Sm@RT international visit

New Zealand

January 28th to February 11th 2023

Report prepared by Tim Keady, Teagasc, Ireland

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 101000471.

Summary

1) A total of 13 delegates (12 and 1 from the Sm@RT and EuroSheep H2020 funded projects) visited New Zealand in late January/early February 2023.
2) Since 1990 there have been major changes in the New Zealand Sheep industry. Sheep numbers have declined by 52%, ewe productivity has increased by 28% and lamb carcass weight has increased by 37% (5.2 kg). These changes marginally decrease (-8%) lamb carcass output and clearly show that New Zealand farmers adopt technical innovations.
3) 99% of all sheep meat is available for export. The main export markets are China, EU and USA accounting for 58, 23 and 12% of exports, respectively.
4) All lambs slaughtered using halal technique.
5) Lambs are not tagged prior to slaughter or sale at live markets– replacements are sometimes tagged on entering a flock as replacements.
6) Dairy sheep and dairy goat numbers have increased in recent years with most of the milk dried to milk powder for export to Asian markets
7) Flock size is considerably larger than in Europe (mean flock size is approximately 2,800 ewes).
8) Large number of ewes are managed per labour unit.
9) Great opportunities exist to use automated data recording, weighing and drafting systems but they need to be cost effective to get a return on investment
10) Uptake of digital technologies on farm is low, particularly on meat sheep farms. Some large meat sheep flocks visited did not adopt digital technologies as perceived too costly and poor return on investment. The adoption of digital technologies is higher in the dairy sector (sheep and goat).
11) Connectivity is an issue in many regions, or areas on particular farms.
12) A lot of interesting research been undertaken on use of technologies to reduce labour and fencing and to improve stock management for beneficial impact on the environment e.g. water and soil management.

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Sm@RT Delegation visit to New Zealand

The Sm@rt delegation visited New Zealand between January 28 and February 11, 2023 to exchange knowledge and experience on innovative technologies with sheep and goat producers, scientists, technology providers, advisors/consultants and other stakeholders. The objective of the New Zealand visit was to:

1) experience New Zealand systems of small ruminant production,
2) see what innovative technologies New Zealand sheep and goat farmers and other stakeholders are using,
3) understand the motivations why they are using these technologies to manage their flocks/herds,
4) view and experience these technologies in use and discuss strengths and weaknesses,
5) liaise with technology providers viewing their latest equipment and business models,
6) have exchanges with scientists on their current and future research on innovative technologies.

The delegation consisted of the following:

a) Claire Morgan Davies (SRUC, UK)
b) Ann McLaren (SRUC, UK)
c) Fiona Kenyon (Moredun, UK)
d) Laurence Depuille (IDELE, France)
e) Jean Marc Gautier (IDELE, France)
f) Eliel González-García (INRAE, France)
g) Tim Keady (Teagasc, Ireland)
h) Brid McClearn (Teagasc, Ireland), EuroSheep delegate
i) Lise Grove (NIBIO, Norway)
j) Renata Klein (UNIDEB, Hungary)
k) Peep Piirsalu (EULS, Estonia)
l) Ilan Halachmi (ARO, Israel)
m) Fabrizio Chessa (AGRIS, Italy)

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Day 1. -Monday 30th January: Mt Nicholas Station Farm visit

Mt Nicolas station is a pastoral let with a 99-year lease that is run by Jack and Kate Cocks. Jack and Kate took over the running of Mt Nicolas from Kate's family 14 years ago. Prior to this Jack and Kate worked as an agricultural consultant and banker respectively. Mt Nicolas is one of 150 pastoral lets from the New Zealand government, which combine to approximately 1.2 million ha. The pastoral lets were established by the New Zealand government in 1948 to encourage people to live in remote rural areas, whilst still maintaining control of the land. Whilst the term of the lease is for 99 years there is a review every 11years. The cost of the lease is based on a number of factors including the following:

1) Stock carrying capacity of the unimproved land which is based on data collated in 1860
2) Improvement ability of the land
3) Profitability of beef and sheep production in the past 5-6 years

At the end of each lease the farms are offered to existing tenants to encourage continuity.

Today the farm is owned by an entity partnership – 80% owned by Jack and Kate

Farm size and location

The farm consists of

a) 36,000 ha (300 – 2000 meters above sea level)
b) 2100 Hereford cattle consisting of 900 cows. The males are sold for slaughter at 30 months with mean carcass weight of 330 kg
c) 29,000 Merino sheep half of which are wethers. Wool production is the major farm enterprise.

The farm is relatively remote, being 100 km from the closest town – 80% of the road is gravel track. They visit the local town once weekly to get farm and household supplies. Due to location Jack and Kate also supervise home schooling of their children in conjunction with online services from a school.

Farm work force

The farm employs a total of 7 people as follows:

1) Jack and Kate – Jack is responsible for animal and crop husbandry. Winter feed consists of 400 large square bales of Lucerne hay and 15 ha of brassicas. No concentrate is used on farm. Kate is responsible for business management.
2) Stock man and 2 young shepherds
3) Cook and her husband who is responsible for maintenance.

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Wool

Wool is the major enterprise on Mt Nicolas Station. Sheep are shorn pre lambing (early September). Shorn at this time so that the fleece is in good quality, and not impacted by pregnancy requirement which may negatively impact wool quality. Also shearing at this time encourages the ewes to seek shelter post lambing for herself and her lambs.

Key points on wool are as follows:

a) They produce fine + superfine wool ~18µm
b) Mean wool price was NZ$15/kg (includes all wool plus crutchings). Top grade wool makes NZ $21 - NZ$27/ kg
c) Mean yield of wool is 4 kg/ewe
d) 80% of wool sold on contract thus wool price is known for up to 10 years in advance
e) 2/3 of wool is sold to the Italian fashion industry, remainder sold for 'active wear'

At shearing the team consists of 19 people, who stay for up to 1 month on-farm as follows:

a) 6 shearers
b) 8 wool handlers
c) 2 pressers
d) 1 pen upper
e) 1 wool grader
f) 1 cook

Total cost of shearing costs is approximately NZ$10 per sheep

Lamb output

Mean ewe productivity is 0.9 lambs reared/ewe joined. Lambs are sold at approximately 1 year old. Jack and Kate are trying to improve ewe productivity and are concerned that lamb survivability may be impacted by source of sires, as lamb mortality between birth and tailing is 30%

Animal management

1) Sheep are shorn pre lambing as this encourages the ewe to seek shelter post lambing for herself and her progeny.
2) Sheep are set stocked from pre-lambing to weaning in flocks of 400 to 700 ewes.
3) At lambing the flock is not disturbed by humans. Lambing commences in early October and no herding occurs until early December at tailing. Lambs are fragile at birth (approx. 2.5 kg). At tailing the lambs are treated for external parasites and the ewes are walked through a shower unit spraying Cyrex (spinosad and cyromazine).
4) Lambs are weaned in January and the ewes go to the mountain.
5) Ewes come off the mountain in early April and are crutched, treated with an anthelmintic and iodine and set stocked.
6) Rams are let out in early May.
7) Sheep are herded once weekly and are moved every 6 weeks during winter.

