ΠΕΔΟMETRON

www.pedometrics.org

ΠΕΔΟ METRICS

Issue 20 **September 2006**

Commission 1.5 Pedometrics, Div. 1 of the International Union of Soil Sciences (IUSS)

Chair: Murray Lark **Vice Chair & Editor: Budiman Minasny**

From the Chair

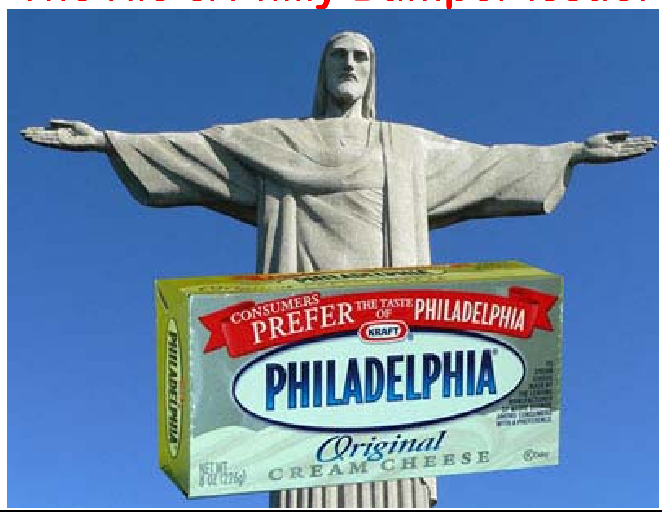
Welcome to the latest edition of *Pedometron*, the Newsletter of the Pedometrics Commission of the International Union of Soil Sciences. This contains reports on recent meetings, research notes, reviews, profile interviews and a report on the Richard Webster Medal, the IUSS's award for excellence in the discipline of Pedometrics.

As incoming Chair, I should like to start by thanking Gerard Heuvelink and Sabine Grunwald, who stepped down as Chair and Vice Chair of the Commission at this year's World Congress of Soil Science. Gerard and Sabine have worked hard to establish our Commission, steering us through the procedures of the IUSS in our transition from working group status. To them, and to Marc Van Meirvenne and Pierre Goovaerts — under who's leadership this process began — we owe many thanks.

The classical pedometrical problem is spatial prediction: how to predict soil properties at unsampled sites, or over blocks, from limited direct observations and other information. In the 1960s Richard Webster and Philip Beckett formulated the question of how to assess the value of soil maps in terms of spatial prediction. This lead to the use of analysis of variance to study soil variation and its description by classification and mapping. The limitations of this model soon became apparent, and in the 1970s pedometricians found that the random functions of geostatistics offered a powerful way to model soil variability at different spatial scales.

Continued next page …

The Rio & Philly Bumper Issue!



INSIDE THIS BUMPER ISSUE

We now know that, by formulating geostatistical prediction in terms of the linear mixed model, we can naturally unite the power of the random function model and the considerable understanding that is contained in soil classifications and maps. This represents the current state of the art of digital soil mapping.

But pedometrics will not continue to flourish as a discipline if it stands still. Some of our effort will always be devoted to improving our methods for spatial prediction, and I hope that the DSM working group will stimulate thought and discussion in this area so that we do more than simply tidy up loose ends. At the same time, I would like to see some broadening of our horizons. As pedometricians we have a quantitative understanding of how the soil varies at different scales in time and space. This should allow us to do more than map the soil, it should enhance the insight of our fellow soil scientists into some of their key problems, and we must be active in developing collaborations to do this.

Let me expand on what I mean with a short example. As a student I was never much excited by soil biology. You could culture some of the bugs in soil, but probably most of the important ones were undetectable this way. I suspect like most pedometricians I became more interested in physico-chemical problems, and in pedology. But soil biology is being transformed by the application of new molecular methods. Now biologists can extract DNA from the soil and start to identify which genes are being expressed by the soil biota in different conditions. I heard a talk two years ago on how molecular investigations had identified an enormous diversity of microbes in soil, and highlighted some possible novel antibiotics, and this was on one sample collected under a tree in Wisconsin! The need for pedometrical input here is enormous; to look at the effects of scale, to identify sampling strategies, to untangle relationships at different scales between the biological data and the physics and chemistry. Some work has been done, but I believe that this is an exciting new frontier for pedometrics, and I hope that we will have started to colonize it by the time I hand over as Chair in 2010.

One innovation in this *Pedometron* hopes to encourage such new thinking. We now have our own "Five questions to a soil scientist", as published in the IUSS bulletin. In the *Pedometron* version we shall ask one pedometrician, and one soil scientist outwith the discipline, to tell us something about their work, but also to speculate about possible future areas for pedometrical endeavour. In this issue our pedometrician is Dr Sam Baxter from the University of Reading. Our non-pedometrician is Prof. Nunzio Romano from Department of Agricultural Engineering Division for Land and Water Resources Management University of Naples "Federico II", Italy. Nunzio is a soil physicist and hydrologist, with a background in hydraulic engineering. Please mull over both these profiles, and see what new ideas they spark off.

Two final comments. Please make good use of our excellent website. Tomislav has done a fine job, and I would like to see more use being made of its facilities for interactive discussion.

And second, don't forget to register for Pedometrics 2007 in Tübingen, Germany from 27th to 30th August, 2007. More details at www.pedometrics.de. Thorsten Behrens is working hard on this, so register, offer a paper or poster, and tell your colleagues about it!

With all good wishes for your scientific endeavours

Murray

From Philly with Love (Photo: Raphael)

18th World Congress of Soil Science

9-15 July 2006, Philadelphia, USA.

The International Union of Soil Science held its World Congress in Philadelphia in July this year, attended by over 2000 scientists. The Pedometrics Commission (co)organized 3 symposia:
(1) Diffuse Reflectance Spectroscopy, Soil Sensing, Remote Sensing and Image Analysis
(2) Soil Sampling in Space and Time
(3) Interdependency of Soils and Soilscapes

Soil Sampling in Space and Time

Jan Hendrickx
Dept. Earth & Environmental Science
New Mexico Tech.

This symposium was organized to address the need for extending the vast body of theory, methods, and applications for designing and optimising soil sampling schemes in space to the joint space-time domain. The extension confronts us with some real challenges, because soil variation over time is entirely different from soil variation over space. These problems occur at various spatial and temporal scales, ranging from centimeters to hundreds of kilometers and from hours to decades. The objectives of this symposium are to draw attention to the problems associated with soil sampling in the joint space-time domain, to offer solutions to some of these problems and to bring interested soil scientists up to date with existing work in this area. The symposium consisted of an oral and poster session.

The oral symposium on 'Soil sampling in space and time' was chaired by Gerard Heuvelink with convenor Jan Hendrickx and held on Friday afternoon. Inconvenient timing, because people were less alert at the end of a full week conferencing and many had in fact already left Philadelphia. However, the turnout was good and we had some nice discussions.

The session was opened by Dick Brus, who gave a keynote on the various designs that one can choose from when monitoring a soil variable that varies in time and space. Dick drew largely on the book *Sampling for Natural Resource Monitoring* (Springer Verlag) that he recently completed with Jaap de Gruijter, Martin Knotters and Marc Bierkens. Next Alex McBratney showed the attractive properties of Latin hypercube sampling. This was Alex's first presentation after being awarded the Richard Webster medal for outstanding contributions to pedometrics (he received it the night before). Alex made clear that Latin hypercube sampling provides an efficient way of sampling variables from their multivariate distribution, because it ensures a full coverage of the range of each variable while maintaining a modest number of observations. Steve Evett compared different measurement methods for measuring soil water content in space and time. It turned out that with electromagnetic sensors unreasonably large sample sizes would be required to accurately assess the soil water content at the plot scale, because these measurements have a small support and are affected by small-scale variation. Sidney Vieira used a rich data set on soil water content measurements in a 1.2 ha field near Ottawa to compare spatial and temporal variation. It turned out that spatial patterns in soil water content were quite stable in time, which is crucial information when choosing sampling densities in time and space efficiently. Finally, Christian Walter tested various sampling schemes on a simulated dynamic landscape of soil phosphorus content. Among others, Christian showed that the temporal trend in soil phosphorus was best estimated with a regular grid with fixed monitoring sites. This nicely confirmed one of the recommendations made earlier by Dick Brus, namely that static designs are better able to detect trends than dynamic or rotational designs.

