Soil and landscape visualisation on the internet

Mark Imhof[A], Pauline Mele[B], Hayden Lewis[C], Matthew Cox[D], Wayne Harvey[E], Damian Bougoure[F], Richard MacEwan[E], Gemma Heemskerk[G], David Cummings[H], Christopher Pettit[G], Angela Fadersen[E], Sonia Thompson[I], David Rees[G] and Doug Crawford[A]

[A] Future Farming Systems Research Division, Department of Primary Industries, 1301 Hazeldean Road, Ellinbank, 3821 VIC, Australia, Email mark.imhof@dpi.vic.gov.au
[B] Biosciences Research Division, Department of Primary Industries, Knoxfield, VIC, Australia.
[C] Future Farming Systems Research Division, Department of Primary Industries, Tatura, VIC, Australia.
[D] Future Farming Systems Research Division, Department of Primary Industries, Spring St, Melbourne VIC, Australia.
[E] Future Farming Systems Research Division, Department of Primary Industries, Epsom, VIC, Australia.
[F] Biosciences Research Division, Department of Primary Industries, Bundoora, VIC, Australia.
[G] Future Farming Systems Research Division, Department of Primary Industries, Parkville, VIC, Australia.
[H] Soil Conservationist, Surrey Hills, VIC, Australia.
[I] Future Farming Systems Research Division, Department of Primary Industries, Knoxfield, VIC, Australia.

Abstract
The Victorian Resources Online website is the principal means for accessing soil and landscape information via the internet in Victoria, Australia. A key focus of the website is the presentation of spatially-based information that currently relies on clickable maps and links to ancillary information. Information presentation is now being continually enhanced by incorporating visualisations that include real-life demonstrations, 'virtual tours' and animation sequences. A 'Virtual Soil Profile' (VSP) is being developed as an interactive three-dimensional (3-D) visualisation of a soil profile. It is being created to increase understanding of the complex dimensions and properties of soils, with an initial focus on understanding soil structure, biology and key soil processes. The VSP incorporates interactive images and animation sequences as well as links to supplementary information.

Key Words
Land resource assessment, communication, spatial, animation, 3-D visualisation, virtual reality.

Introduction
The Internet provides information access to a broad audience, meaning that that the type of information presented needs to be well thought out and packaged. The audience generally can not be specifically targeted, so the onus is on the publisher to produce information with a broad appeal as well as extensive useability. The rapid development of digital communication technologies in recent years has created opportunities for improving both the quality of information presentation and its flexibility to cater for the diverse needs of a range of users. Presentation of information, whether as simple text pages through to more complex dynamic and interactive pages, needs to be in forms that maximise end-user understanding. During the past 12 years, the Victorian Resources Online (VRO) website has been the principal means for disseminating soil and land information via the Internet in Victoria, Australia. The website currently consists of around 7500 web pages as well as 1900 maps and 1000 downloadable documents and reports. Information is provided at a range of scales – from statewide and regional overviews to more detailed catchment and sub-catchment levels. At all spatial scales, information is organised around the key 'knowledge domains' of climate, landform, landuse, soil, water, biodiversity and land and water management. In 2009 the website attracted an average of over 1000 unique users per day.

The VRO website provides a comprehensive range of soil and landscape information, including maps, geomorphological sites of significance, land degradation and soil health information as well as soil pit site details. Where possible, this information is presented at varying levels of detail to cater for a range of users. The website is also a repository for many reports (contemporary and historical) that have been digitally captured, customised and made available as downloadable documents. Soil terminology is linked to a glossary of terms that is being continually enhanced with inclusion of images and visualisation examples (e.g. animation depicting processes such as the soil carbon cycle and dispersion). User profiling shows a wide range of users accessing and using soil and landscape related material – including students and teachers, researchers, consultants, librarians, advisers and extension staff. Visualisation techniques can be used to better communicate spatial and scientific information about soils and landscapes to a range of users such as scientists, administrators, educators, students and the general public. Three-dimensional (3-D)

representations can improve user understanding of soil and landscape relationships, which can be enhanced by incorporating interactivity. 3-D graphics and animation bring more life-like digital reality to computer-based information and the use of video files (ranging from simple animations to full-quality movie video with sound) adds rich information content to a web-pages. Virtual Reality (VR) is the capability of a person to navigate in a digitally generated 3-D environment and interact with computer-generated objects that resemble the appearance and habits of what they are trying to simulate. VR is recognised as an innovative tool for visualising and communicating data to an audience, i.e. an education tool (Barraclough and Guymer 1998), and basic VR functionality is now being explored as part of the early development of the 'Virtual Soil Profile'.

