Using Group Collaborative Investigations to Develop Pasture Biomass Prediction Equations

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Abstract

Graduates from agriculture/agribusiness courses need to understand the multidisciplinary nature of agriculture, to think critically and solve problems in the role of an agricultural advisor. Producers are being exposed to new technologies developed for integration into agricultural production systems. Producers require technical support from external sources such as advisors and consultants, to identify relevant technologies, identify potential constraints of the technology and to support adoption. Information from such technologies may not be relevant to the production system, potentially resulting in information that has limited relevance. It is important that students develop an understanding of the processes used to develop predictive relationships between data generated by technology and the production system. In this study, students worked as collaborative teams, to design and implement an investigation aimed at developing prediction equations for pasture biomass using NDVI and a range of measurable agronomic parameters. The investigation provided students with the opportunity to gain an understanding of the importance and relevance of information to build prediction equations, to develop critical evaluation skills, to identify limitations to the process, propose solutions, and to work as a team to achieve the desired outcomes.

Introduction

The rapid rate of technological change and its role in agricultural production practices, requires tertiary education institutes to produce graduates who are capable critical thinkers and problem solvers, able to manage quantitative data, effective communicators, and able to address challenges across disciplines (Noel & Qenani, 2013). Producing graduates who understand the multidisciplinary nature of agriculture and are able to transfer skills to successful agricultural practice (Botwright Acuña & Able, 2016) is a goal of the Bachelor of Agribusiness (B. Agribusiness) program at Curtin University (Perth, Western Australia).

Technologies such as sensors, computers, data collection devices, decision making software and phone-based applications, are becoming more integrated into agricultural production systems in areas such as soils, cropping, pasture management and livestock production. Collected data may be used directly, or used to develop predictive equations that can inform the decision-making process (Kitchen, 2008), but the knowledge and understanding of the scope and how to apply the information may often be lacking.

Producers often require external support, such as advisors and consultants, to assist them identify appropriate technologies that will provide helpful information and to provide technical support for practice change (GHD & AgThentic, 2018). Uptake of new technologies is driven by producer confidence in the validity and relevance of information to farm location and enterprise requirements. Advisors play a supporting role in assisting producers adopt new technologies. Technologies that provide ‘an instant answer’ (black box approach) may lead to poor decisions due to limited understanding of the use of the equipment, relevance of prediction equations and understanding of the constraints that may limit interpretation of the information.

Real time estimations of pasture and crop biomass are essential for the management of feed resources for grazing livestock. Improving grazing management through more accurate and relevant information has the potential to increase farm profitability for grazing industries by around 10% (Henry et al., 2012) and by $A112/ha to $A288/ha (Gherardi & Oldham, 2003) by increasing pasture utilisation and reducing use of supplements. NDVI (normalized difference vegetation index) is positively correlated with photosynthetically active plant mass, leaf area index and plant biomass, through collection of reflectance data and calculation of the ratio of the red and near infrared bands to provide an index of ‘greenness’ (Andersson et al., 2017; Flynn, Dougherty, & Wendroth, 2008; Khosia, Hula, Raun, & Thomasson, n.d.).

The use of hand-held Passive and Active Optical Sensors (AOS) that collect NDVI data, could provide producers with relevant, real-time data to support grazing management decisions. AOS have been used to determine response to nitrogen inputs (Bronson et al., 2017) in crops, and have the potential to provide estimates of pasture biomass as well as the ability to calculate pasture growth rates (Andersson, 2018; Andersson et al., 2017; Flynn et al., 2008; Kahn, 2017). Although NDVI alone can be used to predict pasture biomass (Flynn et al., 2008) current research has shown that the accuracy of predictions can be improved (Kahn, 2017) by developing equations that include additional plant parameters.

This investigation was developed to help students gain an understanding of the importance of both data relevance and quality to the development of prediction equations for pasture biomass. Understanding both data sources and potential limitations of the information is needed to provide producers with support for the adoption and use of such technologies. The investigation was designed to (i) clarify the approaches to predicting pasture biomass that can be used by producers, (ii) identify plant parameters that are required to develop such pasture biomass predictions, (iii) identify potential constraints to the development and use of prediction equations for producers, and, (iv) develop team skills.

