HOWLEAKY? THE JOURNEY TO DEMYSTIFYING SIMPLE TECHNOLOGY

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Abstract

A decision support tool has been developed to demystify the art of computer simulation. Howleaky? represents a revision of water balance and crop models with the aim of providing insight into the impact of different land uses and management on water balance, soil erosion and water quality. Howleaky?'s distinctiveness lies in its user interface which provide accessible and highly visual representation of inputs and outputs.

Howleaky? represents the latest instalment in daily time step models that are physically based. Similar models have been in use for at least 25 years, but mainly used by a few computer literate "gurus". The capacity to simulate transport of agricultural chemicals in surface runoff has also been included in the model (Rattray *et al.*, these proceedings).

Model verification has shown that similar fits to observed data can be achieved using Howleaky? as have been achieved using similar models that have more detailed crop models and capacity to modify management. Key questions explored by Howleaky? include; how much water is lost as runoff and drainage, what erosion rates are expected from different tillage practices, what are the probabilities of losing pesticides applied, and what are the interactions between crop type, climate and tillage management.

Additional Keywords: modelling, water balance, runoff, erosion, water quality, PERFECT.

Introduction

Access to current science of water balance and erosion estimation and simulation technology is poor generally because many current models have been designed and used by specialists. A new modelling paradigm was conceived to provide educators, planners and managers with an ability to directly explore implications of alternative land management for a range of locations and land uses. At the very least, we hope to demystify simulation technology.

Our aim was to develop a computer based analysis and presentation tool to evaluate alternative land uses and management strategies in terms of a) runoff, erosion and water quality and b) drainage below root zone (salinity risk). This approach aims to put the role of current tools and resources (models, databases and experience) in context, and modify these for ease of use and access. The objectives of making this software tool available are to:

- Build broader understanding of paddock scale water and soil dynamics and implications of land use and management in the land planning and management arena,
- Enable a greater number of people to gain understanding and access to an analysis tool that captures the interrelationships between climate, soils, vegetation type, management and biophysical responses, at the paddock scale.
- Create more transparency and communication between technologists and land managers.

Modelling theory and practice is greater than 25 years old (older than personal computers) and has proven to be extremely useful. That said, models have been limited to 'experts' due to the requirements of model users to be able to operate software at the command line and to deal with a range of unconventional file formats. Quite often programming skills are required so that custom software programs can be developed by model users to help deal with data handling. All in all, a high level of computer expertise and a degree of experience with any one particular model is required to be able to make use of the exploratory capabilities provided by these models. What makes Howleaky? distinctive is the ability to interrogate model input and output files in a simple and transparent manner and an ability to generate reports and statistics of the model outputs from within the interface environment. Additional benefits such as an ability to compare multiple simulations at one time and features such as an ability to import user defined data and compare it with model simulation data within the interface provides for efficient comparisons and calibration processes.

Materials and Methods

The development of Howleaky? has been underpinned by the use of established models and approaches using a state of the art visualisation platform.

Established modeling approach

The modelling concepts employed in the development of Howleaky? are not new. The benefits of using a well-established modelling approach include:

- o An ability to rapidly construct a new model from existing modules.
- o Proven predictive capabilities for water balance and erosion.
- o Demonstrated usefulness of models to explore land use and management scenarios.
- o Build on existing data sets for soils, land uses and management options.

The approach has been to use existing components of available models and build on our understanding of the scope for simple computer based decision support tools. Howleaky? is the latest instalment in a suite of daily time step physically based models which date back to at least the EPIC -The Erosion-Productivity Impact Calculator model (Williams 1983). The basic components of these models are; a leaf area index driven crop model, a soil water budget, the use of a modified USDA curve number approach to estimate runoff and the USLE (Universal Soil Loss Equation) for predicting soil loss. This approach has been adopted to allow the effects of land use and land management on water balance and soil loss to be explored using physically measurable parameters and processes that have a physical basis. The capacity to simulate transport of agricultural chemicals in surface runoff has also been included in the model (Rattray *et al.*, these proceedings) using some similar approaches as GLEAMS - Groundwater Loading Effects of Agricultural Management Systems (Leonard, *et al.*, 1987).

