# Farm-management tools: reasons for the decision not to use specific tools

RA Corner-Thomas [a]*, PR Kenyon [a], ST Morris [a], AL Ridler [a], RE Hickson [a], AW Greer [b], CM Logan [b] and HT Blair [a]

[a]*International Sheep Research Centre, School of Agriculture and Environment, Massey University, Palmerston North, New Zealand;* [b]*Faculty of Agriculture and Life Sciences, PO Box 85084, Lincoln University, 7647, Christchurch, New Zealand.*

* *Corresponding author.* Email: r.corner@massey.ac.nz

## Abstract

There are a large number of management tools available to farmers, however, some are utilised by only a small percentage. The reasons behind the choice not to use a particular tool were investigated using a postal questionnaire that was distributed to all New Zealand sheep farmers in 2014. Farmers were asked first to indicate from a list of 40 farm-management tools those they had used in the previous three years. For tools they had not used, they were asked to select one from a list of eight reasons. A total of 1659 usable questionnaires were received. The most commonly cited reason for not using any given tool was "not relevant to my situation" (50.3%) followed by "benefits not apparent" (15.3%) and "it's an unwanted complication" (15.0%). Demographic factors (age, education, gender, farm type and flock size) influenced the reasons for non-use of 20 of the 22 tools. Reasons for non-use of fecundity-boosting vaccine or quarantine treatment for footrot were not influenced (P>0.05) by any demographic factors. The results suggest that although many farmers do not see the relevance of particular tools to their enterprise, demographic factors can influence their reasons for not using a tool.

**Keywords:** farm-management tools; age; education; gender; farm type; flock size; non-use reason

## Introduction

Sheep-farming enterprises are complex and farmers need to consider a range of parameters when making management decisions, including economic, environmental, social, animal, forages, soils, regulations, compliance to marketing standards. Farmers, therefore, need to be able to plan and forecast in order to optimise the performance of their farming system. There are a large number of farm-management tools available to New Zealand farmers to support their on-farm decision making. In 2011, a report identified 127 tools that were available to New Zealand farmers (Allen & Wolfert 2011). The use of these tools has the potential to improve farm productivity through improved animal health, feed management and data collection. Due to the large number of tools that are available, farmers must choose which tools they will use. There has been a great deal of research regarding the factors that influence the adoption of new technologies (Daberkow & McBride 2003; McBride & Daberkow 2003; Pierpaoli et al. 2013), however, less is known about the use of farm-management tools that have been in existence for a longer period of time. The motivations for farmers to utilise established tools is likely to differ from those for the adoption of new technologies. The adoption of new technologies is widely acknowledged to have two phases: the first is awareness and the second is adoption (McBride & Daberkow 2003). For tools that are well established, awareness is unlikely to prevent adoption of the tool, however, given the large number of tools it is possible that a farmer may be unaware of a specific tool. For established tools dis-adoption may have occurred as the result of poor outcome or performance (Eastwood & Dela Rue 2017). In a questionnaire conducted in 2012 a number of tools were identified that were used by few farmers (Corner-Thomas et al. 2015), however, it was not possible to determine the reasons for the choice not to use a particular tool. The aim of this study, therefore, was to investigate the reasons for the non-use of management tools by New Zealand sheep farmers.

## Materials and methods

A printed questionnaire was distributed to ~12,000 sheep farmers within the 'Heartland Sheep magazine' (NZX Agri, Feilding New Zealand) in October 2014 (Corner-Thomas et al. 2016). The questionnaire contained three sections: section one contained questions about the respondent, such as age, gender and highest education level and the sheep-farming enterprise such as farm size, stock numbers and location. Section two asked the question "Which of the following (if any) management tools have you used in the last three years and which tools are you planning to use in the next three years? For those tools that you are not planning to use please indicate the option that best describes the reason for not using a tool (please choose only one reason per management tool)." (Figure 1). Section three contained some additional questions to clarify responses to section two.