Methods

Landscape and soil visualisation

The desk-top Geographical Information System (GIS) *ArcScene* is being used to overlay spatial information and create 3D scenes. It includes analytical tools and functions that allow the creation of realistic 'fly-over' animations. Other 3-D visualisation programs that produce photo-realistic still images or animations of landscapes using GIS and Digital Elevation Models (DEMs) are also being utilised. The 'Hillshade' tool within *Spatial Analyst* has been effective in generating more realistic map bases that can then be clicked on to access site specific information. By draping aerial photography over the DEM and setting 50 % transparency, a realistic 3-D effect is created for the web-based image map. If available, detailed DEMs have been utilised to create more realistic 3-D landscapes and fly-overs. LiDAR (Light Detection and Ranging) technology uses laser pulses to generate data on the physical layout of the landscape. Aircraft-based LiDAR generates a 3-D data structure using a 1 metre grid and is available for some parts of Victoria. Incorporation of video materials, which can include landscape fly-overs, is now routine within VRO. Screen-capture software is used to record a video file that is then converted to *Flash* format for integration in VRO web pages. Interactive panoramic images have also been developed using open-source *Flash*-based software and included on the website. A range of animation sequences is being created, from simple 2-D process animation (e.g. soil carbon cycle) to more complex 3-D scientific animation (e.g. breakdown of organic material in soil). Animation is created by professional artists from 'storyboards' (a series of hand-drawn sketches that outline all the events in the animation) developed by soil scientists.

Virtual soil profile (VSP)

A 'Virtual Soil Profile' is being constructed as an interactive 3-D visualisation of a three dimensional body of soil from images taken of a field excavated pedon. Utilising *Flash* format, the VSP is being designed so that users can explore it through a web browser. A number of images taken in the field and via light-phase microscope and Scanning Electron Microscopy (SEM) have been used as linking images and as the basis for creation of linked animation sequences. Navigation has been created as a menu option and via clickable 'hotspots' within the soil profile.

Results

Information presentation on the VRO website is now being enhanced with the incorporation of visualisation products to support the more standard web content, i.e. text and graphics. Examples of these are described below.

Landscape visualisation

A focus of the VRO website is the presentation of spatially-based information, including a range of spatial visualisations. There are many examples of site-based information (e.g. soil pit sites, sites of geomorphological significance) adapted (or 'spatialised') into clickable maps that users can click to reveal site-specific information products. Presenting parameter surfaces 'draped' over a DEM can be a useful way to communicate landscape-related patterns and processes. Clickable maps, used on the website to show locations of sites (e.g. soil pit sites), have been enhanced by adding a realistic 3-D background (using DEM and satellite imagery) as depicted in Figure 1. Realistic landscape visualisations are also being developed to demonstrate landscape processes and relationships (e.g. Figure 2).

The information provided on the 'Sites of Geomorphological and Geological Significance' section of the website has been derived from a number of limited distribution publications and developed in association with retired specialists. The VRO website provides maps showing locations of many hundreds of these sites, as well as associated text and images. Video clips are now being routinely used to provide enhanced web

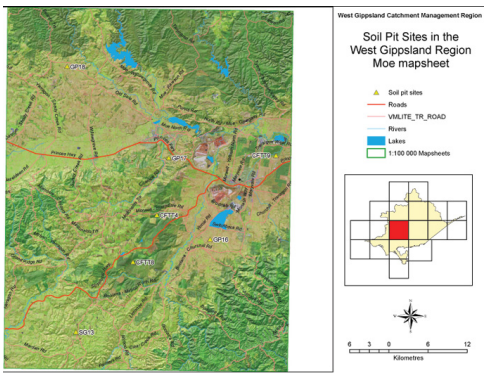

Figure 1. Example of an image map base used to show site locations that can be clicked on to access relevant information.

