PEDOMETRON

PEDOMETRON Sydney, September 1994

Newsletter of the International Society of Soil Science Working Group on Pedometrics (PM) No 2

Pedometrics matures

Pedometrics, the application of statistics and probability to soil, has been with us for most of this century. Yet it was only in 1989 that the Pedometrics Working Group of the International Society of Soil Science first gathered under the auspices of the Bernoulli Society In Leuven. Now the Group can feel that it has fledged: for in September of 1992 it held its first conference at the International Agricultural Centre in Wageningen, with 80 participants from some twenty countries.

Professor Van Vloten of the Netherlands Ministry of Agriculture welcomed the gathering with the good news that the soil is vital, and that we must know how it is distributed in all its variety. That set the scene. It was followed by **R. Webster's** plenary review of the development of pedometrics from its early days of agricultural uniformity trials to prediction in civil and military engineering, to pedogenesis, to the analysis of soil structure, and to modern geostatistics. The last dominated the conference, reflecting the current interest and potential benefits now recognized to derive from its application in land resource assessment and environmental management. The keynote papers by **D.E. Myers, H. Wackernagel, A.B. McBratney, and A. Stein** were on this theme, either wholly or in part, as were most of the 20 volunteered papers and some 15 posters illustrating case studies. The proceedings were published in a special issue of *Geoderma* vol. 62, Nos. 1-2.

The formal part of the conference ended with a discussion led by **S. Yates** and **J. Bouma** and mediated by **P. Burrough**. But the enthusiasm continued with a stimulating seminar on fuzzy sets and fuzzy logic led by Alex McBratney and supported with contributions from **J.J. de Gruijter, I. Odeh, Huajun Tang** and P.A. Burrough in the Winand Staring Centre.

Altogether this was an excellent first conference of the Pedometrics Working Group, for its coverage of spatial statistics in soil science and its application and for the standard of the presentations. The International Society is deeply grateful to the organizing committee, and in particular to Dr J.J. de Gruijter and Dr A. Stein, for all their hard work behind the scenes.

Prof. R. Webster
ETH Zurich

Secretarial notes

In a ISSS council-meeting at the 15th International Congress of Soil Science in Acapulco, August this year, the council reviewed the activities of the various Working Groups, in order to decide on their continuation. On the basis of our report on the past four years and our plans for the next period, the council approved with continuation of our Working Group.

It is evident that there is a broad need for a living, stimulating network for pedologists to communicate about quantitative methods. We got a formal 'green light' again. Let's show that our Group Works!

Also at the occasion of the Congress in Acapulco the chairmanship of the Working Group changed: **Don Myers** (Univ. of Arizona, Dept. of Mathematics) was succeeded by **Alex McBratney** (Univ. of Sydney, Dept. of Agricultural Chemistry & Soil Science).

Thank you Don for the contributions that you made to the WG, especially to its crucial first conference. We heartily welcome Alex, the initiator of the WG, as our new chairman. Thank you in advance for your willingness to devote your time and energy to common interests through the WG.

ISSS WG on Pedometrics; provisional plans for 1994-1998

Meetings

1995

1 day workshop in association with SSSA annual meeting, in October, St. Louis, Missouri, USA.

Theme: Fuzzy sets in soil science.

Setup (provisional): 4 sessions, 3 talks per session, half hour per talk

Session 1: Fuzzy sets, fuzzy measurements and fuzzy decisions

Session 2: Application to soil classification

Session 3: Application to soil mapping

Session 4: Application to land evaluation.

1996

1 day conference in Australia, in association with meeting of the ASSS.

Venue: University of Melbourne

Subject: general

1 day workshop in Wageningen, the Netherlands, as part of meeting organized by ISSS Subcommission on Land evaluation.

Theme (provisional): 1. Soil sampling. 2. Statistical aspects of model validation.

1997
3 day conference in USA, August/September
Venue: University of Wisconsin
Organisation: **Dr Kevin McSweeney** (Dept of Soil Science)
Subject: general

1998
1 day symposium in association with the ISSS meeting in August, in Montpellier, France.
Subject (provisional): Scale in soil science.