*Statistical analysis*

All statistical analyses were conducted using SAS 9.4 (SAS Institute, Cary, NC, USA). The analyses included respondents that had completed section two and had given only one reason for not using a farm-management tool (n=1621). Descriptive statistics were generated for the demographic factors using the frequency procedure for categorical variables and means for continuous variables. The frequency of respondents that used each farm-management tool was determined using generalised model using a binomial distribution and logit transformation. The percentage of respondents that used each tool is presented as the back-transformed mean and 95% confidence intervals

**Table 1** The percentage (back-transformed logit mean with the 95% confidence interval given in parentheses) of respondents that indicated that they had used each management tool in the previous three years.

| Management tool | Percentage of respondents | Management tool | Percentage of respondents |
|---|---|---|---|
| Animal health | | Animal measurements | |
| Facial eczema spore count | 10.9 (9.5 - 12.5) | Fecundity boosting vaccine | 11.5 (10.0 - 13.1) |
| Quarantine - footrot | 17.6 (15.8 - 19.5) | EID tag | 23.6 (21.6 - 25.7) |
| Quarantine - brucellosis | 25.9 (23.9 - 28.1) | Breeding harness | 32.7 (30.5 - 35.0) |
| Salmonella vaccination | 26.5 (24.4 - 28.7) | Breeding values | 48.6 (46.2 - 51.1) |
| Refugia | 32.5 (30.3 - 34.8) | Weigh ewes | 49.5 (47.1 - 51.9) |
| FECRT | 34.1 (31.8 - 36.4) | Non-EID tags | 59.1 (56.7 - 61.4) |
| Quarantine - external parasites | 42.7 (40.3 - 45.1) | BCS ewes | 59.7 (57.3 - 62.0) |
| FEC | 50.7 (48.3 - 53.1) | Examine ewe feet | 69.9 (67.7 - 72.1) |
| Trace element status | 55.5 (53.1 - 57.9) | Pregnancy scanning | 74.6 (72.5 - 76.7) |
| Campylobacter vaccine | 61.8 (59.5 - 64.2) | Weigh sale lambs | 76.8 (74.7 - 78.8) |
| Toxoplasma vaccine | 70.1 (67.8 - 72.2) | Examine ewe udders | 87.5 (85.8 - 89.0) |
| Quarantine - internal parasites | 70.3 (68.0 - 72.4) | Examine ewe teeth | 92.5 (91.1 - 93.6) |
| Prelamb clostridia vaccine | 82.1 (80.1 - 83.8) | | |
| | | Herbage measurements | |
| Environmental measurements | | C-DAX pasture meter | 1.0 (0.6 - 1.6) |
| Soil moisture | 22.4 (20.5 - 24.5) | Pasture probe | 8.0 (6.8 - 9.4) |
| Nutrient budgeting | 33.0 (30.8 - 35.3) | Rising plate | 9.7 (8.4 - 11.2) |
| Soil temperature | 48.0 (45.6 - 50.4) | Sward stick | 25.9 (23.8 - 28) |
| Rainfall data | 79.8 (77.8 - 81.7) | Herbage quality | 31.3 (29.1 - 33.6) |
| Soil fertility test | 86.9 (85.2 - 88.4) | Visual pasture cover | 81.7 (79.7 - 83.5) |
| | | | |
| Software | | | |
| Overseer® | 14.4 (12.8 - 16.2) | | |
| Feed budgeting | 43.6 (41.2 - 46.0) | | |
| Farm mapping | 56.8 (54.4 - 59.1) | | |
| Financial budgeting | 63.7 (61.3 - 65.9) | | |

(Table 1). The frequency that each reason was selected across all 40 farm-management tools was determined using Proc freq and the interquartile range using Proc univariate. Farm-management tools used by less than 50% of respondents (n=22) were further analysed to assess the influence of demographic factors including age (<40, 40 – 49, 50 – 59 and >60 years of age), gender (male and female) and highest level of education (high school, certificate/ diploma or degree/postgraduate), farm type (North Island hill or hard hill, North Island intensive finishing, South Island hill or high country, South Island intensive finishing) and flock size (<300, 300 – 1,000, 1,000 - 3,000, 3,000 – 5,000 and >5,000 mixed age ewes; Table 2). Due to relatively small numbers of "unaware of tool" and "too costly" being selected these were recoded as "other" in the assessment of demographic factors. Chi-squared analyses were conducted to determine the influence of demographic factors on the frequency of respondents that gave each reason for not using a particular farm-management tool (Table 2).