User interface and visualisation

A major step in demystifying the technology has been converting the original Fortran model code from PERFECT (Productivity Erosion Functions for Evaluating Conservation Tillage) (Littleboy *et al.*, 1992) into the object-oriented C++ code in *HowLeaky?*. Defining objects for input and output data has allowed multiple scenarios to be compared simultaneously, and has considerably speeded up simulation times over the PERFECT model where results were streamed to disk. This now allows virtually instant visualisation of the model outputs using many of the third-party libraries and tools that have been used to develop the user interface. A treeview component is used for data input allowing progressive disclosure of interface element catering for a range of user levels. Graphical output tools including charts, spreadsheets, and html reports are used to display model results.

Results and Discussion

While the original design was to keep the interface simple, the hierarchical nature of the interface readily accommodates a range of user levels. In **Figure 1** the map interface and land use selection screen are shown. The map interface can be used to open climate data for different locations on the map, which can be customised for any region. In the land use selection panel, a treeview structure is used for parameter inputs. This is a hierarchical system that can be used to hide parameters that some users may not want to adjust.

A visual reference for the current soil and crop type is displayed in the input panel on the left hand side of the screen (**Figure 2**a). A summary report is provided for all model input and output. Figure 3(b) shows the water balance and erosion summary for a range of land uses and a pie chart is also used to represent the components of the water balance. What we can quickly identify is that they do have differing water balances. In particular we can see the relative differences in drainage (presented from most to least leaky) for a shallow rooted annual crop (wheat), a deep-rooted perennial crop (lucerne) and deep-rooted forest vegetation. The summary report provides a quick visual 'sensibility' check and comparative analysis. Up to three model simulations can be shown. However, the user may wish to compare management options within a single land use. Keeping one simulation as the "base line" and varying the other simulations allows a risk comparison of possible current situations.
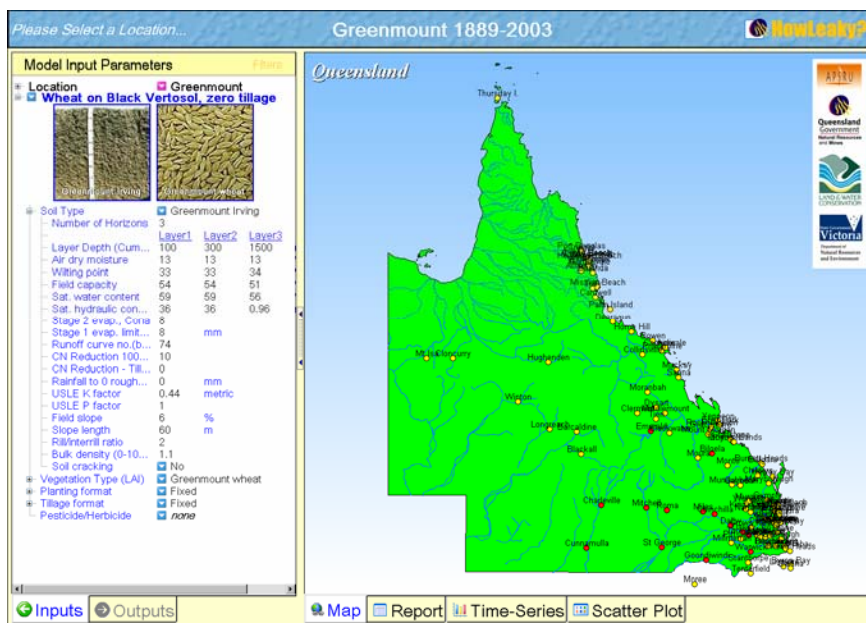
Figure 1. Map and land use selection, note the tree structure for the model input parameters.
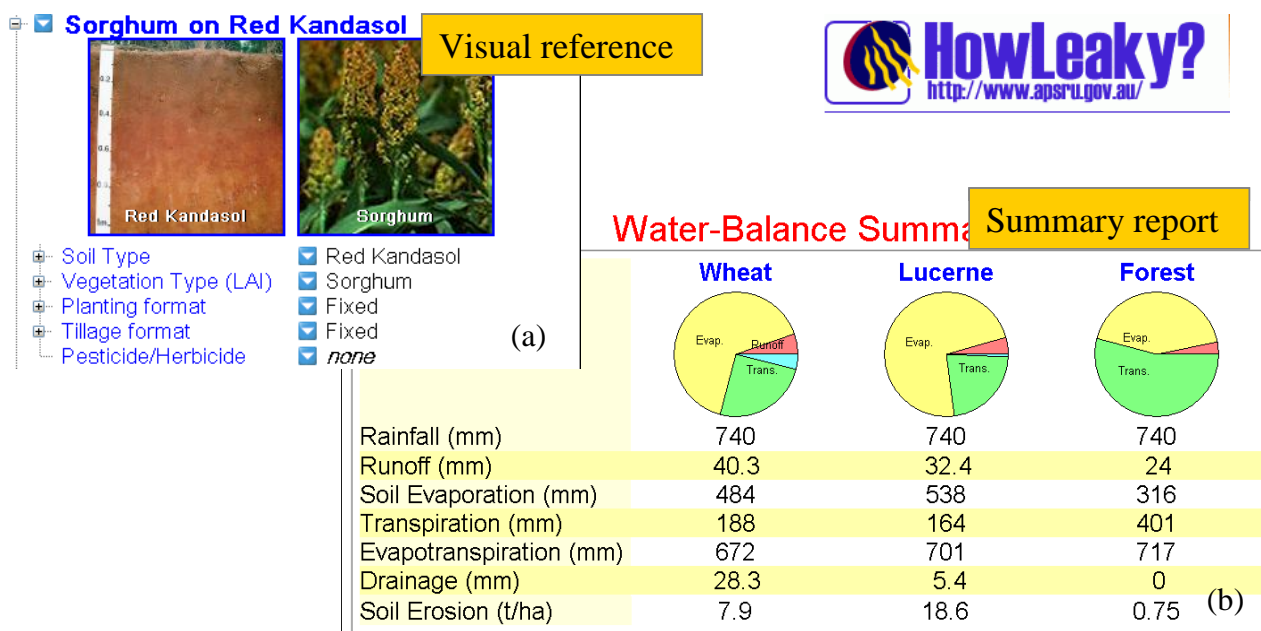

