

Mapping Land Units within Land Systems in Central Queensland Using a Fuzzy Expert System and Terrain Models

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In much of the world, large scale soil maps which would better inform land use decisions are not available. The major impediment to collection of large scale data is the cost of field survey over large areas. One promising approach to increase the efficiency of soil survey is soil-landscape modelling. Soil-landscape models formalise relationships between soil attributes and other environmental variables, particularly landform which may be modelled with terrain data. Experienced soil surveyors implicitly use known and derived relationships between soils and landforms to produce useful maps. An explicit representation of these relationships between soils and landforms could be applied predictively and spatially.

In Central Queensland, large areas of Vertisols are used for dryland agriculture. Water resource development on the Comet River will provide irrigation for more intensive crop production. Large scale soil and land suitability information is required for infrastructure development and farm planning but land resource information in the area is restricted to a small scale land system survey.

Land system surveys contain a wealth of information relating soil features and landform patterns at small scales. Land systems are not soil units, but composite patterns of landform, vegetation and soils. They incorporate smaller non-mapped entities called facets or units which are related to specific landform elements and soil and vegetation features. The distribution of facets within land systems could be mapped if landform elements can be spatially identified thus producing large scale information on soil features pertinent to land managers.

This paper describes a method of identifying facets within land systems using explicit modelling, detailed terrain data and fuzzy rule sets. A high resolution digital elevation model (10m grid) was generated from photogrammetrically sampled elevation values and drainage vectors, using ANUDEM software. A series of raster GIS coverages of landform attributes derived from the elevation grid was generated: elevation, relative elevation, slope, profile, plan and tangent curvature, topographic wetness index and distance from major streams. These attributes were derived using TAPES-G software and other algorithms. A fuzzy rule-based system was developed to classify the raster data sets and consequently to map the likely occurrence of land facets within each land unit. Each land facet was considered to be a single class, and each grid node within a land system was considered to have a degree of membership in each land facet class. Membership functions were generated for each attribute based on the distribution of values within each raster data set. Rules were generated to allocate membership in all facet classes for each grid node within each land system. For example, for Comet Land System, Facet Ct1 represents levees adjacent to active large streams. An appropriate rule set would be: If slope is low Ct1 is medium; if profile curvature is weakly convex, Ct1 is high. The rules were derived from the specific relationships between landform and facet described in the land system survey, and modified according to visual inspection of the terrain data sets, remote sensing images, aerial photographs, and several field traverses. The membership functions and rules were codified in fuzzy system software and a final membership in each facet class was generated using fuzzy algebra. Memberships in each facet class were visualised by mapping of the output raster datasets. The maps indicate the likely location of specific facets (ie. high membership in a facet class) and areas of transition (moderate membership in several facet classes).

The approach produced a large scale representation of soil attributes which better reflects changing land use intensity. The use of a validation data set and subsequent soil sampling allows measurement of reliability levels applicable to statements about specific soil attributes and/or soil variability in specific geographic space. The use of fuzzy class memberships rather than crisp classes permits a more continuous representation of gradually changing landscape attributes, and visualisation of intergrades between classes. It also better reflects the knowledge system from which the rules were derived. The approach is being used in land use planning in the new irrigation areas. It has clear potential in increasing the utility of small scale land system data elsewhere.