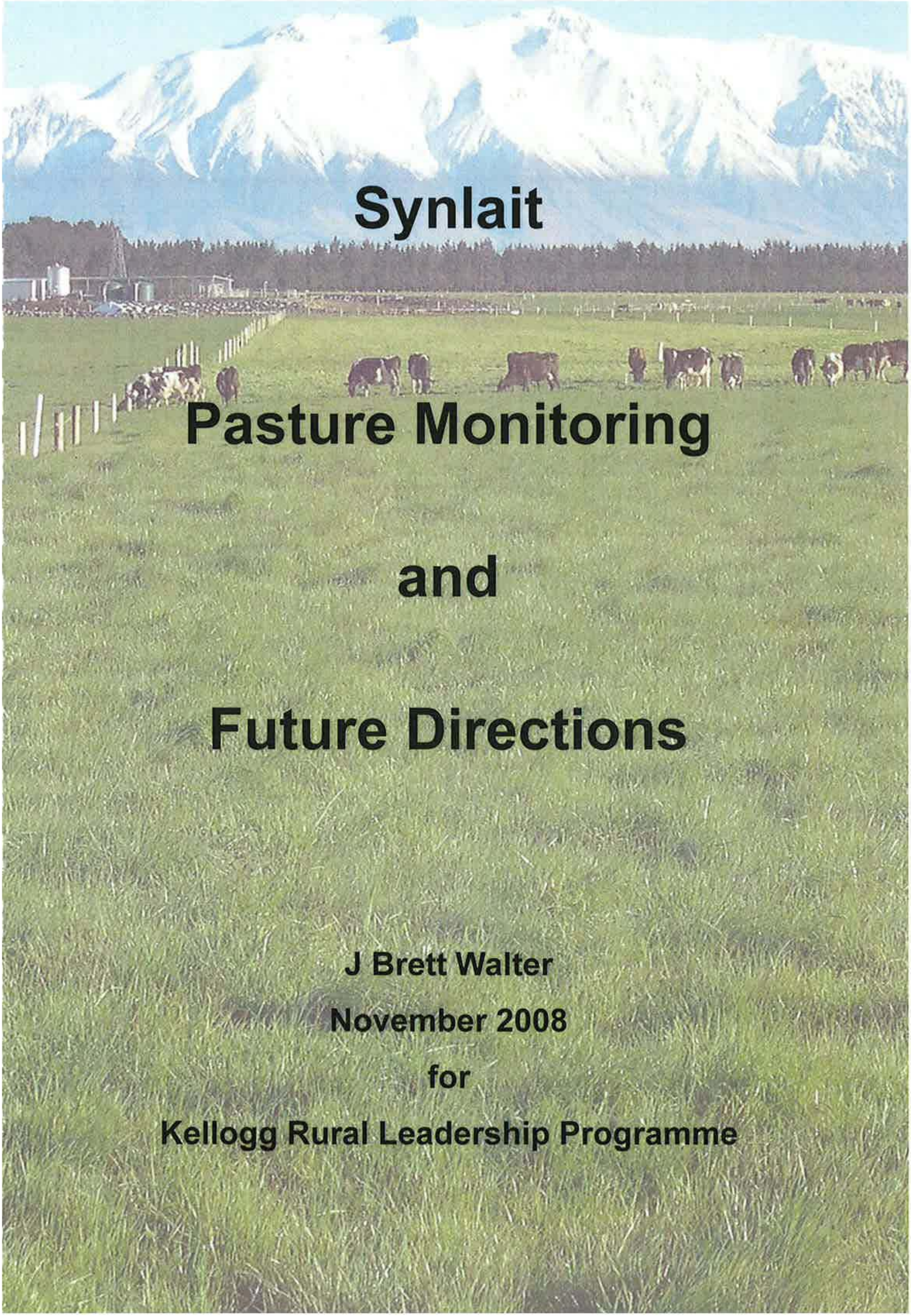

Synlait

Pasture Monitoring

and

Future Directions

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for

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Executive Summary:

Synlait has an established pasture monitoring system across all the Synlait dairy farms. The objective is to provide accurate, consistent and comparable measurements that can be used for management decisions, including pasture allocation, surplus identification and regrassing options.

The Synlait pasture monitoring service has provided a vast amount of data on pasture growth rate and production, across a large range of soil types and irrigation systems. The management of this data and associated information has become fragmented due to the rapid expansion of the service, and the number of farms and paddocks involved.

This report explains the development of the pasture monitoring service, and the systems used to get the information processed and presented to the farm managers. It also explores the scope and outline of a future database to capture and store existing and future Pasture Monitoring data.

The second section of the report explores and details the future direction for this database, with an explanation of other external data that could be imported into an expanded pasture monitoring database. It looks at the possible relationships between pasture growth rate and soil temperature, soil moisture, air temperature and solar radiation. Incorporation of data obtained from two weather stations currently installed on Synlait farms, has been used to show the potential to develop into a robust pasture growth rate predictor, aiding the accuracy of management decisions for the farms.

Further options to include grazing records, soil fertility, fertiliser application and the extent to which pastures have been subjected to attack by insects and their larvae if available are explored.

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Introduction:

Synlait Ltd has established a pasture monitoring project across all the Synlait dairy farms, with the objective of providing accurate, consistent and comparable measurements. This information can be used to improve the quality of management decisions, including pasture allocation, surplus identification and re-grassing options.

The problem with the current systems used is that the data is stored in a number of spreadsheets on the Synlait server, and these are used to process the data to provide information to the farm managers on pasture production and feed wedges. There is a large amount of manual manipulation carried out on this data, with the standard calibration used to convert the data to information on pastures covers. This prevents easy interrogation of the data, and running quick what if scenarios. There is limited ability to import existing data from other sources, such as weather stations and Aquaflex sites, and in the process use all the relevant data to explore what are the most important components that contribute to pasture growth rates.

The first objective of this report is to outline and scope a future database, that initially imports all the raw pasture monitoring data and processes this to give information on pasture growth rates, paddock covers and annual pasture production by paddock and farm. This database will also incorporate the pasture calibration cuts to allow queries to the data using different calibration methods at any time. This will give the ability to integrate the standard calibration method used currently.

The report describes aims and objectives of the Synlait pasture monitoring systems and the set up process. It then investigates the current systems of data capture and manipulation to explain the processes currently used to produce robust information for the farm management teams. This helps to explain the requirements of any future database and the need to automate some if not all of the very manual processes.

The scope and objectives of the proposed database, the standardisation of data capture and input and the ability to interrogate data is explored. An outline of how the database may be structured, which also permits future streamlining is given.

The second objective of this report is to look at optimising the potential of the existing data to be interrogated, for example to predict pasture growth by determining the relationship between the different data sources.

The report is limited to providing scope and objectives for a proposed database and does not develop detailed database specifications. Final design specifications and construction will be developed in conjunction with additional database expertise to ensure that the final outcome meets expectations.

Synlait Pasture Monitoring History:

Synlait dairy farming operations started in the 2001 season at Robindale Dairies, a 600 ha 2000 cow dairy farm, with an 80 bale rotary dairy. Until this time it had been difficult to gather sufficient relevant information in a timely fashion for good decision making. With the introduction of the pasture monitoring system it was possible to make informed decisions on pasture management determined by feed demand, pasture covers and growth rates. A team of staff using the rising plate meter was needed to cover the 600 ha. In the second season the farm increased to 900 ha milking 3000 cows.

Rising plate meter measurements were generally done once a week by up to 3 different team members, one for each block or pivot. Rising plate meter heights were converted to pasture mass with the standard calibration determined by research at Lincoln University Dairy Farm, using a multiplier of 140 and an adder of 500. All pasture data was collated by Michael Woodward, stored in spreadsheets and used to generate a feed wedge and estimates of growth rates by paddock, block and farm. Paddock records of urea applications were also recorded.

From 2004 season onwards, an additional four farms were added to the business with approx 2200 ha and 8000 cows. In 2006 the farms adopted a feed wedge spreadsheet template and generated feed wedges and growth rates for each farm and for each individual paddock, as well as annual pasture production for each paddock and farm. With this spreadsheet the full season's data for each farm was stored in a single spreadsheet.

Although this recording system worked well for many years there were some shortcomings: -

- Inconsistencies related to operators in the measurement of pasture cover using the rising plate readings across blocks within farms and different farms.
- Pasture measurements on large farms took a long time and in the very busy periods of the year, the weekly farm pasture measurement was not done as regularly as necessary to give robust data for farm management and performance decision making.
- Comparisons of annual pasture production of individual paddocks within a farm were not routinely used to identify the lowest productive pastures when regrassing.
- Comparing pasture production between farms was difficult due to inconsistency amongst different operators.

Current Pasture Monitoring:

Background

In the autumn of 2007, the Synlait farm management team developed a project to look at improving the monitoring of pasture production across all the farms in the group. During the 2006 – 2007 season the Synlait farms increased pasture renovation utilising a number of different pasture varieties.

Before undertaking the expanded pasture renovation programme based on previous seasons pasture monitoring it was essential to demonstrate the cost benefit of improving pasture across the farms.

The main objective of the project was to: -

- Determine a robust pasture monitoring protocol for
  - regular
  - reliable
  - repeatable
  - calibrated
  - comparable

  pasture measurements, independent of operator variation for every paddock and farm within the Synlait farms.

To achieve this objective, the process undertaken was:

- Look at new and emerging technologies that could provide better information
- Determine which of these technologies could be utilised immediately
- Develop a business case for establishing a dedicated pasture monitoring service for the Synlait farms
- Present this business case to the Senior Management Team and the Synlait board for approval
- Establish the pasture monitoring team and set up the required plant and facilities

The Rapid Pasture Meter (RPM) was used to measure pre and post grazing for two herds in the spring of 2007. Area allocated to the cows was measured by a GPS (global positioning satellite) device. Pasture feed demand was determined by the number of cows and any additional supplement offered. Predicted milk solids production from these cows was compared to actual milk solids (MS) production from the vat. This was done to give the farm management team confidence that the RPM produced a credible result, that could withstand rigorous critiquing. As a consequence of this initial evaluation a more detail programme was introduced for all Synlait farms from the autumn of 2007. Key features of this process were: -

- Development of a regular monitoring programme for all farms, and allocation of the resources required to do this
- Weekly collection of pasture samples from 12 quadrants (Four representative samples from pastures immediately pre and post grazing and four at the mid point of growth between pre and post grazing) on two farms, one at Te Pirita and one at Dunsandel. After drying, dry matter yields from these samples were used to calibrate the RPM.
- Storage of pasture cut and calibration data for future calculation of a universal calibration of the RPM.

Developments in the 2007-2008 season

The process of establishing detailed pasture monitoring utilising the RPM and the addition of the aquaflex soil moisture monitoring assessment process is discussed in this section.

- The proposal for dedicated pasture monitoring utilising the RPM was approved by the Synlait board, and commenced shortly after in autumn 2007
- The pasture monitoring team employed its first technician, Jilly Reesby, with a background in monitoring services for irrigation management across Canterbury in June 2007.
- A specialised pasture monitoring vehicle was developed and evaluated and incorporated features such as: -
  - Ramps for loading and unloading the RPM
  - A set of electric shears with its own dedicated power supply from the truck to collect pasture yield samples, cut to the ground as per the protocol used by DairyNZ (formally Dexcel)
  - A toolbox for storing any necessary equipment
  - Quadrants for pasture sampling and measurement
- A pasture laboratory was established within an existing building that included:
  - Precision scales
  - Tubs for washing pasture and crop samples
  - Two specialised drying ovens for pasture and crops
  - A microwave oven for rapid DM (Dry Matter) sampling
  - Drying trays and miscellaneous other utensils for the successful DM assessment of pasture and crops.
- Data was stored on spreadsheets on the server and in conjunction with farm information was used to provide weekly calibrated pasture yields, farm covers and current farm growth rate. These included: -

  - Raw data collected from the RPM which represented mean pasture height for individual paddocks on individual farms. Paddocks where cows were still grazing were scored for both the grazed and ungrazed portions separately.
  - Pasture height was converted to kg DM / ha using the calibrated formula from the pasture calibration cuts
  - The pasture yield (kg DM / ha) for each paddock on a farm was then entered into a feed wedge spreadsheet unique to each individual farm. In this way pasture covers for individual paddocks on farm were presented by way of a wedge. Mean farm pasture cover and growth for each individual paddock and for the farm were calculated and stored to enable pasture production by stage of the season for individual paddocks on farm to be calculated.
  - The feed wedges were then printed in PDF format and e-mailed to the farm managers, pasture managers and the farm supervision team.
- In December 2007 the Synlait board approved the installation of aquaflex soil moisture monitoring stations on all the Synlait farms. In the first year 25 individual Aquaflex sites were developed
- The following protocol was used to determine sites for aquaflex installation: -
  - Irrigation process and soil type
  - Rotorainer irrigation systems had twin moisture sensing tapes installed, one installed horizontally at 500mm deep and a second one installed on a consistent gradient from 100mm to 400mm in depth.
- A second technician was employed, Niranjala Gamlath, in December to ensure the monitoring protocol could be maintained with the addition of new farms, as well as providing a regular robust irrigation advisory service.
- Pasture covers were calculated on a weekly basis using the most recent calibration formula to convert the raw data on pasture height to pasture kg DM / ha. However this often created confusion and difficulty in interpretation of results, with movement between successive weeks in the calibration causing changes in the weekly growth rates and covers which challenged understanding.
- A second RPM was purchased in the beginning of 2008 as a backup to the original machine which had proved to be unreliable possibly because of excessive use. Regular use of the original RPM contributed to a build up of moisture on the sensor, cable connection, mechanical and frame component failure.
- Aquaflex data was downloaded during the pasture assessment farm visit and then imported into the aquaflex software on a central computer. This data was used to generate graphs of the soil moisture in relation to field capacity and stress points, as well as soil temperature at 100mm below the soil surface throughout the day. This graph was then interpreted and forwarded to the relevant farm manager with an explanation and recommendation.

The advantages that this system offered over the contracted service in the past were:

- The soil moisture levels on the Synlait farms were monitored every week
- The trends were actual recorded information which provided better predictive recommendations for the farm managers
- If necessary, the farm managers were able to take instant soil moisture capacity readings in the field to confirm any decisions to be made.

- All data is stored in a central server with access permitted to all interested parties but integrity of data was retained by Synlait.
- In the autumn a second vehicle was purchased to allow two pasture meters to be running at any time. This extra resource has made possible the monitoring of the additional hectares purchased in the current season.
- Jilly negotiated with the supplier the storage of a spare sensor at Synlait for use and distribution around the South Island for any user that had a problem. This meant that when a sensor failed, we had the ability to swap sensors and keep measuring until the sensor was repaired.
- This winter (2008) a third technician, Gina Clemens was employed to assist with the farm monitoring, as well as give the team the capability to assist with some of the Synlait research projects.
- The pasture laboratory facilities have been expanded to include 4 specialised drying ovens with associated trays, which allows the team to process more crop dry matter (DM) samples

The Current Season (2008-2009)

The Synlait Farms monitoring team have been responsible during 2008-2009 season for:

- Regular pasture measurements on every paddock across all Synlait farms.
- Ongoing rapid pasture meter calibration pasture cuts but not as regularly as in the first year with existing pastures cut once a fortnight and new pastures cut once a month.
- Soil moisture monitoring and irrigation recommendations to Synlait farms.
- Support and assistance with any Synlait research projects in conjunction with Eric Kolver, Research Manager for Synlait.
- Capture, safe storage, manipulation and presentation of all data collected during the year, primarily in spreadsheets on the server.