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Technology used on-farm

All ewes are pregnancy scanned. Pregnancy scanning is undertaken as they want to understand their low lambing percentage and it facilitates them to save on feeding costs as non-pregnant ewes are removed from the flock.

Connectivity is a major issue, there is no cellphone signal on much of the property.

No farm software is used as they think it is every expensive (charged per sheep!!) and will not give the resolution required (Kate was a banker and is very comfortable with numbers and spreadsheets, so they believe they can do it themselves using Microsoft Excel).

Rubber rings and numbnuts (to mitigate pain) are used for tail docking and castration

Their wish from technology would be something that could help with compliance; there are electronic forms to be completed for health recording, medicine use but they are complicated and collation of these would be desirable.

Sheep health issues

The two main sheep health issues are

1) Footrot – every time the animals are in the handling facility there are walked through a footbath containing a mixture of formalin and zinc
2) Internal parasites – little resistance to anthelmintics has been identified on this farm (with the exception of ivermectin). Ewes are treated pre lambing with a capsule containing ivermectin and bendemazole. This treatment is given solely because the ewes are Merino with the intention of maintaining wool quality. Lambs are drenched at tailing, weaning and every 4 weeks until drafting. They use FECPAK to monitor worm FEC in ewes and treat when FEC over 200 eggs per gram.

Key points

1) Large scale farm with only 7 labour units
2) Basic equipment but big output per labour unit
3) Minimal technology used due to lack of internet and perceived lack of return on investment
4) This farm has the most challenging environment for Merino sheep in New Zealand.

Day 2. – Tuesday 31th January: Eyre Creek station visit, Nathan Howden farm visit

Eyre Creek station visit

Facts and figures of New Zealand sheep farming were presented during the visit and are as follows:

1) New Zealand sheep numbers peaked at 70 million (40 million ewes) in the 1970's but have declined for a number of reasons including an increase in:
    a. dairy cow numbers from 1.5 to 6 million cows which have displaced sheep off the better country,

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   b. deer farming was initiated with approximately 800,000 deer currently in New Zealand of which 50% are hinds,
   c. forestry,
   d. horticulture especially kiwi fruit and grapes.
2) One third of New Zealand land is in conservation areas therefore pasture is protected.
3) Productivity has increased since the 1970's. Productivity and carcass weight has increased from 0.95 to 1.30 and 12.5 to 18.1 kg, respectively. Today 17 million ewes produce the same meat output as 40 million in the 1970's. The improved productivity is mainly due to changes in system (nutrition and technology adoption e.g. pregnancy scanning). Genetics have also improved. Sheep genetic base established in the 1980's but only contains pedigree breeder data.
4) 95% of farmers consider themselves stewards of the land.
5) 32,000 dairy sheep in New Zealand.
6) New Zealand exports approximately
   a. 95% of its cow milk mainly as milk powder, cheese and butter
   b. 85% of its beef
   c. 95% of its sheep
7) New Zealand produces enough food to feed approximately 40 million people.

PAMU (formerly Land Corp)

In the 1800's the Land Department was established with the objective to get land into agriculture by removing scrub etc. This land was used to settle returned servicemen from World War 1 and World War 2.

In the 1980's it was split into 3 sections as follows:

1) Dept of conservation: took all conservation land (National Park, Forest Park)
2) Land information: titles of land, etc.
3) Land Corp took all the farms not wanted i.e. non-productive which required a lot of "work", remote, hard to settle etc.

Recently Land Corp was renamed PAMU. In recent times, Land Corp has provided land for Māori claims. In the past 25 years, they settled 25 farms.

Today PAMU have a total of 115 farms spread from the Northland to the Southland. PAMU farm 180,000 ha plus the 180,000 ha Molesworth Station, which is very extensive. Fifty percent of PAMU farms are in dairying, managing 40,000 cows, mean herd size is 800 cows. The drystock farms have a total of 1.1 million stock units (1 stock unit = 1 sheep = 565 kg DM consumed/animal) comprising of a mixture of beef, sheep and deer. PAMU manage 280,000 ewes (this will increase), 30,000 hinds (which will decrease) and 25,000 beef cows (mainly Angus and will decrease). PAMU employ 700 people, 600 are on farm.

PAMU are involved in genetic projects and are commencing a large project next year aiming to get linkage between hair sheep and current sheep breeds by putting all genetic information on one database. PAMU has a number of subsidiaries as follows:

a) Farm IQ which is a software company. PAMU owns 40%

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b) FarmaX (PAMU just purchased it)
c) Genetics
d) Joint venture with Agresearch for a CT scanner
e) 50% ownership Spring sheep
f) Spray dryer (for milk powder)
g) Deer milk food business

Eyre Creek Station

Eyre Creek Station is owned by PAMU. It has 1600 ha. The livestock includes:

1) 1400 hinds. When fawning the hinds are not disturbed.
2) 300 beef cows - Angus
3) 2500 Romdale ewes (Romney X Pendale) which are joined with Texel sires. All replacements are sourced off farm. Replacements receive a quarantine dose of either cydectine or a triple drench.

Lambs are drafted at 38kg with the objective of achieving an 18kg carcass. Lambs are finished post weaning on an Italian ryegrass clover mixture.

Parasite control: Faecal eggs count are undertaken on lambs. First drench is at weaning and then approximately every 4 weeks.

Technology: Pregnancy scanning and weighing are the main technologies used on this farm. Ewes or lambs are not tagged. Connectivity is an issue on this farm, so they have installed LORA antennas on top of the hills.

Technology projects have been undertaken in conjunction with AgResearch including:

1) Nationwide survey of water quality on deer farms
2) Characterising animal grazing personalities for deer using collars including GPS location and accelerometers
3) Future projects may include projects with sheep

Key points

1) Large scale farm with only 2 labour units operating 3 farm enterprises.
2) Minimal technology used due to connectivity issues and all progeny been drafted for slaughter.

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3) Ewes or their progeny are not EID tagged.
4) There are water troughs in all paddocks.
5) Connectivity is an issue on this farm.

Nathan Howden farm visit

Nathan and Brian Howden farm 390 ha at Waikoikoi, Gore. Stock numbers for the farm include 3,950 ewes, of which 600 are stud ewes (180 Texel ewes and 420 Genetex ewes). Charollais x Texel rams are used on 30% of the ewes. With the exception of 110 ram lambs (which are sold for breeding) and ewe lambs retained as replacements, all lambs are drafted for slaughter. There are also 1150 ewe lambs (950 commercial, 80 Texel and 120 Genetex) plus 20 stock rams.