The theater poster presentations of the symposium on 'Soil sampling in space and time' were chaired by Jan Hendrickx with convenor Gerard Heuvelink and held on Monday afternoon. The setting in the corner of a large poster hall with poor acoustics did not allow for any discussions between presenters and audience. Due to financial and/or visa problems six of thirteen planned posters were absent. It makes one wonder whether the USA should still be considered for future international events of the IUSS. The remaining seven posters covered a wide range of topics from GIS applications in soil surveys on large scales to small scale measurements of soil chemical properties and to evaluations of new soil heat flux plate designs. Attendance with about thirty to forty participants was good.

Richard Webster Award

Margaret A. Oliver
University of Reading, UK.

As Chairman of the Richard Webster medal committee I have great pleasure in announcing that the first person to receive the award is **Professor Alex McBratney.** The committee members were unanimous in their decision.

Below I give the committtee's reasoning for their selection of this nominee according to the guidelines that were established for this award.

1. Application of mathematics or statistics in soil science through published works

Alex has introduced methodologies that apply to soil genesis as well as land management. He has contributed to theoretical concepts of soil formation and their distribution and introduced soil inference systems to soil science. He has applied fuzzy sets to mapping soil classes and has recognized the benefit of using spectral analysis in relation to agronomic practices.

He has published a large body of influential work.

2. Innovative research in the field of pedometrics

This criterion assumes a familiarity and understanding of a broad spectrum of spatial and temporal statistical analyses used in conjunction with diverse concepts of processes and properties in soil science. Alex's innovative achievements have been diverse and have shown strong creativity and great insight.

He has been involved in a large number of research projects that have had considerable impact.

3. Leadership qualities in pedometrics research

Alex plays a major role in promoting digital soil mapping internationally. He leads a group on soil resource assessment that includes basic soil science research and pedometrics, and both are applied to soil management. He leads a well established group in precision agriculture.

4. Contributions to various aspects of education in pedometrics

Alex introduced Pedometrics as a university subject in Australia, developed one of the first, perhaps even the first, university course named pedometrics, has supervised about a dozen PhD students in pedometrics, and developed and teaches a training course for the agricultural industry. He has done a good job of upgrading the syllabus based on pedometrics at the University of Sydney for professionals in the agricultural industry. He has worked on pedometrics for much of his professional life. Alex has held the most prestigious academic post in soil science in Australia. He has taught and inspired many undergraduates. Alex sets a high standard and teaches with a flair and wit that is rare.

5. Service to pedometrics

Alex McBratney proposed the word pedometrics which helped to formalize this new discipline in soil science. He is chairman of the Working Group on Digital Soil Mapping (International Union of Soil Sciences, 2005-present), was chairman of the Working Group on Pedometrics (International Society of Soil Science, 1994-1998), nominated and received Best Paper Awards, (Pedometrics, International Union of Soil Science). He is on the editorial board of Precision Agriculture (1997-present).

Don Nielsen announcing the winner (Photo: Raphael)

Alex on the first principle of Pedometrics (Photo: Raphael) www.digitalsoilmapping.org

IUSS Working Group on Digital Soil Mapping

The main activity for the Working Group is the 2nd Global Workshop on Digital Soil Mapping, held in Rio de Janeiro (Brazil) from the 4th to the 7th of July 2006. It was successfully organized by Dr. Maria de Lourdes Mendonça Santos (Senior Researcher and Responsible for Technical Innovation of Embrapa Solos) and Alex McBratney (University of Sydney). To Lou, Alex & the team, we would like to convey the gratitude of the Working Group.

For the meeting, 75 participants were registered from 18 countries. There were 51 presentations spread over 5 different sessions:

1. DSM challenges: dealing with limited spatial data infrastructures.
2. DSM: protocol, quality, availability and capacity building.
3. New DSM methodologies.
4. DSM Examples – Soil properties.
5. DSM Examples – Soil classes.

Some discussions were done on the priorities of DSM research activities in the near future:

- for countries with limited data infrastructure, work has to focus on developing and testing new ancillary data for deriving information on soil attributes,
- for countries with extensive legacy soil data deriving from traditional soil survey, work should focus on the estimation of their accuracy and the way to use them for soil mapping applications.

The outcome of the workshop will appear as:

> "A.E. Hartemink, A.B. McBratney and M. L. Mendonça-Santos (Eds.). Digital Soil Mapping with Limited Data". Probably edited by Developments in Soil Science, Elsevier (to be confirmed).

During the meeting, Dr. Neil McKenzie (CSIRO, Australia) was elected as Chair and Dr. Florence Carré (European Commission, DG Joint Research Center, Italy) as Secretary of the DSM Working Group.

For the moment, there is no indication of the date and the location of the next workshop on Digital Soil Mapping; but information will be provided on the website dedicated to the working group: www.digitalsoilmapping.org. which will be updated very soon by Dr. Thorsten Behrens of the University of Tübingen, Germany, webmaster of this active website. On behalf of the Working Group, we would like to thank him.

Florence Carré & Neil McKenzie
on behalf of the DSM Working Group.

Organizers of the 2nd GWDSM: Alex & Lou.

2nd Global Workshop on Digital Soil Mapping

4-7 July 2006, Rio de Janeiro, Brazil.

A private sector DSM practitioner's perspective

R. A. (Bob) MacMillan
LandMapper Environmental Solutions.
Edmonton, Alberta, CANADA.

The Second annual Digital Soil Mapping (DSM) Workshop held in Rio de Janeiro from July 5-7, 2006 was very well organized. Attendance was a bit lower than originally anticipated due to the long distances and high costs involved in traveling to Brazil for many potential participants and to last minute travel problems such as the temporary cessation of service of the Brazilian air carrier Varig. There were no delegates from Japan, Africa or Asia but representation was good from USA, Europe, Australia and Brazil. As the only representative from Canada and also probably the only delegate from a private-sector, commercial mapping enterprise, I present here an overview of some impressions I had of the workshop.

Mosaic image of Copacabana beach.

First time visitors to Brazil, like me, took some time to adjust to the challenges of getting from place to place and communicating our needs and intentions in an unfamiliar language. However, apart from our self-imposed anxieties, most systems actually worked quite well and reliably. There was some anxiety in taking the initial trips from the airport to the hotel or the hotel to the conference venue, but once these first trips had been completed successfully, we realized we could relax and rely on the local transport. Taxi trips were priced reasonably, in comparison to most major cities, and were reliable in delivering us to our destinations.

The conference organizers suggested three hotels located relatively close to one another along a strip of Copacabana Beach. The hotels were clean, comfortable and reasonably priced. Excellent breakfasts were included in the price of a room. The area around the hotels was well serviced by restaurants, bars and shops and was safe to walk in, with the exception that walking on the beach after dark was not advised (as at least one delegate quickly discovered). The workshop venue was located several kilometers away from the hotel strip in a building belonging to the Geological Survey of Rio de Janeiro State. This building was an extremely impressive example of colonial architecture and it provided very suitable facilities for hosting the workshop presentations and poster sessions. The audio-visual systems were reliable and well managed by staff provided by the local organizing committee.

The workshop theme and program.

The workshop took as its theme "Digital Soil Mapping for Regions and Countries with Sparse Soil Data Infrastructures" and a program was devised that was expected to address the special challenges of implementing DSM in regions with sparse spatial data.

