

## Research Notes

### Trends in Pedotransfer Function Research

Grant Tranter, Budiman Minasny & Alex. McBratney

#### Introduction

The development of Pedotransfer functions (PTFs) is still an ongoing research topic. The objective of this note is to analyse the trend in PTF research using a bibliographic study.

#### Methods

To learn about the trend in this research we analysed the publication pattern using the ISI Web of Knowledge bibliographic database. This was conducted by searching for the word “pedotransfer” or “pedo-transfer” as a topic, which looks for this term within article titles, keywords, and abstracts. The search was from publication in the database from 1900 to August 2006.

#### Data Synthesis

The term pedotransfer function was coined for the first time in a 1989 paper by Johan Bouma:

Bouma, J., 1989. Using soil survey data for quantitative land evaluation. *Advances in Soil Science* 9, 177-213.

This paper has 116 citations, even though it is not covered by ISI (*Advances in Soil Science* is not listed). Nevertheless, using a special algorithm, we are able to extract the citation number as a function of year (Figure 1).

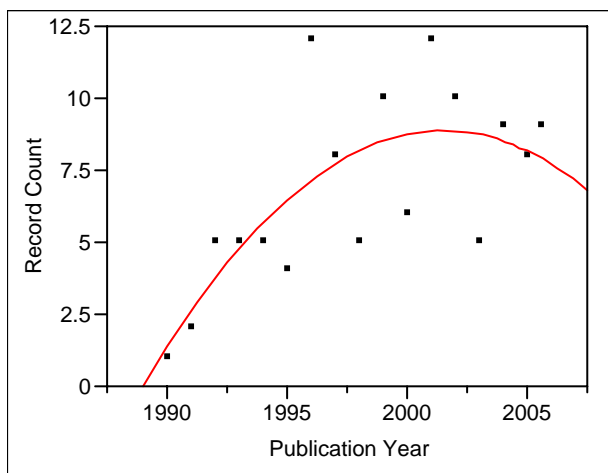


Figure 1. No. of citations of the 1989 Bouma PTF paper. The curve represents a quadratic function fitted to the data.

Figure 1 shows number of citation for the first PTF paper (Bouma, 1989), showing a rapid increase in the first 5 years. A quadratic function fits the data reasonably with  $R^2 = 0.53$ . The trend shows that the citation reached a maximum in year 2001, 12 years after it was published. We called this saturation or ignorance year, when the term becomes fully absorbed, common, and less people refer to the paper.

We then search for papers with keyword “pedotransfer” or “pedo-transfer”. The database reveals there have been 284 publications (since 1991) in this field (Figure 2). The following analysis is based on papers published in journals that are covered by ISI. They are 238 journal papers, 7 review papers, 2 editorial materials and 1 letter. A search through Google scholar gives more than 1500 articles, which includes a lot of unrefereed articles and conference abstracts. The numbers given below represents the information up to August 2006, representing journal papers on the development and utilization of PTFs.

Although the concept of the pedotransfer function has long been applied to estimate soil properties that are difficult to determine, since it is formally recognized and named in 1989 the research into PTFs has gained a new momentum. The concept was known previously as “surrogate” methods, “rule of Thumb”, “pedofunction” (Lamb and Knieb, 1981; Knieb and Schroeder, 1984), “transfer function” (Bouma and van Lanen, 1986), and others. With the introduction of the term PTF, it has gained worldwide recognition as a new field in soil science.

Three years after its conception, the first paper registered using the term pedotransfer function is by Petach et al. (1991). The number of papers from 1991 to 1992 is about 1 per year, since then the number of publications has been steadily increasing by about 2.6 papers every year (Figure 2). The largest number recorded is in 2005 with 46 papers. It remains to be seen whether by the end of 2006 the number (29 papers up to August 2006) will reach 37 as predicted by Eq. (1) or exceeds the year 2005 number. A linear model fitted to the data shows a strong linear response, a PTF for PTF papers can be given as:

$$\text{No. PTF papers} = -5129 + 2.6 * \text{Publication Year} \quad (1)$$

with  $R^2 = 0.86$  and  $\text{RMSE} = 5$  papers. The slope implies that there is an increase in 2.6 papers every year, and the intercept indicates that there is a deficit of 5129 papers in the year 0. The year when no. of paper = 0 is in 1988, which suggests that the 1989 paper is probably about 1 year late for publication.