## Results and discussion

*Demographics*

A total of 1659 of the ~14,000 questionnaires distributed (12%) returned usable responses. Of these, 38 were excluded because they contained more than one reason for the non-use of a tool. The 1621 questionnaires produced a sum total of 16,965 reasons for not using the 40 farm-management tools listed. A previous questionnaire that utilised the same postal method achieved a similar response rate (Corner-Thomas et al. 2017). The respondents represented farms with a median flock size between 300 to 1,000 mixed-age ewes, an effective farm area of 850 ha, and a mixed-age ewe lambing percentage (lambs present at weaning) of 135%. Beef + Lamb NZ (2018) reported that the average New Zealand sheep and beef farm was 371 ha, had a flock size of 1,098 ewes and a lambing percentage of 1.26 lambs per ewe presented for breeding. The respondents in the current study, therefore, had larger farms but a similar flock size and higher performance than the national average.

The majority of respondents were male (90.5%) with 9.5% female. Respondent age classifications were: less than 40 years of age (12.5%), between 40 and 49 years of age (34.3%), between 50 and 59 years of age (20.2%) and greater than 60 years of age (33.0%). The highest level of education of farmers was high school for 46.0%, national certificate or diploma for 33.8% and tertiary degree or post-graduate degree for 20.1%. When demographic data from the current study was compared with the 2012 census data for the agricultural sector a greater proportion of respondents were male (90.5 vs. 32.8%, respectively), had a greater median age (50 to 59 years vs. 40 to 49 years, respectively) and were more likely to have a high

**Table 2** The number of respondents for each farm management tool, the percentage of respondents that cited each reason and the chi$^2$ p value of the effect of respondent age, highest level of education, gender, farm type and flock size on the frequency of responses.

| Farm management tools | n | Reason | | | | | | P value | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Benefits not apparent | Unwanted complication | Labour/ logistics | Not relevant | Use, no benefit, rejected | Other | Age | Educ | Gender | Farm Type | Flock Size |
| EID | 1021 | 18.2 | 20.2 | 4.6 | 35.8 | 1.5 | 19.8 | 0.005 | 0.001 | | 0.04 | 0.002 |
| Weigh ewes | 612 | 22.7 | 18.1 | 16.7 | 33.7 | 6.5 | 2.3 | | 0.01 | 0.02 | | 0.001 |
| Breed value | 581 | 15.2 | 14.6 | 5.2 | 55.4 | 1.6 | 8.1 | | 0.03 | 0.03 | | |
| Breed harness | 924 | 17.3 | 21.4 | 8.0 | 36.0 | 15.9 | 1.3 | | | | 0.02 | 0.001 |
| Fecundity boosting vaccine | 1140 | 14.8 | 18.5 | 2.5 | 44.9 | 7.8 | 11.4 | | | | | |
| Rising plate meter | 1086 | 14.7 | 23.5 | 10.3 | 39.0 | 4.8 | 7.7 | 0.01 | | 0.001 | | |
| Sward stick | 884 | 13.9 | 24.1 | 6.9 | 42.4 | 5.1 | 7.6 | | | 0.01 | | |
| Pasture probe | 1084 | 14.2 | 23.3 | 7.2 | 37.6 | 5.3 | 12.5 | 0.02 | 0.001 | 0.003 | 0.03 | |
| Herbage quality | 703 | 19.1 | 22.6 | 6.8 | 37.3 | 3.7 | 10.5 | | 0.04 | 0.01 | | |
| C-DAX pasture meter | 1220 | 12.4 | 17.6 | 5.6 | 37.4 | 2.8 | 24.3 | 0.001 | 0.001 | 0.02 | | |
| Quarantine treatment for: | | | | | | | | | | | | |
| External parasites | 620 | 15.8 | 5.8 | 3.1 | 70.2 | 1.0 | 4.2 | 0.01 | | | | |
| Brucellosis | 861 | 10.8 | 4.7 | 1.2 | 76.3 | 0.9 | 6.2 | 0.05 | | | | |
| Footrot | 1011 | 12.4 | 4.7 | 2.5 | 75.0 | 1.6 | 4.0 | | | | | |
| Salmonella vaccine | 907 | 19.1 | 6.6 | 1.4 | 58.0 | 6.7 | 8.2 | 0.04 | | | 0.001 | |
| FECRT | 610 | 16.9 | 18.7 | 9.7 | 37.7 | 4.8 | 12.3 | | 0.005 | | | |
| Facial eczema spore count | 1154 | 8.3 | 4.8 | 2.5 | 79.4 | 2.5 | 2.5 | | | | 0.001 | 0.03 |
| Refugia | 654 | 13.8 | 7.5 | 2.8 | 47.3 | 3.1 | 25.7 | | | 0.02 | | |
| Soil temperature | 515 | 20.8 | 15.3 | 9.1 | 47.2 | 2.7 | 4.9 | 0.004 | 0.003 | | | |
| Soil moisture | 842 | 20.6 | 13.3 | 6.5 | 48.3 | 9.4 | 1.9 | | 0.02 | 0.03 | 0.001 | |
| Nutrient budget | 584 | 19.0 | 21.1 | 5.5 | 44.9 | 2.7 | 6.9 | | 0.005 | | | |
| Feed budget | 518 | 14.3 | 22.2 | 7.0 | 46.7 | 3.7 | 6.2 | 0.03 | 0.03 | | | 0.02 |
| Overseer | 810 | 15.6 | 15.6 | 3.7 | 41.0 | 2.7 | 21.5 | 0.001 | 0.005 | | | 0.04 |