Ewe lambs retained as replacements and those which are ≥ 48 kg at 7 months are joined. Mating occurs in April, ultrasound pregnancy scanning is undertaken in June. The ewes are shorn in July (third month of pregnancy). Most of the ewes are wintered on swedes. Lighter and older ewes and ewes carrying triplets are wintered on pasture. Target body condition score is 3.5. Prior to lambing ewes are set stocked at 200-300 ewes per paddock. Lambing occurs in October. Tailing is undertaken at 5 to 6 weeks of age and then the ewes and lambs are managed in a rotational grazing system. Drenching commences in December.

Flock performance

Last year the Howden's weaned 1.5 lambs/ewe joined. Mean lamb wastage is 15% and ewe mortality is 2.5%. Mean carcass weight was 18.5 kg. At weaning of the adult ewe flock 41% of lambs were drafted for slaughter with a mean carcass weight of 17.4 kg. In the ewe lamb flock weaning rate was 1 lamb/ewe joined and 63% were drafted at weaning. Post weaning lambs are grazed on 13 ha of leafy turnip.

Going forward the following goals have been set for the farm:

1) improve lambing percentage (consistently achieving 150%),
2) reduce lamb wastage,
3) draft a higher proportion of lambs for slaughter at weaning,
4) sell more rams for breeding, even with the decline in clients due to dairy, dairy support and tree conversions,
5) promote the Charollais breed,
6) increase shelter on the farm,

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7) achieve better utilisation of grass,
8) develop pit silage,
9) diversification off farm.

As one of their farm objectives was to improve grass utilisation they have started using the GrassCo (www.grassco.co.nz) service to improve rotational grazing as seen on neighbouring dairy farms. Using a CDAX machine it takes approximately 2.5 hours to collect data from the whole farm (covering approx. 101 different paddocks).

GrassCo provides a pasture measuring and farm mapping service to farmers. They currently work with around 60 farms (all dairy enterprises and the Howden sheep farm). The service involves data collection on farm using a custom-built pasture sledge with a CDAX pasture console and reader (which is also GPS capable) pulled behind an ATV or 4x4 vehicle. There are two main options for the farmers in terms of data collection; they can lease/rent a CDAX machine (NZ$15,000), to measure their fields themselves, before submitting the data to GrassCo, or GrassCo go on farm and do all data collection and then submit it for processing. The CDAX machine records 200 readings per second, using a series of LEDs to assess sward height/density values (above 10 mm) for each paddock. Whilst the machine records data in terms of kg/DM, GrassCo prefer to use an index system for ranking the fields rather than kg/DM. To get the full benefit of the system and service, it is recommended measurements should be undertaken weekly, but some farmers measure less frequently. Once the data are collected and has been processed the results for each paddock are sent to the farmer to facilitate them to make appropriate management decisions. Output information include soil temperature report, pasture yield mapping (kg/DM/ha), average pasture cover and pasture growth. In addition, GrassCo provide general region information for farmers who sign up for regular e-mail updates.

Key points

1) Large scale farm with only 2 labour units for 3950 ewes and 1150 ewe lambs
2) Use of technology include pregnancy scanning and use of GrassCo to facilitate grass budgeting and management.
3) A large proportion of lambs are drafted at weaning.

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Day 3. – Wednesday 1st February: Invermay workshop and visit to Scott Technology

AgResearch, Invermay

Agresearch was established in 1946, to undertake research for farmers to improve agriculture in New Zealand.

The workshop was attended by 23 participants. The presentations at the workshop were as follows:

1) Claire Morgan-Davies (SRUC, UK) presented an overview of the Sm@RT project, its aims, steps, and activities to-date.
2) Brid McClearn (Teagasc, Ireland) presented EuroSheep, with an overview of the EU thematic network, its aims and objectives regarding sheep health and nutrition management; solutions, tips and tricks and documentation EuroSheep has produced to-date.
3) Lise Grøva (NIBIO, Norway) presented results of studies on the use of GPS from Norway. In Norway, radiocollars are used and 100,000 sheep are tracked by GPS annually. There are 4 main companies providing these collars (Telespar, Find my, Smart bella and NoFence). Lise also presented data on temperature and heart rate to detect sheep fever. In Norway, they are working on deer tracking and have a dedicated website to track them for behaviour and culling policies.
   In Norway sheep farmers are organised in grazing group. In one of these groups, all the ewes have GPS collars, which provides a good dataset. They coupled this dataset with a map of land grazing quality. Other issues facing these grazing groups are conflicts with predators, people (week-end cabins), forestry, etc. This causes challenges for sheep and reindeer farming. In Norway, they also have a Norwegian sheep recording system, which has started to integrate the information onto one platform. This could give useful benefits of the technology, information, documentation, tools, and information for grazing groups.
4) Laurence Depuille (IDELE, France) presented information on the evaluation of virtual fences in le Mourier in France. They undertook 2 evaluations. The first evaluation was a pilot type evaluation involving a one day adaptation period after which the ewes understood the stimuli i.e. fewer alerts. A second evaluation was undertaken in a rotational grazing system. One group had collars fitted while the second group were without collars. They observed no differences in weight change, behaviour or BCS, but there were differences in grazing behaviour close to the fence.

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5) Jenny Juengle (AgResearch) presented the Smart Shepherd which is based on proximity sensors. The type of data provided is the frequency that 2 animals are of certain distance from each other's (by sound) as well as the time stamp. There is a hit/minute. The battery life is approximately 2 weeks. There is no accelerometer data. It is not a real time technology; the data is stored on the collars has to be downloaded.
   It is used to look at:
      i. ewe-lamb relationship
      ii. ram mating behaviour and mating date (to estimate lambing date)

   Potential outcomes of the technology include:
      a) selection for ewes for embryo survival
      b) ram mating success
      c) targeted management for lambing (by group)
6) David Stevens (AgResearch) is interested in virtual herding and is collaborating with eShepherd, Gallagher and PAMU studying virtual fence collars on deer. The potential applications of this technology are environmental protection, landscape development and productivity. A collar sends an electric pulse when the animal goes near the virtual boundary set by the stockperson/researcher. It works with solar panel and a counterweight at bottom. The system works with Lora network, and gets a hit once every 15 min. There is no access to real data as it is a commercial product. There is a dashboard to visualise position of the animal. There is a new collar being developed. The proposed business model is a lease model or sale/support model. You need a base station for the LORAWAN system. The technology has gone through animal welfare research for development.
7) Bryan Thomson (AgResearch) presented his research looking at deer personality interaction to resources. In the past, the testing methods were very old and time consuming. Now a unit with GPS, solar panel, motion sensors, SD cards (not real time) and a battery pack id is used. It sits on deer's neck. The unit can be programmed to record frequency GPS, accelerometer, delay start, on & off time. There is a timestamp data with 3 axis as excel type. Three behaviours are being looked at (resting, ruminating and grazing). They use 3D printing for the case. They use activity, sociability and exploration to convert to personality. They could also look at aggression and boldness, but this is more tricky. The challenges encountered include:

      i. sourcing components
      ii. programme and design capability
      iii. welfare considerations
      iv. reduce wastage (rechargeable batteries)
      v. deer eat the collars
      vi. keeping up with advances in technology
      vii. control costs

After the workshop the delegates went outdoors to view facilities and to hear of ongoing work at Invermay which included:

1) CT scanner which was installed in 1996. At Invermay, the scanner is used for sheep and deer and most of the animals scanned are for genetic studies. Annually ,between 2000-3000 animals are scanned to determine body composition i.e.meat, fat, organs etc. The scanning information is fed into the genetic database and results in re

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ranking in the evaluations. It is estimated that CT gives an extra 60% for genetic gain. The cost of scanning a ram is $400.