Training

Two one-week self-financing training courses to be developed each with five expert instructors.

Venue: Netherlands, US and Australia in different years. At present the courses will be presented in association with Graduate School of Production Ecology, Agricultural University, Wageningen, Dept. of Soil Science, University of Wisconsin-Madison and Dept. of Agricultural Chemistry & Soil Science, University of Sydney.

Course 1: Geostatistics for problem solving in soil science
Course 2: Fuzzy sets for problem solving in soil science

Development of a course book and presenters to be decided. Course coordinators are **Dr Alfred Stein** for course 1, and **Alex McBratney** for course 2. If anyone is interested in these courses please contact them.

Newsletter

The Newsletter will be issued at least twice per year. **Dr I.O.A. Odeh** (University of Sydney, Dept. of Agric. Chem. & Soil Sci.) has agreed to edit it for the next two years.

ISSS WG on Pedometrics; report on 1990 - 1993

(Report presented to ISSS)

The major activity of the Working Group was the organisation of its first international conference: PEDOMETRICS-92 "Developments in spatial statistics for soil science". It was held in Wageningen from 1-3 September 1992, with 80 participants from some twenty countries. The aim was to present current statistical research in soil science, to exchange new ideas on statistical procedures and important general questions from soil science and to bring statisticians and soil scientists together.

R. Webster presented a plenary review of the development of pedometrics. Four major themes were distinguished: spatial interpolation, multivariate spatial statistics, sampling strategies and the use of prior information. Geostatistics generally dominated the conference, reflecting the current interest in it and the potential benefits now recognized to derive from its application in land resource assessment and environmental management. The keynote papers by D.E. Myers, H. Wackernagel, A.B. McBratney and A. Stein were on this theme, as were most of the 20 volunteered papers and some 15 posters illustrating case studies. The formal part of the conference ended with a discussion led by S. Yates and J. Bouma.

As an addendum to the conference the Winand Staring Centre hosted an informal presentation of fuzzy classification and fuzzy logic on 4 September. It was led by A.B. McBratney with contributions of I. Odeh, Huajun Tang, P.A. Burrough and J.J. de Gruijter.

The proceedings of the conference have been published as a special issue of Geoderma (1994, Vol. 62, Nos. 1-2).

A Newsletter on Pedometrics has been issued to communicate plans and activities of the Working Group, to signal *unsolved problems and ongoing research in pedometrics, and to announce reports and theses.*

The "Best publication in pedometrics" for 1992 has been awarded, the one for 1993 is on its way (see elsewhere in this Newsletter).

Plans for the next four years have been developed and discussed with colleagues involved. These include a meeting each year and two courses (see elsewhere in this Newsletter).

Dr J.J. de Gruijter, Secretary
Wageningen

Minutes of business meeting at Acapulco

At the 15th International Congress of Soil Science in Acapulco (Mexico) the Working Group on Pedometrics had a business meeting on the following agenda:

1. Report on activities in 1990-1993, presented by the secretary (see above).
2. Change of chairmanship.
3. Plans for the period 1994-1998, presented by the new chairman.

See elsewhere in this Newsletter for information on these points.

The following topics were discussed by the participants:

Meetings

It was noted that the original schedule for Pedometrics conferences as presented in the meeting did not anticipate an event in Europe until 1998 in Montpellier, and that would imply too long a period without any Pedometrics meeting in Europe. In response to this it was proposed and agreed that the WG co-operates with the Subcommittee on Land Evaluation to organise a 2 or 3 day workshop in 1996 in Wageningen.

Mailing list

It was noted that special attention is needed for updating the mailing list. Announcements in the ISSS Bulletin are useful, but these have a limited distribution only. As a complementary action it was suggested to screen the literature for authors in Pedometrics.

Newsletter

It was generally considered as useful to have a newsletter for communication, but it was stressed that this is only possible as long as somebody is prepared to do the editing and as long as there is enough response and input from the readership.