Picture 1: - The first pasture monitoring truck is shown towing the pasture meter taking height readings across a paddock.

The next section of this project reviews how the current pasture and soil moisture monitoring data is structured and stored and what form and functions a future database storage system will provide.

Future Requirements

Stage One

Designing a database involves defining:

1. Pasture Monitoring Procedures
    - Data collection
    - Data manipulation
    - Information reporting
    - Ability to run other scenarios
2. RPM calibration procedure
    - Data collection
    - Data management and manipulation to give a standard calibration
    - Handling outliers in the data
    - Standard calibration vs variable calibration
3. Pasture monitoring database scope and outline

Stage Two

Collation and incorporation of other useful data and information that is currently being collected into the same database or an add-on database to provide comparisons and predictive capability using:

- Pasture growth rates as discussed in the previous section
- Soil temp from the aquaflex sites
- Soil moisture from the aquaflex sites
- Weather station information located at
    - Te Pirita on Robindale Dairies
    - Dunsandel on Dunsandel Dairies
- Soil fertility and fertiliser applications
- Grazing records
- Pasture parasite information (e.g the extent of grass grub damage)

Ensuring the incorporation of any relevant information into a suitable format to:

- Develop some predictive forecasting of growth rates and pasture performance
- Collate and utilise existing pasture models currently being used and developed.

Stage One

1. Pasture Monitoring Procedures

I. Data Collection

- The RPM measures pasture height on a predetermined track, taking readings the full length of the paddock.
- Where cows are grazing with a break fence, readings are taken on each side of the break.
- The proportion of each break is determined by the proportion of the multiple readings taken on each break (demonstrated later).
- Each measurement run has a date, farm name, paddock number and run number.
- Raw data is extracted from the rapid pasture meter in a csv (comma separated values) format, which is then opened in Microsoft Excel. See table 1.
- The data includes the paddock number, the number of readings taken in each sample, and the average height recorded for this sample. This is shown in the table 1.

II. Data Manipulation

- The average height (AH) for the paddocks is calculated by:

  AH = ((na x a) + (nb x b))/(na +nb)

  where: -

  na = number of readings at height "a" in mm

  a = height in mm for sample "a"

  nb = number of readings at height "b" in mm

  b = height in mm for sample "b"

  (height a x no: of readings on a) + (height b x no: of readings on b)

  ÷

  (no: of readings of a + no: of readings of b)

- The paddocks with multiple readings need to be averaged as per the above equation, to give a single height or average height for each paddock. With the possibility that more than two readings can occur for a single paddock, any database needs to be able to accept multiple data entries for individual paddocks.
- Then each paddock's height is converted into a cover value in kg DM / ha using the nominated calibration in the top right hand cells of the spreadsheet, known as the Synlait Calibration. (see table 2).

Table 1: - An example of raw rapid pasture meter information for the Decade farm in early October 2008

Date of run → 01-Oct; Farm Name → Decade; Paddock Number; Number of individual readings in each run; Average height of the run

01-Oct		Decade	
	25	113	96
	24	102	106
	23	102	44
	22	89	90
	21	103	48
	20	103	96
	19	102	40
	18	92	76
	17	105	96
	16	108	64
	15	98	48
	14	104	100
	13	127	90
	12	121	74
	11	61	52
	11	59	130
	10	121	114
	9	122	68
	8	119	94
	7	116	116
	6	120	86
	5	122	44
	4	119	118
	3	76	146
	3	42	68
	2	52	54
	2	55	132
	1	58	112
	1	16	60

Multiple readings on paddock 11

height ***a*** = 52mm and no: of readings on ***a*** = 61

height ***b*** = 130mm and no: of readings on ***b*** = 59

This calibration has been determined for all the calibration cuts done during the 2007-2008 season and standardised for the entire season (See appendix 1 for attached paper by Eric Kolver). Paddock height is converted to pasture cover in kg DM/ha, by multiplying mean paddock pasture height by the slope and then adding the intercept value as below.

Pasture cover (kg DM/ha) = (Height x Slope) + Intercept

(see Table 2 – rapid pasture meter heights converted to pasture cover kg DM/ha).

For example pasture cover in paddock 25 was

cover = (96 x 25.712) + 366.93 = 2835.28 kg DM/ha

Table 2: - An example of the conversion of mean paddock height (mm) data to pasture cover (kg DM/ha).

01/10/2008

Slope		25.712	Synlait Calibration
Intercept		366.93	
R2			
Paddock No.	Heights(mm)	kgDM/ha	
25	96	2835	
24	106	3092	
23	44	1498	
22	90	2681	
21	48	1601	
20	96	2835	
19	40	1395	
18	76	2321	
17	96	2835	
16	64	2012	
15	48	1601	
14	100	2938	
13	90	2681	
12	74	2270	
11	90	2681	61x52mm and 59x130mm
10	114	3298	
9	68	2115	
8	94	2784	
7	116	3350	
6	86	2578	
5	44	1498	
4	118	3401	
3	118	3401	76x146mm and 42x68mm
2	94	2784	52x54mm and 55x132mm
1	101	2964	58x112mm and 16x60mm

III. Information Reporting

- The paddock heights are then entered into the Feed wedge spreadsheet. (see Table 3 below).
- The feed wedge spreadsheet gives an average farm cover for the whole farm. Paddock covers are weighted by the paddock area as a percentage of the effective farm area.
- Using data collected from the farms about grazing, cropping, the making of supplements or regrassing, the paddocks are assigned an actual or an estimated growth rate for each period, with the entry of Gzd in the centre column.
- Once the grazing data is entered, the wedge can be generated by selection of the period of interest in the wedge graph date cell and by running the relevant macro by clicking on the create wedge button.

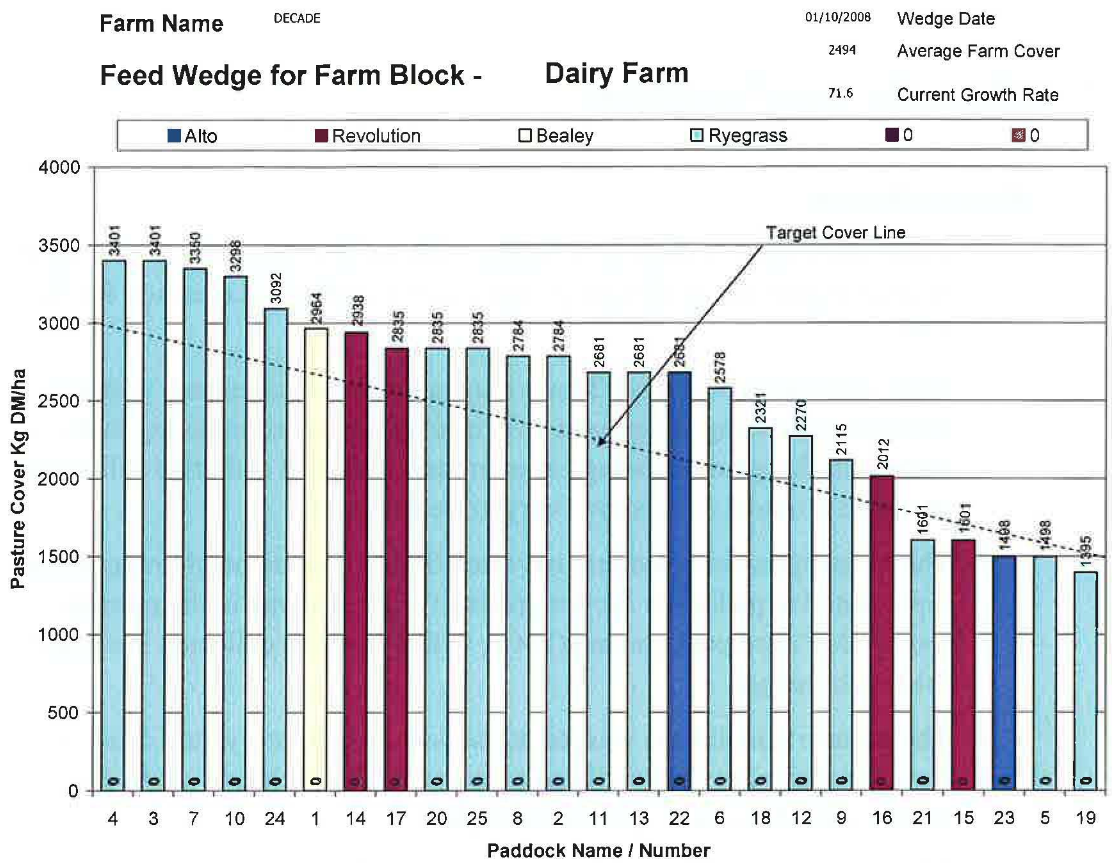
Table 3: - Feed wedge spreadsheet data entry table from late September to early October showing the date of assessment, paddock number and area and grazed status since the last pasture assessment.

Wedge Graph Date: 01-Oct-08 | Create Wedge

PASTURE M

Farm Block	Dairy Farm		25-Sep-08		Date	01-Oct-08		Date	07-Oct-08		Date
Total area		170.0 ha	6	Days		6	Days		6	Days	
Average Cover			2664	Average Cover		2494	Average Cover		2646	Average Cover	
Average Growth			76.2	Average Growth		71.6	Average Growth		123.7	Average Growth	
No. Grazed Paddocks			7	Paddocks Grazed		8	Paddocks Grazed		11	Paddocks Grazed	
No. Paddocks			25	Total Paddocks		25	Total Paddocks		25	Total Paddocks	
Cover change/day			54.3	Cover change/ Day		-28.3	Cover change/ Day		25.3	Cover change/ Day	
Area (ha)	**Name/No:**	**Type**	Cover	Gzd	Growth	Cover	Gzd	Growth	Cover	Gzd	Growth
6.25	25	Ryegrass	2475		94	2835		60	3607		129
6.25	24	Ryegrass	2372	Gzd	Gzd	3092		120	2012	Gzd	Gzd
7.25	23	Alto	4121		103	1498	Gzd	Gzd	2578	Gzd	Gzd
7.25	22	Alto	2270		129	2681		69	2835	Gzd	Gzd
13.50	21	Ryegrass	2630	Gzd	Gzd	1601	Gzd	Gzd	2372		129
5.50	20	Ryegrass	2475		77	2835		60	3607		129
6.50	19	Ryegrass	3195		120	1395	Gzd	Gzd	2372		163
6.50	18	Ryegrass	1910	Gzd	Gzd	2321		69	2887		94
6.50	17	Revolution	2424		43	2835		69	2655	Gzd	Gzd
6.50	16	Revolution	1447	Gzd	Gzd	2012		94	2732		120
6.50	15	Revolution	3607		60	1601	Gzd	Gzd	2424		137
6.50	14	Revolution	2681		51	2938		43	1653	Gzd	Gzd
6.50	13	Ryegrass	2424		26	2681		43	3247		94
6.50	12	Ryegrass	1807	Gzd	Gzd	2270		77	3144		146
6.50	11	Ryegrass	2887		43	2681	Gzd	Gzd	2424	Gzd	Gzd
6.50	10	Ryegrass	2732	Gzd	Gzd	3298		94	2218	Gzd	Gzd
6.50	9	Ryegrass	1755		21	2115		60	2784		111
6.50	8	Ryegrass	2527	Gzd	Gzd	2784		43	3350		94
6.50	7	Ryegrass	2732		137	3350		103	2064	Gzd	Gzd
6.50	6	Ryegrass	2321		103	2578		43	3350		129
6.50	5	Ryegrass	3247		86	1498	Gzd	Gzd	2424		154
6.50	4	Ryegrass	2784		103	3401		103	1653	Gzd	Gzd
6.50	3	Ryegrass	3607		94	3401	Gzd	Gzd	2321	Gzd	Gzd
6.50	2	Ryegrass	3504		34	2784	Gzd	Gzd	2218	Gzd	Gzd
7.00	1	Bealey	2552		47	2964		69	3581		103

- The feed wedge generated from the cover in table 3 is shown below in Graph 1.
- Paddocks are listed in order of cover, commencing at the highest cover on the left hand side of the page. Current farm average cover and the current growth rate since the last measurement period are shown in the top right hand corner of the page.
- This information is distributed to each farm manager and herd manager, to assist in their grazing management decisions.



Graph 1: - Feed wedge with pasture cover shown in descending order for Decade dairy farm on the 1st October 2008

IV. Ability to run other scenarios

- For the 2008-2009 season, the paddock pasture covers only are being distributed to each farm and pasture manager. Paddock covers are then entered by farm managers into the pasture coach software currently being promoted by DairyNZ consultants. This software utilises an access database that incorporates some of the features that we will be looking for in a database for Synlait farms pasture monitoring. There are key additional elements that we will require which are not built into pasture coach but may be able to be adapted into the software.
- Pasture coach has a number of features that are useful for on farm decisions but may not be as necessary in a centralised database, for example a rotation length calculator and a feed wedge predictor
- The rotation length calculator determines the missing variable when 5 out of the 6 variables required to predict an outcome are entered. For example by including rotation length, pre and post grazing levels, farm area, number of cows and feeding level the required growth rate to maintain a desired grazing round can be determined.
- The feed wedge predictor enables the shape of a future feed wedge based on selected criteria to be predicted, for example when paddocks are removed for silage or re-grassing.

2. RPM Calibration Procedures

I. Data Collection.

- Calibration cuts are done on a regular basis as determined each year by the desired improvement thought possible in the calibration equation for the RPM.
- Each calibration includes 12 individual pasture measurements with the RPM and the rising plate meter over a set quadrant, culminating in the pasture in the quadrant being cut to ground, weighed and dried following the same protocol as used by DairyNZ technicians.
- The 12 samples collected are harvested from 3 pasture height ranges from representative paddocks for pre grazing (PrG), midway in the grazing round (MP) and post grazing (PoG), with 4 samples collected in each of the height ranges.
- The pasture samples are washed at the pasture laboratory, and dried to constant weight in fan ventilated ovens at 72°C which provides a dry matter yield from each quadrant sample.
- The dry matter yields, rapid pasture meter and rising plate meter readings are entered into the calibration spreadsheet.

II. Data management and manipulation to give a standard calibration.

- For each period, a regression curve is calculated with Microsoft Excel to determine the slope and intercept for the calibration formula for both measuring instruments for this period.
- The whole season's data was stored and used to determine a standard calibration for this season.