Currently they are focusing on meat eating quality. One area of research is differences in body composition and fat repartition (two animals with the same weight can have a really different fat repartition). A second area of research is the size of the rumen and to determine if there is a correlation with the methane production.

2) Greenfeed (device to measure methane production of animals when they are eating);

At Invermay, they are adapting the greenfeed for deer at pasture. The main issue is to find the best concentrate distribution (how many grammes and what frequency) to get the deer to keep their head in the greenfeed for approximately 2 minutes.

3) Work on feed efficiency and feed intake: Twenty automatic feeders have been installed on the experimental farm. Tricia Johnson is working on feed intake and feed efficiency. Ten animals are allocated to one automatic feeder. Sheep feeding behaviour could be really different for animals with a low or high rate of intake, or on the number of eating events, the duration of eating events etc. There is inter-animal variability in feeding behaviour but intra-animal stability. They have also put a halter with an accelerometer on sheep to measure the rumination and feed intake. They can determine when the sheep is eating or ruminating, is there differences in rumination data, is there a relationship to rumen size. The size of the rumen is directly linked to the methane production (less methane production with small rumens)

4) GPS collars and lambing location: GPS collars were developed for ewes to study behaviour and location of lambing. The GPS data is continuous when the animal is

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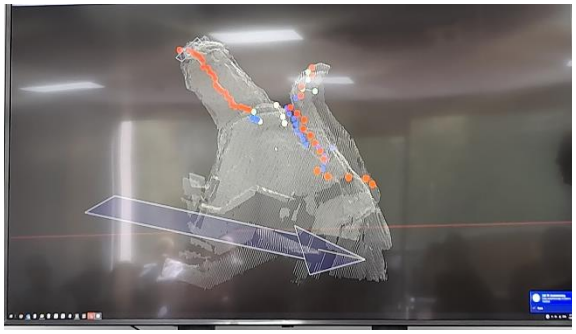
moving and every 10 minutes when it stops. When the location of the ewe is not moving for several hours, the lambing is imminent. Location of lambing at pasture is different between ewes. They are trying to identify why. The GPS data of ewes after lambing was recorded and ewe behaviour can be different which may be related to the characteristics of it lambs.

Scott technology

Scott is a global company (based in Dunedin, www.scottautomation.com) that delivers smart automation and robotic solutions for industries. Scott started in the mining industry and are now providing smart automation solutions to meat processing, materials handling and logistics, mining, industrial automation and manufacturing, and automated guided vehicles (AGV). All lambs in NZ are Halal slaughtered.



In meat processing they provide automated and robotic technology for processing including imaging analysis for carcass grading and automatic detection of carcass parts (front/hind/rib) and carcass boning. They focus on need for high yield and no loss. They use 3D scanners and one 3D reconstruction (between all meshes) is less than 0.6 second to keep the pace of the production chain. This technology has been developed during the last 15 years by a team of 10 to 15 people. Different cuts are required by different customers so robots must be able to make these and to work quickly on the production line. Cutting can be done tilted to improve yield.

Labour saving and health and safety (keeping hands away from knifes etc.) is always a key focus. They have developed a stopping mechanism (with cameras) to prevent damage to operatives' hands/fingers They want to minimize the need for rebuilding/adjustment of existing slaughter plants.

Currently in NZ there are 3 robots whilst in Australia there are 2 slaughter plants each having 3 robots. Whilst the benefits of robots are improved yield, accuracy and health and safety, robots are unlikely to replace people.

They use x-ray to improve grading and cuts. It gets information on where ribs are etc. People cannot walk inside the x-ray room.

RFID tags on carcasses facilitate information being passed back to the producer i.e. grading info.

They are working on dexa grading which is dual-energy x-ray absorptiometry grading which enable the calculation of lean meat, fat and bone content. This can be done for up to 15 carcasses per minute.

They provide RGB-imaging for carcass classification (EUROP scale). This classifies carcasses based on fat cover and lean and is based on images. With only RGB cameras the system is easy to install and integrate with existing plants.

About 40% of lambs go through these machines in Australia and New Zealand. One machine can handle approximately 1 million lambs per year (600/hour, 3000/shift). Setting up the machines

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accurately is a major task that could take 5 to 7 years as required. A team is located in France and they work on carcass qualification.

Scott have looked at developing robots for milking, shearing etc. Previously, automated milking was tried but was considered hard to solve as a business model because cows are large and move. Also, farm conditions with live animals are more complicated than production lines and so will be more expensive.

Hyperspectral imaging has the ability to measure pH and fatty acid profile e.g. omega 3 and 6. Hyperspectral imaging helps make businesses safer, more productive and more efficient e.g. cuts in carcasses which are 1mm can result in major monetary loss over time.

A number of videos are available on the @ScottTechnologyLtd YouTube channel: https://www.youtube.com/channel/UCsejuqB6YRROJfm_eaiwIVA

Key points

1) Technology is being used to undertake carcass grading and processing.
2) Angle of the cut (in breaking carcasses) can impact on meat loss, thus financial loss.
3) All lambs in New Zealand are slaughtered using the halal technique.

Day 4. – Thursday 2nd February: Prattley/Datamars visit – livestock equipment and handling technology

Prattley initially started by developing and manufacturing mobile sheep yards. Today, Prattley is recognised as a leader in the production of sheep weighing and autodrafting equipment and providing management software. The main pieces of equipment manufactured are weigh crates, drafting equipment, gates and loading ramps. The mechanical and manufacturing processes of Prattley are complemented by the RFID electronic components produced by Tru-Test.

Prattley produce all their products at this site. Graeme Ward (MD) gave a guided tour of the manufacturing facility from the intake of steel to the dispatch of products. While we were there a container of weighing and auto-drafting equipment was been prepared for export to Ireland. Prattley employs 18 employees in manufacturing. The alloy used in their equipment is light and soft (i.e. easily bent) when it arrives at the factory. After being bent into position during the manufacturing process it is placed in an oven for 5 hours at 180°C, which hardens it. Some of the manufacturing process is automated e.g. robotic welding of components. Prattley uses up to 4000 components in their manufacturing process. All equipment is checked for correctness before leaving the factory. Most weighing scales are fitted with panel to automatically read electronic ear tags, thus weighting and drafting is automated.