The program began with a full-day field trip north and east of Rio de Janeiro. The field trip took us through three quite different landscapes representative of mountainous uplands, a coastal plain and an intermediate area between the two. The organizers had located, described, analyzed and classified several soil profiles in each region.

It was perhaps inadvertently instructive how the three soil profiles in the mountainous area were all classified quite differently (as Cambisols and Ferrasols) but all three appeared to occur in essentially similar environmental settings and landscape positions, towards the lower bounds of steep colluvial slopes. The differences in classification, for what appeared to be relatively similar settings, provided a clear, if perhaps unintended, illustration of the problem of reconciling point scale observations and classifications with the kinds of regional scale landform-related entities that can typically be mapped using available data sets and DSM technologies. The field trip involved a long drive but it did give us all an opportunity to come together and get to know one another and to see something of the local countryside. We even got to listen to the final part of the world cup match in which Italy eliminated Germany.

The oral presentations were organized into five sessions and a final wrap-up discussion. While the presentations were of uniformly high quality and covered the full range of topics typically associated with DSM, only a few stood out as examples of clear advances in technologies for DSM. The presentation by Budiman Minasny caught my attention because it showed how new soil spectroscopy scanning technologies might provide possibilities for creating standardized characterizations of point soil profile data at the scale of individual soil profiles to soil pores. I seldom work with detailed point observation or laboratory sample data but I can appreciate where the ability to rapidly characterize soil profile attributes could be very helpful in building up the large data sets of consistent and correlated point observations necessary to apply DSM techniques in areas of sparse soil data.

Admiring the Latossolo Vermelho (Photo: Raphael)

The presentation by A-Xing Zhu was notable for its efforts to compare several different approaches to predicting the spatial distribution of individual continuous soil properties. It provided an example of an effort to compare the efficacy of several alternative approaches that is all too rare in DSM research to date. Presentations by several of the Brazilian delegates illustrated, for me, the fact that they have ample capabilities to assemble both point data sets of profile observations and areal maps of the spatial distribution of conceptual soil-class entities. The knowledge required to apply DSM techniques broadly exists in Brazil and implementation of DSM techniques is mainly limited by lack of availability of DEMs and other predictor data sets of appropriate spatial resolution. Neil Jarvis contributed his observation that more of the presentations were concerned with the prediction of classed soil entities than with the spatial distribution of individual soil properties and he contended that rapid production of coarse resolution maps of single soil properties to support global modeling and monitoring efforts ought to be a priority. This raised the long standing debate of whether users of DSM products are better served by continuous maps of soil properties or categorical maps of soil classes. Finally, the presentation of Elizabeth Bui reminded me that while we usually focus our efforts in DSM on making predictions, the techniques of DSM, as with any modeling techniques, can be as useful when applied to search out unexpected patterns and to improve our understanding of spatial relationships as when they are used exclusively to make predictions.

Teach them young

My main impressions

Overall, my main impression is that there have not been many new and startling advances in DSM techniques since the first Digital Soil Mapping workshop in Montpelier in 2004. It would appear that DSM techniques have reached a plateau where, at least temporarily, the techniques have developed to a level where they are adequate enough to produce relatively useful maps. Consequently further refinement of techniques has not been a high priority. Despite several obvious differences most efforts to apply DSM techniques share many similarities in terms of the input data sets used as predictors and the nature and kinds of output maps produced. The impression I came away with was that DSM was approaching a cross-roads where it would be necessary to decide whether it was time to commit to widespread adoption and application of DSM methods in support of operational mapping activities at national and state levels or whether it was necessary to continue to conduct further research to improve and refine DSM technologies prior to introducing them for widespread operational use. The presentation by John Hempel from the USDA NRCS suggested that this was a moot question and that the only feasible option for continued operational production of soil maps in the US was to move towards comprehensive adoption and implementation of DSM methods. This may be true in the abstract, but the workshop provided very few examples of use of DSM technologies to produce maps for large areas on an operational basis. It was also obvious that many of the examples of application of DSM technologies remain focused on demonstrating and improving the methods for producing predictive maps and that direct links of the resulting maps to applications that use the information to guide decision making are still quite rare. This led to the standard calls to provide improved linkages between soil information and applications that make use of it. Neil McKenzie provided an example of how digital soil information was being delivered to users to inform their decisions in Australia. In my opinion, the main challenge between the end of this workshop and the convening of the next will be to see whether DSM methods can be moved successfully from the research domain (the lab bench) into the realm of routine operational use.

Strong points of the conference

The strong points of the conference were the very successful efforts that the local organizers put into organizing an attractive and relevant program, preparing an interesting field trip and arranging for effective meeting facilities. The local organizing committee also arranged for enjoyable evening social events. It is always a personal highlight for me to have an opportunity to meet face-to-face with many of the most widely acknowledged authorities in DSM at a single venue. This workshop did not disappoint in that regards as, with only a few exceptions, many of the most widely recognized DSM practitioners were in attendance. The format for presentations provided adequate time and session chairs did a good job of keeping the program on schedule with the help of presenters who kept to their allotted time limits. The 10 minute time frame provided for presentations appeared to me to provide adequate time for presenting while allowing for discussion both within the framework of the sessions and outside during one-on-one encounters.

One-on-one encounters

What could have been better?

The following comments are offered in the hope that they will contribute to improvements in future workshops.

It was not clear to me that the workshop was able to effectively address the main theme of applying DSM in areas of sparse soil spatial data. The presentations mainly dealt with applications in areas where both soil knowledge and quality soil input data were generally more readily available. Alfred Hartemink made the observation in his presentation that rich countries tend to also be well endowed with both data and knowledge while both data and knowledge tend to be sparse in less rich countries. Many of the DSM techniques developed to date benefit from the availability of considerable amounts of both data and knowledge and do not lend themselves well to transfer to data poor environments. The conference may well have helped contribute to the advancement of DSM in areas of sparse data, such as Brazil, simply by identifying the issue and by hosting a DSM workshop in a region with sparse data. However, very few of the papers specifically addressed how DSM methods could be adapted to operate effectively in areas of sparse spatial data. It might have proven useful to have selected an area of local interest and to have assembled a set of example data for that area which could have been processed through various DSM protocols to illustrate application of different techniques in an area of sparse data. It might even have been desirable to have scheduled a half day or a full day during which participants would have been asked to process the example data through their own procedures or watch as others processed the data through their software. This would have resulted in production of a series of output products for a single area of interest that could then have been reviewed and compared by the workshop participants. Such a comparative analysis might have proven useful by allowing local participants to see what could be accomplished in their areas of interest using data available to them. Future DSM workshops might consider including such a "***DSM Olympics***" as an integral part of the workshop schedule.

Praia Vermelha (Red Beach) and the Sugar Loaf

Plusses and minuses

Plusses

- Well organized
- Presentations kept on time and to schedule
- Competent and effective logistical and AV support for presentations
- Generous and welcoming local hosts
- Attractive venue for presentations
- Attracted participation of a large number of well established DSM practitioners

Minuses

- A long way to go for most North Americans, Europeans and Australians
- Visa and entry requirements added an extra layer of effort and cost to preparations
- Focus of many presentations was on general overviews of techniques and methods and not on applications involving clear links to decision making
- Few new or startling developments in DSM methods as DSM methods appear to have hit a plateau now that they are "good enough" to produce useful maps
- Paradoxically, few examples of applications of DSM methods clearly linked to decision making by end users
- Local participants expressed concern with high costs for their participation
- Many efforts focused mainly on using terrain derivatives. Discussions indicated that DSM needs to expand to include consideration of sub-surface (geological) and above surface (land cover/ vegetation/ climate) controls on the distribution of soils and soil properties

A pedologist's perspective

Humberto G. dos Santos, Soil Researcher
Embrapa Solos, Rio de Janeiro, Brazil

Gorge Pimentel and Humberto (Right) leading the field trip.