school education (46 vs. 20%, respectively; Statistics New Zealand 2013).

*Use of farm-management tools in the previous three years*

For the majority of tools the percentage of farmers that used the tool increased between 2012 and the current questionnaire in 2014 (Corner-Thomas et al. 2016). The reasons for the increases are likely to vary between tools for example the greater use of EID ear tags may have been due to improvements in ease of data handling (Rutten et al. 2018) whereas increased use of breeding values might reflect the diffusion of knowledge throughout farmer networks (Valente & Rogers 1995). Twenty-two of the 40 tools were used by less than 50% of respondents (Table 1).

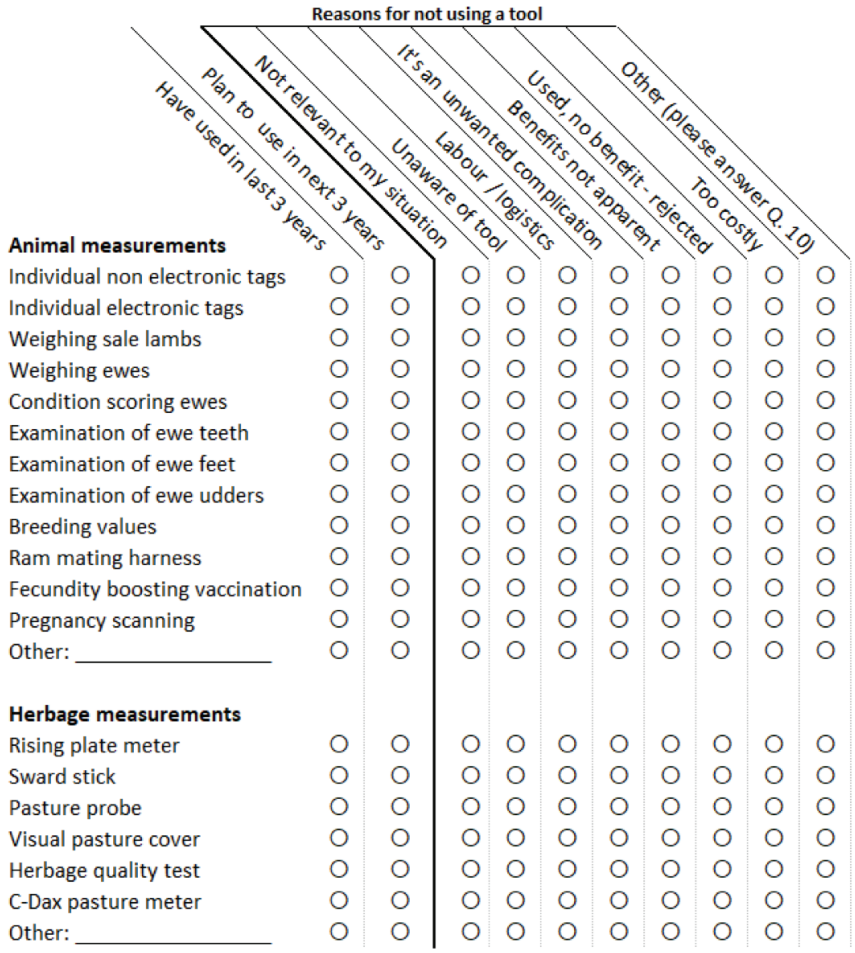
*Reasons for non-use of tools*

The most frequently selected reason for non-use of tools was "not relevant to my situation" (n=8536, 50.3%). The motivation to adopt new technology and the diffusion of new information has received a great deal of attention (Daberkow & McBride 2003; McBride & Daberkow 2003; Pierpaoli et al. 2013), however, little information is available regarding the reasons that farmers do, or do not, use existing tools. Many of the tools listed have been available for many years and, therefore, as a result of the diffusion of information through farming networks (Valente & Rogers 1995) awareness of the tool is less likely to be an impediment to their use. The relatively low percentage of respondents that selected "unaware of tool" (n=930, 5.5%) suggests that a lack of awareness was not an impediment to the use of the tools provided in the current questionnaire.

The structure of the questionnaire listed "not relevant to my situation" as the first option (Figure 1), therefore, it is possible that this response was over-represented in this dataset due systematic positive bias (Siminski 2008). For some tools listed, there would likely be widespread regional variation in the incidence or requirement for the tool. For example, facial eczema is predominantly an animal health issue in the North Island and has a low incidence in the South Island (West et al. 2009). Other tools, however, appear to have little regional variability, for example, the information generated from herbage quality testing is likely to be of benefit to any New Zealand farm (White & Hodgson 1999). There is, however, the potential for unforeseen regional influences that were not detected in this survey.