III. Handling outliers in the Data.

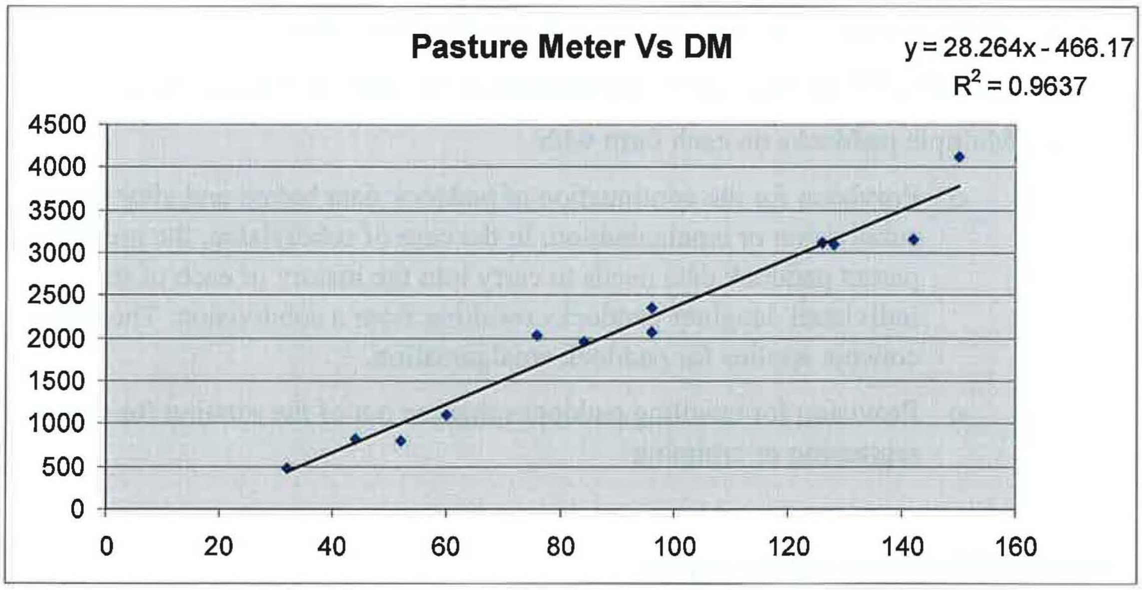
- Any outlier data that was collected during the calibration process, was manually assessed and retained or removed from the seasonal calibration based on the level of discrepancy in relation to the remaining data.
- Any future database will need to have a mechanism to assess outlier data and determine how to handle these results.

IV. Standard calibration versus variable calibration.

- The farm managers struggled with the calibration changing from week to week last year.
- Covers can change dramatically due to a change in calibration, from one period to the next
- Standard calibration will give more consistency to the information provided each week to the managers.

Table 5: - Pasture height and cover used for the calibration in September 2008

15/09/2008				
quadrat	**height**	**kg DM/ha**	**Dry weight g**	**Plate reading**
80	96	2358.843497	59.9	13.6
81	76	2035.93003	51.7	10.5
82	96	2075.309721	52.7	12.8
83	84	1961.108617	49.8	12
84	150	4123.053659	104.7	26.4
85	126	3107.057628	78.9	18.5
86	142	3146.437319	79.9	18
87	128	3091.305752	78.5	17.2
88	60	1106.56932	28.1	5
89	52	799.4077294	20.3	6.8
90	32	472.5562933	12	4.8
91	44	823.0355441	20.9	5.2



Graph 2: Regression relationship between pasture height and cover for September 2008 with slope and intercept shown in the top right hand corner

3. Pasture Monitoring Database Scope and Outline

The proposed database scope will need to be sufficiently versatile and robust to handle many variables that may not be an issue for general one farm pasture monitoring. Due to the large number of farms, the database will need to be able to work with data straight from the various sources with minimal data manipulation done outside of the database. The proposed database, while incorporating many of the features of the pasture coach software, will have specific requirements in relation to data importing functions as well as RPM calibration data and information. It must be able to run queries on different conversion equations that will generate different pasture covers and growth rates. The scope of the database is detailed below in the sections which follow.

Farm, Block and Paddock setup requirements:

- Multiple farms with additional properties added over time
- Identified blocks that can be interrogated as an entity within each farm
- Multiple paddocks on each farm with:
    - Provision for the continuation of paddock data before and after future subdivision or amalgamation. In the case of subdivision, the previous parent paddock data needs to carry into the history of each of the individual daughter paddocks resulting from a subdivision. The same concept applies for paddock amalgamation.
    - Provision for handling paddocks that are out of the rotation for silage, regrassing or cropping

Standard farm data input / import

Data needs to be imported directly from the files produced by the Rapid Pasture Meter(see table 1 above for the format of the data straight from the RPM). This will involve:

- Checking the csv file for errors
- Converting the csv to an xls format as required
- Ensuring that the file format matches the agreed standardised layout with columns and rows, which will involve date and farm ID (identification) being copied into columns.
- Multiple paddock entries being correctly formatted to enable importation into the individual paddock field
- An access table, possibly called "Raw Heights", that stores:
    - Date
    - Farm ID
    - Paddock ID

- RPM number of readings
- RPM average height

Calibration cuts data import function

Calibration cuts need to be processed in the laboratory. Currently they are entered into a Microsoft Excel S/S and imported into the database. Necessary features of the input data are:

- Standardised data format for all calibration cuts data in Excel format will include:
  - Date
  - Farm ID
  - Pasture type (for example new or established)
  - Quadrant ID
  - RPM height
  - Rising plate meter height
  - Dry weight (as per Synlait protocol for measuring pasture DM)
- The calibration cuts will be processed by the database to provide
  - a DM cover for each quadrant
  - the best fit regression curve with automatic and / or manual handling of outliers
  - An ID for this calibration so it can be referenced to if running scenarios with different conversion equations for pasture cover
- Current standardised calibration for conversion to pasture DM cover

Specific farm and trial data input / import

In the event of trials being done on farms to assess the performance of pasture types or treatments, there needs to be provision to capture additional data from quadrants within individual paddocks and with different treatments. An example of this would be the Eco-N trial with 4 sites consisting of 3 treatments: Control, Treatment 1 and Treatment 2. Each site had one quadrant of each treatment. The format of this type of data may not be consistent enough to standardise within the pasture monitoring database at this time.

Outline of processing required and information generated by the database

The database needs to be able to process and generate information from the data on:

- Individual paddock pasture covers using:
  - The nominated default standardised Synlait equation

    - Any other conversion equation generated by selecting an individual calibration cut or by selecting a period of calibration cuts over a defined date range.
- Paddock histories of growth rates and pasture production which can be revised with selection of alternative conversion equations for different periods of the year
- Pasture growth rates for grazed paddocks based on the option of:
    - Using the average for all ungrazed paddocks on the farm
    - Using a calculated average growth based on a grazing date and pasture residual left in the paddock on that date, compared to current pasture cover on the paddock.
- Farm pasture covers and feed wedges for each period showing average farm growth rate and cover presented in table as well as a graphical format.

Stage Two

Additional Monitoring information

There are a number of additional sources of monitoring information currently being collected around the Synlait farms that have the potential to be incorporated into some component of the pasture monitoring programme. This would give some modelling capability for the farms.

There is an opportunity to collaborate with a number of existing models available to determine predictive growth rates, and to compare actual results and those predicted. McCall and Bishop-Hurley (2003) investigated pasture growth models for use in whole-farm diary production modelling and concluded that a major failing pf most such models was the evaluation of the models against data. This emphasises the importance of the data set that Synlait has accumulated and it potential to be used to test existing models and any future models that may be developed. They also state that to be useful, a model must be able to assist in achieving a stated objective. Other models that could be utilised are the Stockpol models, as well as weather models developed by NIWA which gives some predictive weather forecasting for running in pasture models. One strength of the data set from Synlait is the access to two weather stations, as well as soil moisture and temperature data, linked to measured pasture production throughout the year.

In this next section, a description of the systems that are used is given. Stored data is used to demonstrate what capabilities are required from any database storage system.

Aquaflex Monitoring systems

Description:

Aquaflex is a technology developed by Lincoln Ventures to constantly measure the soil moisture levels and temperature, to assist in the management of irrigation systems. This system is installed in strategic positions on Synlait dairy farms, with often more than one installation per farm, to provide information to the manager for sound management decisions. These systems provide:

Soil moisture monitoring

- On an incline from 100mm to 400mm soil depth
- 500mm soil depth

Soil temperature monitoring at

- 100 mm soil depth

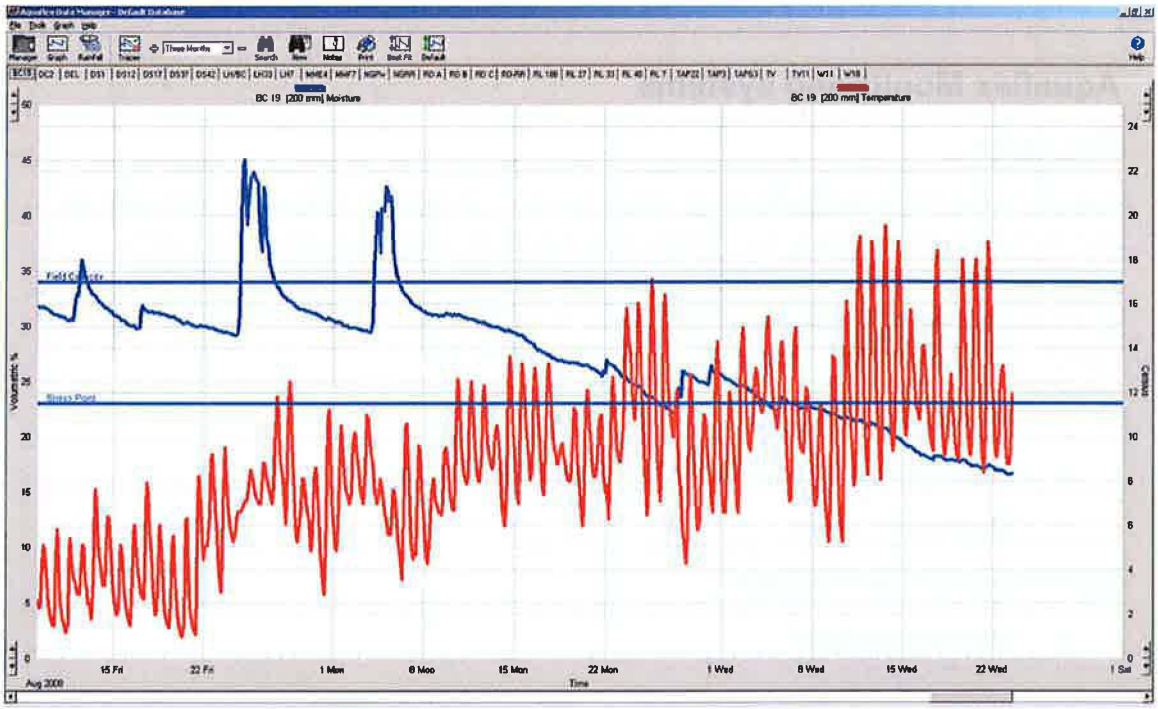
The location of each site is determined by the criteria below:

- Soil type
- Irrigation system
- Proximity to other Aquaflex sites

These criteria result in varying number of monitoring sites on each farm with a range of one to five. Currently there are more than 30 sites installed on Synlait farms.

Each site contains a data logger to record continuous readings form the sensor or sensors if more than one is on the site. This data is then downloaded from each site into a palm data recording device and then imported into software specifically designed for aquaflex, based around an Microsoft Access database. The data file extension is AQD which is the aquaflex derivative from MS Access but the data is formatted in Access 2000 database file format. The Aquaflex software provides information from the data on the current soil moisture levels and temperatures. This is done by the manipulation of the raw data in the software, using conversion ratios based on information provided on soil type etc. Any Synlait database that incorporates the soil moisture component will need to be able to undertake the same conversion of raw data to useful information on soil moisture.

The derived information is then presented to the farm manager in a graphical format (see Graph 3 below), with some attached recommendations on the appropriate use of the farm irrigation potential over the next week.

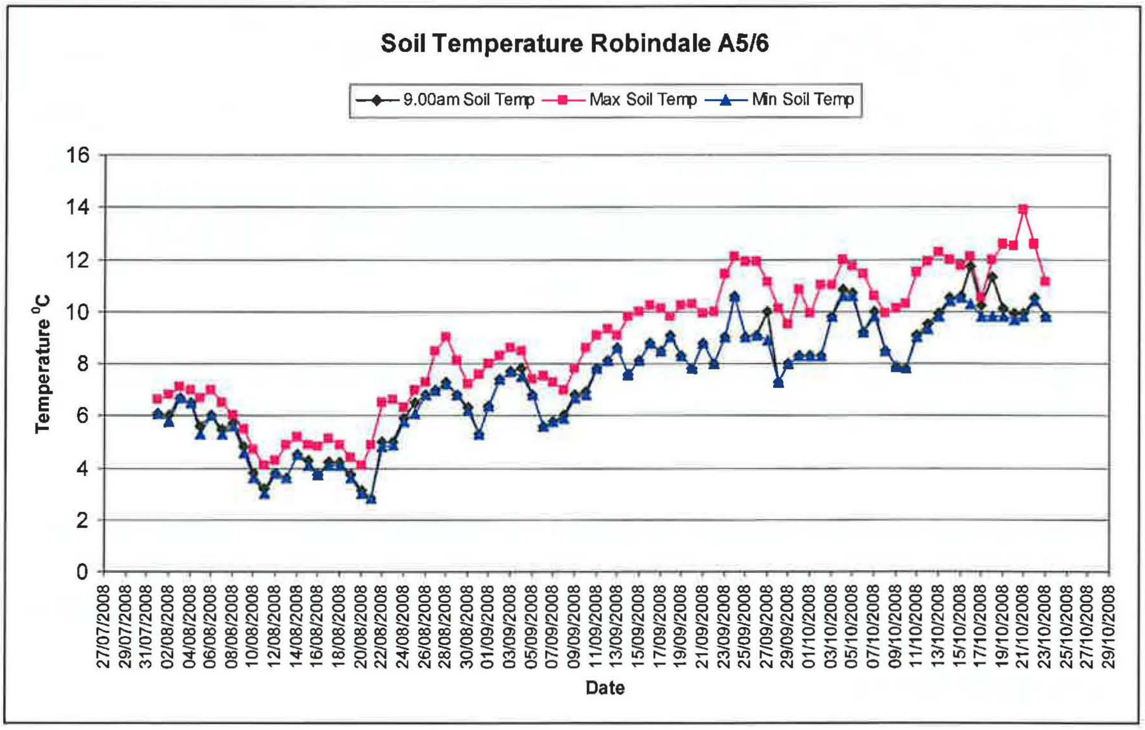


Graph 3: Soil moisture for a three month period between August 9 and November 1 is plotted in blue with the lower blue horizontal line representing wilting point and the upper blue horizontal line representing field capacity. Soil temperature at 100mm is also shown for the same period and plotted in red.