The 2nd GWDSM was a unique opportunity to assemble a number of practiced professionals from diversified technological backgrounds and experience related to soil mapping, data processing, information interpretations and knowledge applications.

The workshop program efficiently organized was very well timed to allow a considerable amount of quality presentations, proceeded by keynote presentation and followed by discussions and conclusions that indeed enriched the meeting.

From my point of view the workshop dealt with subjects far beyond soil mapping itself, extending to soil information systems, GIS based approaches, data bases, prediction of soil properties and use of legacy information.

Most of the new technologies and tools discussed in the workshop are already available and applicable, to improve soil mapping techniques, data interpretations and updating of existing soil maps and making of new ones.

In fact, the new tools for data gathering and processing, as well as methods to approach the several steps of soil mapping and soil information interpretations brought to open discussion, reinforced soil mapping and pointed to new challenges of basic research and showed many possibilities for making utilitarian interpretations from basic soil information.

In conclusion, I would say that the workshop discussions and new proposals surpassed my expectations, although many challenges remain ahead before we can fully use all the available resources to make digital soil maps or soil properties spatial distribution.

Amir, our youngest pedometrician.

Let's talk about ….

Sudoku Sampling

by Dennis Walvoort

In the last couple of years Sudoku puzzles have become extremely popular. Each self-respecting newspaper or magazine publishes at least one Sudoku puzzle a week. However, the focus of this note is not on the recreational aspects of this addictive brainteaser, but on its mathematical properties and its potential usefulness to pedometricians.

For the few readers not familiar with Sudoku, we'll start with a brief introduction to the puzzle and its relation to Latin squares. Next, we will demonstrate how its mathematical properties can be employed for deriving sampling schemes. Finally, a limited simulation study is presented in which the precision of Sudoku sampling is compared to that of other sampling methods.

Sudoku

A traditional Sudoku is a square grid of 3x3 blocks each consisting of 3x3 cells (Figure 1). Each cell is assigned a single digit in the range 1 to 9 so that each digit appears only once in each row, column and block. As such, the traditional Sudoku is a special type of Latin square of order nine with the additional constraint of no repeated digits in each block. This constraint will be referred to as the block constraint. A Sudoku *puzzle* is a partially completed grid and has to be solved by logical reasoning … and lots of patience. The total number of valid Sudoku grids has recently been shown to be 6670903752021072936960 (Felgenhauer & Jarvis, 2005; Sloane, 2006, A107739). This number may seem to be quite impressive, but it is almost insignificant compared with the total number of possible Latin squares of the same order (Sloane, 2006, A002860).

Latin squares

Latin squares have been known since medieval times. However, the name "Latin square" (*quarré latin*) is from the eighteenth century and was coined by the great Swiss mathematician and physicist Leonhard Euler. Euler (1776; 1782) used Latin squares as a starting-point for the construction of magic squares. Latin squares were introduced into statistics by the famous mathematician and biologist Ronald A. Fisher.

1	4	7	2	5	8	3	6	9
2	5	8	3	6	9	4	7	1
3	6	9	4	7	1	5	8	2
4	7	1	5	8	2	6	9	3
5	8	2	6	9	3	7	1	4
6	9	3	7	1	4	8	2	5
7	1	4	8	2	5	9	3	6
8	2	5	9	3	6	1	4	7
9	3	6	1	4	7	2	5	8

Figure 1. A traditional Sudoku grid of order nine.

1	2	3	4	5	6	7	8	9
2	3	4	5	6	7	8	9	1
3	4	5	6	7	8	9	1	2
4	5	6	7	8	9	1	2	3
5	6	7	8	9	1	2	3	4
6	7	8	9	1	2	3	4	5
7	8	9	1	2	3	4	5	6
8	9	1	2	3	4	5	6	7
9	1	2	3	4	5	6	7	8

Figure 2. A normalized Latin square of order nine which has been used for the derivation of the Sudoku grid in Figure 1.

In Chapter 8 of his influential work "Statistical Methods for Research Workers" (Fisher, 1925) he demonstrated the use of Latin squares for the design of experiments.

Latin squares have also played an eminent role in statistical sampling (Raj, 1968). Sampling schemes based on Latin square sampling have only one sampling unit in each row and column. Conover (1975) generalized this concept to an arbitrary number of dimensions. His methodology was formally published as "Latin Hypercube sampling" in McKay *et al.* (1979)

and further refined by Iman & Conover (1982) and Stein (1987) by inducing rank correlation among the variables.

Sudoku sampling

So far we have seen that a Sudoku grid is a special type of Latin square and that Latin squares can be used for sampling. This naturally leads to the idea of using Sudoku grids for sampling. I shall now elaborate this idea.

To obtain a sampling scheme based on a Sudoku grid, several steps have to be taken. First we have to generate a Sudoku grid of order *n*. In the same way as Euler used Latin squares as a basis for deriving his “*quadratis magicis*”, I use Latin squares as a basis for deriving Sudoku grids. Let us start with a Latin square of order *n* in its normalized, reduced or standard form. This is a Latin square having its first row and first column in natural order (*i.e.*, 1, 2, ... *n*). A normalized Latin square of order *n* can be constructed by applying some modular arithmetic (modulus *n*). An example of a Latin square of order nine is given in Figure 2. Note that this configuration is not the only normalized Latin square of order nine that exists. Indeed, it is only one example out of a total of 377597570964258816 possible configurations (Sloane, 2006, A000315).

A normalized Latin square can be converted into a Sudoku grid by enforcing the block constraint. That’s not hard to accomplish. Some rearrangement of columns will do the trick (compare Figures 1 and 2). The resulting Sudoku grid is only one of many valid configurations (Sloane, 2006, A107739). The other grids can be derived by permuting digits (recoding), bands (horizontally adjacent blocks), stacks (vertically adjacent blocks), rows within bands, and columns within stacks. All resulting grids will be true Sudokus because these permutations respect the rule that each digit may occur only once in each row, column and block.

Having obtained a valid Sudoku, the next step is to sample all cells with a specific digit. An example of a Sudoku sampling scheme of order nine is given in Figure 3. Another example of order 100 is given in Figure 4.

A simulation experiment

Sudoku sampling is a special case of Latin hypercube sampling that also respects the block constraint. As such, Sudoku sampling will generally result in a more even coverage of sampling space. This will be illustrated by a limited simulation experiment.

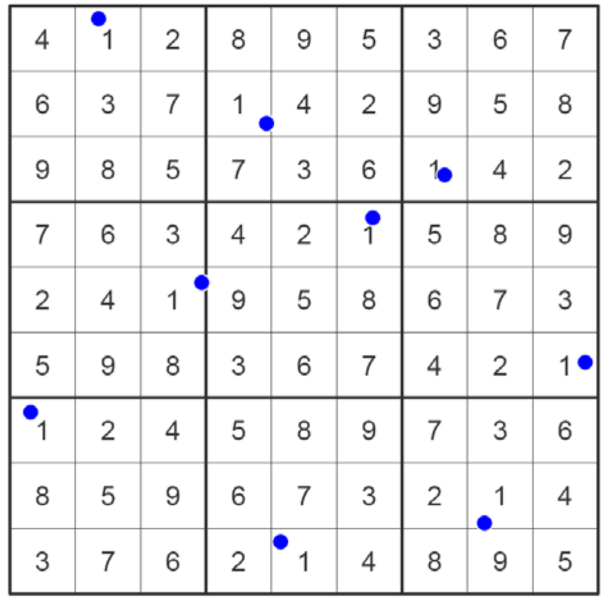


Figure 3. A Sudoku sampling scheme of order nine.

