

SMARTFARMS ENVIRONMENTAL MONITORING SYSTEM

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Abstract

The Smartfarms environmental monitoring system provides a simple and credible system of collating on-farm environmental health information. The system provides farmers with tools that enable them to measure and demonstrate their farm's environmental performance. Smartfarms takes quality assurance and compliance a step further. Currently the implementation and physical impact of activities such as land retirement, riparian fencing, riparian planting, reducing tillage and increasing biodiversity on-farm go unnoticed. Smartfarms provides a platform for land managers to show their impact on the environment.

In our experience most farmers are undertaking a range of activities to look after their environment. However, the benefits of these activities are long term. The concept with Smartfarms is to make annual physical measurements of soil, water and air quality which reflect progress with time (5-10 years say). In this way farmers can demonstrate their impact on the environment which may help show progress to a range of stakeholders and improve profitability. Experience to date shows that while the measurements per se are important, equally important is the provision of a tool for engagement and learning for farmers. The system is available to all farmers who could use some or all features. Monitoring kit is \$90 and at this stage subscription is free. A website and App are available (www.smartfarms.org.nz) and has been tested by farmers.

Smartfarms provides for off-line data entry to cope with all rural conditions. There is a focus on making simple, quick, easy and robust measurements and quickly providing data in digital form for further analysis. Smartfarms facilitates this in a seamless, paperless and easily auditable way.

Introduction

Most farmers aim to operate sustainably and continually improve their practices and infrastructure so that they may leave their land and business in a better state than when they started farming. The principles of sustainable land management are not generally in dispute, but farmers need some effective tools so that customers can recognise this. For example farmers who are doing significant work in addition that required for compliance don't necessarily get recognition for that extra work in the market or by regulators. A two pronged approach to is required to solve this by both demonstrating on-farm environmental performance and using that evidence from the ground to develop techniques of communicating with the

market in a way which differentiates NZ product as high value. The Smartfarms farm environmental monitoring system can facilitate the former of those two aspects through simple, practical farmer level tools and measurements that provide a feedback loop to farmers – helping show how they are progressing with sustainable land management. These on-site measurements and process indicators could be related (digitally) to other Quality Assurance (QA) systems as required. For example the NZ Sustainability Dashboard could provide a facility to centralise this sort of information for export markets and already does so for Sustainable Winegrowers and Kiwifruit growers (<http://www.nzdashboard.org.nz>).

Most export products are backed by a QA scheme eg Supply Fonterra. Smartfarms has been designed to augment rather than compete with these. High level farm systems checklist (Figure 1) and Property level assessments (Figure 2) are included so that the status of QA systems, farm environmental plans and nutrient budgets and alike are recognised. Aspects such as cash flow budgets, succession plans, areas of land retirement are also recorded.

Farm: Ardroy
 Checklist date: 17 Oct 2017

Economic / financial plan	Yes
Economic / financial plan notes	Cash Manager
Nutrient budget	Yes
Nutrient budget notes	Fonterra
Succession plan	In progress
Whole farm plan / land environment plan	Yes
Whole farm plan / land environment plan notes	Ex GWRC Fresh start, just for planting and fencing
Active nutrient management plan	Yes
Active nutrient management plan notes	Moderate applications based on need including effluent blocks
Employment contracts for all staff	Yes
Community involvement	Yes
Community involvement notes	Range of Trusts
Compliant with consent requirements	Yes
Compliant with consent requirements notes	Eff pond still to be commissioned
Current with required Quality Assurance System	Yes
Health and Safety Management System	Yes
Animal welfare	Yes
Restoration plan for larger native habitat areas	Yes
Restoration plan for larger native habitat areas notes	Ex GWRC
Do you use genetically modified organisms including in trials on the property?	No
Is your farm a conventional or organic farm?	Organic

Figure 1 Example of a Smartfarms Farm Checklist

Assessment date: 29 May 2018

<u>Soil</u>								
Area of erosion prone land: 0.00 Area of erosion prone land actively managed to reduce soil erosion: 0.00								
<u>Vegetation diversity</u>								
Plantation forest area: 0.00 Native forest / scrub area: 0.50 Wetland area: 0.50 Diverse pasture species area: 60.00 Vegetation diversity notes: Plantain, chicory, red clover, "fruit salad" white clover, 2 x ryegrasses, cocksfoot								
<u>Waterway Management</u>								
Length of waterway: 2500 Length with all stock excluded: 2500 Length where stock not excluded: 5000 Length with cattle only excluded: 2500 Length with vegetation cover: 190 Number of trees planted in riparian area: 2000 Number of track crossings or track runoff discharge points: 4 Length of eroding banks: 0 Waterway Management notes: Note only cattle on the farm, planting on 1250m/1m spacing ? estimate 2000 trees planted. Erosion rare, maybe a few metres in a flood.								
<u>Animal Welfare</u>								
Percentage Stock deaths: 2 Animal Welfare notes: 230 cows, young stock off, 5 deaths								
<u>Birds</u>								
<table border="1"><thead><tr><th>Species</th><th>Abundance</th></tr></thead><tbody><tr><td>Blackbird</td><td>lots all the time</td></tr><tr><td>Skylark</td><td>lots all the time</td></tr><tr><td>Swallow, Welcome</td><td>lots all the time</td></tr></tbody></table>	Species	Abundance	Blackbird	lots all the time	Skylark	lots all the time	Swallow, Welcome	lots all the time
Species	Abundance							
Blackbird	lots all the time							
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Swallow, Welcome	lots all the time							