"Benefits not apparent" (n= 2750, 16%) and "it's an unwanted complication" (n=2694, 15%) were the next most common reasons selected. Interestingly, the percentage of respondents that selected "benefits not apparent" showed less variation (inter quartile range (IQR): 14 – 19%) among

**Figure 1** Reproduction of the animal health and herbage measurement sections of first half of question 9 as presented in the questionnaire




tools compared with "it's an unwanted complication" which varied greatly (IQR: 7 – 21%; Table 2). Both of these responses suggest that the information or benefits generated through the use of these tools were either not seen or the value generated from the tool was not did not outweigh the cost of its use. In the literature on the adoption of new farm management technologies, the cost of implementing new technology is weighed against the perceived benefits as an important motivation to adopt a new technology or practice (Pierpaoli et al. 2013).

The fewest respondents selected "used, no benefit – rejected" (n=730, 4%). It is not clear, however, if this is because farmers were not willing to try new tools or that their relevance was not apparent. It should be noted that the wording of the question in the current questionnaire asked only for the most important reason for not using a particular tool. Therefore the pattern of responses may have been different if the question asked for the respondent to indicate all reasons for not using a particular tool.

*Relationship between demographic factors and reason for non-use of tools*

Two tools, fecundity-boosting vaccine and quarantine treatment for footrot, were not affected (P>0.05) by any of the demographic factors tested (Table 2). The reasons cited for non-use the remaining 20 tools were influenced (P<0.05) by either one (n=6), two (n=6), three (n=6) or four (n=2) of the demographic factors. Due to the large number of comparisons, only examples of the influence of each demographic factor are discussed.

Age influenced the reasons for non-use of ten of the 22 tools (Table 2). The influence of age on the reasons for the non-use of the C-DAX pasture meter showed that "not relevant to my situation" was selected by fewer respondents than expected due to chance by respondents < 40 years of age (27.8 vs. 37.2%, respectively) and a greater number of respondents > 60 years of age (43.9 vs. 37.3%, respectively). Age has been consistently reported to influence the adoption of new technologies (Prokopy et al. 2008). Younger farmers have a greater planning horizon (Baumgart-Getz et al. 2012), tend to be more educated and are hypothesised to be more willing to be innovative (Daberkow & McBride 2003).