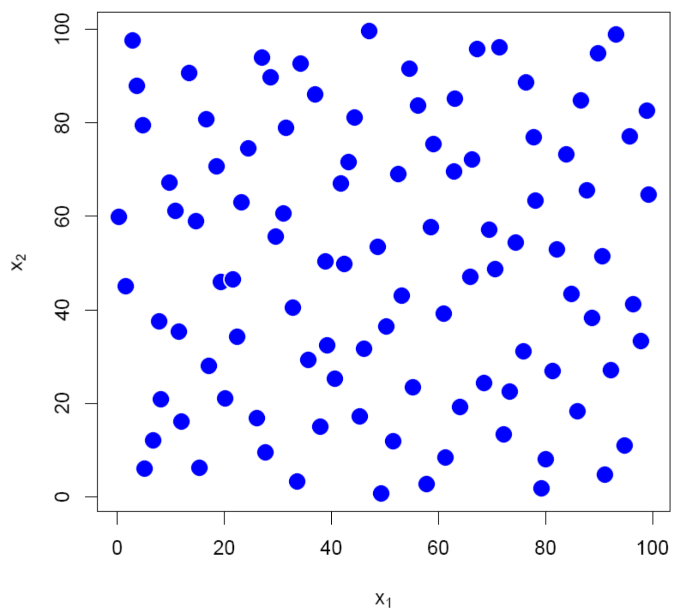


Figure 4. A Sudoku sampling scheme of order 100.

Three sampling methods will be applied to estimate the mean density of a bivariate standard normal distribution. The sampling methods are: simple random sampling (SRS), Latin hypercube sampling (LHS), and Sudoku sampling (SS). All methods are known to give unbiased estimates. Each sampling method has been repeated 1000 times in order to estimate the standard error of the mean density. The sample size is 100. The results are given in Figure 5. It can be concluded that Sudoku sampling resulted in the highest precision.

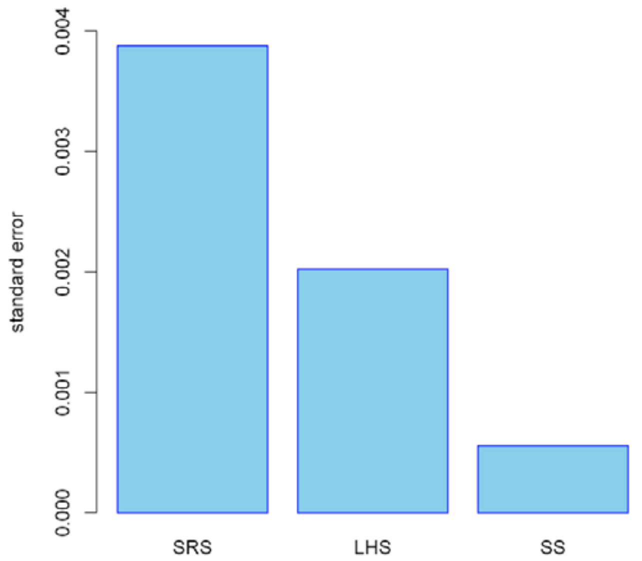


Figure 5. Standard errors obtained by means of simple random sampling (SRS), Latin hypercube sampling (LHS) and Sudoku sampling (SS) for estimating the mean density of a bivariate standard normal distribution.

Conclusions

Sudoku sampling seems to be a promising sampling method when the aim is to evenly cover sampling space. More research is needed to explore its properties, efficacy and efficiency. For the sake of clarity, all examples in this paper were two-dimensional. However, the method can be generalised to an arbitrary number of dimensions. Although not addressed here, Sudoku grids also seem to be promising for the design of experiments.

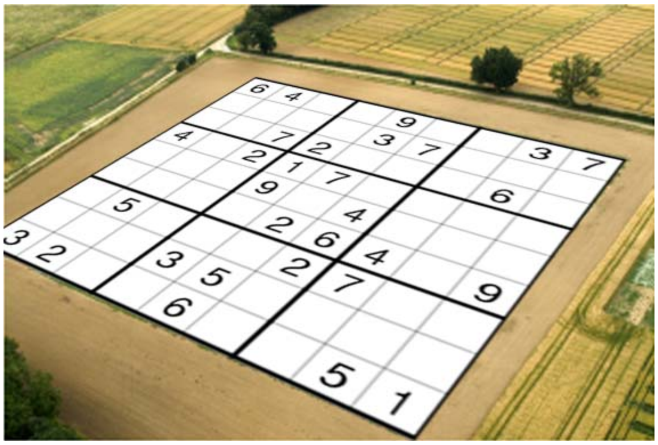


Figure 6. Sudoku can be used for designing field experiments.

References

Conover, W.J., 1975. On a better method for selecting input variables. Unpublished manuscript reproduced in appendix A of J. C. Helton and F. J. Davis, 2002. Latin Hypercube Sampling and the Propagation of Uncertainty in Analyses of Complex Systems. Sandia National Laboratories Albuquerque, New Mexico and Livermore, California, report SAND2001-0417

Euler, L. 1776, 1849. De quadratis magicis. Presented to the St. Petersburg Academy on 17 October 1776. Published in *Commentationes arithmeticae* 2, 1849, pp. 593-602. Reprinted in L. Euleri Opera Posthuma 1, 1862, p. 140-151. Available at www.eulerarchive.org

Euler L., 1782. Recherches sur une Nouvelle Espèces de Quarrés Magique. Verhandelingen uitgegeven door het Zeeuwsch Genootschap der Wetenschappen te Vlissingen 9: 85-239

Felgenhauer, B. & F. Jarvis, 2005. Enumerating possible Sudoku grids. http://www.afjarvis.staff.shef.ac.uk/sudoku

Fisher, R.A., 1925. Statistical Methods for Research Workers. Oliver and Boyd, Edinburgh, 270 pp.

Iman R.L. and W.J. Conover, 1982. A distribution-free approach to inducing rank correlation among input variables. Commun. Stat., B11(3): 311-334

McKay, M.D., W.J. Conover, and R.J. Beckman, 1979. A comparison of three methods for selecting values of input variables in the analysis of output from a computer code. Technometrics 21:239-245

Raj, D., 1968. Sampling Theory. McGraw-Hill, New York, 302 pp.

Sloane, N. J. A, 2006. The On-Line Encyclopedia of Integer Sequences, http://www.research.att.com/~njas/sequences/A107739

Sloane, N. J. A, 2006. The On-Line Encyclopedia of Integer Sequences, http://www.research.att.com/~njas/sequences/A002860

Sloane, N. J. A, 2006. The On-Line Encyclopedia of Integer Sequences, http://www.research.att.com/~njas/sequences/A000315

Stein, M. 1987. Large sample properties of simulations using latin hypercube sampling. Technometrics 29: 143-151

Author's profile

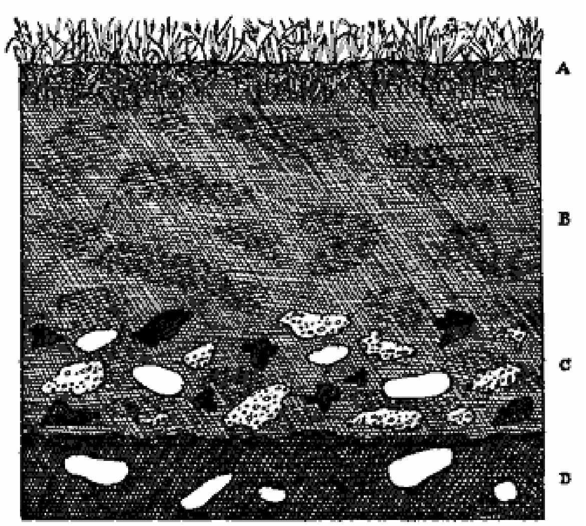
Dennis Walvoort has been practising pedometrics for more than a decade. He comes from the The Achterhoek, and is currently a researcher at Alterra, Wageningen University and Research Centre, The Netherlands. His specialty and research interests are in Pedometrics, integrated water resources management, geostatistics, and Geographical Information Systems. He lives, teaches, writes, and plays Sudoku on the North bank of the Rhine.