Key observations for this period are:

- Significant rainfall events during the end of August and beginning of September, which have dropped the soil temperature at that time.
- The area is currently under moisture stress, due mainly to a pump being out of action
- Soil temperatures have steadily risen from August, but during late September and early October, soils temperature have dropped back.
- The range in maximum and minimum temperature varied considerably, warranting more investigation into the possible impact on subsequent pasture growth rates

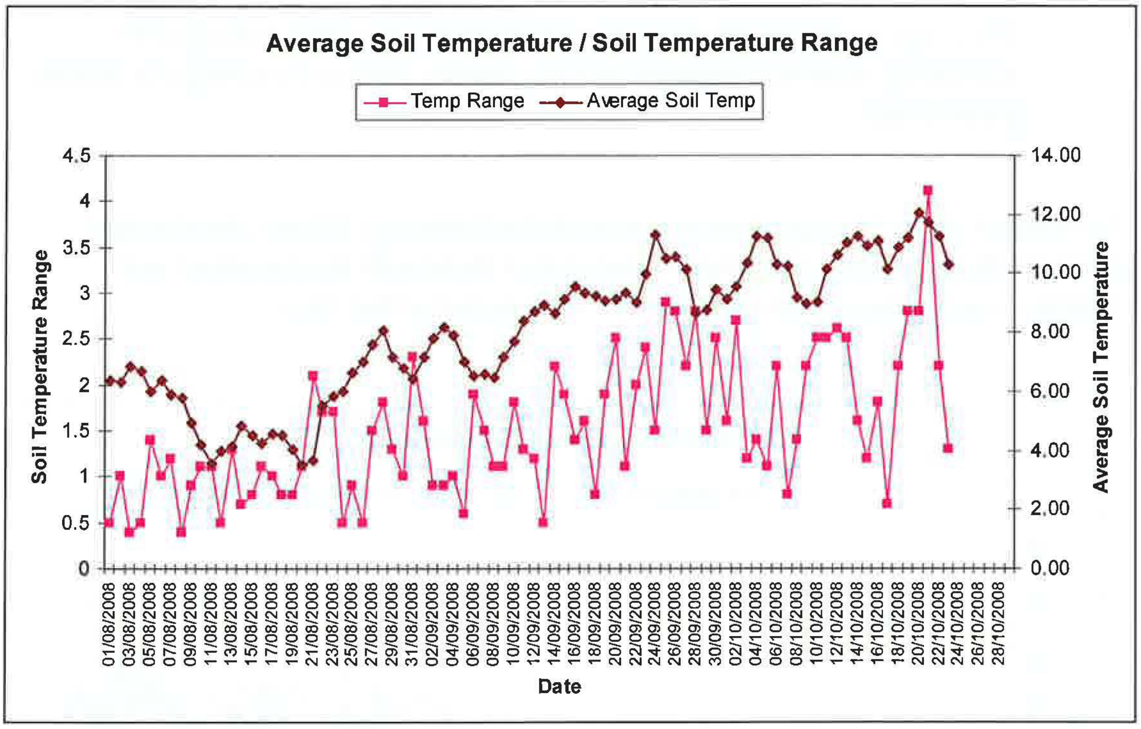
In Graph 4, the soil temperature was recorded at 9.00am at 100mm, the standard protocol for measuring temperature, and plotted along with the maximum and minimum soil temperatures over each 24 hour period at that time.



Graph 4: - Soil Temperatures at 9.00am 100mm depth and minimum and maximum soil temperature over 24 hours in paddock A5/6 on Robindale farm from July 27 to October 29.

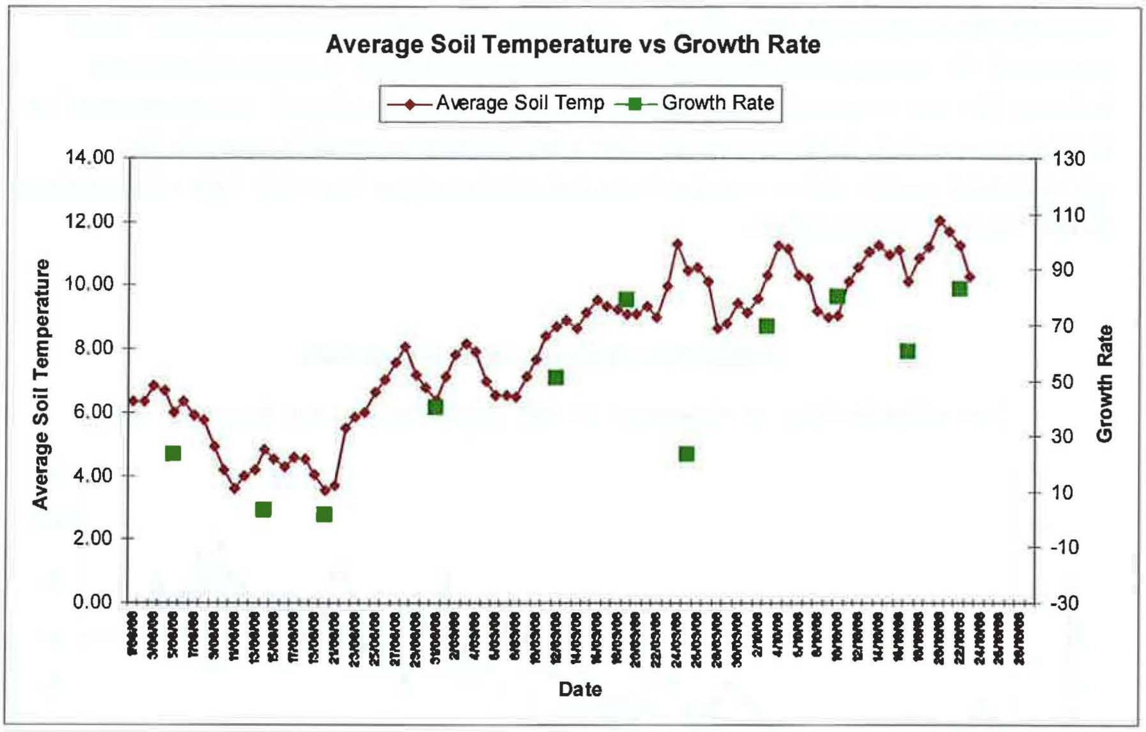
As spring progressed the range in temperature during the day has increased except for short periods where the range has dropped back. This is demonstrated in Graph 5 below which plots the average soil temperature as opposed to the 9.00am soil temperature. The 9.00am soil temperature is generally the lowest temperature recorded in the 24 hour period but this may not be a true reflection of the contribution to pasture growth compared with the range in temperature during the 24 hour period (see Graph 5).

As spring progressed there was a steady increase in the average soil temperature however there was still considerable daily variation in temperature. Rainfall during this period not only dropped the soil temperatures, but also decreased the range in temperature during the 24 hours period.

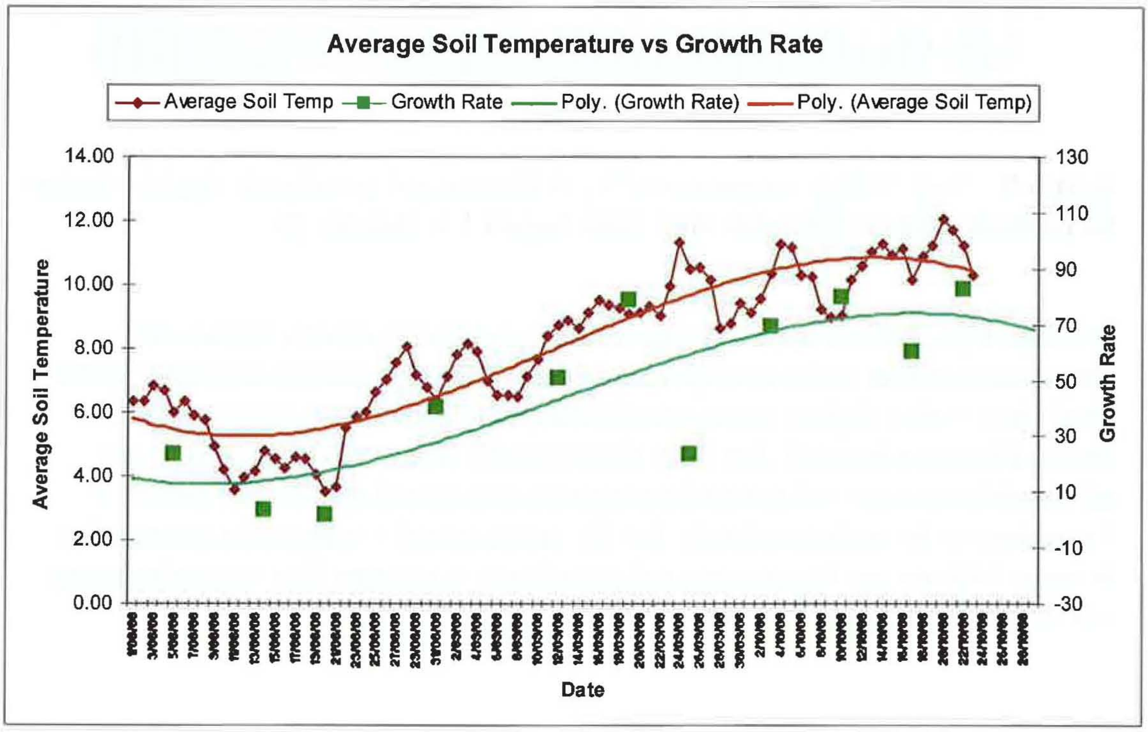


Graph 5: - Average 24 hour soil temperature and daily range in temperature at 100mm between August 1 and October 28 in paddock A5/6 on Robindale farm.

Pasture growth recorded through this period was compared with soil temperature in Graph 6 for the same time scale. There were a number of growth periods when it wasn't possible to measure pasture due to the soils being too wet. This has resulted in a larger than planned spread between readings but there is still enough data to demonstrate the trends.

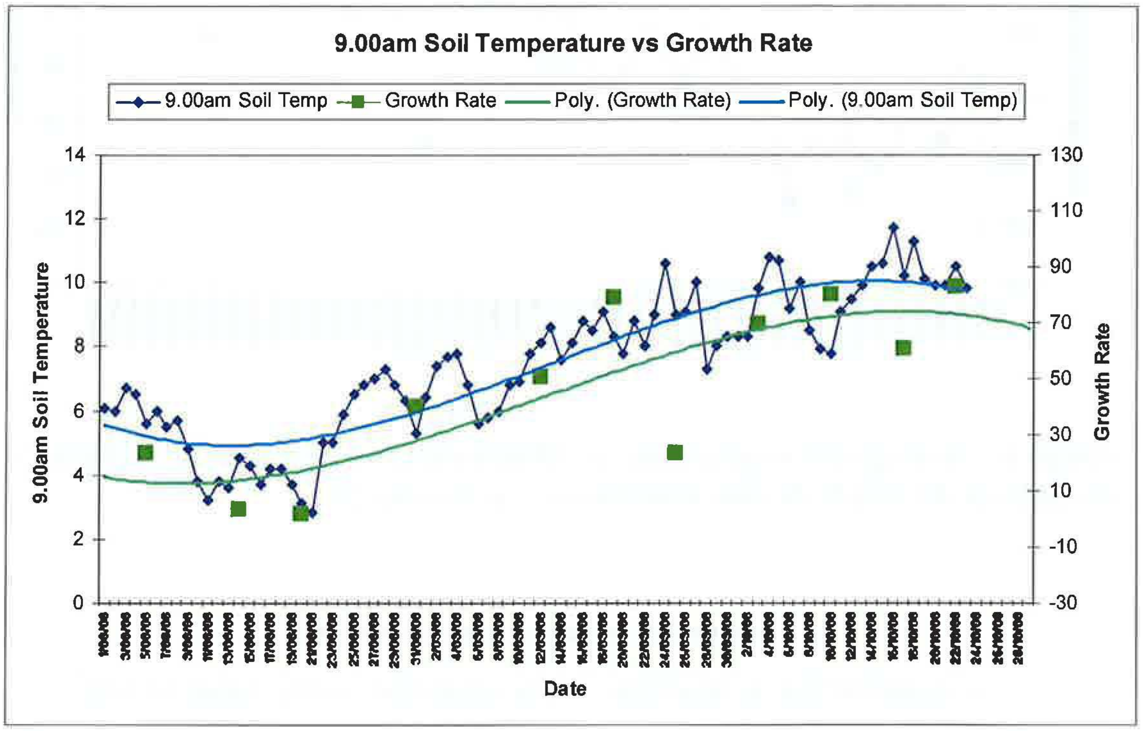


Graph 6: - Average soil temperature () at 100mm and pasture growth (kgDM/ha/day) for paddock A5/6 on Robindale from August 1 to October 27.



Graph 7: - Average 100mm soil temperature (^{0}C) and pasture growth rate (kg DM/ha/day) trends for paddock A5/6 on Robindale from early August to late October Trends

In Graph 7 there is a close relationship between soil temperature and growth, especially when adjustments are made to the respective scales on each axis to demonstrate longer term trend lines. An extension of the relationship shown for a portion of the spring to the entire season may enable a more detailed relationship between the soil temperature and the growth rates to be developed. The purpose of the Synlait monitoring database is to provide a mechanism to quickly compile the relevant data, and to derive comparisons and relationships from this data with minimal further manual manipulation.



Graph 8: - Soil 9.00am temperature (^{0}C) at 100 mm and growth rate (kg DM/ha/day) for paddock 5A/6 at Robindale farm from August 1 to October 28.

In Graph 8 growth rate for the spring period is compared with the 9.00am soil temperature instead of the average temperature. There is a smaller difference in the trend lines, with a slightly closer relationship at the higher temperatures later in spring. Plotting additional data from the remainder of the season will enable the relationship between 9.00am soil temperature and growth rate for this region of Canterbury to be studied in detail. For the spring period it appears the relationship between 9.00 am soil temperature and growth rate is stronger than that with average soil temperature (figure 8 vs. figure 7).

Weather Station Monitoring Systems

Synlait have two automatic weather stations located on farm. One is located at Te Pirita and the second one at Dunsandel. The original station at Te Pirita was installed by Lincoln Ventures when the farm was first converted and included an aquaflex strip as well as external weather monitoring. The second weather station was installed at Dunsandel for monitoring as a condition of the Synlait milk plant resource consent granted by Environment Canterbury. These two stations collection slightly different data (see table 4 and 5) One of the objectives for future monitoring is to standardise the weather information collected and ensure that both stations record the necessary data.