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Following the tour of the factory floor, equipment produced by Datamars (Trutest) for individual identification and weighing were demonstrated and discussed. These included the weigh indicator XR5000 and various handhelds.

There was an interesting discussion around the use of weighing and drafter systems in New Zealand. Issues raised included:

a) Limitations in New Zealand for the use individual information (history) for traceability and other issues in commercial flocks as the animals are not individually identified (EID). The situation is different in breeders' flocks.
b) How to use the data to achieve the best benefits?
c) Post purchase support for clients who purchase the equipment to maximise return on investment.
d) The upgrade from XR3000 to XR5000 due to the superiority of XR5000 in reactivity and ergonomics
e) Use of UHF tags

Key points

1) Most sheep are not EID tagged in New Zealand.
2) Potential for the use of automated data recording, weighing and drafting systems to reduce labour but must be cost effective.
3) Most farmers have manual drafting and weighing systems.

Day 5. – Friday 3rd February: Lincoln University Workshop

Morning session (AM)

There was a workshop held at Lincoln University that was attended by 20 delegates. A summary of the presentations are as follows:

1) John Hickford (AgResearch): an overview of New Zealand. A change of government resulted in the removal of subsides. Prior to this production was headage based. The loss of subsidies meant a loss in farming and there was a need to increase efficiency. This resulted in an improvement in ewe productivity. In the 1980's mean ewe productivity was 1 lamb reared/ewe joined. Today it is 1.4 lambs reared/ewe joined. Approximately 80% of this improvement is due to management and nutrition and 20% due to genetics.

   Main markets for lamb are China (more volatile), EU/UK and America.

   New Zealand agricultural products have a low carbon footprint as they are produced from pasture. There are carbon counting issues for farm produce. Need to have standardised methods to measure it. Petroleum products are the worst offenders. Also need to stop measuring carbon as kg CH4/kg product and measure it in terms of quality nutrition.

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Andy Greer remarked that lots of initiative comes from the farmers. The loss of subsidies in 1980s and the wool crash in the 1990s meant NZ farmers had to adapt and change fast. Now NZ farmers are also highly qualified in NZ (many to least BSc level).

2) Stewart Collie (AgResearch): Novel uses for wool were discussed which included:
    a. wool as a source of protein and keratine
    b. wool keratin used to colour. Karen Murrell lipstick is a world first to use wool keratin to colour
    c. as an additive for manufacturing for 3D printing of protein and other biopolymers. Proteins do not melt. They denature or breakdown.
    d. used a hydrogel as it is a low density structure (eg. Thermo-barriers in spacecraft)
    e. used as a film/membrane from keratine – e.g. raincoats
3) John Hickford (AgResearch): Cow grazing personality. Cows' movement within a paddock is defined as her home range. There is interest in this area as the paddocks are very large (100 ha) in the highlands with varying topography. They are using GPS tracking collars every 5 min and superimpose radar data from pasture information. They also want to identify genes that effect grazing behaviour and are also using SNP chip technology. The gene of interest is the GRM5 gene as it influences home range in mice and may influence grazing behaviour in cattle.
4) Ilan Halahmi (Sm@RT – ARO, Israel): quantified the value of using an early warning systems (EWS) and UHF sensors at a water trough for the TechCare project. He also discussed the merits of RFID vs camera for facial recognition.
5) Eliel Gonzalez (Sm@RT – INRAe, France): presented results for the TechCare project on the walk-over-weigh system and concluded that it is showing promising results for animals self-weighing when outdoors.
6) Laurence Depuille (Sm@RT – IDELE, France): presented current research looking at estimating body weight and body condition score of sheared sheep using 3 D imaging.
7) Jean-Marc Gautier (Sm@RT – IDELE, France): presented results on the use of UHF technology to study the frequency of visits by sheep and lambs to various resources (e.g. drinking trough) for the TechCare project. Low frequency and UHF tags have a reader range of up to 80 cm and several meters, respectively.
8) Peter Pletnyakov and Alison Spera (students from Canterbury University): presented results on data integration using wearable technologies. Looking at home range of cattle. Spatial method: use hotspots, kernel density, minimum convex polygon, nearest neighbour (latter good for variable landscape)
9) Fiona Kenyon (Sm@RT – MRI, UK): presented information on targeted selective treatment (TST) for the control of internal parasites. She presented the theory behind the concept of TST. It is based on the 'happy factor' which is a short term body weight gain. Anthelmintic use is reduced by up to 50% using TST. The use of TST reduced labour (requirements for dosing) and costs (less anthelmintic). In relation to refugia, it works before resistance develops but is an issue after resistance occurs. For TST to work the following is required
    a. EID tags
    b. body weight
    c. pasture cover
    d. download the data to Tru-Test
    e. set up drafting rules
    f. record anthelmintic use

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Lincoln University Farm visit (PM)

In the afternoon there was a tour of the campus. Interesting points from the tour included:

1. The vineyard was set up to test automatic vehicles (robot).
2. Sheep production

a. studies on animal behaviour in the future (with GPS collars) for welfare purposes including effects of shade at pasture and age at tail docking,

b. gates in all paddocks are made to facilitate the use of a weight crate,

c. all sheep have electronic identification,

d. mixed grazing with goats - 20% of goat in the sheep flock has a positive impact on pasture management and quality.

Evening discussion on technologies uptake

Following the farm visit there was a round table discussion on the uptake of technologies by New Zealand farmers. There was a lot of focus on dairy cows in the discussion. Ms Robin Dyne (Lincoln University) and Callum Eastwood (Dairy NZ) were an integral part of the discussion.

The following are the main discussion points from dairy cow experiences:

- Few organisations are funded by government (250 Dairy NZ staff).
- Most dairy farmers are on the north island - high evapotranspiration which is good for crop; crop farmers are used to using technology and many have changed to dairying as it is more profitable.
- Average herd size is 440 cows.
- Some farms with larger herds (700 cows) have more workers (10 people).
- Regulations drive technology use.
- For tech adoption, the approach is:
    - what are the challenges?
    - can tech help?
    - what are the barriers for adoption?
- Main barriers for adoption are:
    - lack of connectivity
    - lack of interoperability (come also from companies that do not want to share data)
- Work with AgResearch to develop tools based on data analysis.
- Technology adoption driven by:
    - compliance
    - subsidies (example of a dairy coop that provide subsidies with 80% of adoption)

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- return value (money, lifestyle, others)
- time saving is an important driver for tech adoption

- Wearable tech
  - has issues with algorithms especially when developed in EU (or somewhere else). Bad prediction in NZ systems (need work to adapt them)
  - saves time
  - useful to make up for less skilled staff by providing health alerts, help at calving, etc.