Best Paper Award

During its first conference in 1992 in Wageningen, it was decided that the Working Group on Pedometrics will issue a yearly award for the best paper in Pedometrics. The state of affairs is now as follows. It was explained that for 1992 the selection was done by the Chairman and the Secretary of the WG, due to lack of response from an ad hoc committee that was originally formed to do the selection. To reduce personal bias and still have a practical procedure, the plan is for each year to ask a well-known expert to make a preselection of 5 papers, from which the readership of the Newsletter is to select the best paper. In order to further reduce personal bias it was suggested to increase the number of papers to be preselected to 10 or 15.

Best Paper for 1992 is that of **Tang & van Ranst Huajun Tang & Eric van Ranst** (1992). Testing of fuzzy set theory in land suitability assessment for rainfed maize production. Pedologie XLII, 129-147.

Citation:

For a significant advance in the quantification of land evaluation methods allowing further critical analysis.

Best Paper Award for 1993:

The following preselection of papers, the abstracts of which are presented below, has been made by R. Webster. The best paper will be chosen by a popular vote of the readership of the newsletter. **Readers are please asked to read through the abstracts and vote on the ballot paper provided.**

Bierkens, M.F.P & Burrough, P.A. 1993. The indicator approach to categorical data. Parts I and II. Journal of Soil Science 44, 361-381.

Abstract:

In this paper, the first of two, we present the indicator approach to describe the spatial variability of categorical soil data. Indicator kriging is used to obtain conditional probability of soil data at unsampled locations. A new concept of map purity is defined. Using Sequential Indicator Simulation (SIS), equi-probable realizations of classified maps can be drawn which reflect the probability of occurrence of each class and honour the observed spatial connectivity patterns of classes and the classes found at the observation sites. When categorical data are used for land resourse assessment, the uncertainty accruing from map impurities can be assessed by performing the analysis on each of the maps generated by SIS. In part II of this series, the methods are demonstrated using a case study on the mapping of water table classes and a land use suitability analysis for pasture.

Crawford, J.W., Ritz, K. & Young, I.M. 1993. Quantification of fungal morphology, gaseous transport and microbial dynamics in soil: an integrated framework using fractal geometry. Geoderma 56, 157-172.

Abstract:

The consequence of heterogeneous structure for nutrient acquisition by soil fungi, microbial dynamics and transport in soil are studied. Fractal geometry provides the unifying theme and forms the basis of a theoretical framework for studying dynamics in heterogeneous media. The interpretation of foraging strategies of soil fungi are presented which suggest that the process governing branching and hyphal mass distribution are independent. Classical diffusion is shown to be inappropriate for the study of diffusion in heterogeneous soil and a new theory is proposed which incorporates heterogeneity and pore tortuosity. The consequences of structure for microbial spatial and temporal dynamics are examined and it is found that an understanding of these and related processes such as nutrient cycling must include the role of structure. While stressing the need to appreciate the relevance of the theory to any particular application, it is shown that quantitative fractal geometry can yield insights into the mechanism whereby spatial organisation influences the interaction between structure and biotic processes in the soil.

Goovaerts, P. & Chiang, C.N. 1993 Temporal persistence of spatial patterns of mineralizable nitrogen and selected soil properties. Soil Science Society of America Journal 57, 372-381.

Abstract:

To assist N-fertilization planning and to avoid N-pollution problems, an evaluation of soil N-mineralization ability is imperative. In addition to the accuracy of that evaluation under laboratory conditions, knowledge of its spatial and temporal variation is helpful for further analyses. This study aimed to characterize the spatial variation of soil mineralizable N, to investigate its spatial relation with basic soil properties (oxidizable C, pH, electrical conductivity, exchangeable NH_4, and gravitational water content), and to examine the changes in the spatial patterns and correlation structures during the winter. In October and April 1988, 73 samples were collected from spots 1 to 57 m apart in a long-term fallow plot. Nitrogen-mineralization ability was measured through an anaerobic incubation experiment. The study of scale-dependent correlation structures and spatial patterns was carried out through a multivariate geostatistical analysis. The mean and standard deviation of most properties studied changed slightly during the winter. Nitrogen-mineralization ability was mainly explained by the amount of oxidizable C, which appeared to be well correlated with gravimetric water content. The spatial structure of all the soil properties measured was characterized by large variation at small distance (<1 m) and by the independent at observations beyond 12 m. In addition, most of the spatial patterns showed a temporal persistence, i.e., high and low values generally occurred at the same locations before and after *winter.*