Table 4: – A sample of the weather data collected from Te Pirita Weather station in January 2008.

year	day	time	vassala temp	vasals RH	wind speed	wind direction	solar rad	hourly rainfall	soil temp 1	soil temp 2	soil temp 3	ch1	ch2	ch3	ch4	ch5	ch6	ch7	ch8	ch9	ch10	ch11	ch12	batt volts
2008	01/01/2008	100	7.7	86.8	-0.042	17.5	0.218	0	18.87	18.49	16.98	0	0	0	0	0	0	7	0	0	0	0	0	12.36
2008	01/01/2008	200	6.691	87.7	-0.031	16.87	0.436	0	18.38	18.44	17.01	0	0	0	0	0	0	7	0	0	0	0	0	12.35
2008	01/01/2008	300	6.226	90	0.592	16.87	0.218	0	17.92	18.39	17.05	0	0	0	0	0	0	7	0	0	0	0	0	12.34
2008	01/01/2008	400	5.754	90.3	7.59	39.24	0.436	0	17.48	18.3	17.05	0	0	0	0	0	0	7	0	0	0	0	0	12.32
2008	01/01/2008	500	5.484	90.6	5.885	36.27	0.218	0	17.14	18.21	17.08	0	0	0	0	0	0	7	0	0	0	0	0	12.31
2008	01/01/2008	600	5.788	89.7	5.856	50.18	5.448	0	16.79	18.09	17.08	0	0	0	0	0	0	7	0	0	0	0	0	12.29
2008	01/01/2008	700	8.89	83.9	7.56	15.85	100.5	0	16.5	17.98	17.08	0	0	0	0	0	0	7	0	0	0	0	0	12.56
2008	01/01/2008	800	11.8	78.8	11.09	41.69	237.8	0	16.3	17.86	17.08	0	0	0	0	0	0	7	0	0	0	0	0	12.61
2008	01/01/2008	900	14.87	65.52	14.43	34.58	390.8	0	16.19	17.75	17.08	0	0	0	0	0	0	7	0	0	0	0	0	12.7
2008	01/01/2008	1000	17.1	57.3	22.23	48.2	569.2	0	16.25	17.61	17.09	0	0	0	0	0	0	7	0	0	0	0	0	12.65
2008	01/01/2008	1100	19.55	52.6	18.87	66.77	663.6	0	16.56	17.52	17.05	0	0	0	0	0	0	7	0	0	0	0	0	12.64
2008	01/01/2008	1200	20.78	49.97	21.86	56.33	733	0	17.16	17.42	17.05	0	0	0	0	0	0	7	0	0	0	0	0	12.65
2008	01/01/2008	1300	21.38	50.03	23.71	57.97	743	0	18.05	17.36	17.01	0	0	0	0	0	0	7	0	0	0	0	0	12.68

Table 5: – A sample of the weather data collected from Dunsandel Weather station in September 2008.

TOA5	CR800Series	CR800	6916	CR800.Std.06	CPU:Synlait Cr800.CR8 MK3.CR8	60994	Min10					
TIMESTAMP	RECORD	batt_volt_Min	PTemp	WindDir	WindSpd_Avg	WindSpd_Std	GustSpd_Max	GustSpd_TMx	GustDir	RainMM_Max	Air10m_Avg	Air3M_Avg
TS	RN											
		Min	Smp	Smp	Avg	Std	Max	TMx	Smp	Max	Avg	Avg
08/09/2008 14:30	0	12.45	16.69	190.6	0.057	0.062	0.2	08/09/2008 14:25	190.6	0.2	15.64	16.42
08/09/2008 14:40	1	12.46	16.96	190.6	0.005	0.021	0.1	08/09/2008 14:30	190.6	0	15.86	16.62
11/09/2008 16:40	2	12.89	11.06	164.9	3.97	0.593	5.1	11/09/2008 16:37	157.7	0	8.58	8.95
11/09/2008 16:50	3	12.91	10.43	168.3	3.703	0.528	4.9	11/09/2008 16:41	158.9	0.2	8.55	8.9
11/09/2008 17:00	4	12.98	10.29	155.5	3.721	0.525	5.4	11/09/2008 16:55	150	0	8.49	8.89
11/09/2008 17:10	5	12.94	9.97	162.2	3.666	0.699	5.1	11/09/2008 17:09	152.2	0	8.42	8.73
11/09/2008 17:20	6	12.9	9.5	161.7	3.705	0.508	4.8	11/09/2008 17:11	157.5	0	8.19	8.44
11/09/2008 17:30	7	12.87	9.59	150.8	3.07	0.421	4.2	11/09/2008 17:27	157.5	0	8.2	8.41
11/09/2008 17:40	8	12.84	9.64	179	3.394	0.506	4.8	11/09/2008 17:32	154.8	0	8.23	8.43
11/09/2008 17:50	9	12.83	9.66	166.9	3.26	0.499	4.3	11/09/2008 17:45	172.2	0	8.22	8.41
11/09/2008 18:00	10	12.82	9.64	177.2	3.296	0.468	4.6	11/09/2008 17:58	159.8	0	8.12	8.29
11/09/2008 18:10	11	12.8	9.62	190.3	3.056	0.42	4.2	11/09/2008 18:01	184.6	0	8.02	8.18
11/09/2008 18:20	12	12.8	9.55	188.6	3.281	0.64	5.1	11/09/2008 18:16	192.6	0	7.93	8.09
11/09/2008 18:30	13	12.8	9.48	194.9	2.538	0.746	4.6	11/09/2008 18:21	168.5	0	7.91	8.04

Currently there are some key differences between the two weather stations and one of the future recommendations is that we standardise the information recorded in any future data base from these weather stations.

The original Te Pirita site records:

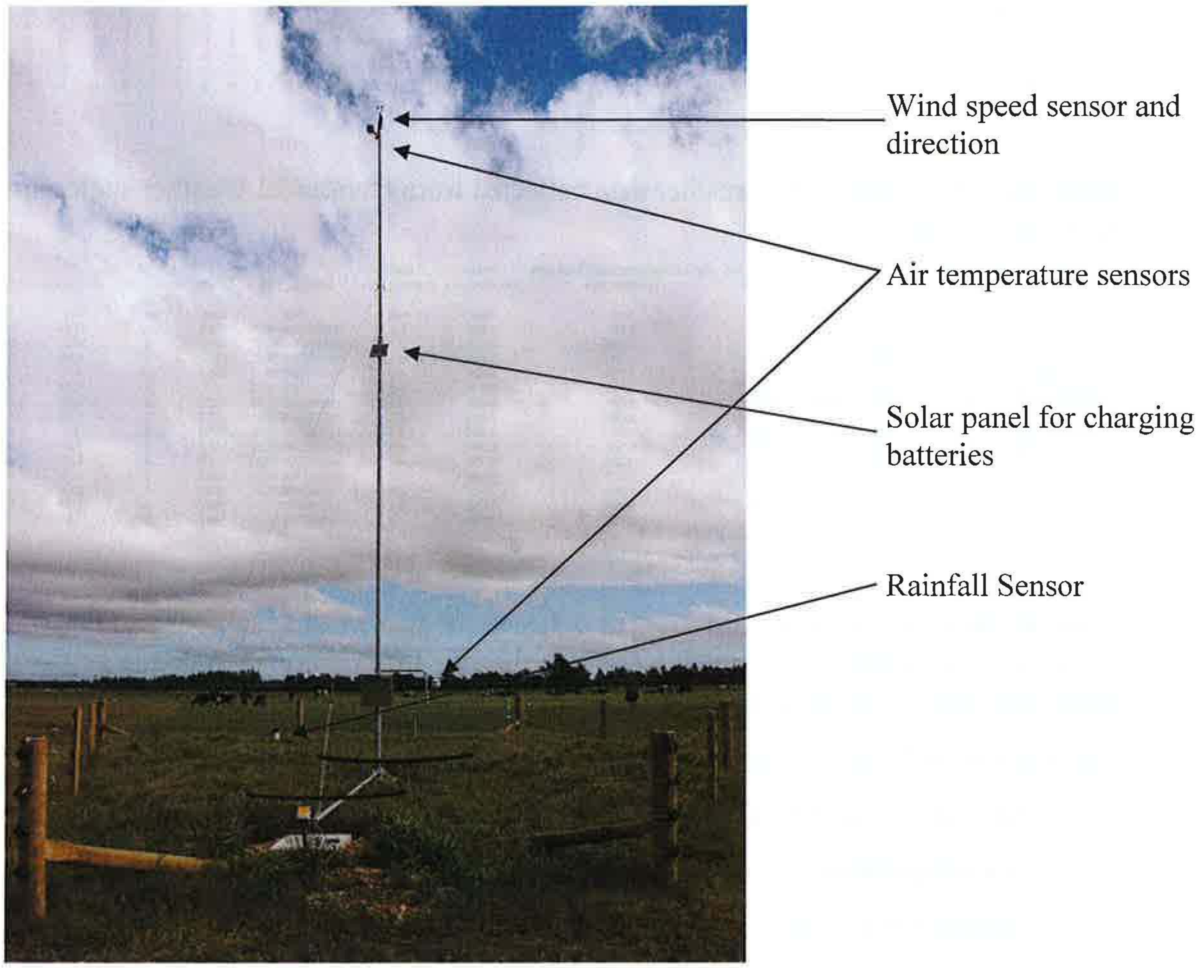
- Date and time at hourly intervals
- Air temperature
- Relative Humidity
- Wind Speed
- Wind Direction
- Solar Radiation
- Hourly Rainfall

- Soil Temperature at 3 different depths

And has numerous extra channels available

The newer Dunsandel site records:

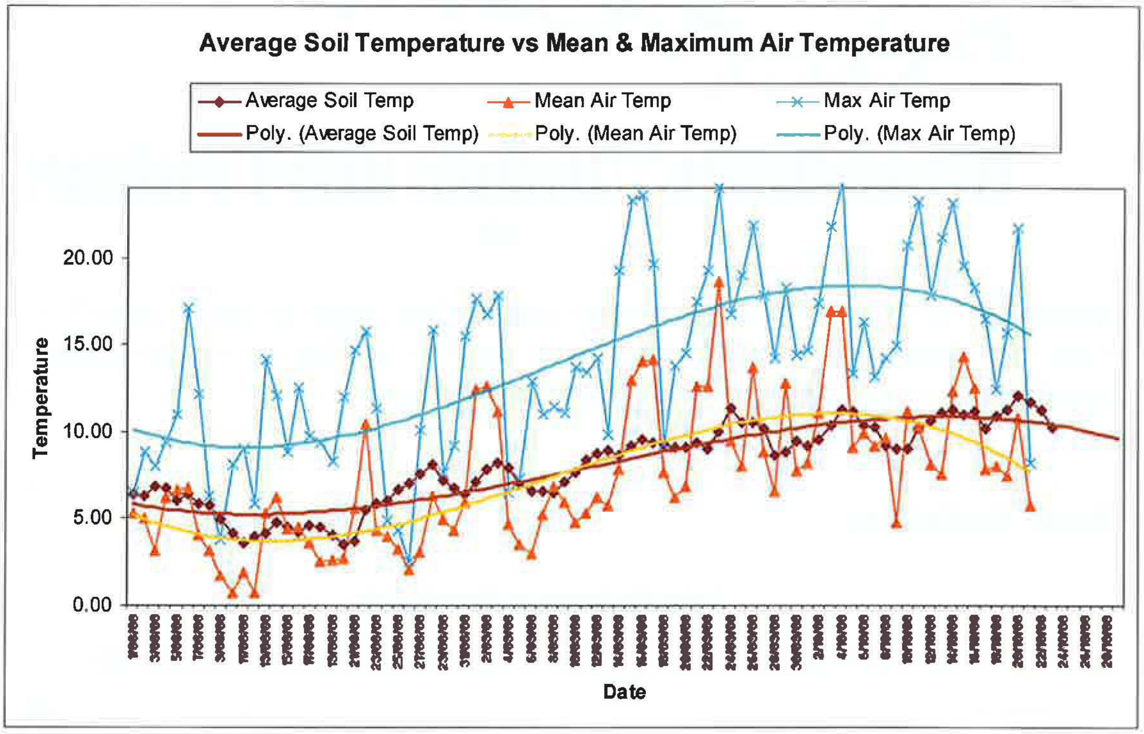
- Date and Time recording in 10 minute intervals
- Air Temperature at 3 different heights
- Wind speed Direction
- Wind Speed
    - Average
    - Standard
    - Gust speed maximum
- Gust speed maximum and time of day
- Gust speed direction
- 10 minute Rainfall



Picture 2: - The weather Station at Dunsandel with the measurement sites for various recordings indicated.

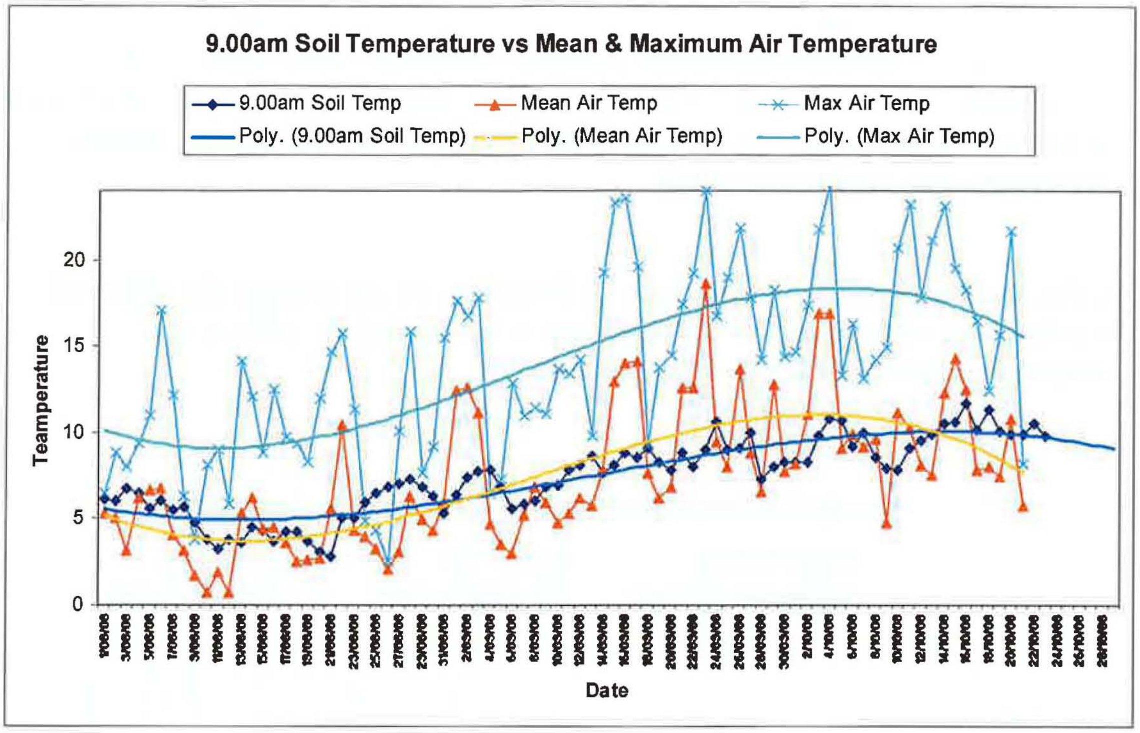
To make useful comparisons between weather components and pasture growth at Te Pirita and Dunsandel it is essential that both stations, while originally intended for slightly different purposes, collect the same key data. These can then be used for comparisons and pasture growth rate modelling. The option of installing solar radiation and relative humidity monitors on the Dunsandel site is under consideration. It is essential that measurement points for example of air temperature are standardized at a preferred height above ground level, and that both sites have sensors installed somewhere very close to this height.

Using the data already collected at the Te Pirita site, we can compare the mean and maximum air temperatures, soil temperature at 9.00am and the average soil temperature during the day (see graphs 9 and 10).