Figure 2. Example of input screen showing visual display of soil and vegetation type (a) and summary outputs (b).

For the user who is interested in knowing more about the reasons behind model predictions, and how the various outputs varied over time, a time series analyser is provided. Figure 3(a) shows an example of the time series output for the soil water over a period of a few years for the summary given in **Figure 2**. There are three distinct data series, the top line (wettest) represents wheat, the middle line is lucerne and the bottom (driest) is for forest. Additional information can be determined from this time series report such as what periods of the year, and how frequently, drainage may have been occurring. In this example the time series are overlayed. Data can be stacked for any time series (**Figure 4**). In this case, the wheat scenario has been highlighted and shows additional information of daily runoff, drainage and soil water. Inspection of dynamics of water allows a user to gain a feel for interactions between different processes.
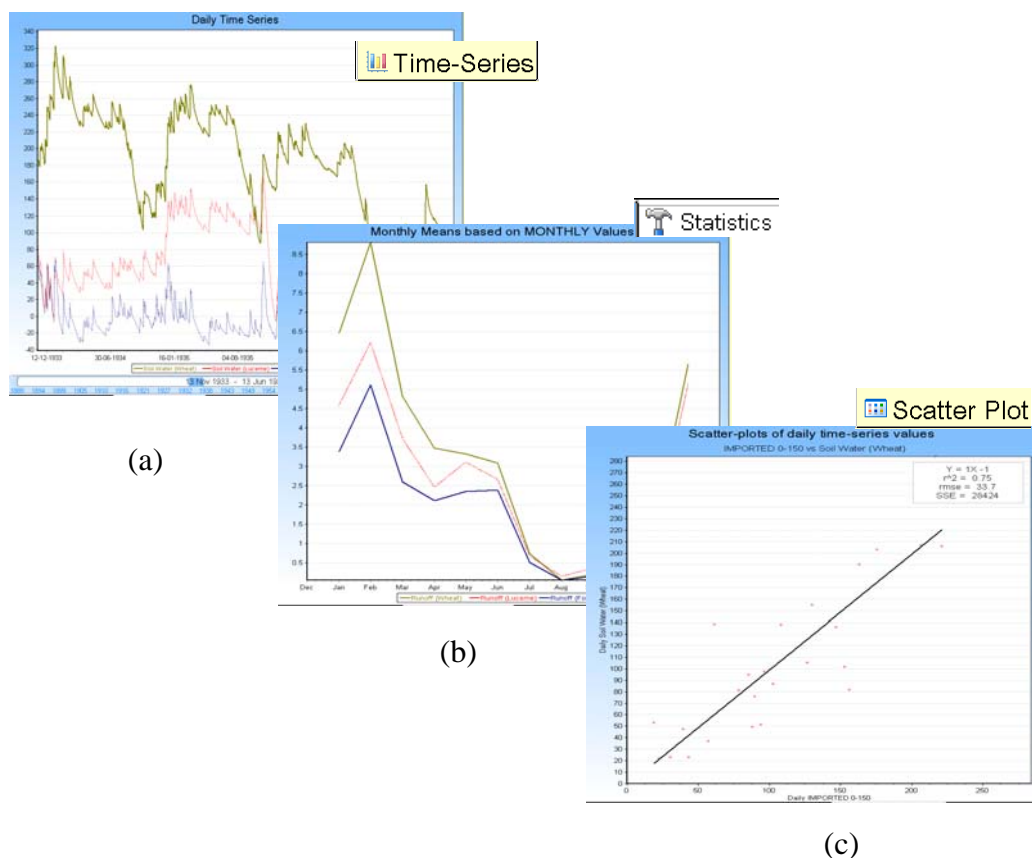
(a)

(b)

(c)

Figure 3. Example of *HowLeaky* output screens showing (a) time series data, (b) statistics and (c) scatter plots

Statistical data is shown in Figure 3(b) where the average monthly runoff for three land uses is shown. A scatter plot analysis tool is also available to plot data sets against each other to explore relationships that might exist. It is most frequently applied to looking at observed and predicted data, allowing the modeller to get 'best fit' parameters using both visual and statistical outputs within the interface.
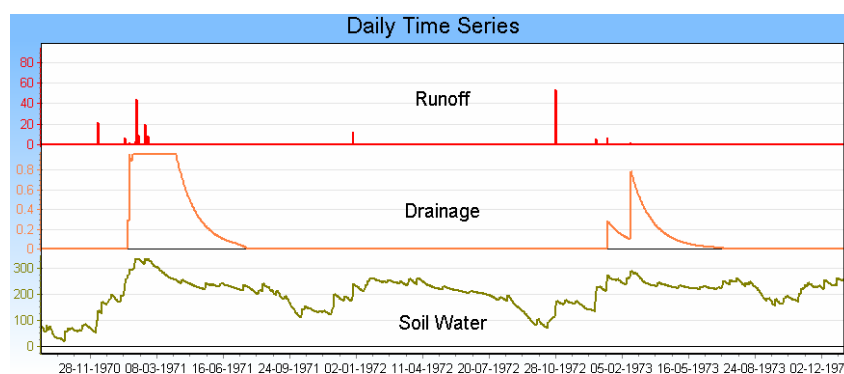

Figure 4. Example of *HowLeaky* output time series showing "stacked" runoff, drainage and soil water data

All of the model interface features demonstrated here go towards the concept of de-mystifying modelling by opening the black box as it is often perceived. Using these features modellers and students have easy access to summary comparisons of modelled land use or land management scenarios. They may wish to explore the "why did this occur" questions in more detail. These features open the model up to scrutiny and move it away from the black box theory of models where outcomes are taken on face value from "experts", or as is often the case, disregarded because of lack of transparency.