Rappoldt, C. 1993. Modelling the geometry of worm burrows systems in relation to oxygen diffusion. Geoderma 57, 69-88.

Abstract:
An approximate method is described that enables the application of diffusion models to a system of worm burrows. The geometry of the real burrow system is replaced by a model system consisting of soil cylinders with different radii, each with a worm burrow along its axis. A process model, describing for instance oxygen diffusion and respiration, is then applied to the cylinders of the model system. Each cylinder radius represents a characteristic length scale that occurs in the system and a weight factor expresses the relative abundance of each scale. The weights are obtained from the statistical distribution of the distance from a point in the soil to the nearest burrow axis. Hence, application of the method requires distance measurements in three dimensions. In case of randomly located rows, the distance distribution can also be obtained from measurements in a cross section of the system.

As an example, cross sections of sulphide-containing homogeneous clay soil are studied. The black clay has become partly oxic due to the presence of worm burrows from which oxygen has entered the soil. The oxidized soil has a light color. Digitized photographs of cross sections are analysed with the help of an oxidation model randomly positioned burrows. Assuming a constant distance over which oxygen has entered the soil, prediction are made about the pattern of oxidized soil visible at a cross-sectional surface. These model results are compared with the observations. The assumption of a fixed penetration distance does not explain the observed patterns. Differences in burrow age form the most likely explanation.

Rasiah, V., Kay, B.D & Perfect, E. 1993. New mass-based model for estimating fractal dimensions of aggregates. Soil Science Society of America Journal 57, 891-895.

Abstract:
Values of the fractal dimension, D, for soil aggregates may vary with the model used and the assumptions invoked in formulating the model. The objectives of this study were to: (i) develop a new mass-size-based model, not assuming that probability of failure, P, and bulk density, r, are scale-invariant for the estimation of D (defined D_R), and (ii) compare the values of D_R with those obtained using three other procedures. In the first procedure, manually counted aggregate numbers were used in the number-size relation model for the estimation of D (defined D_n). Aggregate numbers were computed, assuming scale-invariant r, in the second procedure and these numbers were used in the same number-size relation model for the estimation of D (defined D_m). In the third procedure, a mass-size-based model, which has an upper limit of D and assumes scale-invariant r, was used for the estimation of D (defined D_T). Aggregate-size distributions and P for different sizes of aggregates arising from fragmentation during wet-sieving in water were obtained for three soils under two cropping treatments (CT) using a modified from of Yoder apparatus. The P of soil aggregates ranged, depending on soil type, CT, and aggregate size, from 0.30 to 0.90. Values of D_R ranged from 2.02 to 3.19 and those of D_m and D_T ranged from 2.32 to 3.28 and from 2.46 to 2.84, respectively. Significant 1:1 linear correlations existed only between D_R and D_m and between D_m and D_n. Values of D_R, D_m, and D_T were strongly influenced by soil type, CT, and estimation model used. The interaction between clay and organic matter content and CT accounted for 74% of the variability in D_R, compared with 54% for D_T and 52% fro D_m.

Perfect, E., Kay, B.D. & Rasiah, V. 1993. Multifractal model for soil aggregate formation. Soil Science Society of American Journal 57, 896-900.

