

Spatial frameworks to support digital soil mapping in Victoria

David Rees^A, Nathan Robinson^B, Mark Imhof^C, Bernie Joyce^D and Richard MacEwan^B

^AFuture Farming Systems Research Division, Department of Primary Industries – Parkville, Victoria, Email David.Rees@dpi.vic.gov.au,

^BFuture Farming Systems Research Division, Department of Primary Industries - Epsom, Victoria, Email Nathan.Robinson@dpi.vic.gov.au, Richard.MacEwan@dpi.vic.gov.au

^CFuture Farming Systems Research Division, Department of Primary Industries – Ellinbank, Victoria, Email Mark.Imhof@dpi.vic.gov.au

^DSchool of Earth Sciences, University of Melbourne, Email ebj@unimelb.edu.au

Abstract

The development of a digital soil mapping (DSM) program for Victoria, Australia is envisaged. The digital soil layer will consist of a specified grid populated by attributes with calculated error terms. A spatial framework is regarded as a useful and efficient means of development of the DSM and would allow for spatial unconformities (i.e. spatial stratified sampling). The new Victorian Geomorphological Framework (VGF) has been used as a refinement for the boundaries used in the national ASRIS scheme and for the development of Primary Production Landscapes (PPLs) in Victoria. The three spatial frameworks provide reference areas for point-derived datasets.

Key Words

Geomorphology, spatial hierarchy, soil survey, land systems.

Introduction

The land and soils that support our agricultural industries are managed in many different ways, reflecting the diversity of Victoria's landscape, and their condition and inherent capability provides a basis for sustainable land use. Spatial frameworks that collate information on soil and land resources support land management and land use decision-making through the provision of spatial data for modelling and reporting purposes. In Victoria, the previous most commonly used spatial hierarchy was based on land systems; derived by integrating environmental features including geology, landform, climate, soils and native vegetation using an ecological approach (Christian and Stewart 1946) and used by Rowan and Downes (1963) and Gibbons and Downes (1964) in Victoria. A number of land system and soil/landscape surveys were subsequently combined to form a land systems map of the state. The advent of Digital Elevation Models (DEM), Geographic Information Systems (GIS), Airborne Gamma-Ray Spectrometry (AGRS), Light Detection and Ranging (LiDAR) and satellite imagery have provided opportunities to re-assess landscapes, refine boundaries and define critical land attributes, improving the overall quality of this information. Geomorphology is the study of landforms, their origin and evolution, the investigation of relationships between landform development and processes that shape and configure these landforms such as tectonic movement, volcanism, erosion and deposition cycles (Hills 1975). Importantly, geomorphology provides a 'fundamental template on which landscape processes and human interactions with those processes take place' (Conacher 2002). Geomorphology has been integrated as a spatial hierarchy of land unit descriptions known as the Victorian Geomorphology Framework (VGF). Recently the VGF, land use maps, climatic records, and regional experience of agronomists and land managers have been integrated to define and determine Victoria's major 'Primary Production Landscapes' (PPL).

In parallel to development of the VGF, a national project has been collating soil and terrain data and representing this spatially as the Australian Soil Resource Information System (ASRIS). This spatial hierarchy for land units provides on-line access to primary soil and land data on behalf of the National Committee on Soil and Terrain (NCST). The VGF and units sit within and complement this national approach. The three spatial hierarchies (VGF, PPL and ASRIS) will be discussed in this paper with reference to their current and future application to support digital soil mapping in Victoria. The recent collation and review of soil and land surveys will also be described for future integration in a Victorian soil condition monitoring program and the generation of soil parameters for systems-based landscape modelling.

Spatial frameworks

Victorian Geomorphology Framework

The VGF describes and defines details of Victoria's landscapes and provides a hierarchy to align past and future soil and land information. The classification system followed an existing framework established by

Hills (1975) using landscape morphology as the major factor in the determination of geomorphological areas. The 'tiered' system incorporates geomorphological, pedological and ecological information, enabling users to gain an understanding of both soil and vegetation distribution. The most recent version of statewide land systems derived from the Jenkin and Rowan (1987) two-tier framework included nine 'level one' divisions and 29 'level-two' divisions. The revised VGF was expanded to a three-tier system, incorporating eight 'level-one' divisions (Figure 1), 34 'level-two' divisions and 95 'level-three' divisions. A comparison of the level-one divisions is provided in Table 1. Updates of the VGF are available on the Victorian Resources Online (VRO) website http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/landform_geomorphology.