Approach

Final year university students, undertaking a pasture management unit in B. Agribusiness, evaluated the potential for hand-held NDVI sensors to be used to estimate biomass for a range of pasture species commonly grown in Western Australian grazing systems. The investigation ran over one semester and was designed to address a number of the threshold learning outcomes that have been identified as of importance to agriculture graduates – knowledge of agriculture (TLO2), inquiry and problem solving (TLO3) and personal/professional responsibility (TLO 5) (Botwright Acuña & Able, 2016).

The investigation was carried out at the Field Trials Area (FTA) on the Curtin University, Perth campus. Facilities of this type provide opportunities for experiential learning activities (Parr & Edwards, 2004; Parr & Trexler, 2011), including trial design, implementation and management. Duplicate raised planter beds were sown with a number of pasture species (legumes and grasses) with a range of growth habits. Each planter bed contained a single species with the exception of the mixed ryegrass beds. The species were lucerne (*Medicago sativa* cv Blue ace), subterranean clover (*Trifolium subterraneum* cv Dalkeith), tetraploid ryegrass (*Lolium perenne*), French serradella (*Ornithopus sativus* cv Maguarita), commercial ryegrass mix (annual, perennial) and white clover (*Trifolium repens* cv Tribute). Each planter bed was split into 2, providing 4 replicates for each species (2 beds x 2 plots/bed).

Through a series of directed workshops, the class worked as a team to plan the investigation, identify the measurable parameters that could be correlated with biomass and develop the methodology that would be used. In the first workshop students shared knowledge and experiences on the use of NDVI as a tool in cropping and shared ideas on the potential for NDVI to inform grazing management decisions. In the second workshop, students used reports from recent research programs (Andersson, 2018; Kahn, 2017) together with identification of agronomic features of the species in the investigation to (i) identify pasture (agronomic) parameters that could be measured to assist in prediction of pasture biomass, (ii) determine methodology to be used in the investigation, and (iii) to set the timing of data collection. Tasks were allocated by the team to ensure all data were collected. Master spread sheets were set up for capturing the data at each collection.

The final workshop was run to critically review the data by identification of discrepancies with the data set. Students used this workshop to validate data, and clarify methodology used in data collection. In this workshop students shared ideas on the approach to development of the prediction equations for the species in the investigation. Students drew on knowledge from both crop production and statistics academic units to identify approaches to the development of prediction equations for green biomass using one or more of the measured parameters. In addition, the relevance of single species or multiple species equations for use on-farm was addressed. As part of this discussion, the group identified areas that could be improved in future iterations of the investigation. Peer discussion and teamwork in all aspects of the investigation was expected to improve the learning experience, build team skills through sharing of knowledge and ideas, and to improve understanding of the process and challenges in the development of prediction equations (Froyd & Simpson, 2008; Kirkup, 2015).

Outcomes

New technologies have the potential to enable farmers to boost productivity and efficiency of agriculture through better informed decision making (StartupAUS & KPMG, 2016). Barriers to the uptake of new technologies include lack of confidence in the information and its relevance, lack of understanding of the relationships between data and information relevant to decisions, the lack of local experts (Kitchen et al., 2002), and the identification, analysis and understanding of the variables and factors needed to make efficient management decisions (Kitchen et al., 2002). Kitchen et al. (2002) have identified that precision agriculture education needs to be incorporated into and across agriculture disciplines. This investigation provided students with the opportunity to expand the use of hand-held NDVI to pastures.

Initial expectations from the workshop discussions were that the best predictors would be the same for all species in the investigation. Students used single and multiple regression to identify the parameter(s) that were the best predictors of green biomass for each species. Through comparison of the agronomic features of the species in the investigation, students developed a better understanding of the relationship between plant structure and green biomass. Through discussion on growth habits, stage of growth, and single or multispecies pastures, students acknowledged that the best predictors may not be the same for each species. Students also acknowledged the importance of using parameters that could be measured on-farm by farmers, allowing them to develop prediction equations that would be relevant to their pastures.