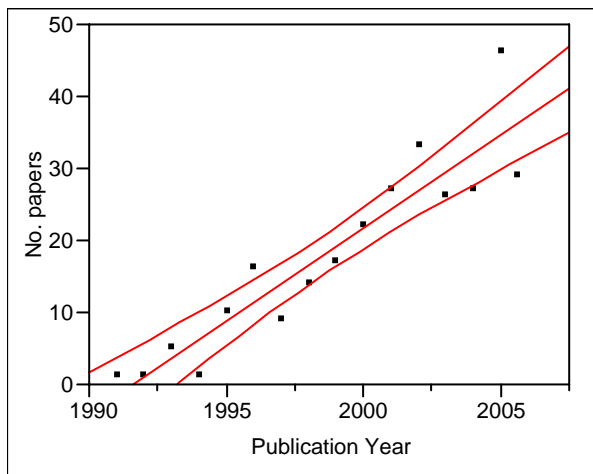


Figure 2. Number of PTF papers as a function of publication year. Straight line represents line of best fit, the enveloped lines represent 95% confidence interval (data from ISI Web of Knowledge).

Most PTF papers have been published in Geoderma (16.5 %), followed by the Soil Science Society of America Journal (15.8 %), and the Australian Journal of Soil Research (6.7 %). The others appear in Agriculture, Environmental Science, Hydrology and Water Resources Journals. Of particular interest are the few articles appeared in Applied Geochemistry, Biomass & Bioenergy, and Chemosphere.

With respect to discipline (Figure 3): 67% are within soil science, followed by water resources (17%), agronomy (13%), and environmental science (10%). The rest are from various fields, include civil engineering, geosciences, limnology, meteorology & atmospheric sciences, entomology and even oceanography. The oceanography paper is by Young et al. (1999).

Most PTFs deal with hydraulic properties (60%), and related to water (77%) but PTFs have been widely accepted and used in various fields.

In addition to the broad subject category, we analysed the topics covered using a combined keyword search. The patterns revealed are as follows:

- Mathematical techniques used: most used (linear) regression (22%), 14% used neural networks while regression trees just 3%.
- Most of the PTFs developed using empirical models, there are 13% that developed physical-based models.
- There are 66 papers (23%) contains the word “spatial”, this is an interesting finding as PTFs are dealt not only as non-spatial data points, but considering spatial context.
- 21 papers (7%) is associated with the landscape.

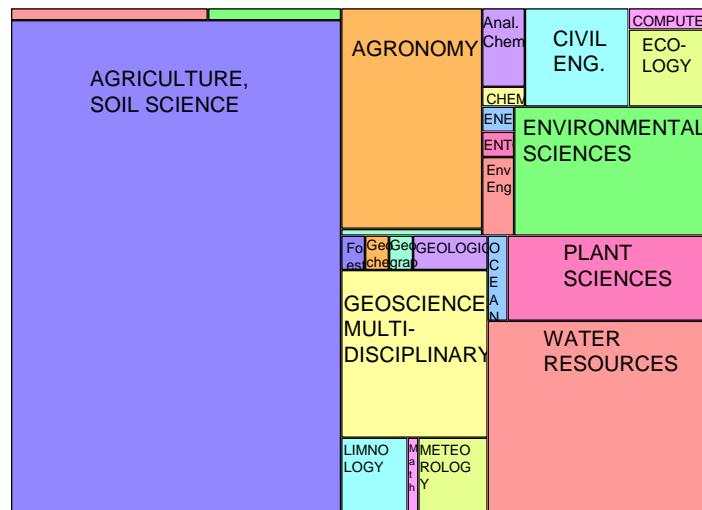


Figure 3. Tree Map of subject category by No. of PTF papers.