Abstract:
Dry aggregate size and strength distributions are important structural characteristics. We present a theoretical model based on multifractal for predicting one characteristic from the other. For a specified stress, s, the strength of dry aggregate of normalized equivalent cubic length x_* was expressed as a probability of failure, $\{P(x_*)s\}$. A method was developed for calculating $\{P(x_*)s\}$ from tensile strength data. At intermediate levels of stress (0.3 - s - 0.9 MPa), $\{P(x_*)s\}$ decreased with decreasing x_*. A Pareto distribution was used to model this scale

Please indicate your order of preference for the Pedometrics Best Pa
1993 by allocating a number between 1 for best preference a:
preference title:

Bierkens, M.F.P & Burrough, P.A ______________

Crawford, J.W., Ritz, K. & Young, I.M. ______________

Goovaerts, P. & Chiang, C.N. ______________

Rappoldt, C. ______________

Rasiah, V., Kay, B.D & Perfect, E. ______________

Perfect, E., Kay, B.D. & Rasiah, V. ______________

Please send your vote by 15 December, 1994, to the Secretary of the W
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dependency. The distribution's parameters, q and r, determine the probability of failure of the largest aggregate and the rate of change in scale dependency, respectively. The r increased and the q decreased logarithmically with increasing s. The fractal dimension, D, was used to characterize the number-size distribution of dry aggregates after fragmentation. For mass-conserving cubic fragmentation, D is related to $\{P(x_*)s\}$ *by multifractal spectrum,* D ª $\log\{8(2^T - qx_*^{-T})\}/\log\{2\}$. *Previously published dry-sieving data were reanalyzed. The number-size distribution determined by visual counting gave a spectrum of fractal dimensions as predicted by the theory. Values of D ranged from 2.53 at* $x_* = 4.7 \times 10^{-1}$ *to 3.46 at* $x_* = 7.5 \times 10^{-1}$. *The multifractal spectrum was used to estimate q and r inversely. Further research is required to determine the level of stress with these values.*

Best Paper Award for 1994:
Preselection of papers to be made by J.J. de Gruijter. The best paper will be chosen from a popular vote of the readership of the newsletter.

There's nothing new under the sun

Much of modern work in Pedometrics is concerned with spatial variation and mapping of soil properties. Of increasing interest is work on soil uniformity for understanding field experiments and for site-specific soil management. Early work in this area can be found in three papers in 1925 by the Rothamsted soil physicists Keen and Haines. They were concerned with the variation of force for tillage. The first paper describes the instrumentation capable of real-time recording, the second looks at soil uniformity 'by mean of dynamometer and plough'. An isoline map of draft force from that paper is shown below. The final paper dealt with the Rothamsted classical experiments which are in their 151st year. The results for the Broadbalk experiment are shown as a perspective plot (familiar to all users of surface plotting programs) but constructed by quite different means. A perusal of these papers would be quite rewarding.

See Keen, B.A. and Haines, W.B. (1925). Studies in soil cultivation. I, II, III. *Journal of Agricultural Science* **15**, 375–406.

To a soil monolith

{pedology –
is that all there was to it?}

...And that man from the Ministry
That pedological go-and-get-it,
He'll measure you in your pit and
take a likeness of you
With Kodachrome or possibly
Munsell-chip you.

The labmen will then get you
with thin sections vet you
Surmising what's your age.
In jars they'll particle-size you
Endeavouring to analyse you
Since that's now all the rage

Then when you're tabulated
Recorded and debated
And properly written down,
They'll put you in a case
In that Museum place
In Wageningen town.

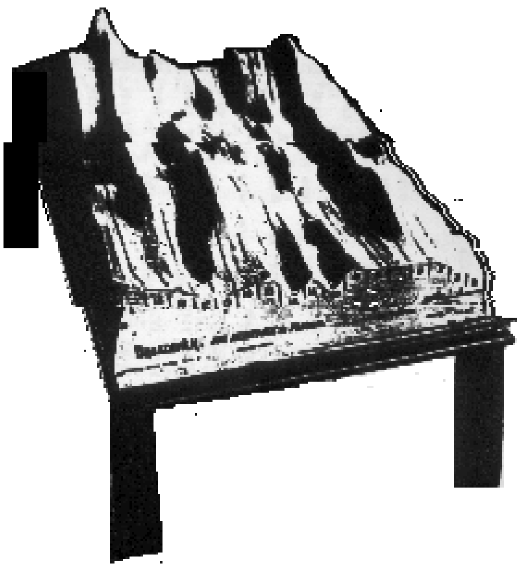
(Adapted and translated by Alex McBratney from the Scots poem 'Sic Transit Gloria Mundi' by J.K. Annand.)