Although the investigation required the development of teamwork, students submitted an individual report for assessment. The report allowed students to demonstrate understanding of the investigation as well as the ability to critically evaluate both the data and assess the value of the approach to on-farm practice. Although the general approach was similar, some students explored the potential value of combining data from species with similar growth habits, as the means to generate more robust equations with broader application of the prediction to pastures. This led to improved understanding that the value of such tools is dependent on the relevance and validity of the data used to develop the tools.

Effective project-based learning requires authentic problems, should be student-driven and should involve a constructive investigation that includes both inquiry and knowledge building (Barron & Darling-Hammond, 2008). Students demonstrated continued building of knowledge through the semester by the increasing depth of questioning and exploring of issues that arose through the investigation. As a result of discussions after the initial data collection, the initial data set was not included in the final analysis. Methods were modified following the discussion through consensus prior to the next data collection. The process of issue recognition, constructive discussion and the resulting consensus, demonstrated maturing critical thinking and problem-solving skills. As the investigation progressed groups improved channels of communication, as the importance of standardising data collection methods and identifying potential issues became clear. Through the discussion process students recognised the importance of standardising methodology and data records as critical to being able to generate prediction equations with acceptable r^2 values.

As part of the final report, students critically assessed the methodology, identified constraints and limitations to the investigation, and proposed changes that could improve the outcomes and relevance of the investigation. Although students had shared ideas in the workshops on constraints to the investigation, the reports demonstrated a broad range of understanding of both the potential constraints to the investigation, as well as the possibilities for application of this approach on-farm. Most students recognised the potential disconnect between single species prediction equations and practical grazing applications where systems are likely to contain multiple plant species of both grasses and legumes. Key outcomes of the investigation included (i) a better understanding of the relationship between species growth habits and biomass, (ii) recognition that data needed to represent the species over the production year rather than a restricted period of time to expand the NDVI values, (iii) that equations are improved by having large data sets rather than limited data sets, (iv) that the highest r^2 may not be the main focus – having prediction equations relevant to multiple species may be preferable and (v) that many students were confident that they could develop prediction equations to pastures on their own farms. The importance of variability due to use of different NDVI meter types was mentioned by some members and was proposed as a comparison that could be included in future investigations. The range of new questions and suggested areas of improvement demonstrated that many of the students were able to clearly identify ways of filling knowledge gaps (Kahn & O'Rourke, 2004).

In this learning environment, the collaborative group was able to take control of the investigation, transforming the group into 'student agriculturalists' (Low & Bennett, 2016). Through the semester, students developed a better understanding of teamwork, moving from individual ideas and approaches, to a consensus approach towards both undertaking the investigation and critically assessing the collected data. At the beginning of the semester, students contributed to the discussion with information from background reading. As the planning progressed, students were observed to take ownership of the investigation and share personal experiences and ideas. This development is in line with the role of a team as the "advancement of individual and collective knowledge" (Volkov & Volkov, 2015) and results in a deeper learning experience for most team members. The methodology used in the investigation was developed from reading available reports, identifying parameters that could be correlated with pasture biomass, and trialling them with the plots and plant species in the trial area. Students worked together using the trial plots to determine the height at which NDVI should be measured, the methods for measuring plant height and the cutting heights for harvesting plant biomass, including the options of single or multiple cuts at each measurement date. Students working together as a collaborative group demonstrated many benefits identified by other researchers (Barron & Darling-Hammond, 2008) including improved social interaction between group members, increasing self-confidence and a greater willingness to share ideas.

Conclusion

This investigation provided students with the opportunity to develop collaborative skills in defining, planning, implementing and objectively assessing the outcomes of a project to develop pasture biomass prediction equations. Students were able to draw on knowledge from other units within their degree as well as personal experience, to collaboratively build their understanding of the importance of standardised procedures and data presentation. In addition, the investigation enabled students to gain understanding of the ways in which tools and applications are developed for use by producers and increased their confidence in assisting producers in the uptake of new technologies.

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