Figure 2: Example of a Smartfarms Property Level Assessment (truncated bird species list)

The process of establishing a monitoring programme using the Smartfarms system involves registration on the website, entering a physical address for the farm, and entering data such as total and grazed area along with other detail. The farm checklist and property level assessment can also be completed online. Access is password protected and users can control who can see and access their data. . A measurement kit comprising a water clarity tube and soil water infiltration measurement device is provided for \$90 and registration is free. In this way a number of people can interact with a farm data set such as buyers and regulators. Figure 3 shows the monitoring kit.



Figure 3 Smartfarms environmental monitoring kit including water clarity tube and soil water infiltration measurement device

Indicators

Land management is the key to water quality outcomes. The Smartfarms system has been designed to be operated by farmers or their agents with two half days of measurement per year to track key farm based indicators. There may be 50 or more such indicators for a farm business. Initial work has focused on a system and tools to collect a selection of in-field information on pastoral farms for simple sustainability indicators like:

- metres of riparian fence and / or size of retired area(s)
- number of new seedlings planted in retired areas
- growth of plants in retired areas (native or exotic)
- % soil organic matter, structure, earthworms
- what flora and fauna are present in the waterway or wetlands
- how many species of birds are present on the farm
- how far can be seen on a clear day
- Are GMOs used on the farm

On-site measurements on farms are the key focus of the system. Three assessment types are available - for either soil, waterway, and air. The on-farm sites are set up with a mapping tool on the website. Once located the Smartfarms App can be downloaded from either iTunes or Google Play and utilises the same identification as for the website. The assessment forms will appear on the App. Date and farm is available from a drop down menu and there are options to get a location from global positioning system (GPS) and /or take photos for each type of assessment. Air assessment simply asks how far to the most distant landmark can be seen on a clear day and how many days smoky conditions prevent that. Land assessment requires counting worms in a 200mm cube divet of soil in winter or early spring and measurement of time taken for a water to infiltrate through the device either under the fence or in the paddock. The waterway assessment is largely a simple version of National Institute of Water and

Atmosphere's SHMAK kit (stream health monitoring and assessment kit) with some additional questions on the structure of the waterway such as depth of pools and riffles. Individual site assessments may take 5 to 15 minutes. It would be expected there would be one for air, three to six for land in line with management blocks and two for waterways (best and worst). Indicators have been chosen to reflect medium term changes (five to ten years). For example the annual list of the range of bird species can indicate impacts to biodiversity over time such as the impact of increasing trees on a farm.

Data from laboratory analysis for samples taken from sites can also be entered via the website. This includes phosphate and organic matter levels in soil and dissolved phosphate, nitrate and E.coli levels in water.

Reporting

A series of basic online reports can be generated by the Smartfarms system as either a tabular or line graph format. Reports can be customised by farm, site and date range. These reports can be downloaded as an excel spreadsheet. At this stage five report types can be generated. This can be expanded if there is demand. .

The results from measurement of earthworm (counts) demonstrate how the system works by getting farmers engaged with the process. Measurement involves digging a 20cm x 20cm x 20cm spade divet from the soil, pulling this apart carefully and counting the number worms present. This takes about 10 to 15 minutes per site to do. In some cases two divets are dug up and the number of worms was averaged. The process stimulates discussion about soil quality, pasture management and soil management. Earthworms are in indicator of soil function. They feed on plant litter and dung and move this organic matter through the soil, increasing fertility and helping soil structure. The burrowing and casting activity of earthworms through soils helps soil porosity and improves available moisture and water infiltration. Land management has an influence. For example earthworms may be stimulated by increased food supply (more organic matter), by avoiding pugging events and avoiding cultivation.

Figure 4 shows an example of how earthworm numbers can be reported to farmers. The range of earthworm numbers per divet for farms and sites from September 2017 is shown along with the values for a farm. In Figure 4 the example farm had low to average worm counts which increased slightly between October 2017 and October 2018. Lower numbers tended to be associated with recent cropping and cultivation and soil with compact blocky structure. Higher numbers tended to be associated with direct drilled diverse pasture species such as chicory, plantain and annual clover.