The following are the main points from the discussion on the uptake of technologies in sheep production:

1) Why is pregnancy scanning so well adopted?
   It is done by someone else (i.e. service provider), is a good predictor and assists in feed management
2) The Fresh water farm plan may motivate sheep farmers to use tech
3) Four step of advice for sheep tech adoption
   a) identify the problems
   b) do we have a solution without techology?
   c) if not, then look at tech and talk to farmers about it (choose the right one)
   d) invest wisely
4) Main difference between dairy and sheep:
   a. more staff in dairy therefore technology is more useful
   b. the cost is less an issue in dairy
5) Technologies that may be used in the future in NZ include:
   a. WOW with EID
   b. systems that talk to each other
   c. traceability (but EID needed; used on some farms)
6) Virtual fencing
   a. 16 NZ$/cow/month
   b. Issue with wool for sheep

Day 6. – Saturday 4th February: Travel to Kaikoura

Day 7. – Sunday 5th February: Free day

Day 8. – Monday 6th February: Bank holiday. Travel from Kaikoura to Picton for ferry to Wellington. Then drive to Palmerston North

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Day 9. – Tuesday 7th February: Agresearch Grasslands, Palmerston North Workshop and Massey University field visit

Morning session – Workshop at AgResearch

The workshop was attended by 27 people (13 from Sm@rt, 14 New Zealand). A summary of the presentations are as follows:

1) Claire Morgan Davies (Sm@RT - SRUC, UK): presented an overview of the Sm@RT project.

2) Jason Wargent (Massey University): gave an overview of his research work and start-up company (Biolumic) which employs 40 people between New Zealand and USA. The mission of Biolumin is to 'unlock the potential of plants' and induce agronomical valuable traits. This involves a short application of Ultraviolet (UV) light which triggers a series of spiralling responses inside a plant or seed. Specific 'recipes' of UV light are applied once to either seeds or seedlings before they are sent to farmers for sowing/planting. Time of exposure is short; sec/min for seeds; days for seedlings. Working to find solutions for broad range of agricultural challenges e.g. drought resistance, quick seed trait development, quality and yield, chemical free plant protection. They have developed a range of molecular markers to understand the impact of the UV treatment. Recent studies on ryegrass showed a 36% increase in yield on each of three mowings ("grass haircuts") compared to non-treated plants. Also working on plants such as maize and soya which should be ready for commercialisation within 5 years.

3) Kioumars Ghamkhar (AgResearch): is director of the seed bank, is researching pastoral genomics and is interested in getting better estimates of pasture growth, while reducing labour requirement. He is using sensors/digital data to measure plant morphology. He talked about
    a. LIDAR system which uses imaging vehicle for biomass measurement. There are 3 versions built as an alternative to visual grass measurement/harvesting. These machines are used to measure botanical composition and yield thus saving time and labour. The system can monitor growth in real-time but growth varies so need regular (weekly) measurements to understand grass growth.
    b. use of Red/Green/Blue (RGB) imaging to estimate composition of mixed species swards (as LIDAR doesn't work) as visual estimates are inaccurate and manual measurement is expensive.
    c. plans to incorporate the LIDAR and RGB systems together.
    d. Hyperspectral Imaging (HIS) and RGB for weed identification. The system can identify 4 different weed types (thistle, buttercup, yellow bristle grass and wind grass) and then "map and Zap" where they are and then focus a laser on the centre of the plant to kill them.

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e. Aerial and space imaging as an alternative to walking and using plate meters and technologies such as the CDAX machine which measure with an accuracy of 80%.

4) Valeria Giovanetti (Sm@RT – AGRIS, Italy) (via video link): Beharum – accelerometer-based device to record feeding behaviour. The device has been developed with a private company. The accelerometer is held either in the collar or headcollar, and data either stored on memory card in the collar or uses LoRA. Prototype is developed but there is no funding for further development at the moment. Field trials with grazing sheep have been undertaken to record bite rate and bite mass, and device can estimate grazing time, ruminating time and other activities. Recording rate is 100Hz, but a program has been developed to select the 3 top peaks as a way to reduce data and therefore energy costs of sending. Battery life is currently 24hrs at 100Hz, but they are looking to define optimal epoch to ID feeding behaviour with as little data as possible e.g. by using an algorithm to only focus on the 3 top 'peaks' in each second. Sampling at 1 Hz (once per min) means battery life is 48hrs. Accuracy of identification of behaviours is high 92-95%.

5) Renata Klein (Sm@RT – UNIDEB, Hungary): – presented information on small ruminant farming in Hungary. Hungary is a relatively small country (93,000 km^2), about ½ size of South Island of New Zealand. It is mainly flat, but has large climatic differences, with the east being very dry and west wet. Only 8% of land is used for grazing, which is mainly between late April to late September. They only have meat sheep systems, with a range of traditional (but not productive) breeds e.g. Racka, Tsigai and Cikta, thus a diverse range of more commercial, foreign breeds have been introduced. Farms are either owned by large companies, with 20,000 sheep, or are owned by individuals, who have very small flocks. Mean farm size is 15 ha. Farming is dominated by older people, so technology is seen as a way to improve interest and therefore recruit younger people to the industry.

6) Ebu Avci (Massey University.): Robot for gut microbiota sample collection (video). Gut bacteria can be a marker for a range of infections in humans but are also thought to affect moods. However, it is difficult to collect samples from the small intestine, where most of the bacteria reside. They have developed a capsule robot, which can pass through the intestine to collect samples. The device is about 4cm in length, with an internal battery. Part of the wall of the device opens on a hinge to scrape along the small intestine, collecting a mucus sample. Future work includes adding functions (e.g. open at a programmable location), motorisation to assist capsule passage through gut. Development currently aimed at human use. There is a potential problem in terms of animal use, due to the issues associated with getting the device through and out of the rumens.

7) Peter Tozer (Massey University) – Integration of solar panels into farm systems "Agrivoltaics". Solar panels are relatively new at large scale in New Zealand. The aim is to have 3,000ha of agrivoltaics within 5 years, but there is little understanding of how to incorporate solar panels into farm systems while still using land for agricultural production. One of the challenges is land availability as a lot of good land is developed for housing. The panels cause shading and affect access to land. Currently they are evaluating the effects of shading (underneath the panels), suitable panel height (to avoid livestock/machinery damage) and the effects of the microclimates created on

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productivity, pasture growth rates and issues such as facial eczema or plant fungal disease. To be cost effective an area of 5-6 ha is required. Modelling the incorporation of Agrivoltaics can be adapted for various impacts. Data collection still ongoing including pasture growth and fungal spores, cost of the systems, value of electricity generated to producer and/or to company, impacts on the overall farming system e.g. productivity/profitability and different regional models.

