Simplifying farm system modelling outputs via user experience methods

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Abstract
Scientific decision-support tools meant for use by farmers and agronomists in the paddock often present data in graphs, which many people without scientific training cannot understand easily. Altering the way in which data are presented can have a positive effect on user understanding. Two alternative methods for presentation of complex modelled data are explored: graph explanation and graph simplification. Both methods show promise in increasing user understanding of the data presented.

Keywords
Graph literacy, user experience, modelling, agriculture.

Introduction
An important consideration for scientific decision-support tools is ensuring that correct and scientifically valid conclusions are drawn from presented data. Many agricultural decision-support tools rely on displaying information in charts and graphs, yet studies have shown that up to 1/3 of the general population have low graph literacy (Galesic and Garcia-Retamero 2010), defined as the ability to understand and make inferences from graphically presented information (Okan et al. 2016). There is also a direct correlation between graph literacy and education (Galesic and Garcia-Retamero 2010). With 62% of farmers having secondary school as their highest level of education (Australian Bureau of Statistics 2012) and some agronomists lacking formal higher education, it is important to ensure that decision-support tools for farmers and agronomists present data in ways that can be readily understood.

Methods
Qualitative research has been undertaken both formally as a series of one-on-one interviews and informally during expos, field days and other events – anywhere where an existing or potential product user can be observed and questioned while using the product. While this form of research does not provide the same type of exact data as quantitative research, it does provide useful insights for product designers and is commonly practiced in the field of user experience. Qualitative research cannot tell you what percentage of people will have difficulties understanding or using your product, but it does tell you that one person did, which can also be valuable.

Results and Discussion
Yield Prophet® is a Nitrogen decision-support tool that utilises APSIM (Agricultural Production System Simulator), developed by CSIRO and its APSRU partners to model crop production (Hunt et al. 2006). It is delivered as a web-based subscriber tool to farmers and agronomists across Australia. The main output of Yield Prophet is a yield probability curve, generated using 50 years of historic climate data (Figure 1).

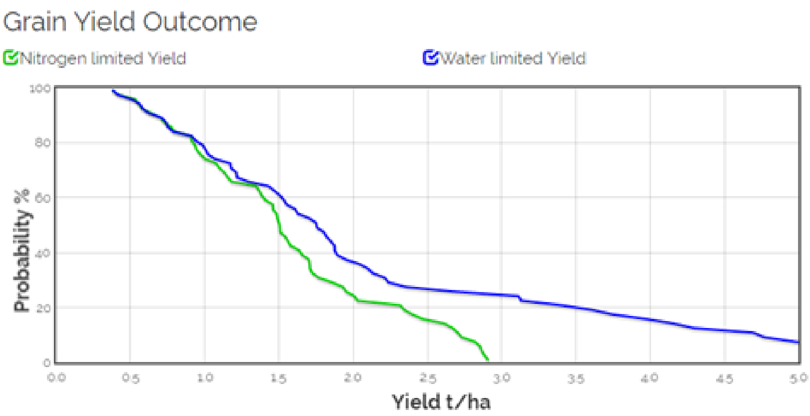

Figure 1. An example Yield Prophet yield probability curve for a wheat paddock.

The yield probability curve is a complex graph, and people with a high graph literacy can infer a large amount of information from this graph. In qualitative studies, farmers and agronomists were asked to explain and interpret the yield graph for the researcher in their own words. The level of graph literacy displayed by these explanations varied from high to low. It should be noted that probability is a generally poorly understood mathematical concept (Fuller et al. 2002), and combining probability with the line graph format is likely contributing to this graph being particularly difficult for users to understand.

Participants with high graph literacy were able to easily explain both features of the graph and the action they would take as a result of viewing the graph. Of particular note was that participants with high graph literacy related the slope and shape of the curve to the certainty of the prediction, and described the point at which the N-limited and water-limited lines diverged as relating to the amount of nitrogen currently available to the crop.

Participants with low graph literacy varied in their approach to the graph. Some participants avoided answering the question by questioning the validity of modelled outputs, and it is hypothesised that these participants could not read the graph at all. Other participants described the graph in terms of rules of thumb they used to interpret it. It was noted by some participants that these rules of thumb were learned by discussion with their agronomist or mentor. Strategies utilised included:

- Percentile-based reading – Reading the graph at either 50% or 80% probability (or both) to determine the predicted yield for the paddock. The choice of 50% or 80% probability was related to the risk tolerance of the farmer and agronomist, and the perception of the paddock's soil and location as being good or bad (despite the APSIM model being based on both localised soil and weather data).
- Minimum yield – Using the yield value at 100% probability as the "guaranteed" minimum yield of the paddock. Participants indicated that they used this as a data point in decision around input return-on-investment and in grain marketing.
- Yield gap reading – Estimating the difference between the Nitrogen-limited and Water-limited yield lines, and multiplying this by the approximate figure of 40 kg of Nitrogen required per tonne of grain (for wheat crops) to provide a rough calculation for Nitrogen application.

