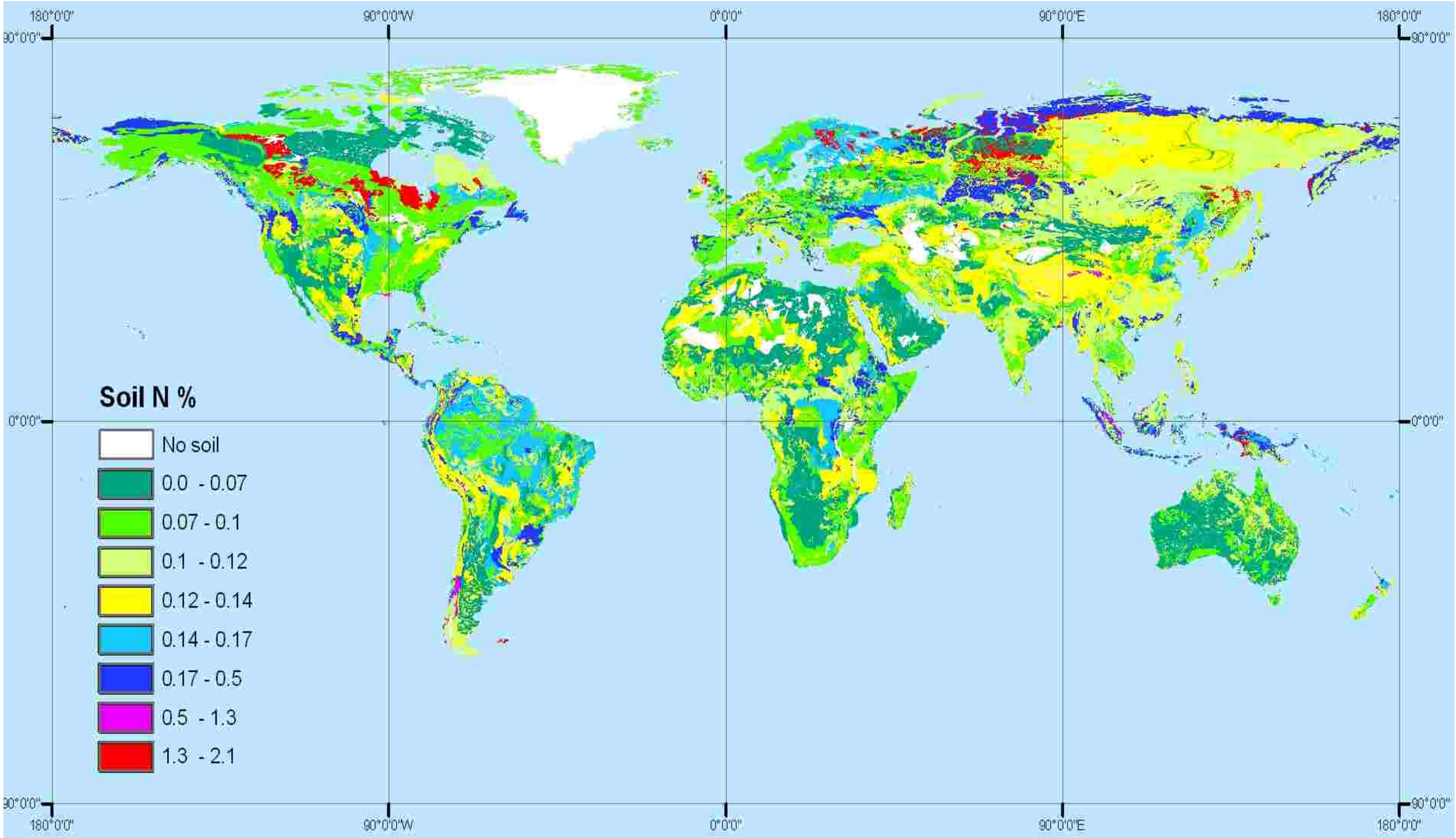
- 26 major soil orders (A-Z)
- 106 soil units
- Three texture classes (fine, med, coarse)
- Dominant Soil in each SMU
- Derived soil organic C map, based on estimates of organic C% for each soil order and texture class (Batjes 2002)