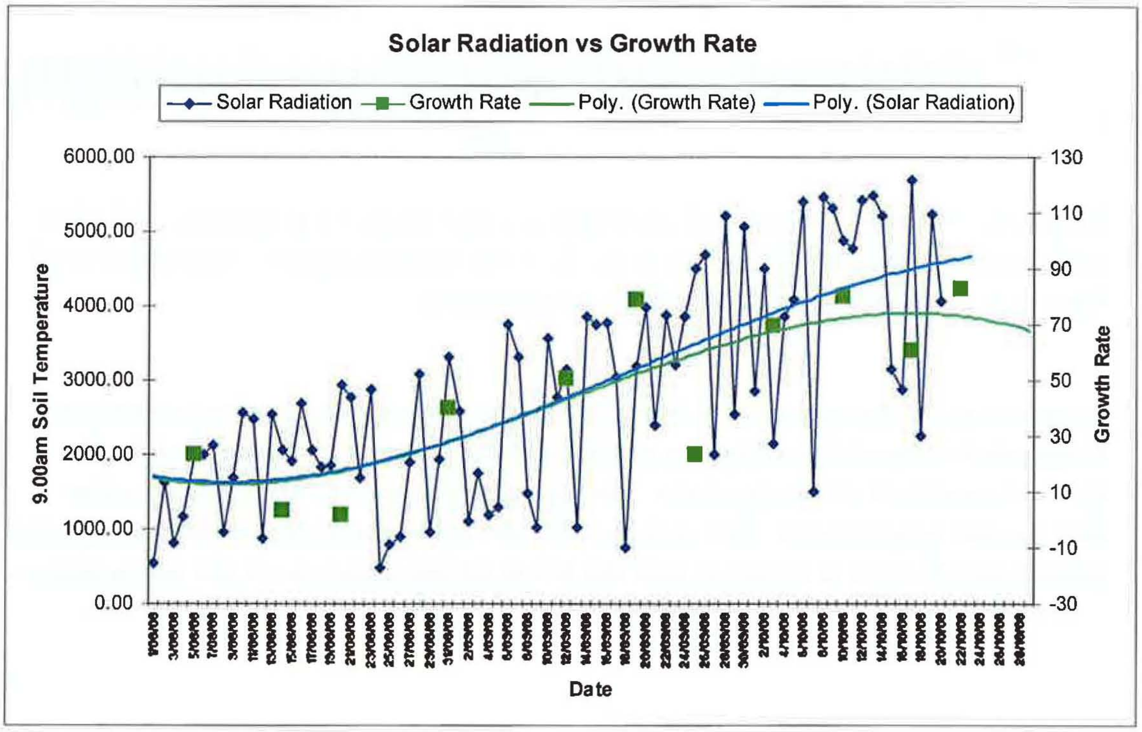
Graph 9: - Average 100 mm soil and mean and maximum air temperature (^{0}C) from early August to the end of October at the Te Pirita weather station, Smoothed trend lines were derived for each temperature measurement.

It appears in the spring period at least, there is not a strong relationship between soil temperature measured as either the average for the day or at 9.00am and either the mean or maximum air temperatures. The air temperatures are much more reactive than the soil temperatures. This indicates that the use of the air temperatures to predict pasture growth rates in spring at least are not as robust as the use of soil temperatures.



Graph 10: - 9.00 am soil temperature and mean and maximum air temperature (^{0}C) from early August to the end of October at the Te Pirita weather station, Smoothed trend lines were derived for each temperature measurement

Solar Radiation



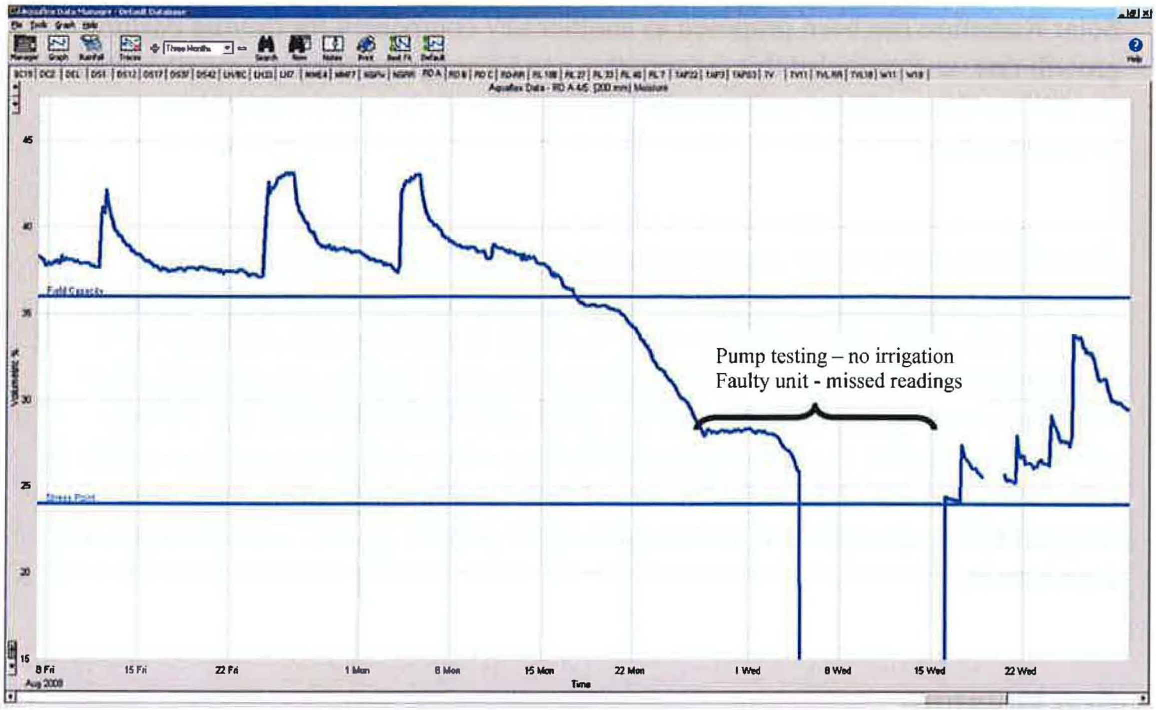
Graph 11: - The relationship between solar radiation and growth rate from August 1 to October 28 at Te Pirita. Smooth trend lines have also been plotted.

Solar Radiation has been proposed as another key component for driving pasture growth rate, and provided this information can be collected from our weather stations we will be able to derive and examine the strength of the relationship between the two parameters.

The relationship between solar radiation and growth appears strong until mid September (graph 11) but weakens as solar radiation increases beyond this time. Factors other than solar radiation may contribute to this changed relationship for example moisture stress. In the 2008 season it appears this site experienced some moisture stress (graph 12). To obtain a good relationship between any climatic variable and growth it is important to determine what other dominant factors may be influencing growth It is critical to record for example when soil moisture has dropped below the optimum level for maximum pasture growth, as discussed in the next section.

Soil Moisture

Soil Moisture levels which indicate plant available water are yet another parameter that needs to be considered which impact significantly on pasture growth rates if in deficit. It is essential that the Synlait monitoring data collection system can demonstrate a strong relationship between pasture growth rate and the optimum soil moisture level for maximum pasture growth. Currently irrigation on Synlait farms is managed to maintain soil moisture status between the field capacity (where soil water holding capacity is at a maximum and where any additional water drains from the profile), and the stress point, (where the soil has no further easily extracted plant water), for each individual soil type, but we don't know if we are operating in the optimum range for pasture production. Pasture growth may be greater where moisture status does not get too close to the stress point, and is maintained in a tighter band closer to the field capacity point. However there are some disadvantages to being too close to field capacity, with minimal opportunity to capture and store rain events. (see Graph 12)



Graph 12: - Soil moisture readings from an aquaflex strip at 200mm in paddock 4 at Robindale farm from August until the end of October 2008. Horizontal lines indicating field capacity and stress point are labelled.

Soil Fertility and Fertiliser Applications

Annual soil fertility tests for selected sites on each Synlait farm are scanned and stored on the Synlait server. This information is generally in PDF format and is accessible to all interested parties. The recommended fertiliser plan for each farm is also stored in the same location in PDF format but this is only the recommendation and does not always represent what actually gets applied.

With new technologies emerging in the fertiliser spreading industry, it is anticipated that we will be able to get actual GPS records for all fertiliser applications information of fertiliser and urea for each paddock on every farm. This creates new opportunities for traceability of fertiliser, as well as heading towards automatic nutrient budgets based on the data captured during the season.

Any future Synlait database must be able to incorporate the current soil fertility information and reference it against the individual paddock or paddocks where the sampling is done, as well as recording all the fertiliser applications that occur during the year. This information may also feed into the growth rate calculations, with the potential to assess response rates when all other data is considered.

Grazing records

Currently each farm provides grazing records at weekly intervals which are utilised in the calculation of current growth rates. These paddocks are included in the calculation if they have a grazing date and a residual pasture height or they are excluded from the farm growth rate and assigned the average growth rate for the farm during this grazing period.

Pasture Parasites

This is an area of interest for the future. For example a data base system may be useful in determining the effect of a measured infestation of grass grub on pasture growth at differing times of the year and the effect of different managements of this pasture pest. This information can potentially be recorded in the database to monitor if there is any significant reduction in pasture growth, and at what population levels it becomes economic for specific treatments that may be available.

Conclusions:

Synlait farming operations have promoted and encouraged extensive farm monitoring. Such information collection is only useful if it can be easily analysed and used to improve management and financial performance. For example there is a company wide approach to pasture monitoring and recording, that ensures that monitoring is done regularly and to a consistent level of accuracy. A large scale farm monitoring process has been developed producing a detailed set of data across all the farms.

However at present this data set is fragmented due to the rapid growth of the Synlait farming business, and the nature of data capture with multiple Excel spreadsheets. While this has served our purpose to date, it is restricting our ability to quickly extract and interrogate the current data to provide relevant and timely information for example the impact of changing some of the variables, like the standard equation to convert height to cover.

At present data input requires several manual steps involving data coping, pasting and subsequent manipulation, which leads to higher error rates in the output of information reports. This process needs to be seamless with importation of data directly from the data measurement device for example the RPM. Any checking can be done by the team during and after this process, but the data doesn't need extra handling.

The primary outcome from this report will be the development of the initial pasture monitoring database to import all existing data, and new data. This database will be tested and refined, and will be able to be expanded and modified as required in the future.

There are several sources of other external information currently being collected across Synlait farms, that needs to be standardised and incorporated into the same pasture monitoring database. This collated information on the same data base will give the Synlait team the ability to test any pasture growth model options that may predict growth rates on individual farms. There is good evidence, from the preliminary analyses of the information presented in this report, that there is a strong relationship between pasture growth rate and soil temperature, soil moisture levels, and solar radiation.

The Synlait pasture monitoring database has the potential to be utilised by other outside organisations, including Livestock Improvement and DairyNZ, which could provide Synlait with further analyses and assist the New Zealand dairy industry.

Recommendations:

The recommendations from this report are that Synlait monitoring systems need to:

1. Standardise data collection across all the farms for all the parameters required and specified in the report
2. Develop systems where there is minimal manual data entry with import functions for data entry from the rapid pasture meter and the aquaflex sites.
3. Develop a database that initially:
    a. Captures or imports directly raw pasture measurement data from the pasture monitoring equipment for all farms
    b. Converts the raw data into information for the managers on feed wedges, growth rates, paddock performance ranking across all farms
    c. Stores all calibration data
    d. Converts all calibration data into information on regression curves and equations
4. Develop an interface with the aquaflex data so this can be imported into the same database as the pasture monitoring
5. Work with other interested parties to ensure that we are able to maximise the benefit from the data already collected and future data collection. Some of the interested parties will include but not be limited to,
    - Livestock Improvement and their software learning systems division
    - DairyNZ and their whole farm model division
    - NIWA and their predictive weather forecasting model
6. Provide for future additions to the database to allow the input and/or capture of climate data to allow the statistical comparisons and with the pasture monitoring data.
7. Explore the option of capturing and entering all soil fertility information and fertiliser applications with a link if possible to GPS information directly for the spreading contractors
8. Have the potential to add in stock information and production figures and to be able to link this to the harvesting of pasture when linked to the pasture production.

References:

McCall D.G. , Bishop-Hurley G. J. 2003 A pasture growth model for use in a whole-farm dairy production model. *Agricultural Systems 76 (2003) 1183-1205*

Webby R.W. , McCall D.G. , Blanchard V.J. 1995 An evaluation of the Stockpol^{TM} model. *Proceedings of the New Zealand Society of Animal Production 1995, Vol 55*

Appendix 1:

Synlait equations for the Plate and Rapid pasture meter (Prepared by Eric Kolver)

29 July 2008

Synlait Plate meter equation
Pasture cover (kg DM/ha) = 203x+78
Where x=average height in clicks

Synlait Rapid meter equation
Pasture cover (kg DM/ha) = 25.712x+366.93
Where x=average height in mm

The Synlait plate meter equation and the Synlait rapid meter equation will give the same pasture cover result (i.e. you can use the Plate meter to monitor the feed wedge produced by the Rapid meter).

Pasture cover kgDM/ha	Plate meter clicks	Rapid meter mm
1499	7	44
1702	8	52
1905	9	60
2108	10	68
2311	11	75
2514	12	83
2717	13	91
2920	14	99
3123	15	107
3326	16	115
3529	17	123
3732	18	131
3935	19	138
4138	20	146
4341	21	154
4544	22	162
4747	23	170
4950	24	178
5153	25	186

How to use
The Synlait equation for the Plate and the Rapid meter will be used throughout the whole year (no changing of calibrations through the year).

These Synlait equations are based on the weekly calibrations that Synlait have made during last season.

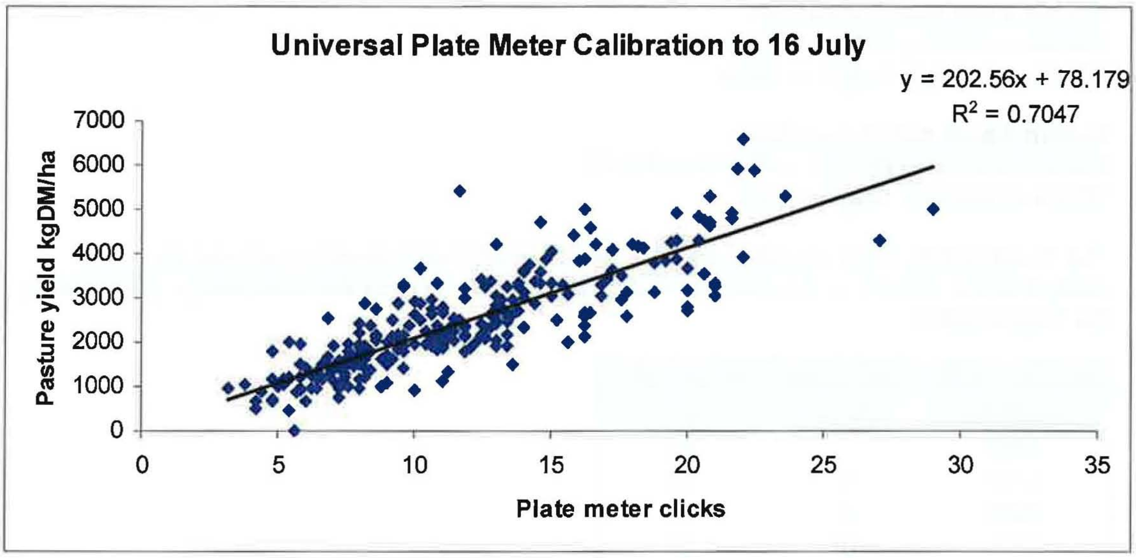
We need to put this new Synlait Plate meter equation into all our plate meters so that the pasture covers they read are the same as feed wedge results you get from the Rapid meter.