Table 1. Broadest division (Tier 1) of Geomorphological units for Victoria

Victorian Geomorphology Framework
1. Eastern Uplands (EU)
2. Western Uplands (WU)
3. Southern Uplands (SU)
4. Northern Riverine Plains (RP)
5. North west Dunefields and Plains (DP)
6. Western Plains (WP)
7. Eastern Plains (EP)
8. Coastal Features (CF)

Figure 1. Victorian Geomorphological Framework (Tier 1) overlain by Jennings and Mabbitt (1986) map units



Primary Production Landscapes

The Primary Production Landscapes (PPLs) of Victoria is the spatial hierarchy used to identify major agricultural divisions across the state. The PPL hierarchy is a two-tier system that comprises six regional units and twenty two sub-regions. Each PPL has been described according to the agricultural industries and associated farming systems that operate within major geomorphological regions (as determined by the VGF) and inherent soil management issues and associated major soil types are identified. Regional location, physiographic divisions (incorporating terrain and geomorphology) and major soil types were used to delineate PPLs. These PPLs were characterised for dominant soil types and associated inherent management issues. Landform descriptions have been collated from those of the VGF. PPLs were also described by major agricultural industries and practices that occur within them.

Australian Soil Resource Information System (ASRIS)

ASRIS (McKenzie *et al.* 2005: http://www.asris.csiro.au/index_ie.html) provides access to a suite of primary and interpreted soil and land parameters. As an online (web interface) system, the ASRIS structure is a spatial hierarchy of land-unit mapping integrated with individual field sites (e.g. soil site). Land qualities are described along with a functional soil database that informs the spatial context throughout the seven-levels of ASRIS (see comparison with the VGF in Table 2).

Alignment between spatial frameworks


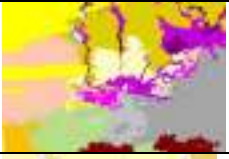



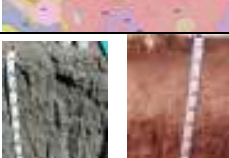
Victoria is well positioned to provide these high level stratifications for ASRIS, as they are being developed in parallel. Within ASRIS, land qualities are defined in greater detail at lower levels (4 to 6) and summaries are provided at higher levels (1 to 3). Level 7 represents an individual soil site in the landscape. The land qualities provided in the system relate to fundamental soil parameters relevant to soil health including soil thickness, water storage, permeability, fertility, salinity, and erodibility. The PPL framework is being promoted as a hierarchy that can be used to stratify soil health monitoring across Victoria and which could offer a practical approach to soil health/condition monitoring across regions.

Soil and land surveys/studies to inform a Victorian digital soil mapping program

In Victoria there are over 350 documented soil and land surveys/studies, undertaken by various state and federal government organisations during the last 80 years. Many of these had little or no associated soil and land mapping, so fewer than half of these were considered suitable for digital soil mapping purposes. The surveys range in scale from 1:10 000 (soil survey) to 1:250 000 (land systems) (Figure 2). Within surveys, the range of soils, soil site density, and scale of mapping and intended purpose of the survey all strongly influence the quality of the final mapping product. The criteria used in a recent assessment and stratification

of surveys included year, undertaken, spatial extent, potential to link mapping units with the VGF, potential to refine mapping, number of soil sites and or quality of site information, purpose of survey, and a subjective estimation of survey quality (incorporating an assessment of surveyor experience, number of reference sites assessed and map scale).

Table 2. Relationship between VGF hierarchy and ASRIS levels

VGF tier illustration	VGF tier level	VGF nominal mapping scale	VGF divisions	ASRIS level and tract name
Not applicable				1 Division
	1	1:5 000 000 to 1:1 000 000	8	2 Province
	2	1:1 000 000 to 1:500 000	34	3 Zone
	3	1:500 000 to 1:100 000	95	4 District
	4	1:100 000 to 1:25 000	not defined	5 System
	5	1:25 000 to 1:100	not defined	6 Facet
	6	> 1:100	not defined	7 Site

Stratification and spatial alignment results

From the stratification process, 106 surveys were considered valuable from a future digital soil mapping perspective for Victoria. The assessment of soil and land surveys assumed an ability to disaggregate the broader-scale surveys or provide existing components/land element descriptions; usually at less than 1:25 000 scale (less than 1:35 000 scale is used here). In total there are 51 surveys at a scale finer than 1:35 000 that equate to level 5 of the VGF and level 6 (or ‘facet’) of ASRIS (these are unlikely to require further refinement given the resolution of survey information); 37 surveys at a scale between 35 000 and 100 000 (level 4 of the VGF and level 5 (or ‘system’) of ASRIS), and 18 surveys at a scale greater than 100 000 that equate to level 3 of the VGF and level 4 (or ‘district’) of ASRIS (Figure 2a to 2c). Significant overlap occurs between the surveys at the same scale and across scales (Figure 2d).

Conclusion

The spatial frameworks of the VGF, PPL and ASRIS are complementary and will provide a valuable hierarchy as part of state and national stratification (for assessing wind erosion, water erosion, soil carbon and acidification) and to guide future development of a digital soil mapping program for Victoria. These frameworks will enable data and information products to be integrated and derived at a range of scales. The continued enhancement of these frameworks and provision of digital soil products to users will be reliant upon new analytical approaches and ancillary data sources to inform these mapping programs.