- Only 33 papers (11%) reference uncertainty, this area is still not adequately dealt with.
- Topics are still dominated by predicting soil hydraulic properties, with areas in saturated hydraulic properties 22%, unsaturated properties 20%, and solute transport 12%.
- PTFs used in combination with simulation models 23%.

Table 1 shows the top 10 PTF producing countries. It appears that countries with abundance of soil data resources are able to develop and utilize more PTFs (Figure 3). Countries with large areas and sparse data infrastructure, e.g. Australia and Brazil contributes considerably. However developing countries from Africa, South America, and Asia mainly have 1 paper. While there is a great need for PTFs in developing countries, an expensive investment in building a soil database is needed first. PTFs still remain to be developed by countries with rich soil infrastructure.

Table 1. The top 10 PTF producer countries.

Countries	No. papers (1991-August 2006)	Percentage of total (284 papers)
USA	83	29.2%
Germany	47	16.5%
The Netherlands	31	10.9%
Australia	30	10.6%
Canada	23	8.1%
France	19	6.7%
Brazil	18	6.3%
Belgium	15	5.3%
England	14	4.9%
Italy	13	4.6%

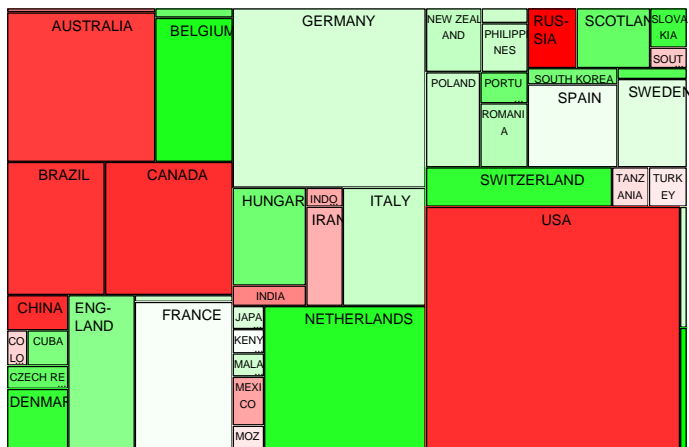


Figure 3. Tree Map of Country by No. of PTF papers coloured by land area. Deep green shows relative small land areas and deep red large land areas.

Finally, Table 2 shows the top 5 PTF authors. The author who has published most PTF papers is Walter Rawls from USDA ARS in Beltsville with 18 PTF publications within 15 years. Johan Bouma, the father of PTFs ranked 3<sup>rd</sup> with 12 publications, sharing it with Yakov Pachepsky and Marcel Schaap.

### Conclusions

Pedotransfer functions are still an ongoing research topic with an average increase of 2.6 papers per year. The validity of Eq. (1) needs to be tested in 2010. It will be interesting to see whether the rate will increase or will reach a steady-state saturated condition. We can then define several key years:

- It took 3 years to get the term and concept of PTF to sink in, accepted and used by others.
- It took 5 years to gain a momentum for increase.
- It took 12 years for the term to be general, and widely used.

Although the concept has been used and explored since 1907 (Briggs and McLane, 1907; according to Eq. 1 there was a deficit of 215 PTF papers in that year), giving it a new name has formalize a new field of research in soil science and become an avenue of expression for many soil scientists. However, PTFs remain a plaything for countries with rich soil databases. While most PTFs are still for predicting soil hydraulic properties, new field are being explored.

Table 2. The top 5 PTF producers.

Rank	Author	Country of Origin	No. of papers	Percentage of 284 papers
1	Walter Rawls	USA	18	6.3 %
2	Budiman Minasny	Australia	14	4.9%
3	Johan Bouma	The Netherlands	12	4.2%
	Yakov Pachepshy	USA	12	4.2%
4	Marcel Schaap	USA	12	4.2%
4	Alex. McBratney	Australia	11	3.9%
5	Feike Leij	USA	9	3.2%

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### Author's profile

**Grant Tranter** is currently undertaking a PhD at the University of Sydney. His work focuses on the development of a working Soil Inference System for the prediction of numerous soil properties. His research interests included hydrology, pedology and landscape delineation. Grant comes from the Blue Mountain. He is an avid sportsman, currently also learning Javanese.