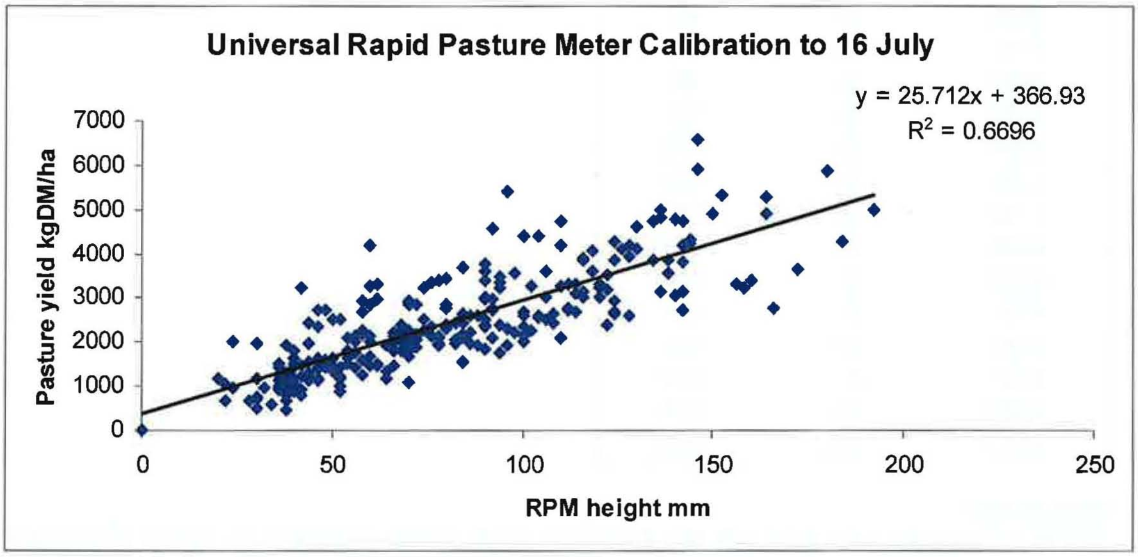
The target for grazing residuals is still 7 clicks, and 7 clicks still equals 1500 kg DM/ha cover.

The monitoring last season showed that we have more kg DM/ha at pre-grazing heights than we would previously have measured using the traditional equation i.e. 18 clicks on the traditional equation equals 3000 kg DM/ha, on the Synlait equation it equals 3732 kg DM/ha. You will still be targeting pre grazing covers that result in a grazing residual of 7 clicks (1500 kg DM/ha).

Extra information

The Synlait equations include one year of calibration data (12 July 2007 to 16 July 2008; 24 calibration sets) that were made at Robindale. There have reasonable R^2, which means that 70% of the variation is explained by the equations. Continued calibration cuts during the 2008/2009 season will make these equations even more robust (they will be updated at the end of the 2008/2009 season).

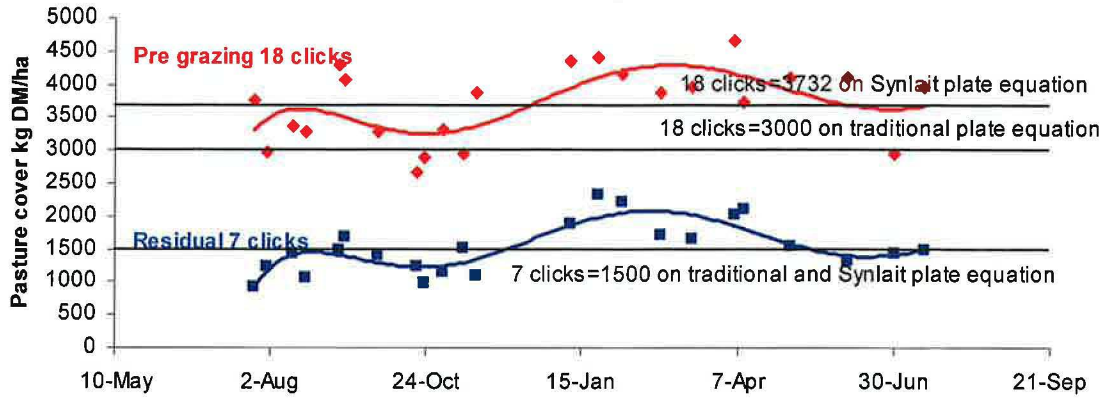




The results of the 2007/2008 season of calibrations show that 7 clicks was sometimes lower and sometimes higher than the 1500 kg DM/ha that 7 clicks is associated with using the traditional plate meter equation. The Synlait plate meter equation also predicts 1500 kg DM/ha at 7 clicks.

If 18 clicks is used as an indicative pre grazing cover, last years data showed that 18 clicks was associated with covers much higher than the 3000 kg DM/ha that the traditional plate meter equation would predict. The Synlait equation equates 18 clicks to 3732 kg DM/ha.

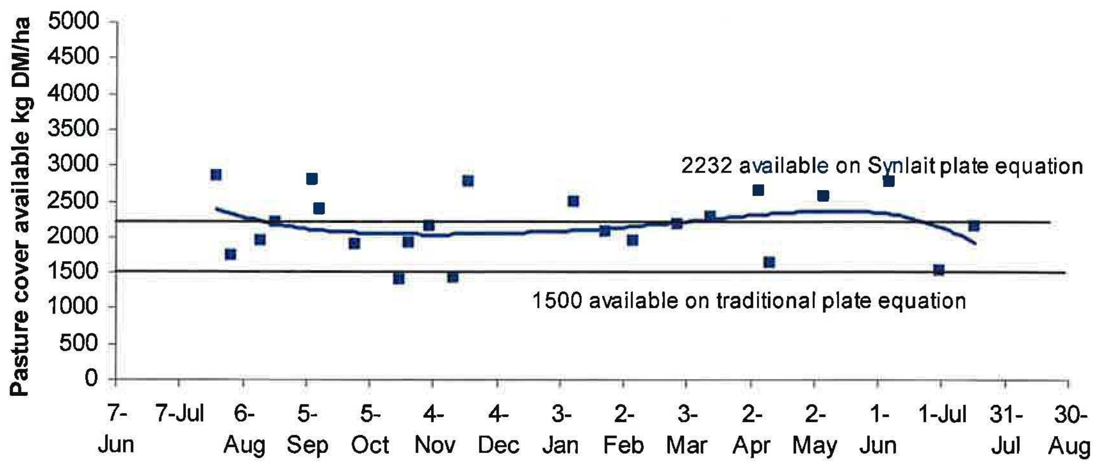
Synlait pasture cover at 7 and 18 clicks (2007/08)



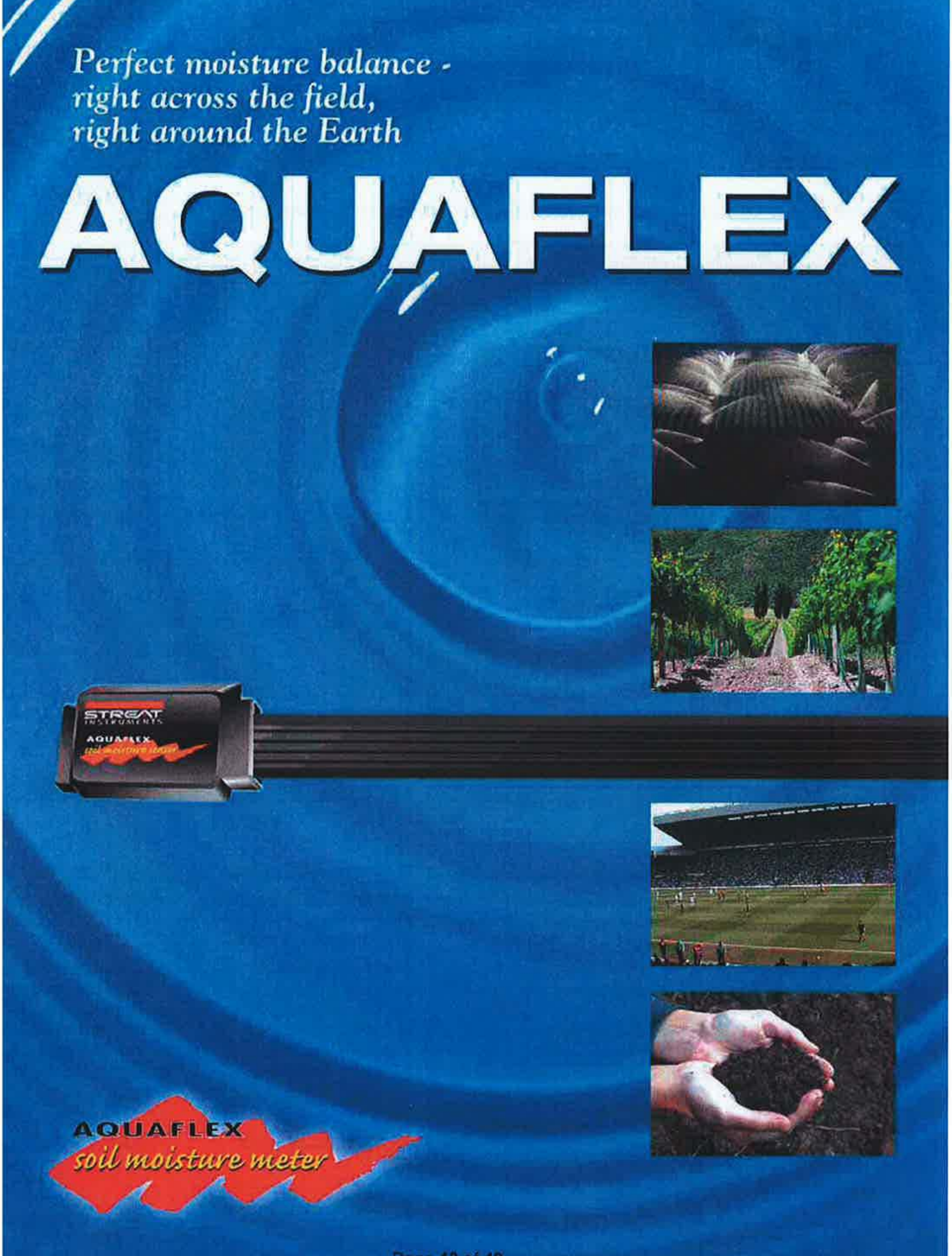
The key point is not whether the equation gets the exact pre grazing or residual figures right, but whether available pasture (pre minus residual) can be estimated (the gap between the two lines in the above graph).

The graph below shows that while available pasture does jump around week to week, it is very difficult to manage when you have a calibration equation that changes from week to week. Anyway, when you fit a line through the available pasture data for the whole season, on average the available pasture doesn't change too much throughout the year. This indicates that we should be OK to use one equation for the whole year (and much easier on the farm as 7 clicks always equals 1500 kg DM/ha throughout the whole year).

Synlait available pasture between 7 and 18 clicks (2007/08)



Appendix 2:


Perfect moisture balance -
right across the field,
right around the Earth
AQUAFLEX
STREAT INSTRUMENTS
AQUAFLEX
AQUAFLEX
soil moisture meter

Proven soil moisture measurement

With multiple repeat purchases of AQUAFLEX from vineyards to sports stadiums around the world, the unique AQUAFLEX System is now a proven leader in the field of soil moisture measurement technology.

Leeds United ground staff install AQUAFLEX at Elland Road Stadium. Norman and Craig say " We find it a very useful turf management tool and very easy to use. It was easily installed and created very little disturbance during installation."

AQUAFLEX installation in a USA vineyard. 'AQUAFLEX is a vital tool for effective irrigation management.'

AQUAFLEX

The most accurate and repeatable analysis of soil moisture of any system available.

For every application:

- Golf courses
- Tennis courts
- Cricket grounds
- Football stadiums
- Horse racing tracks
- Botanical gardens
- Parks
- Horticulture
- Vineyards
- Orchards
- Arable crops
- Pasture
- Compost
- Biofilters
- Landfill
- Hydrological and meteorological monitoring

AQUAFLEX
The Soil Moisture Sensor that Speaks VOLUMES!

Measuring average moisture over a significant 3 metre (10 feet) length and in a cylindrical volume of 6 litres (370 cubic inches) of soil.

AQUAFLEX is the only soil moisture sensor that overcomes the problems of measuring soil moisture content at one point only in a relatively small amount of soil.

AQUAFLEX
Robust and dependable for every application

AQUAFLEX sensors are manufactured to the highest quality standards with high quality components, providing built-in durability, dependability and reliability.

This sets AQUAFLEX apart from other methods of moisture measurement.

AQUAFLEX
The ultimate soil moisture measurement system for every irrigation manager.

The choice is yours. If accurate measurement is what you want, AQUAFLEX has the answers -

- Spot readings
- Continuous loggings
- Telemetry or automatic control

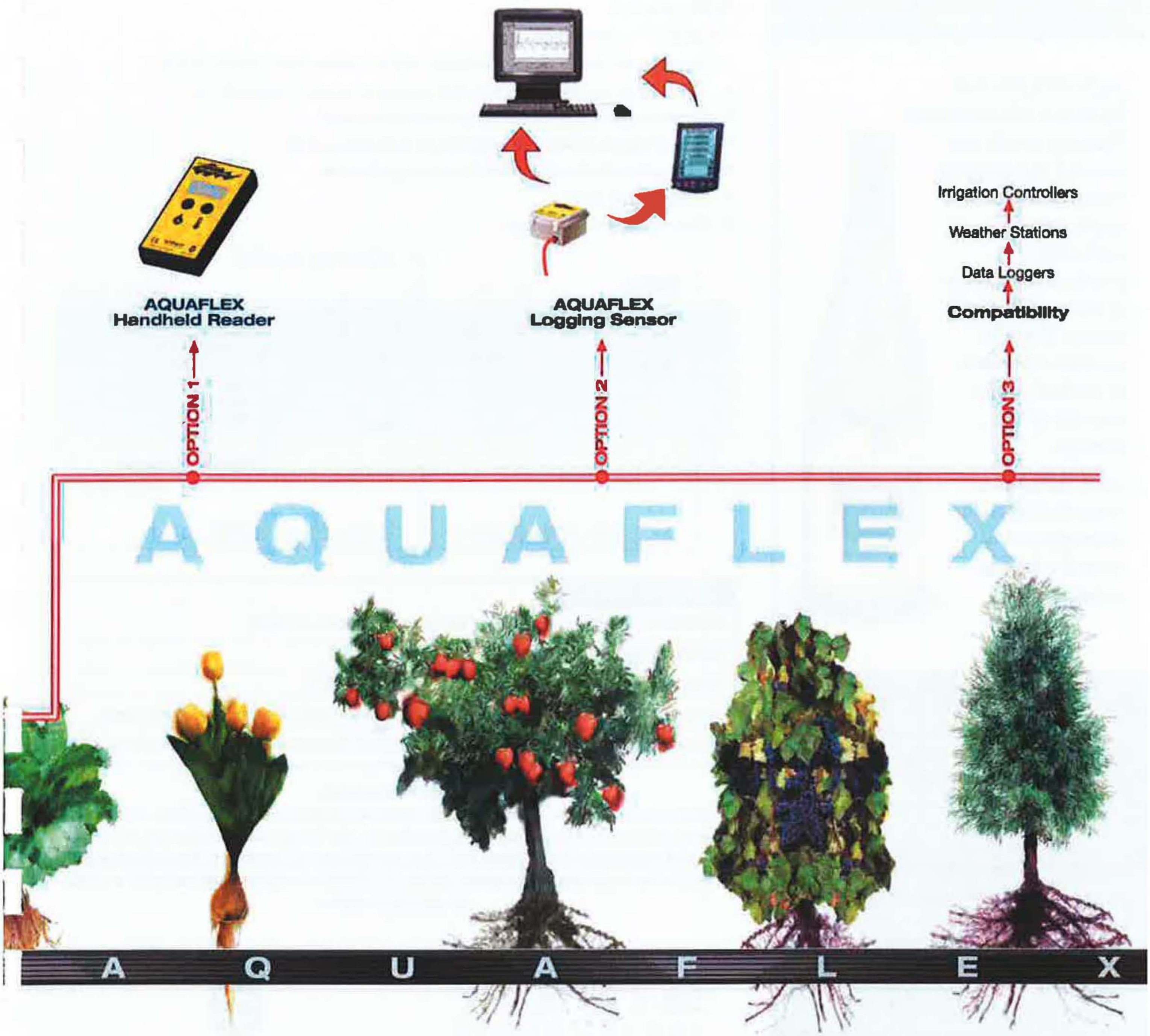
AQUAFLEX *does it all*

AQUAFLEX
The profitable solution

Critical to better irrigation control techniques is the growing need for food producers to control growing costs while maintaining quality. Superior levels of irrigation management are central to achieving this.