Do you know…

The number of worms which live within an acre of garden soil is 53,767 and they weigh 356 pounds. This estimate is given by Charles Darwin (1881) in his book "The Formation of Vegetable Mould through the Action of Worms". Darwin loved earthworms, he played music to them, and credited them with great intelligence. He also loved exact number, and in fact the number is based on a more conservative calculation by Hensen (1877) Zeitschrift fur wissensch. Zoolog. Bd. xxviii., 1877, p. 360. Hensen estimated the number of worms in a hectare of land is 133,000 and the average mass of a single worm is three grams. However Darwin added:

"It should, however, be noted that this calculation is founded on the numbers found in a garden, and Hensen believes that worms are here twice as numerous as in corn-fields. The above result, astonishing though it be, seems to me credible, judging from the number of worms which I have sometimes seen."

Earthworms are responsible for transport of soil within the soil profile and across the hillslope. Some even believed they are the cause of soil spatial variation. Darwin observed that small objects left on the surface of the soil will soon get buried, and that large stones sink slowly downwards through the action of earthworms.



Darwin's sketch of a soil profile. A, turf; B, vegetable mould without any stones; C, mould with fragments of burnt marl, coal-cinders and quarts pebbles; D, subsoil of black, peaty sand with quartz pebbles. (Darwin, 1881)

Worms burrow into subsoil, ingest soil materials, and bring fine soil material to the surface. Larger particles, such as gravels, will be left behind and sunk in the profile. With time, worms will produce a texture contrast layer, fine materials overlying coarser materials, called stone lines.

Darwin summarised the amount of fine earth brought to the soil surface by earthworms: for a dry, sandy, grass-field: 56 mm in 10 years. While for an argillaceous, very poor, and only just converted into pasture (so that it was for some years unfavourable for worms), the amount is 21 mm in 10 years. And the worms produced an average of 6 tons of the castings annually on a hectare of land.

Darwin further made a soil inference:

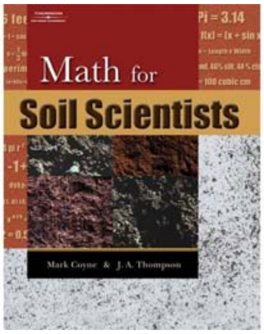
If the number of worms lived in an old pasture land is half of the garden soil, or 26,886 worms, and taking an average of 15 tons as the weight of the castings annually thrown up on an acre of land, each worm must annually eject 20 ounces. A full-sized casting at the mouth of a single burrow often exceeds, an ounce in weight; and it is probable that worms eject more than 20 full-sized castings during a year. If they eject annually more than 20 ounces, we may infer that the worms which live in an acre of pasture land must be less than 26,886 in number.

Our revered pedometrician Richard Webster is also fond of earthworms, as shown in his 1965 article in Nature, *A horizon of pea grit in gravel soils*. The paper doesn't contain any statistics, only two graphs of the particle-size distribution of the soil horizons. Dick noticed that earthworms can penetrate to sufficient depths to avoid extreme condition of drought and frost, but they find it difficult to penetrate gravel. For survival in gravel soils, they retire to that part of soil where the gravel surface is deepest, at the same time furnishing their quarters with a few small stones with size 2-5 mm.

To summarise, Darwin wrote: "It may be doubted whether there are many other animals which have played so important a part in the history of the world, as have these lowly organized creatures."

Book Review

Math for Pedometric?



Math for Soil Scientists, Mark S. Coyne and James A. Thompson, Math for Soil Scientists, Thomson Delmar Learning, Clifton Park, NY (2006) ISBN 0-7668-4268-1 US$ 26.95, 285 pp.[1]

It's always intrigued me why in American English the abbreviation is 'math' and not maths as for example in the British and Australian dialects — it sounds almost as if there is only one mathematic in the US and several mathematics in other places. [Or even pedometric in the US and pedometrics elsewhere.] (I guess it's a lot like the 'aluminum' aluminium divide [but that has something to do with the transient neologisms of Sir Humphrey Davy.])

This title suggests this is a textbook on maths for soil scientists. What is it really?

It covers a range of topics in soil physics, chemistry, biochemistry and biology which require some basic calculations. I guess pedology — if it's covered at all (doesn't it require calculations? Or is that what we're doing?) — is dealt with by some fairly basic statistics. The topics completely enumerated are basic calculations, significant figures, metric units, converting units, soil texture and surface area, bulk and particle densities, soil water, soil strength and structure, water and air flow, soil temperature, chemical buffering, equilibrium concentrations, redox reactions, kinetics, isotopes, microbial growth, counting microbes, decomposition rates, respiration, mineralisation, immobilization, quantifying microbial processes, microbial ecology and diversity, fertiliser recommendations, lime requirement, application rates and nutrient availability, pH, cation and anion exchange capacity, solubility and solution concentration, descriptive statistics, error analysis, inferential statistics, and finally sampling. Phew! (Or too many?)

The book is a bit limited mathematically in that it doesn't get as far as the differential or integral calculus, and I don't recall seeing a matrix. However even as a fairly experienced soil scientist I learned a few new things and re-learned much that I had forgotten. I was amazed to see that the acre-inch is a unit still in use. (I wonder if the foot-poundal is still out there – this used to flummox me in High School – and those from non-anglophone countries will wonder what I'm going on about.) The sooner we all move to SI the better! The rockets will get to Mars!

Some of the chapters are perhaps too brief and therefore are of limited use. For example, I contrast the five pages on sampling with the recent 332-page pedometric treatment of the subject (de Gruijter et al., 2006) which I commend to all.

In my experience students really struggle with quantitative concepts and calculations these days — they prefer the visual to the mental. Anything that helps this situation is useful, so this book probably offers a useful response to a recent query like "I am really having problems understanding the equations in soil physics and what they are used for. I was just wondering if you knew of any really good textbooks that explain this equations and their meanings simply?" (The question is of course also an indictment on the quality of my soil physics teaching.) Thankfully, there are many examples and worked problems in the book. But here lies an enormous problem for us, the pedometricans – lots of students have difficult with what amounts to arithmetic without considering the much more abstract concepts with which we deal.

My conclusion is that this is a useful textbook on basic calculations for introductory and intermediate courses in soil science. I guess it's a gentle tutorial guide for instructors and undergraduates. This book is different and I think that it's a good start. Perhaps some more advanced techniques using differential and integral calculus and adsorption isotherms and fitting kinetics properly using non-linear models could be added in future. Most of all I liked the diversity of applications. It is a good reminder of the breadth of soil science, and thereby a useful diverse list of potential pedometric problems – as I keep saying it's not just geostatistics.

I'm still not entirely sure what 'math' is, but I suspect there are many more than one here. I'm left wondering how a *Math(s) for Soil Scientists* written by a pedometrician might look. Now, there's a challenge, and an opportunity, for ……….. Tomi?

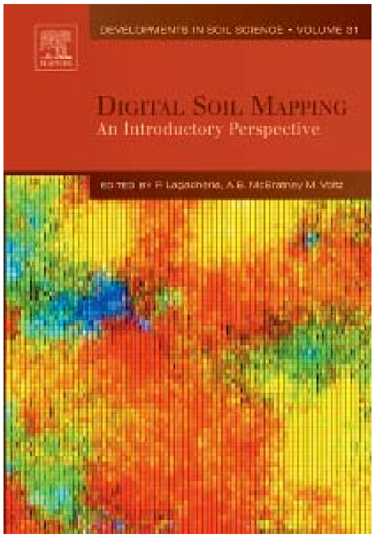
Alex McBratney
The University of Sydney
NSW 2006
Australia

References

de Gruijter et al., 2006 J.J. de Gruijter, D. Brus, M.F.P. Bierkens and M. Knotters, Sampling for Natural Resource Monitoring, Springer, Heidelberg (2006) 332 pp.