Education influenced the reasons selected for the non-use of the most tools (n=12; Table 2). Education influenced the reasons for the non-use of EID such that a greater percentage of respondents with a degree/postgraduate than was expected due to chance selected "benefits not apparent" (28.3 vs. 18.4%, respectively) and fewer selected "not relevant to my situation" (23.6 vs. 35.6%, respectively). Greater years of education has been associated with the increased adoption of new technologies (Prokopy et al. 2008) which may be the result of greater information processing abilities (Thomas et al. 1990). In the current study, farmers with a university education may have had greater abilities to evaluate the new technology and concluded that it would not add benefit to their enterprise.

Gender influenced the reasons selected for the non-use of nine tools (Table 2). The influence of gender on the reasons for non-use of the rising-plate meter showed that there was a greater percentage of female respondents than was expected by chance that selected "labour/logistics" (21.8 vs. 10.3%, respectively) and fewer that selected "benefits not apparent" (7.9 vs. 13.9%, respectively) or "it's an unwanted complication" (14.9 vs. 22.8%, respectively). Our previous questionnaire on the use of farm-management tools by New Zealand sheep farmers showed that gender influenced the use of only two of the 20 tools (Corner-Thomas et al. 2015), however, in the current study, gender influenced the reasons for not using a quarter of the tools. Gender has been shown to influence the ways in which women and men source information and their willingness

to try new things (Kilpatrick et al. 1999). Druschke & Secchi (2014) suggested that social networks and "peer to peer learning may be more relevant to female landowners.

Farm type had the least-frequent influence on the reasons for the non-use of tools (n=6; Table 2). Farm type influenced the reasons for the non-use of the salmonella vaccine such that a greater percentage of respondents than was expected due to chance from South Island finishing farms selected "use, no benefit, rejected" (12.5 vs. 7.1%, respectively) and fewer selected "not relevant to my situation" (48.7 vs. 57.8%, respectively). For tools such a use of the salmonella vaccine and facial eczema spore counting, it is, perhaps, unsurprising to see differences among farm types as these animal health issues show regional variation in their incidence (West et al. 2009) which is likely to influence the farmers perception of the potential value of the tool. The decision to use a tool is a combination of the potential benefits that it can provided which is weighed against the investment required to either implement or use the tool (Marra et al. 2003). It is, therefore, likely that farmers with a greater risk of these animal health problems would be more likely to adoption tools for their prevention.

Flock size influenced the reasons for non-use of eight tools (Table 2). Flock size influenced the reasons for the non-use of weighing ewes such that a greater percentage of respondents than was expected due to chance that had farms less than 300 ha selected "use, not benefit, rejected" (8.7 vs. 6.5%, respectively) and fewer selected "not relevant to my situation" (26.0 vs. 33.3%, respectively). In addition, a greater percentage of respondents than expected due to chance that had farms greater than 5000 ha selected "labour/logistics" (34.3 vs. 16.9%, respectively). It is generally hypothesised that adoption of technology will occur earlier on larger farms due to a willingness to invest in the technology (Reichardt & Jurgens 2009).

## Conclusion

The aim of the current study was to investigate the reasons for the non-use of farm-management tools by New Zealand sheep farmers. The results indicate that the reasons for the non-use of tools that were used by less than 50 percent of respondents was predominantly due to the perception of a lack relevance of the tool to the farming enterprise rather than to a lack of awareness of the tool. The reasons for the non-use of tools varied by farmer demographic factors. These results suggest that to improve the uptake of particular management tools a unique and targeted approach is required for the specific tool and the demographics of the intended audience. That is not to say that all tools should be used, it is likely that for each enterprise there is a suite of tools that can be used to optimise productivity. To allow farmers to make decisions about what tools are needed there needs to be economic and investment analyses to quantify the performance and management benefits of each tool (Rutten et al 2018).

## Acknowledgements

This research was funded by Massey University and Partnership for excellence.