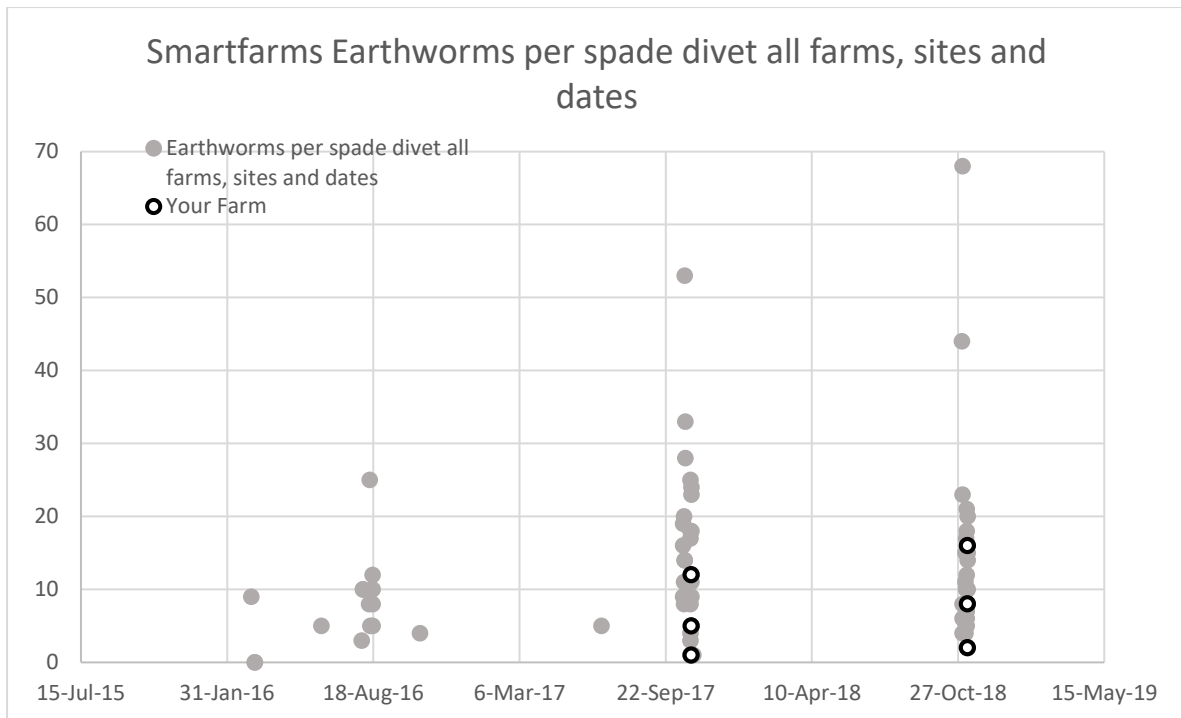


Figure 4 Range of earthworm counts recorded using Smartfarms Environmental Monitoring System

Counting worms starts the conversations about soil quality and this is almost more valuable than the measurements themselves. Once engaged in a conversation interest grows and additional measurements like water infiltration rate and testing for soil organic matter enter the conversation. During these conversations the question of “how many worms should I have” often came up. The answer is not simple but numbers can be compared with the Earthworm Threshold Indicator shown in Table 1. The reason the answer is not simple as ideally the type of worm found should be also be identified. Once again conversation which develops around this which could lead to more complex environmental monitoring on farms. On the face of it having at least one rather than no earthworms is a good thing and it would seem that a good number of worms is around 14 per spade.

Earthworm trends

The Smartfarms system showed that the average number of earthworms per spade across 30 sites in late October 2017 was 14.3 and in early November 2018 the average was 14.2 across 26 sites. During our measurements, earthworm numbers at individual sites varied from year to year (up or down). However, when values were averaged by farm they tended to be stable between 2017 and 2018. The analysis across all farms and sites back up that assertion. This shows that farmers should not get worried when worm numbers are lower than previous year for a particular site as that could be a function of recent management (pugging or cultivation) or variability of distribution within a paddock but they should take note of farm averages over time. Comparing average values for their farm is more useful and could reflect changes in management like switching from cultivation to direct drilling for pasture and crop establishment.

Table 1 Earthworm Threshold Indicator (reprinted from “Earthworms” by Nicole Schon, AgResearch Ltd)

Earthworm Threshold Indicator		
Earthworm numbers (per spade) at which they may be limiting their contribution to soil services		
Worm Type	Soil Services	Limiting
Epigeic	Organic matter incorporation, carbon storage	< 1
Endogeic	Creation of soil pores, aggregate size and strength, nitrous oxide production, water infiltration	< 14
Anecic	Creation of soil pores, aggregate size and strength, organic matter incorporation, carbon storage, nitrous oxide production, water infiltration	< 1

Conclusion

Counts of earthworms provide one example of a physical indicator which can be tracked using the Smartfarms system to monitor the key resources that must be maintained. The existing range of indicators within Smartsfarms can be used to broadly assess water quality, the health of a waterway and soil quality along with wider environmental management across the landscape. The system allows for rapid entry / upload of measurements, images etc to an online database, enabling farmers to make available information about the performance of their farming operation potentially showing the progress being made through on-farm activities in a credible way. A standard and auditable set of information on the farm can be provided by Smartfarms which could be linked to the product as it moves through the supply chain and can be communicated end customers.

Experience to date shows that while the measurements per se are important, equally important is the provision of a tool for engagement and learning for farmers.

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