8) Estelle Dominata and Duy Tran (AgResearch) – Bioeconomics in a digital age is integrated farm planning for farm system design (3 year project). There are four value types, namely culture, environment, society and economy. There are two main areas, 1. The planning process, 2. Identification of needs and tools that can be used to help with farm planning. The planning process has been the main focus and the process entails:
    a) vision
    b) set goals
    c) assess natural resources,
    d) boundaries within which system needs to operate (what the land can take)
    e) performance of system
    f) monitoring and recording

    Geo-design: integrates different models to solve all spatial issues. Need to understand the context of how farm operates and involves different stakeholders (farmers, IT specialists, GIS experts etc). This allows overall farm planning, what should be done and at what scale, the functions of the landscape can be mapped, and the modelling allows a number of versions to be considered and get pros/cons of each. Currently, they can model pasture growth, but not animal movement, and in future can include GHG emission tax.

9) Peep Piirsalu (Sm@RT – EULS, Estonia) – presented information on sheep behaviour in cold temperatures and post-drying hay technology for goats. In Estonia, 60% of sheep production is organic. Mean dairy cow milk yield is 10,053 kg which is the highest in the EU. Summers are moderately warm (mean 16-17 °C), winters moderately cold (mean -2.5 to -7.5), snow cover can last for up to 4 months. Agricultural production is mainly grain, dairy cows and forestry. Sheep numbers are low. There is a move to keep sheep outside all year, but need to evaluate if this is acceptable in Estonian climate. Studies were undertaken between March and April in 2017 and 2108 using 260 and 270 ewes, respectively. Results from the studies showed that 93% of ewes stayed outside, and only a max of 50% went inside. When the wind chill increased, more ewes went indoors. The less favoured conditions of high wind speed and high humidity meant more sheep were indoors. The highest number of sheep indoors was when the temperature declined to -20^{o}c.

    Post-drying hay technology for goats aims to achieve consistent high feed value hay. Grass is mowed and after 1 day it is transferred to bunkers above the sheep shed. Technology measures air temperature and humidity and can turn on air streams if grass not fully dried.

10) Zach Dewhurst (Massey University) - spatial distribution of dung under regenerative and conventional grazing practices and their effects on phosphate leaching. Aim is to determine if a drone can be used to determine the spatial distribution of dung pats. A drone can do a fly over a 9-ha paddock in 10 minutes. They are comparing two beef and

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sheep farm management systems, namely a high stocking density with a quick rotation, and a reduced stocking density and a longer rotation. Although it only took 15 minutes to fly over each area (plus 5 minutes of processing) the drone found fewer dung pats (60% (range 30-80%) when compared to GPS. The reduced detection rate by the drone is probably associated with shade created by long pasture, bare soil patches, cows treading pasture into the ground and trees.

11) Lise Grova (Sm@RT – NIBIO, Norway): presented the Amazing Grazing project, which has just started. How can meat and wool from sheep on rangeland grazing be part of a sustainable food system? A Children's TV show in Norway 'Don't do this to the climate' recently said cows and sheep lead to more avalanches. The portrayal of agriculture is often negative in the media. Fast fashion results in high amount of waste and is a high emissions industry, being the third most polluting industry. In environmental modelling wool is considered poor (but this is due to lack of understanding of benefits). The project is a multi-actor project including; farmers, producers, processors, consumers and media, with 4 Work Packages: 1. Lifecycle analysis, 2. Protein in/out, 3. Smart interview (using tool SMART-Frame tool made from SAFA guidelines) 4. Economy, 5. Climate calculator – SHEEP. Trying to address sustainability from a range of different angles.

Afternoon session – Massey University field visit

This involved a field visit to view 2 studies as follows:

1. Study 1: Nitrate leaching during winter grazing of deferred pasture and cover crops presented by James Millner.
   In New Zealand the annual target for N leaching is <30 kg N/ha. In New Zealand it in common practice for animals to be wintered outdoors on forages such as swedes, turnips and kale. There is concern when winter grazing catch/fodder crops because of the high rainfall and high stocking rate. A trial is ongoing to evaluate the effect of crop type on leaching of nitrogen. There are 4 treatments: 1) deferred grass grazed by cattle, 2) deferred grass grazed by sheep, 3) swedes only, 4) swedes with Italian ryegrass. The swards had 5 replicates and were grazed by sheep or 1 year old dairy heifers. The trial uses lysimeters (tubes of soil) to measure the amount of actual evapotranspiration which is released by the three sward types. Preliminary results show that there is leaching of 10kg N/ha/year when grazed by sheep and 30-40kg N/ha/year when grazed by cattle. The difference between cattle and sheep is probably associated with differences in urine distribution by the animals. The drain for the lysimeters are 1 metre deep in the soil (example diagram below).

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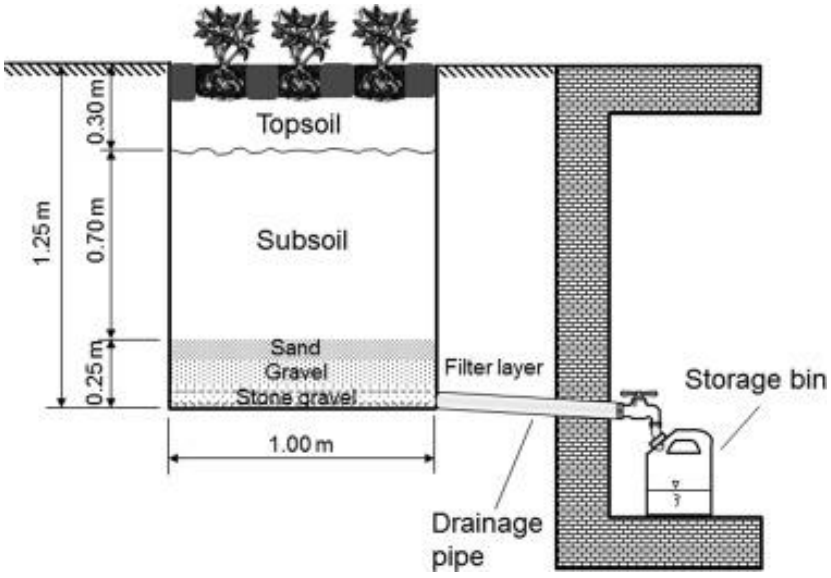

2. Study 2: Regenerative agriculture comparing conventional farming practices to regenerative practices in both dairy and sheep systems presented by Danny Donaghy.

   The project is called 'Whenua Haumanu' and is about nurturing the land through pastoral farming. The project is led by Massey in collaboration with AgResearch, Lincoln University, and Dairy Trust Taranaki. The budget is NZ$26 million and will last for seven years. The objective is to explore regenerative farming practices and conventional pastoral practices in both dairy and sheep systems, involving both conventional and incorporating regenerative farming practices. The study consists of 2 sward types (standard pasture [PRG, red clover, white clover]; diverse pasture consisting of 21 species) and 2 grazing managements (conventional grazing management; regenerative practices [longer rotations and larger residuals]). Currently there are 180 sheep on 12 hectares (stocking rate may be reduced in future), and 72 dairy cows on 36 hectares. The regenerative system will start with half the nitrogen application compared to the conventional system and which may be reduced depending on performance. Regenerative system will also plant trees and hedgerows and have a longer grazing rotation and higher post-grazing sward height. Two soil types are used; free-draining and a high clay content soil.