## References

Allen J, Wolfert S 2011. Farming for the future: Towards better information-based decision-making and communication. Phase 1: Australasian stocktake of farm management tools used by farmers and rural professionals. 48 p.

Baumgart-Getz A, Prokopy LS, Floress K 2012. Why farmers adopt best management practice in the United States: A meta-analysis of the adoption literature. Journal of Environmental Management 96: 17-25.

Beef + Lamb NZ 2018. Compendium of New Zealand farm facts. Wellington, New Zealand, Beef + Lamb New Zealand. 28 p.

Corner-Thomas R, Kenyon P, Morris S, Ridler A, Hickson R, Greer A, Logan C, Blair H 2017. Farmer perceptions of the relative usefulness of information providers and technology transfer methods. New Zealand Journal of Agricultural Research 60: 245-262.

Corner-Thomas RA, Kenyon PR, Morris ST, Ridler AL, Hickson RE, Greer AW, Logan CM, Blair HT 2015. Influence of demographic factors on the use of farm management tools by New Zealand farmers. New Zealand Journal of Agricultural Research 58: 412-422.

Corner-Thomas RA, Kenyon PR, Morris ST, Ridler AL, Hickson RE, Greer AW, Logan CM, Blair HT 2016. Brief communication: The use of farm-management tools by New Zealand sheep farmers: Changes with time. Proceedings of the New Zealand Society of Animal Production 76: 78-80.

Daberkow S, Mcbride W 2003. Farm and operator characteristics affecting the awareness and adoption of precision agriculture technologies in the us. Precision Agriculture 4: 163-177.

Druschke CG, Secchi S 2014. The impact of gender on agricultural conservation knowledge and attitudes in an iowa watershed. Journal of Soil and Water Conservation 69: 95-106.

Eastwood C, Dela Rue B 2017. Precision grazing management-understanding farmer uptake of grazing software. Proceedings of the 1st Asian-Australasian Conference on Precision Pastures and Livestock Farming. Pp. 16-18.

Kilpatrick S, Johns S, Murray-Prior R, Hart D 1999. Managing farming: How farmers learn.

Marra M, Pannell DJ, Ghadim AA 2003. The economics of risk, uncertainty and learning in the adoption of new agricultural technologies: Where are we on the learning curve? Agricultural Systems 75: 215-234.

Mcbride WD, Daberkow SG 2003. Information and the adoption of precision farming technologies. Journal of Agribusiness 21: 21-38.

Pierpaoli E, Carli G, Pignatti E, Canavari M 2013. Drivers of precision agriculture technologies adoption: A literature review. 6th International Conference on Information and Communication Technologies in Agriculture, Food and Environment (Haicta 2013) 8: 61-69.

Prokopy LS, Floress K, Klotthor-Weinkauf D, Baumgart-Getz A 2008. Determinants of agricultural best management practice adoption: Evidence from the literature. Journal of Soil and Water Conservation 63: 300-311.

Reichardt M, Jurgens C 2009. Adoption and future perspective of precision farming in germany: Results of several surveys among different agricultural target groups. Precision Agriculture 10: 73-94.

Rutten C, Steeneveld W, Lansink AO, Hogeveen H 2018. Delaying investments in sensor technology: The rationality of dairy farmers' investment decisions illustrated within the framework of real options theory. Journal of Dairy Science 101: 7650-7660.

Siminski P 2008. Order effects in batteries of questions. Quality and Quantity 42: 477-490.

Statistics New Zealand 2013. Census of population and dwellings.

Thomas JK, Ladewig H, Mcintosh WA 1990. The adoption of integrated pest-management practices among texas cotton growers. Rural Sociology 55: 395-410.

Valente TW, Rogers EM 1995. The origins and development of the diffusion of innovations paradigm as an example of scientific growth. Science communication 16: 242-273.

West DM, Bruere AN, Ridler AL 2009. The sheep: Health, disease & production. 3rd ed. Wellington, New Zealand, The New Zealand Veterinary Association Foundation for Continuing Education. 477 p.

White J, Hodgson JG 1999. New Zealand pasture and crop science, Oxford University Press.