DSMW, non-soils



Derived soil total %N map

OrgC%, latitude, soil order C:N, for organic and mineral soils (>10%orgC) Resolution 5 x 5 minutes



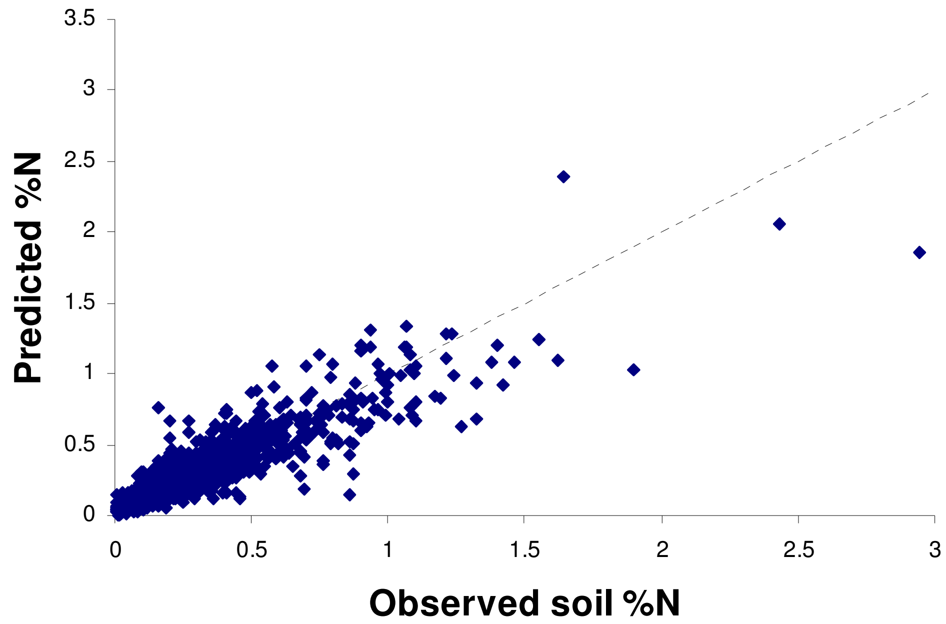
Summary of total % N

- Equations derived for soil total %N:
- All based on soil organic C%, plus other information as available:
  - With **site** information – soil order, texture and latitude
  - With **soil** information – pH, %clay
  - With site **AND** soil information
- Maps derived, based on the DSMW (FAO 1974 legend) – soil order, texture class and OrgC%
- Can use either maps or equations to predict soil total %N in ecosystem models
- Uncertainty analysis demonstrates that error in inputs is not amplified in the outputs

Summary of all soil %N PTFs

Parameters	**Obs%N**	Model 1	**Model 2**	Model 3	**Model 4**	Model 6
OrgC%			✓	✓	✓	✓
Latitude		✓	✓	✓		✓
Texture class				✓		✓
Soil order C:N		✓	✓	✓		✓
pH		✓			✓	✓
%clay		✓			✓	✓
% sand		✓				
Org/min 10%orgC		✓	✓		✓	✓
Org > 40 deg OR>1500m				✓		
Original derived model						
% variance explained		49.0	**80.4**	82.2	**82.3**	83.4
RMS		0.02489	**0.00956**	0.00868	**0.00864**	0.00812
Number		2365	2365	2365	2365	2365
Median %N	0.160	0.195	0.159	0.163	0.162	0.163
Correlation with Obs %N	1	0.682	0.896	0.905	0.907	0.914
RMSE		0.178	**0.099**	0.095	**0.093**	0.090