Model testing
In presenting *HowLeaky?*, a short summary of model testing to date was considered a priority. While much is made of the interface it is essential that the science supporting the model be tested for validity. *HowLeaky?* has been tested against data collected from a catchment study on the Darling Downs that compared water balance, erosion and crop yields for a range of tillage management practices (Freebairn and Wockner, 1986). The model was compared for its ability to predict; crop yield, soil cover, soil water, runoff and erosion. Howleaky? produced similar fits to these data as Littleboy *et al.* (1992) found using PREFECT, although only average planting dates and tillage rules were able to be applied using Howleaky?.

In particular the ability of the model to predict the effect of management on erosion is presented here. Figure 5 demonstrates that the model was quite adequate in predicting residue cover (%) over a range of fallows and crops, with different tillage management. Since cover is a major driving factor in erosion, this predictive capacity is essential to the ability for predicting long-term erosion estimates. It is heartening that this predictive ability can be demonstrated using a simply model of tillage and cover relationships. Figure 6 shows observed and predicted erosion over a range of tillage management scenarios. The model was able to adequately represent the major soil loss trend for a range of tillage practices.
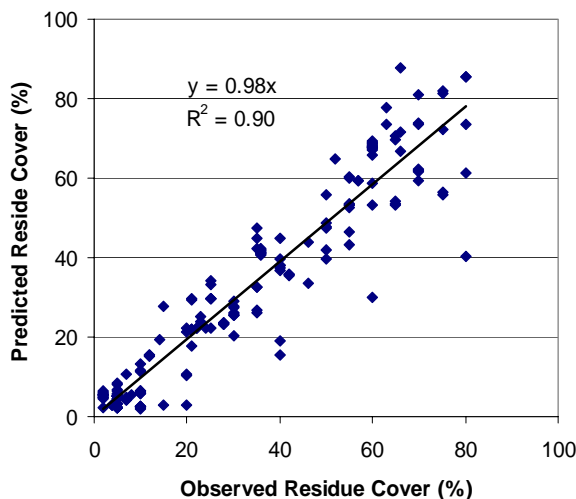

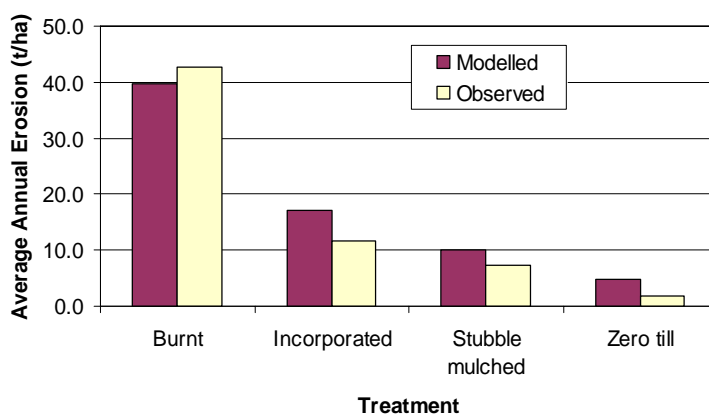**Figure 5. Scatter plot of observed vs predicted cover (%).**

Figure 6. Graph of observed and predicted erosion for a range of tillage management practices

Conclusions

Our espoused enthusiasm for the role of water balance driven tools and new interfaces represents an experiment to determine whether such a tool can be useful in supporting natural resource management planning and decision making. We are confident that it is easier to determine risks of erosion, pesticide runoff and deep drainage using a water balance model than from subject assessments or the use of statistical approaches such as the USLE (Wischmeier and Smith, 1978). All of the model interface features demonstrated here go towards the concept of de-mystifying modelling by opening the black box as it is often perceived.

While these new age models may be more accessible, they still require a reasonable level of support. Models can "codify" a certain amount of knowledge, but there will always be a need for experts in different disciplines to be involved in important natural resource decisions. The multiple attributes and players of any natural resource issue will still require expert synthesis skills to be working in conjunction with land managers.

Supporting material

Further description of *HowLeaky?* is available from the following website and a beta version is available for download. http://www.apsru.gov.au/apsru/Products/HowLeaky/index.html

Acknowledgements

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