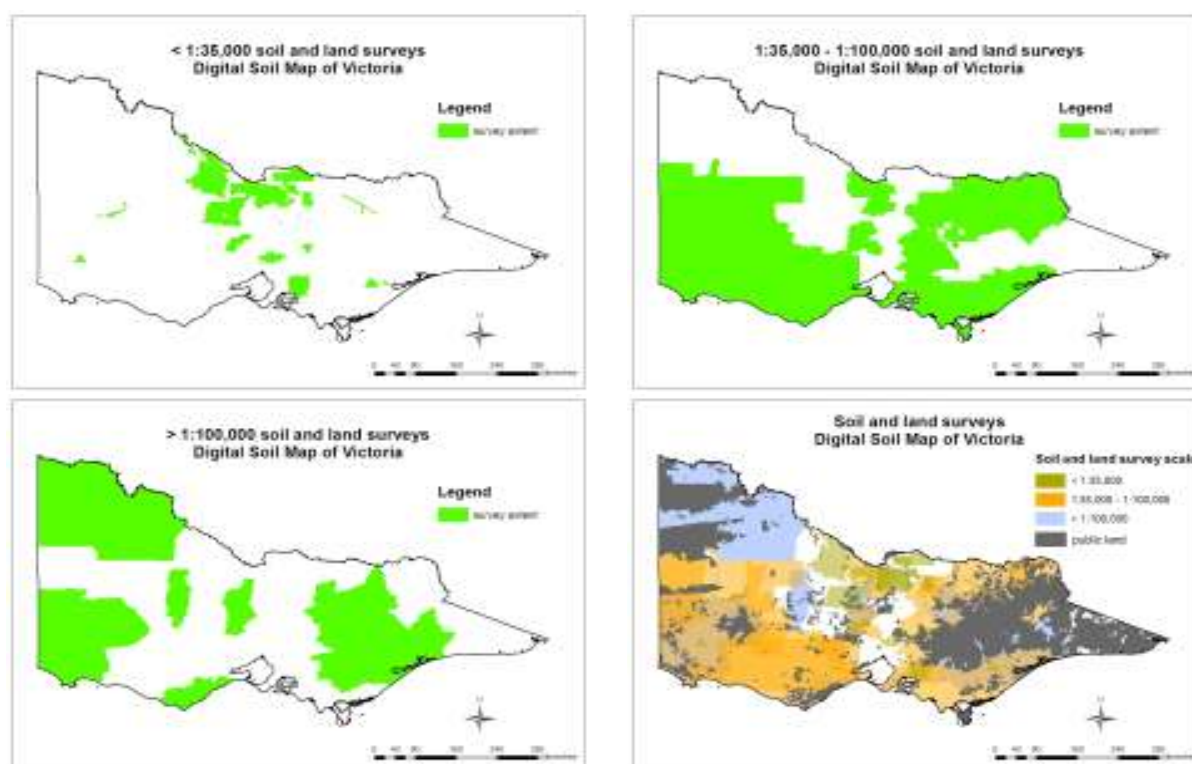


Figure 2. Soil and land surveys: a) finer than 1:35 000 scale; b) between 1:35 000 and 1:100 000 scale; c) coarser than 1:100 000 scale; d) various scales with broad surveys overlain by finer scale surveys (note surveys are partially transparent in order to portray the overlap between survey scales).

References

- Christian CS, Stewart GA (1946) 'General Report on Survey of the Katherine-Darwin Region'. Land Research Series No. 1. (CSIRO: Australia).
- Conacher A (2002) A Role for Geomorphology in Integrated Catchment Management. *Australian Geographical Studies* **40**, 179–195.
- Gibbons FR, Downes RG (1964) 'A Study of the Land in South-western Victoria'. Technical Communication No. 3. Soil Conservation Authority, Victoria.
- Hills ES (1975) *Physiography of Victoria* (First edition). (Whitcombe & Tombs: Melbourne).
- Isbell RF (2002) 'The Australian Soil Classification'. Revised Edition. (CSIRO Publishing: Collingwood, Victoria).
- Jenkin JJ, Rowan JN (1987) Physical Resources. In 'Agriculture in Victoria'. (Eds DJ Connor, DF Smith) (Australian Institute of Agricultural Science: Melbourne).
- Jennings JN, Mabbutt JA (1986) Physiographic outlines and regions. In 'Australia, a geography. Volume 1. The natural environment'. (Ed DN Jeans) (Sydney University Press: Sydney)
- McKenzie NJ, Jacquier DW, Maschmedt DJ, Griffin AE, Brough DM (2005) 'The Australian Soil Resource Information System, Technical Specifications'. Australian Collaborative Land Evaluation Program.
- Rees DB (2000) 'Land Systems of Victoria'. Edition 3. Technical Report No. 56. (Centre for Land Protection Research: Bendigo).
- Rowan JN, Downes RG (1963) 'A Study of the Land in North-western Victoria'. Technical Communication No. 2. (Soil Conservation Authority: Victoria).