Developing a Quantitative Analogue of Conventional Soil Survey for the Prediction of Soil Properties at Resolutions from 100m to 1km

Neil J. McKenzie* and Philip J. Ryan**

* CSIRO Land and Water
GPO Box 639
Canberra, ACT, 2601, Australia
e-mail: neil.mckenzie@cbr.soils.csiro.au

** CSIRO Forestry and Forest Products
PO Box E4008
Kingston, ACT, 2604, Australia

A large proportion of conventional soil survey activity has been concerned with spatial prediction at resolutions between 100m and 1km. In conventional surveys, point observations of soils are extended to broader regions using qualitative and complex mental models of relationships with more readily observed landscape features. The mental models are rarely communicated and users of surveys find it difficult to separate evidence from interpretation. Accuracy and precision of mapping are not often stated and soil variation is usually portrayed simplistically as being discontinuous with map units having sharp boundaries. Conventional surveys also provide maps of preclassified soil types, with minimal information on patterns of variation within polygons. Emerging technologies have created opportunities for the development of a more scientific survey method which generates predictions of individual soil properties with a stated accuracy and precision. A central task for such quantitative survey is development of explicit statistical or rule-based models that replace the implicit mental models used by soil surveyors. A related task is the development of readily observed environmental explanatory variables of pedological significance that can be used for extending point observations to areas. Geographic information systems and statistical software are a prerequisite. However, advances with digital elevation models (DEMs), terrain analysis, global positioning systems and gamma radiometric remote sensing have removed many impediments for predicting soil properties at resolutions between 100m and 1km. The use of these technologies for quantitative soil survey is illustrated using an example from the Bago and Maragle State Forests in southeastern Australia. A simple stratified random sampling scheme was adopted for the 50,000 ha area using digital geology, landform and climatic variables. An index of local landform was generated using a high resolution DEM with a grid size of 25 m. Climate surfaces of annual rainfall and evaporation were generated using the DEM in conjunction with the ESOCLIM and SRAD computer programs. These predictions were combined to generate a simple index of the annual water-balance. The climate and landform digital coverages were classified and cross-tabulated to generate a coverage of 12 discrete environments in each geological unit. Replicated instances of each environment were then randomly selected and sampled. Detailed field descriptions of readily measured properties were made at 172 sites. Generalized linear models and regression trees were then used to generate spatial predictions of soil properties using the stratifying variables and gamma radiometric survey data as explanatory variables. The resulting spatial predictions have resolutions unmatched by comparable conventional methods although they have large confidence intervals. The survey method is strongly influenced by Jenny's functional factorial approach and is a quantitative analogue of conventional survey. Making each phase of the survey process explicit, consistent and repeatable exposes many of the difficulties of predicting soil distribution at scales relevant to management. Examples are presented of soil properties amenable to prediction along with those that are less tractable. Landscape complexity in polygenetic systems, issues of scale and the relative merits of quantitative and intuitive predictive models are discussed.