What's new?

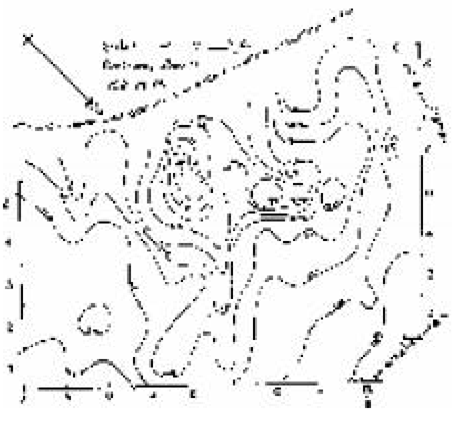
This section highlights topics of recent or emerging importance. The editor would be pleased to receive short articles along the lines of the ones below. (This would be a useful experience for research students.)

Fuzzy sets & semantic uncertainty

There are many occasions in soil science, especially in soil description, when the data represent a concept that is somewhat vague or is qualitative, *e.g.* the degree of aggregate development as



Perspective diagram from 1925!



Soil isodyne map from 1925!

observed in the field. The conventional approach is to divide the data into a few rather coarse categories, e.g. 'apedal', 'poorly aggregated', 'moderately aggregated' and so on. Subsequent Boolean become cumbersome if there are too few the system will be inadequately descriptive. A desirable extension is to define an analogue of an adverb: an operator to qualify a qualifier. This allows us to represent concepts such a 'fairly shallow' and 'extremely shallow'. This can be achieved by applying power functions to a fuzzy set to generate a new set. Fig. 1 illustrates how 'very' and 'fairly' can be represented by squaring and taking the square root of the original function respectively. Having defined several fuzzy sets it is then possible to use a calculus which generalises many of the Boolean logical operation of hard sets (Dubois and Prades 1988; Burrough 1989) making it relatively easy to generate a fuzzy-set representation of the phrase 'fairly, but not very, shallow' as illustrated in Fig. 2. Starting with the set 'shallow' defined above and shown in Fig. 1. We can then generate the set 'fairly shallow' by taking the square root of 'shallow'; then the set 'very shallow' by squaring 'shallow'; then the set 'not very shallow' by negating the set 'very shallow'. Finally we take the intersection of these two sets using the minimum operator producing the final set shown in Fig. 2.

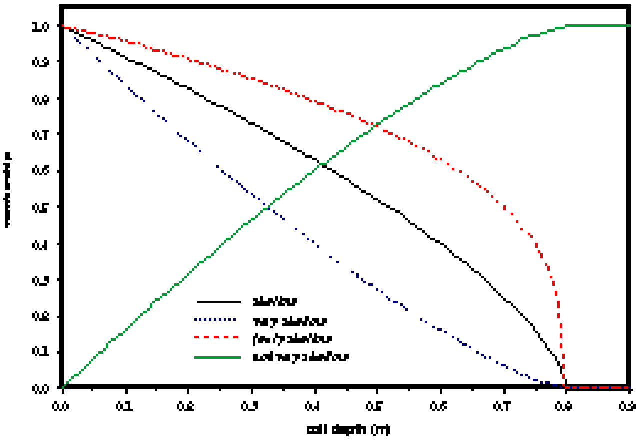


Fig. 1

Triantafilis and McBratney (1992) define a fuzzy set for soil suitability for an accumulated suitability score (s) of the form $\mu_F(s) = e^{-0.1s}$. Odeh et al. (1991) give a fuzzy coding for soil structural form. Burrough (1989) gives further examples.