G) Predicting total %N without knowledge of soil order or location



Model 4: OrgC%, pH, %clay, org/min

- 82.3% variance explained
- RMS = 0.00864
- N = 2365

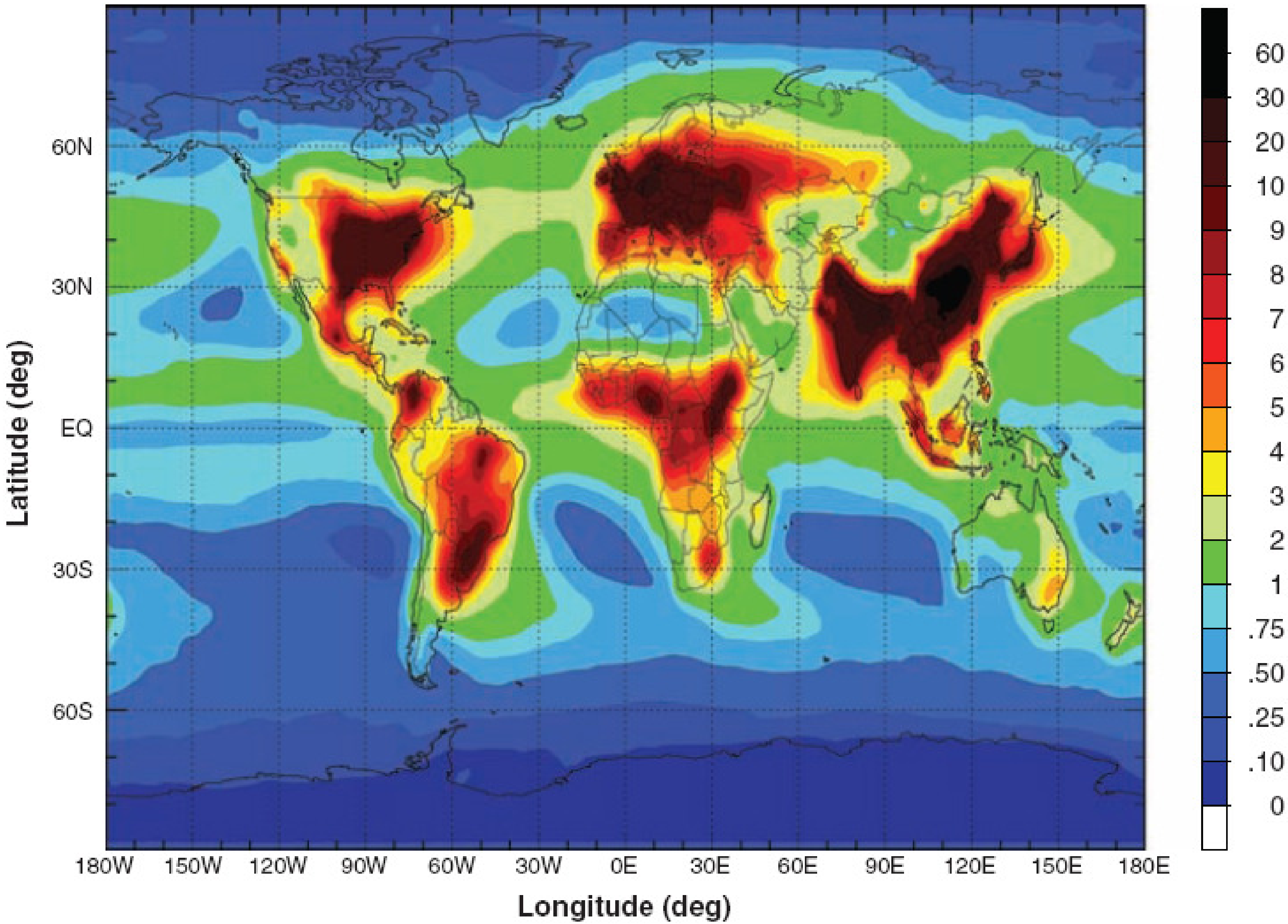


Fig. 2. Estimated N deposition from global total N (NOy and NHx) emissions, totaling 105 Tg N y^{-1}. The unit scale is kg N ha^{-1} y^{-1}, modified from the original units (mg m^{-2} y^{-1}) (*16*).

Galloway et al Science 2008