Figure 2. A visualised landscape showing the estimated mid-Holocene high sea stand of 1.5 m AHD, indicating where Coastal Acid Sulfate Soils may occur.

content and animations. Content includes landscape fly-overs that are being developed to provide a 'virtual tour' of these sites (e.g. Mt Noorat example shown in Figure 3). There is potential to supplement these with historical footage and audio-visual recordings of retired experts describing landscapes in the field (e.g. retired specialist providing commentary on a landscape as shown in Figure 4).

Figure 3. On-line video clip of a 'virtual tour' of Mt Noorat (a site of geomorphological significance).

Figure 4. On-line video clip of retired expert (Jim Rowan) describing landscape features in the field.

Soil visualisation

A current focus of the website is on providing access to 'soil health' related information. Recent developments have centred on providing information on topics such as soil structure, soil biology and organic matter. This is being continually enhanced with the inclusion of multi-media material such as videos and animation sequences, aimed to provide users with a more interactive and visual learning experience.

Virtual soil profile

A 'Virtual Soil Profile' is intended as an educational aid to increase understanding of the complex dimensions and properties of soils. It is being progressively developed as a visualisation tool to enhance soils education and training through improved awareness and understanding of soils and their function. The initial objective has been to display aspects of soil morphology and biology and their relationship to soil aggregation and management as well as depicting key soil processes (e.g. residue decomposition and the soil carbon cycle). Zooming functionality allows viewing at increasingly finer scales – from the pedon and component soil horizons, to peds, through to macro- and micro-aggregates. Animation is being developed to enable soil biology to be viewed at increasing levels of detail - ranging from macro-fauna (e.g. earthworms) to litter transformers (e.g. nematodes) to bacteria and fungi. Initially the VSP is being developed to support soils education and training as a stand-alone application, but will be progressively incorporated into the Victorian Resources Online (VRO) website for access by a broad range of users.

Supplementary images, analytical data, publications and other websites are being linked to the VSP through a simple menu that allows exploration of soil properties and functions. Navigation is available via a menu option or by clicking 'hotspots' on the soil profile. Apart from rotating and zooming, users are also able to click on 'hotspots' linked to images, video and animation related to aspects of soil aggregation (e.g. macro-

aggregates, micro-aggregates), physico-chemical processes (e.g. dispersion) and biological processes (e.g. microbial decomposition by extra-cellular enzymes, soil carbon and nitrogen cycles). Figure 5 provides examples of material being presented.

Figure 5. Examples of material presented as part of the Virtual Soil Profile and Victorian Resources Online website: (upper left) earthworm animation; (lower left) soil carbon cycle animation; (upper and centre right) Virtual Soil Profile menu views; (lower right) video clip of dispersion.

Conclusion

The Victorian Resources Online (VRO) website represents a useful model for the effective dissemination of a wide range of soil and landscape related information. Evaluation of users is providing valuable insights into how 'next users' access and use soil and landscape information, and has highlighted the educational benefits. Visualisations are now being increasingly added to the website to enhance communication and user evaluation will be undertaken to assess the effectiveness of these recent developments. Visualisation of complex and varied soil and landscape data can be enhanced and integrated through virtual models. The technology to create such models is readily available and affordable. The 'learning public', particularly those coming through school and university are now used to (and expect) high quality graphics and animation. The challenge for soil science communicators is to match high levels of graphic reproduction with good quality and stimulating information. It is proposed that the more visual and interactive material currently being presented as part of the VRO website will contribute to making soil and landscape information more attractive and understandable for young people and those without more formal training.

References

Baraclough A, Guymer I (1998) Virtual Reality – a role in environmental engineering education. *Water Science and Technology* **38**, 303-310.

Victorian Resources Online website, Department of Primary Industries www.dpi.vic.gov.au/vro