In the best case, the strategies employed by participants to decipher the graphs obscure key inferences that a user with a high level of graph literacy can draw from the graph. In the worst case, they are not scientifically valid and can result in real-life consequences for the modelled paddock, and hence the farm business. The question then becomes – how do we design tools that are based on scientific modelling but can be understood in a scientifically valid and useful way by a person without a scientific background?

During the design of subsequent products we have looked at alternate ways of presenting these data, to attempt to alleviate some of the issues discussed above.

Graph explanation

Farm4Prophet is a whole farm risk management product that integrates long-term pasture, animal and crop production modelling provided by AusFarm (Moore et al. 2007) with financial projections and Monte-Carlo-based financial risk analysis. It allows farmers and agronomists to ask big picture "What if?" questions regarding a farm's setup – for example, "What if I change my enterprise mix to add more livestock?". The output desired by scientists was a probability curve of modelled decadal cashflow balance – another complicated concept for non-scientists to understand. As the graph was a requirement of the project, alternative methods were needed to ensure that the graph would be understandable to all product users.

Project team members with high graph literacy were shown some graphs created by the product's modelling engine, and asked to explain their interpretation of the graph. It was agreed that while there were a number of minor factors, the key knowledge that experts took from the graph was the change in the risk profile of the farm, which could be explained as the percentage of decades in which the farm makes a profit.

The underlying software was programmed to create a simple key statement explaining the graph to the user as an expert might, for example, "Increasing your livestock increases your risk". This is followed by a statement comparing the percentages read directly from the graph. Because of small random differences in modelling outputs from run to run, all written percentages presented to users are rounded to the nearest 5% - this avoids issues with users seeing a different output when a scenario is repeated. An explanation of the process behind the graph's creation is also provided to give further insight to interested users. This is displayed in Figure 2 below.

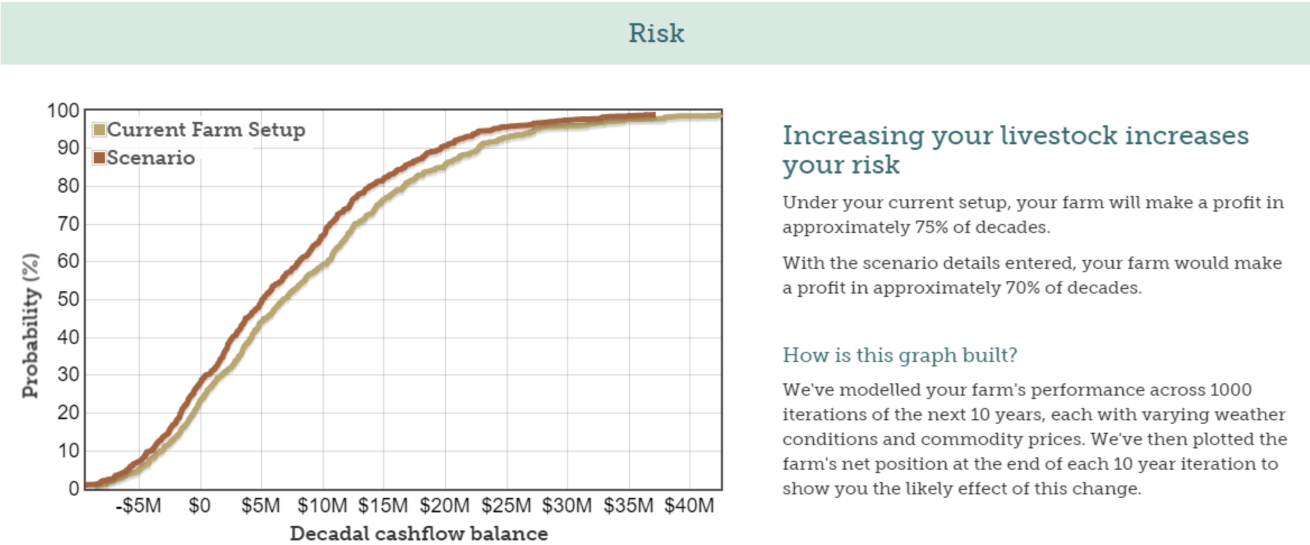

Figure 2. Example risk outputs created by the Farm4Prophet website.

Farm4Prophet has not yet had an opportunity for formal usability testing. Small-scale display of the product to interested parties has yielded promising results with both low and high graph literacy users. It is hypothesised that this design allows each type of user to look first at the content that interests them, allowing them to engage with the product at an appropriate level.