[1] This is an altered version of a review that will appear in a forthcoming issue of the *Geoderma*

Upcoming Book



Digital Soil Mapping. An Introductory Perspective (Developments in Soil Science, Volume 31). Editors: Philippe, Alex McBratney, and Marc Voltz. Elsevier. Available in October 2006

This book is the outcome of the first Global Workshop on Digital Soil Mapping held 14-17 September 2004 in Montpellier. It compiles the main ideas and methodologies that have been proposed and tested within these last fifteen years in the field of Digital Soil Mapping (DSM). Beginning with current experiences of soil information system developments in various regions of the world, this volume presents states of the art of different topics covered by DSM: Conception and handling of soil databases, sampling methods, new soil spatial covariates, Quantitative spatial modelling, Quality assessment and representation of DSM outputs.

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).

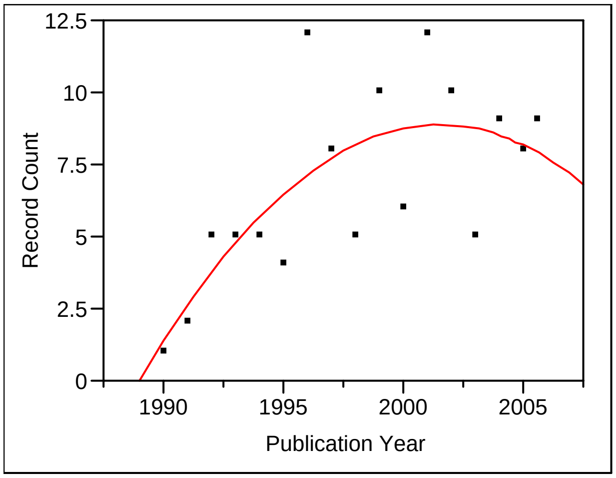


Figure 1. No. of citations of the 1989 Bouma PTF paper. The curve represents a quadratic function fitted to the data.

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; Kneib 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 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.

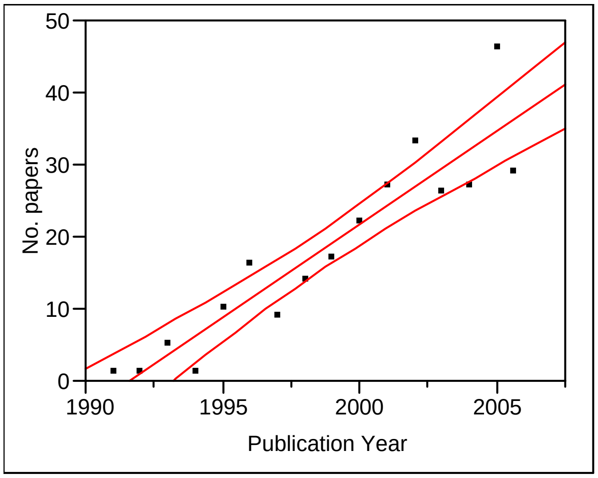


Figure 2. Number of PTF papers as a function of publication year. Straight line represents line of best fit, the enveloped lines represent 95% confidence interval (data from ISI Web of Knowledge).

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.

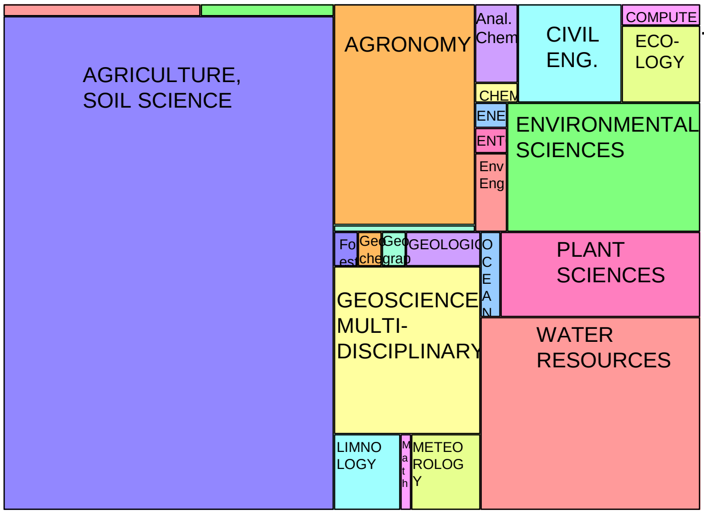


Figure 3. Tree Map of subject category by No. of PTF papers.

- 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%

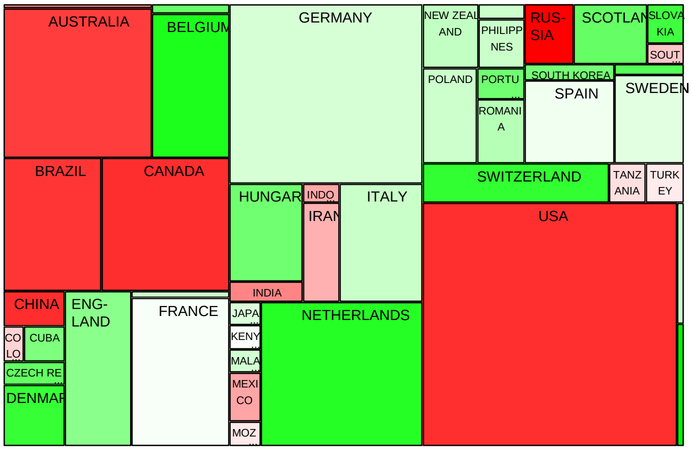


Figure 3. Tree Map of Country by No. of PTF papers coloured by land area. Deep green shows relative small land areas and deep red large land areas.

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 3rd 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%
	Marcel Schaap	USA	12	4.2%
4	Alex. McBratney	Australia	11	3.9%
5	Feike Leij	USA	9	3.2%

References

Briggs, L.J., McLane, J.W., 1907. The moisture equivalent of soils. USDA Bureau of Soils Bulletin 45, 1-23.

Bouma, J., van Lanen, H.A.J., 1986. Transfer functions and threshold values: from soil characteristics to land qualities. In: Quantified land evaluation procedures, Proceedings of the international workshop on quantified land evaluation procedures, 27 April - 2 May 1986. Washington, DC.

Kneib, W., Schroeder, D., 1984. Evaluation of the pedofunction plant-production in Schleswig-Holstein. Zeitschrift fur Pflanzenernahrung und Bodenkunde 147, 425-434.

Lamp, J., Kneib, W., 1981. Zur quantitativen Erfassung und Bewertung von Pedofunktionen. Mitteilungen der Deutschen Bodenkundlichen Gesellschaft 32, 695-711.

Petach, M.C., Wagenet, R.J., Degloria, S.D., 1991. Regional water-flow and pesticide leaching using simulations with spatially distributed data. Geoderma 48, 245-269.

Young MDB, Gowing JW, Hatibu N., Mahoo, H.M.F., Payton, R.W. 1999. Assessment and development of pedotransfer functions for semi-arid sub-Saharan Africa. Physics and Chemistry of the Earth Part B-Hydrology, Oceans and Atmosphere 24, 845-849.

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.

Pedometrician Profile

Dr. Samantha Baxter,
Lecturer in the Department of Soil Science,
University of Reading,
UK.

How did you first become interested in soil science?
While studying a soil science module for my geography degree at Kingston University. The lecturer, Dr Jane Entwistle was very enthusiastic. I was intrigued by the multifaceted nature of soil colloids and their mineralogical properties.

How were you introduced to pedometrics?
I pursued my interests in space and soil science at the University of Reading where I took the M.Sc. in Soil Spatial Analysis and Land Evaluation. This was taught mainly by Professors Stephen Nortcliff and Margaret Oliver. I was taught about soil as a complex continuous medium and introduced to geostatistics as a means to quantify the spatial variation of soil properties.

