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Modelling crops and cropping systems – evolving purpose, practice and prospects.

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Cropping systems are characterised by complexity and variability. Complexity arises from inherently complex plant and soil processes combined in an almost infinite set of permutations and combinations and variability associated with biotic and abiotic drivers that are inherently variable in both space and time. This variability is amplified by the management interventions practiced by farmers. Modelling has evolved over the last 70 years as a means of describing and interpreting complex and variable performance and increasingly as a means of predicting likely performance in prescribed circumstances for better decision making.

In this paper we reflect on the evolution of quantitative approaches to describing and predicting crop growth and cropping system performance. We begin with early mathematical descriptions of plant and crop growth and soil processes dating from the 1940's and 50's. We explore the early crop models of the 60's and 70's and the more comprehensive crop-soil models of the 1980's. Cropping systems models with comprehensive systems management capabilities began to gain currency in the 1990s and the ancestry of these models and relationships with broader land systems models examined. Over this long period, the ambitions held by model-makers' for model applications grew and the paper will summarise the very broad range of model applications that have emerged in the early 21st Century from the 60 years of quantitative analysis of crop and cropping systems in the 20th Century.

Throughout this history of model making and application, a creative tension has existed between "statistical" and "mechanistic" approaches to model specification. Statistical approaches have found favour in circumstances where comprehensive data are available to develop robust models useful in a broad range of situations. Mechanistic (or phenomenological) approaches have found favour in situations of sparse data where extrapolation beyond the data available is likely to be more successful. The paper concludes with a look forward – will the rapid developments in sensors, sensor networks, monitoring and the internet of things reduce the historical data constraints that have limited statistical approaches? Will be see more model-data fusion and integration of statistical and mechanistic approaches to model building and application in the decades ahead? What benefits are likely to flow from such trends?