Graph simplification

Yield Prophet Lite is a free calculator that allows growers and agronomists to estimate potential yield values for crops based on rainfall and fertilisers applications using the Sadras and Angus (2006) formula. It is available on the web, and for iPad and iPhone through the App Store.

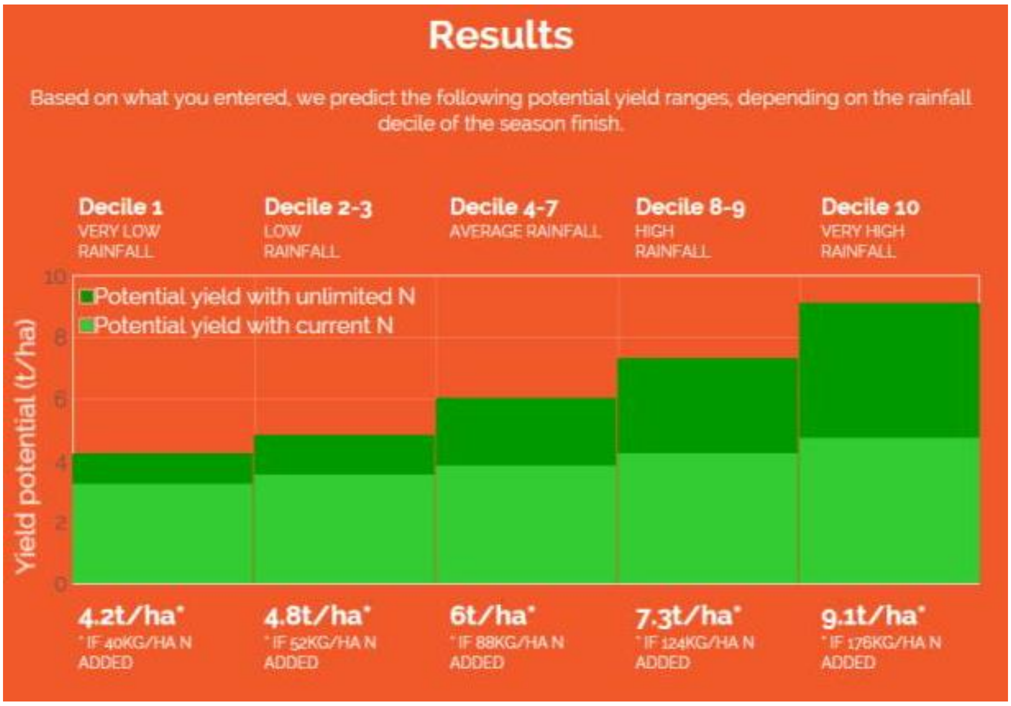

Figure 3. Example Yield Prophet Lite outputs for a wheat paddock.

Yield Prophet Lite is required to provide a very similar output to the full Yield Prophet (yield values vs probability), but was challenged to simplify the outputs for presentation to users without a high level of graph literacy. Prior research has shown that users are faster (Simcox 1984) and more accurate (Carswell and Wickens 1987) at reading data points when viewing bar graphs compared with line graphs, and less likely to describe trends when viewing bar graphs than line graphs (Carswell et al. 1993). For these reasons, it was desirable to display the yield prediction curve as a bar graph instead of a line graph. To display the continuous probability data on a bar graph, transformation and simplification of the data was required. Rainfall deciles were chosen as a way of returning the probabilistic data to something more concrete and well-understood by farmers, and these deciles were further grouped to be displayed as five bars on the chart, representing Very Low Rainfall (Decile 1), Low Rainfall (Decile 2-3), Average Rainfall (Decile 4-7), High Rainfall (Decile 8-9) and Very High Rainfall (Decile 10) (Figure 3). The actual figure used to determine the decile's rainfall for calculation is taken from the middle of the decile range.

Yield Prophet Lite has been informally tested during field days, expos and other events over the past year, and general feedback towards the new graph has been very positive. Comments from users presented with the new graph have indicated their immediate ability to read and understand the graph, their understanding of deciles as a probability measure, and their understanding of the darker bar sections as relating to the effect on yield of additional nitrogen application. This is very promising and future formal usability tests should be conducted to gain more concrete data around this.

Conclusion

As the need for additional agricultural productivity rises, there is an increasing need for scientific modelling and research to be quickly and easily applied by Australian farmers and agronomists. The uptake of technology and the internet on farms enables the rapid delivery of scientific decision-support tools to the paddock, but care must be taken to ensure that the information presented by these tools can be easily understood and applied by farmers and agronomists. Considering graph literacy and exploring different ways of presenting data is a small change that can have a big effect on the efficacy of scientific decision-support tools in the paddock.

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