What recent paper in pedometrics has caught your attention, and why?
David J. Brown, Ross S. Bricklemyer and Perry R. Miller (2005) Validation requirements for diffuse reflectance soil characterization models with a case study of VNIR soil C prediction in Montana. *Geoderma* 129, 251–267.

The use of visible and near infrared reflectance as a quick, inexpensive tool for soil characterisation with associated data-mining techniques looks like an interesting method to investigate.

What problem in pedometrics are you thinking about at the moment?
How can we use legacy soil data bases to gain information about the state of the soil in space and time? The fertility status of agricultural top-soil has been monitored for several decades in different countries at different spatial scales. Such databases are not always immediately suitable for spatial analysis and digital soil mapping, and various questions are raised. For example, how we deal with imprecise spatial coordinates? How do we use data when they are collected from different depth intervals? How can we integrate data collected on coarse scales in the field with those measured at finer scales in the laboratory?

What big problem would you like pedometricians to tackle over the next 10 years?
Quantifying soil function in response to different climate change scenarios.

Non-Pedometrician Profile

Prof. Nunzio Romano

Professor of Agricultural Hydraulics
University of Naples "Federico II",
Italy

How did you first become interested in soil science?
During the second semester of courses when attending my Ph.D. in Hydraulic Engineering.

What are the most pressing questions at the moment in your area of soil science?
To improve the prediction of the hydraulic conductivity function; to have more tools so as soil hydraulic behavior can be incorporated in simulation models at larger scales with a more functional view.

What statistical and mathematical methods are used in your area of soil science?
Stochastic/Geostatistic methods;
Analytical and numerical techniques to solve differential equations;
Perturbation methods;
Transformation and spectral methods.

Are you aware of any work by pedometricians that might be relevant to your science?
Yes, I follow with interest the works by pedometricians.

What big problem would you like pedometricians to tackle over the next 10 years?
(i) the scaling problem in soil hydrology, and to deal more specifically with the determination of aggregated/ effective soil hydraulic parameters,
(ii) including information on soil structure (for large scale applications, better if soft information in the sense of pedotransfer functions) to take a big step forward in gaining more reliable predictions of unsaturated hydraulic conductivity of soil.

Pedometrics website

Pedometrics website recently got a facelift. Thanks to Tomislav Hengl, our webmaster, we can now post articles, discussion and job seeking information. So we should use it.

When I Google "Pedometrics" it gives 15100 sites, but I can only find few groups calling themselves Pedometrics with *specific pedometrics content* in the web page. (This excludes sites that only list Pedometrics as one of their research topic, and conferences). I think the www is a good way of promoting pedometrics and your work. This list is what I can find, and may not complete. So, start your Pedometrics page.

- Lee Buras, Iowa State University
http://www.pedology.ag.iastate.edu/

- Pierre Goovaerts
http://home.comcast.net/~goovaerts/pedometrics.html

- Sabine Grunwald, University of Florida
http://grunwald.ifas.ufl.edu/Pedometrics/what_is_pedometrics.htm

- Alex. McBratney, The University of Sydney
http://www.usyd.edu.au/su/agric/acpa/people/alex/Pedomagician.htm

- Jim Thompson, Western University Virginia
http://www.caf.wvu.edu/plsc/soilscience/Thompson/Research/pedometrics/index.html

These are sites that we can contribute, and make Pedometrics more noticeable:

- Wikipedia
http://en.wikipedia.org/wiki/Pedometrics

- Amazon Pedometrics Listmania!
http://www.amazon.com/gp/richpub/listmania/fullview/RXV9GVC2ES2YE

Upcoming Events

Workshop on modelling of pedogenesis. 2-4 October 2006, Orleans, France.
http://soilmodel-workshop.orleans.inra.fr/

International Symposium on Terrain analysis and Digital Terrain Modelling, 23/-25 November 2006, Nanjing, China. www.tadtm2006.net/

International Symposium on Advances in GIS. 10-11 November 2006, Arlington, Virginia, USA www.itc.nl/acmgis06

Pedometrics 2007. 27-30 August 2007. Tuebingen, Germany.
http://www.pedometrics.de

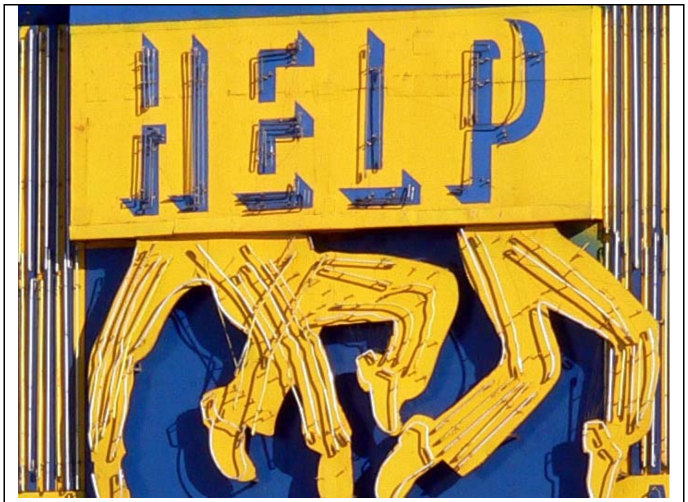
Global Workshop on High Resolution Digital Soil Sensing & Mapping. 5-8 February 2008. Sydney, Australia.
http://www.digitalsoilmapping.org

COMING SOON TO YOUR FAVOURITE PEDOMETRICS JOURNALS

Vacant Position

- **Postdoctoral Research Fellow**

Job description: "Methods of spatio-temporal analysis of landscape variability" The position is to be filled as soon as possible. The successful applicant will develop new methods for analysing spatio-temporal variability in agricultural landscapes and apply these methods within ongoing ZALF research projects. Using (geo-)statistical and/or mathematical approaches (e.g., wavelet analysis), space-time structures of different landscape compartments (soil, vegetation, land use pattern etc.) have to be analysed based on data provided by non-invasive methods. For this purpose, high resolution digital elevation models, remote sensing data as well as geophysical information will be used. Procedures of multidata fusion should also be developed. In addition, the researcher will contribute with statistical consulting activities to other research projects. The position is initially limited for one year with the option of extension for two more years (1+2). A continued collaboration is intended.
Deadline to apply: 31/10/2006
Requirements: Applicants should have a PhD in agriculture, geosciences or applied geostatistics with a focus on GIS-based, spatial modelling (peer-reviewed papers), excellent skills in geostatistics and multivariate data analysis as well as software knowledge (ArcInfo/ArcGIS, ecognition, ERDAS Imagine, SAGA, R and its spatial statistical packages, etc). Willingness of interdisciplinary scientific work is a precondition, knowledge of German language will be helpful, but is not essential.
More information: Prof. Dr. habil. Michael Sommer, phone: 0049 33432 82282
http://www.pedometrics.org/jobs.asp?id=20



Looking for: Articles, photos, information about your work, theses, upcoming events, pictures, art works, poems, etc. Send to: vchair@pedometrics.org.

Pedometrics 2007

The biannual Pedometrics conference will take place at the Institute of Geography, University of Tübingen, Germany, 27 to 30 August 2007.

The conference covers all major topics of pedometrical research and application. It comprises geostatistics, the research fields of the related working group on digital soil mapping, proximal soil sensing, as well as soil fractals, wavelets and spatial accuracy.

We welcome all soil scientists, soil surveyors, soil geographers, environmental scientists and engineers, GIS specialists, geostatisticians, statisticians, and mathematicians to join the conference and exchange their knowledge.

Pedometrics 2007

A Pre-Conference Workshop on Uncertainty Propagation Analysis will be held by Gerard B.M. Heuvelink and James D. Brown. A Field trip introducing the soilscapes and the famous vineyards of Baden-Wurttemberg follows the conference.

Online abstract submission will start in October 2006.

For more information, visit: www.pedometrics.de