Triantafilis and McBratney (1992) have mapped *land versatility*, a quantitative substitute for the original notion of land capability, which is defined as the mean of the utility memberships for a range of crops, *i.e.* wheat, pasture, cotton, sunflower etc., this is an example of the complex combination operator (Burrough 1989). Further important work on land evaluation based on a fuzzy set modification to the FAO system has been published by Tang et al. (1991) and Tang and Van Ranst (1992). There is substantial scope for the use of such techniques in environmental soil management where, because of spatial variation, many cheap and somewhat vague measurements may be more useful than a few, expensive and certain measurements. Work is required on a more objective formulation for membership functions.

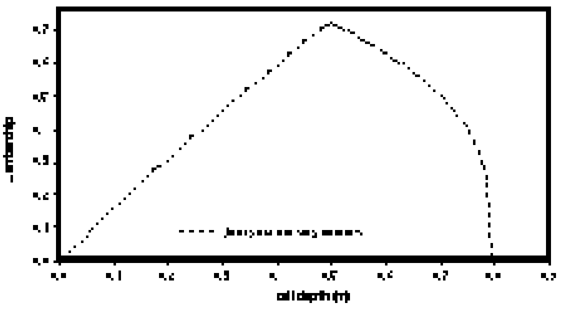


Fig. 2

Abstracted from McBratney, A.B. 1992. On variation, uncertainty and informatics in *formulated and these may be tested to further improve our capacity for spatial prediction.*

As expected, CTI is a useful predictor because it combines contextual site information via the upslope catchment area and slope respectively. Plan curvature was not expected to have a strong predictive power because it does not include contextual information. However, it was significant in predicting A horizon and solum depth along with CTI. This suggests that local-scale pedogenic, as well as hillslope scale, processes are influencing soil profile development. Upslope mean plan curvature provided the best logistic model fit for the probability of an E horizon occurrence. This indicates that the overall upslope convergent and divergent flow processes may control E horizon development. The next best logistic fit was provided by CTI, which in part, measures some of the same types of landscape processes as upslope mean plan curvature.

The second study, which is much more detailed than the first, was carried out in a subcatchment in the Central Mt. Lofty Ranges of South Australia. Five geomorphic attributes, slope gradient, plan convexity and profile convexity, the upslope distance and area, were derived from DEM. Both the root mean square error and mean rank of performance indicate ordinary and universal kriging as the most inferior of all the methods as the methods do not use the covariables. Universal kriging is slightly better than ordinary kriging as the former incorporate "drift" or changing local trends into the kriging equations. Whereas, isotopic cokriging is generally outperformed by multi-linear regression, heterotopic cokriging was more precise as it used more of the local information. However, heterotopic cokriging performed better than all the other methods in predicting topsoil gravel and subsoil clay; regression-kriging model C (regression followed by modelling of the target variable and kriging of regression residuals to a fine grid, and then summing the modelled values and kriged residuals) is best in predicting depth of solum and depth to bedrock. This could be ascribed to different noise-to-signal ratios among the soil variables. Generally, regression-kriging model C is superior to other methods by either coming first or second in mean ranking or standard deviation of ranks as the model involved summation of the regressed and kriged regression residuals of the target variable which compensates for relative insensitivity of either regression or kriging (when used separately) to unsystematic variation of the variables. An added advantage of model C is its flexibility and its potential for the regression part to be replaced by generalised linear or additive models or even the non-linear models, eg. generalised additive, tree-based models or neural networks.

Abstracted from Odeh, I.O.A., Gessler P.E., McKenzie, N.J. and McBratney, A.B. 1994. Using attributes from DEMs for spatial prediction of soil properties. Paper presented at the International Conference on "Resource Technology- RT' 94", The University of Melbourne, Australia, September 26-30, 1994.

References

McKenzie, N.J. and Austin, M.P. 1993. A quantitative Australian approach to medium and small scale surveys based on soil stratigraphy and environmental correlation. Geoderma, 57: 329-355.