AQUAFLEX *meets these needs.*

SPATIAL AVERAGING, PRE



AQUAFLEX
For increased crop and turf quality

AQUAFLEX provides the irrigation manager with far more reliable information than ever before about soil moisture content and temperature.

AQUAFLEX is a vital tool in providing greatly increased crop and turf quality and yields.

AQUAFLEX
Easy to install and operate

The AQUAFLEX Sensors are easily installed in the ground at an appropriate depth for the application and measurement required.

AQUAFLEX ***measures where it matters!***

AQUAFLEX
Easy connection to your existing systems

The AQUAFLEX Moisture Sensor system can be connected to a wide range of irrigation controllers, weather stations, data loggers and industrial controllers providing both existing and future irrigation systems with reliable information for minimising water waste and maximising crop and turf yields.

AQUAFLEX
Superior technology

AQUAFLEX measures soil moisture using a technique known as Time Domain Transmission (TDT) which insures optimum accuracy and stability.

AQUAFLEX's unique application of this technology also provides spatial averaging and compensation for soil temperature and soil conductivity.

Appendix 3:

FARMWORKS

pasturemeter

Rapid Pasture Meter

THE NEW PASTURE METER REPRESENTS A REVOLUTIONARY ADVANCEMENT IN THE RAPID MEASUREMENT OF PASTURE DRY MATTER. THE TECHNOLOGY UTILISES OPTICAL SENSORS THAT ARE INSTALLED IN A SKID TYPE TRAILER. THE OPTICAL BEAMS CONTINUALLY MEASURE PASTURE HEIGHT AS THE TRAILER IS TOWED BEHIND A FARM VEHICLE. A MOUNTED DISPLAY UNIT CONVERTS THE HEIGHT MEASUREMENT TO KgDM/Ha USING A PRE-SELECTED FORMULA.

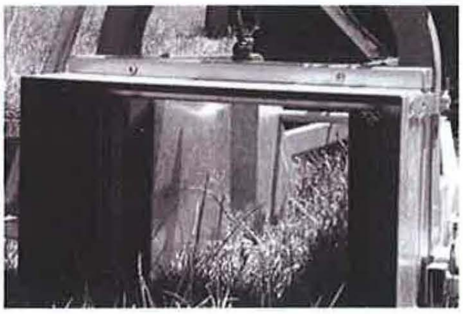
- The Rising Plate Meter has traditionally been the mainstay of the dairy farmers pasture measurement kit, however the increase in both farm size and herd size has made plating onerous which has tended to compromise technique and eventually accuracy as speed is increased.

- The Pasture Meter unit is mounted on a trailer and pulled behind an ATV. Speeds of up to 20km per hour are acceptable with 200 readings per second being taken.

  This provides a significant improvement on the traditional plate meter and probe devices.

  KgDM/Ha readings are recorded on a display mounted onto the ATV placed in front of the driver.

- Pasture height is read by sensors mounted into a metal "tunnel" which is pulled through the pasture.



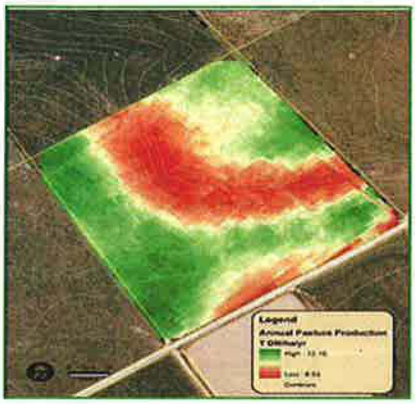
- The base model will provide an instant display of pasture DM for the current paddock in which the unit is operating while the top of the range model will incorporate Bluetooth™ and GPS technology and integrate with FARMWORKS P-Plus PDA and desktop software. The software encompasses mapping, feed budgeting and a pasture growth predictor.

Rapid Pasture Meter

FARMWORKS
Rapid Pasture Meter

- Additional advantages of the Pasture Meter is that it will be able to be used on moderate slopes and eventually with other species such as green feed cereals and lucerne subject to successful calibration trials.

- The Pasture Meter has been designed to measure pasture residuals which is seen as important to ensure maximum utilisation from a farmer's pasture. Much of the guarding around the unit is designed to keep the sensors clean while measuring heavily soiled paddocks.



The Tier 3 System mapping will create pasture yield maps from individual pasture readings that are linked to a GPS coordinate. This will allow farmers to identify poor performing areas in the paddock and to implement corrective actions.

The Pasture Meter will be available in three versions:

Tier 1 – simple read only with P-Plus Pasture Cover Software to record pasture covers.

Tier 2 – Bluetooth™ Wireless enabled to allow automatic upload of the data from the display unit to P-Plus Pasture Cover/Feed Management Software or optional PDA software.

Tier 3 – Bluetooth™ Wireless and GPS enabled to allow automatic upload of each pasture measurement to PDA and/or P-Plus Mapping and Feed Management Software.

P-Plus PDA Software is an optional extra for Tier 2 and an integrated component of the Tier 3 system.

Need to know more,
telephone FARMWORKS on 06 3239059,
email info@farmworkspfs.co.nz or visit
www.farmworkspfs.co.nz

FARMWORKS
TOOLS FOR MAXIMUM GROWTH

Disclaimer:
Whilst every effort has been made to ensure accuracy, neither FARMWORKS Precision Farming Systems Limited or C-DAX nor any employee of either company, shall be liable on any ground whatsoever to any party in respect of decisions or actions they may make as a result of using this information.

Appendix 4:

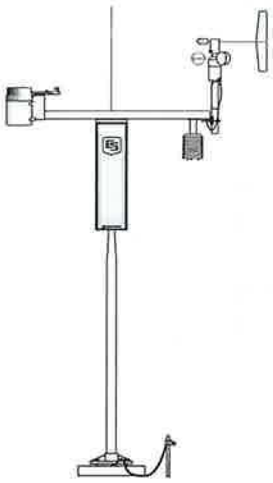
CAMPBELL SCIENTIFIC, INC.

MEASUREMENT & CONTROL SYSTEMS

Weather & Climate

Benefits of Our Stations

1. Choose a preconfigured weather station or configure your own.
2. Stations can measure most commercially available meteorological sensors.
3. Communications options include phone, cellphone, voice-synthesized phone, satellite (DCP), and radio.
4. Stations operate reliably in harsh environments.
5. Dataloggers provide on-site statistical and mathematical capabilities.
6. Batteries and solar panels allow long-term, remote operation.
7. Stations are easily expandable—add new sites or add sensors to existing sites.
8. Powerful software supports programming, data retrieval, and data display.



ET106 ET/Weather Station (preconfigured)

www.campbellsci.com/weather-climate

Our stations are known for their precision measurement capability, rugged construction, wide operating temperature ranges, versatility, research-grade accuracy, and low power consumption.

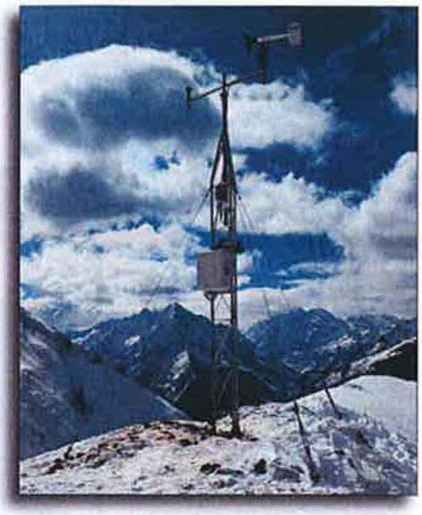
From single research stations to meso-scale networks, Campbell Scientific weather stations have become the worldwide standard for climatological and meteorological monitoring. Our stations have measured conditions in the Sahara Desert, Brazilian rain forests, and both the Arctic and Antarctic. Accurate measurements, proven reliability, and the ability to customize each station make our weather stations ideal for all types of meteorological and climatological monitoring.

We offer several weather station configurations. Our preconfigured stations feature a standard suite of pre-wired sensors, easy installation, and simplified programming. Custom stations offer a wider selection of sensors and data transfer peripherals, providing greater flexibility.

Dataloggers

Our weather stations are based around a programmable datalogger (typically a CR10X or CR23X) that measures the sensors, then processes, stores, and transmits the data. Our dataloggers have programmable execution intervals, wide operating temperature ranges, on-board instructions, and ample input channels for commonly used sensors. Wind vector, wet bulb, histogram, and sample on maxima or minima are standard in the datalogger instruction sets. Our dataloggers interface directly to most sensors, eliminating external signal conditioning.

Data are typically viewed and stored in the units of your choice (e.g., wind speed in mph, m s^{-1}, knots). Measurement rates and data recording intervals are independently programmable, allowing calculation of 15-minute, hourly, and daily data values from 1-minute or 1-second measurements, for example. Conditional outputs, such as rainfall intensity and wind gusts, can also be recorded. The program can be modified at any time to accommodate different sensor configurations or new data processing requirements. If needed, channel capacity can be expanded using multiplexers, including a model designed specifically for thermocouples.



Wireless communications and low power use allow long-term, remote operation.

Sensors

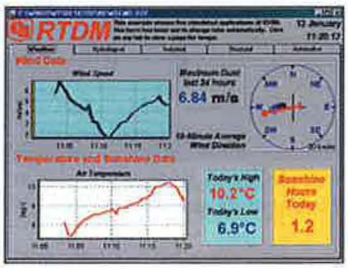
Almost any meteorological sensor can be measured by our dataloggers, allowing stations to be customized for each site. Typical sensors used on our stations include, but are not limited to: wind speed and direction, solar radiation, temperature (air, water, soil), relative humidity, precipitation, snow depth, barometric pressure, and soil moisture. In some locations, hydrological sensors provide additional measurements, such as water level of a nearby stream.

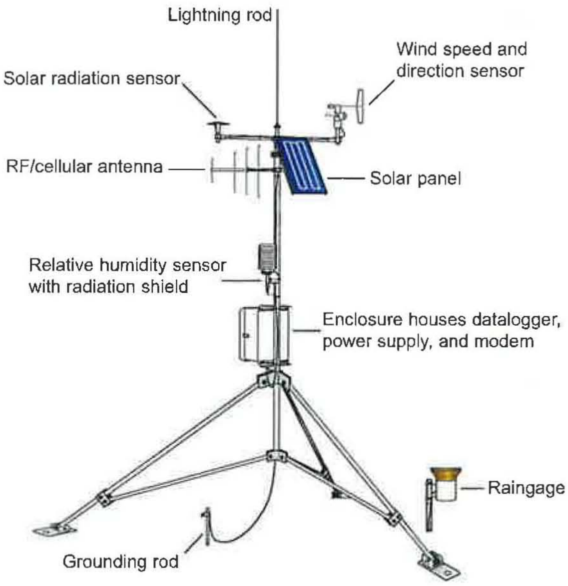
Data Retrieval

We offer multiple communications options for data retrieval; options can be mixed within the same network. Telecommunications options include short-haul, telephone (landline, voice-synthesized, cellular), radio frequency, multidrop, and satellite. On-site options include storage module, card storage module, and laptop computer.

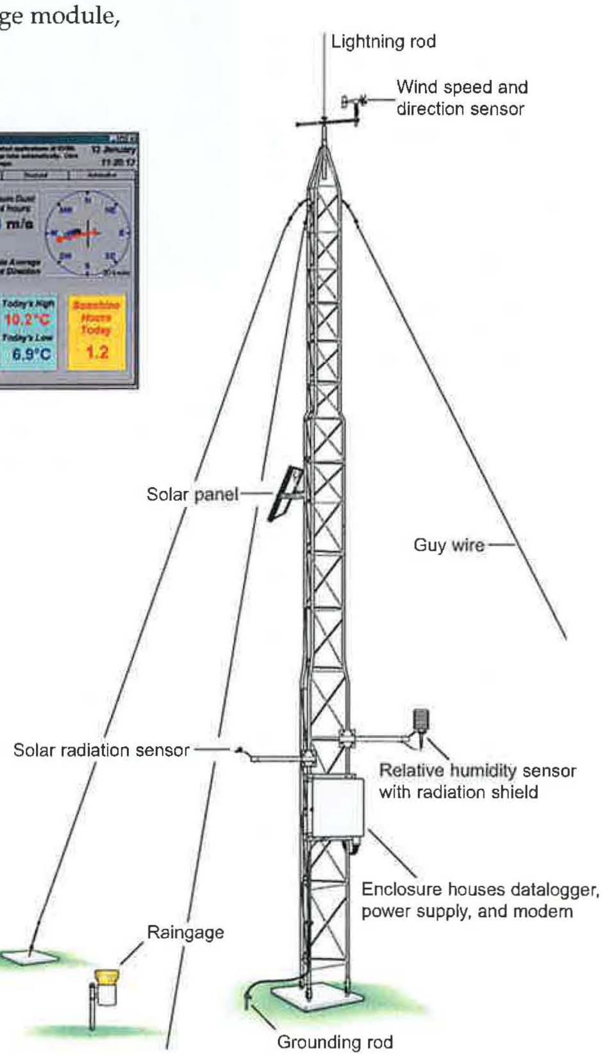
Software

Our PC-based support software simplifies the entire weather monitoring process, from programming to data retrieval to data display and analysis. Our software automatically manages data retrieval from networks or single stations. Robust error-checking ensures data integrity. We can even help you post your data to the Internet.





Typical Tripod-based Station



Typical Tower-based (20 or 30 ft) Station