Moore, I.D., Gessler, P.E., Nielsen, G.A. and Petersen, G.A. 1993. Soil attribute prediction using terrain analysis. Soil Science Society of American Journal, 57: 443-452.

Odeh, I.O.A., Chittleborough, D.J. and McBratney, A.B. 1991. Elucidation of soil-landform interrelationships by canonical ordination analysis. Geoderma 49: 1-32.

Odeh, I.O.A., McBratney, A.B. and Chittleborough, D.J. 1994. Spatial prediction of soil properties from landform attributes derived from a digital elevation model. Geoderma, in press.

Successful doctoral theses in the field of Pedometrics in 1993 and 1994

(Compiled by J.J. de Gruijter)

Bierkens, M.F.P., 1994. Complex confining layers. A stochastic analysis of hydraulic properties at various scales. Winand Staring Centre, P.O.Box 125, 6700 AC Wageningen, The Netherlands.

Bosma, W.J.P., 1994. Transport of reactive solutes in heterogeneous porous formations. Agricultural University, Dept. of Soil Science and Plant Nutrition, P.O.Box 8005, 6700 EC Wageningen, The Netherlands.

Brus, D.J., 1993. Incorporating models of spatial variation in sampling strategies for soil. Winand Staring Centre, P.O.Box 125, 6700 AC Wageningen, The Netherlands.

Domburg, P., 1994. A knowledge-based system to assist in the design of soil survey schemes. Winand Staring Centre, P.O.Box 125, 6700 AC Wageningen, The Netherlands.

Frapporti, G., 1994. Geochemical and statistical interpretation of the Dutch national ground water quality monitoring network. University of Utrecht, Dept. of Physical Geography, P.O.Box 80115, 3508 TC Utrecht, The Netherlands.

Heuvelink, G.B.M., 1993. Error propagation in quantitative spatial modelling; applications in Geographical Information Systems. University of Amsterdam, Dept. of Physical Geography, Nieuwe Prinsengracht 130, 1018 VZ Amsterdam, The Netherlands.

Jansen, L.L.F., 1994. Methodolgy for updating terrain object data from remote sensing data. Winand Staring Centre, P.O.Box 125, 6700 AC Wageningen, The Netherlands.

Papritz, A.J., 1993. Estimating temporal change of soil properties. ETH Zårich, Institute for Terrestrial Ecology, Grabenstrasse 3, 8952 Schlieren, Switserland.

Robbez-Masson, J-M, 1994. Reconnaissance et delimitation de motifs d'organisation spatiale: application a la cartographie de pedopaysages. (Eng.: Segmentation of textured images: application to the survey of pedologic landscapes.) Laboratoire de Science du Sol, INRA, place Viala, 34060 Montpellier cedex 1, France.

Tang Huajun, 1993. Land suitability classification based on fuzzy set theory and modelling of land production potential of maize and winter wheat in different zones of China. University of Gent, Dept. of geology and soil science, Krijgslaan 281/S8, 9000 Gent, Belgium.

Van Orshoven, J., 1993. Assessing hydrodynamic land qualities from soil survey data. Catholic University of Leuven, Institute for Land and Water Management. V. Decosterstraat 102, 3000 Leuven, Belgium.

Yonghalermchai, C., 1993. Etude d'objets complexes sol/plante, a differents niveaux d'organisation, de la parcelle au paysage. Laboratoire des Sols, Institut National Agronomique, route de Thiverval, 78850 Thiverval-Grignon, France.

Short articles and thesis titles should be sent to:

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DEADLINE FOR THE NEXT ISSUE IS FEBRUARY 1, 1995.

Pedometrics is a Working Group of Commission I (Soil Physics) of the International Society of Soil Science (ISSS).Information about ISSS is available from the Secretary General:

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Institut fur Bodenforschung, Universitat fur Bodenkultur,
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A-1180 Vienna,
AUSTRIA

Committee (1994-1998)

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