   Multiple aspects of pastoral farming, from pasture to plate, will be evaluated. Below ground measurements include investigations of soil biodiversity and microbial DNA, nutrient levels and losses, plant root growth, carbon cycling and storage, soil physical structure, earthworms and moisture levels. The paddocks have suction cups and lysimeters installed to measure leaching. Above ground includes plant growth, quality and fermentation characteristics, persistence and health, greenhouse gas losses, animal production, reproduction and welfare, and the quality of animal products including meat, wool, milk and milk products.

   Initially they need to establish the research farms with diverse pasture mixes. Adjoining and within paddocks, native browsable shrubs will be planted as shade and shelter options for grazing animals. There are three main research sites for the program: Massey University's Dairy 1 farm grazed by dairy cows, Pasture and Crop Research Unit grazed by sheep, and Lincoln University's Field Research Centre grazed by sheep. Other collaborating sites include

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Dairy Trust Taranaki's Waimate West farm, On-Farm Research project underway at the Poukawa Research Farm, and Northland Dairy Development Trust's project underway at the Northland Agricultural Research Farm. The programme will allow all the farms to share results, research methods, and measurements.

Mixed sward with 21 species to be trialled on regenerative farm

Day 10. – Wednesday 8th February: Maui Milk Farm Visit

Maui milk has their own farm and 13 milk suppliers milking approximately 14000 ewes. Most of the milk is mainly used for infant formula (milk powder) as less issues with lactose and it is easier to digest. They received Chinese funding to buy barns and equipment. The nutrient composition of sheep milk fat is superior than that of goats milk. China is their main market.

Waikino station

Waikino station is the nucleus flock for all farms in Maui milk and is the base for Maui Sheep Milk New Zealand's genetics programme. Waikino initially invested NZ$ 4 million in establishing the buildings on the farm, including 64 unit rotary milking parlour and housing for all ewes. Currently they are milking 790 ewes and aim to increase to 1500 ewes next year. The farm consists of 770 ha, 170 ha used as the milk platform and the remainder used for the genetics programme. The farm was originally purchased to be used as a breeding programme to cater for 100 suppliers.

Initially they imported Lacune genetics from France and crossed Coopworth, Awassi and East Friesian with the objective of developing a breed which is registered as Southern Cross dairy sheep. The Southern Cross dairy sheep are heavily weighted towards Lacune and are bred with the objective of

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optimising sheep milk supply in New Zealand conditions. Currently, lactation yield is approximately 400 litres/ewe. Mean peak yield is 2.6 litres/ewe but some have peaked at 6 litres/day. Current milk price is NZ$7/kg milk solids which is approximately NZ$3/litre.

Ewes lamb from August and the flock are milked twice daily until Christmas and then once a day until the end of lactation. Ewes carrying triplets and quadruplets, and hoggets are lambed indoors. If Maui milk were developing the farm again they would not build any sheep housing. Lambs are removed from their dams after 2-3 days and are artificially reared. They are weaned at around 18kg. Replacements lamb at one year of age. Post lambing ewes receive lucerne silage when indoors, as part of a TMR containing 800g maize and protein per ewe daily, which is for approximately 20% of lactation. Post lambing ewes receive up to 1kg concentrate in the parlour daily. Maui milk aim to operate a grass only based system. Currently the ewes graze ryegrass pasture during the day and chicory or Lucerne based pastures at night. Ewes receive 150 g starch based concentrate at milking.

The milk is collected 3 times a week. The milk of the first 4 days of lactation (colostrum) is not sold.

Breeding

During breeding all ewes receive a cedar and prostaglandin and are initially AI'ed. Subsequently natural mating occurs. Only lambs from AI matings are kept as replacements. Currently there is a 40% replacement rate as the aim is to rapidly increase the genetic merit of the flock. They cull heavily for udder issues, feet and lameness, and poor production. Main issues are pneumonia, mastitis and lameness.

Sheep health issues

Pneumonia is a major issue especially in lambs. Approximately 4 and 17% of female and male lambs die due to pneumonia. Other health issues include toxoplasmosis, clostridial diseases (use covexin 10), salmonella (use salvexin), campylobacter (campivac), leptspirosis and mastitis (use rapid mastitis test).

Technology on farm

There is a lot of technology on the farm as follows:

1) Rapid entry 64 unit rotary parlour (with milk meter but not used because never worked)
    a. 2.30 minutes milking per ewe (1 tour not more)
    b. 2h milking for all flock
2) Lambs are EID tagged and DNA sampled at birth. EID is to facilitate
    a. drafting
    b. feeding in parlour
3) Weigh crate and auto sorter used once a month.
4) Once monthly udders are scored, feet scored, milk recorded, milk composition
5) Twice annually ewes are BCS
6) Indoor feeding equipment including TMR wagons, conveyor belt systems indoors.

Going forward

If Maui were establishing the farm again they would

1) not build any sheep accommodation
2) operate a grass-based system of production

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3) reduce technology on farm as they believe that the current level of technology over complicates their system. The main technology they would use is an autodrafter after milking.

Key points

1) A new venture into sheep milk production and a rapidly expanding flock now focusing on milk from grazed pasture especially mixed species swards.
2) Excess technology over complicates a system and does not give an economic return on investment. If designing the farm again they would
    a. not build any sheep accommodation
    b. reduce the technology as it over complicates the system. They would get contractors e.g. milk recording, to do monthly measurements
    c. omit indoor feeding and all the equipment required

Day 11. – Thursday 9th February: Maui Milk supplier Paul Schuler and Spring Sheep Milk Co.

Paul and Kevin Schuler, Te Aroha

Their grandfather purchased the original farm (46 ha) which had 100 cows. Today Paul and Kevin farm dairy cows, dairy sheep and dairy goat enterprises on 230 ha. The dairy goat milking operation was established in 2014 and they started milking sheep 3 years ago. Paul has spent a lot of time in Brazil between 2002 and 2010 developing dairy farms. When in Brazil Paul adopted the attitude of empowering the farm staff, thus giving them responsibility. Now he only spends approximately 2 weeks annually there and the rest of his time in New Zealand. On his return home in 2010, he decided to work with small ruminants to spread enterprise risk and to help balance the environmental footprint of the farm. Kevin is an ex rugby player (ALL Black 1989 – 1995) and coached both in New Zealand and Japan.

Currently they are farming 380 dairy cows, 1600 goats and 835 sheep. The farm is run as one unit (not split by enterprises) so they calve in the autumn, kid in June and lamb in August. Farming as one unit allows flexibility to adjust the different enterprises for greatest returns on farm investment. This was easy to do as the system for cows is already in place so no extra capital needed.

Most of the cows are autumn calving, which is unusual in New Zealand, and the remaining 80 are due to calve in spring. Most of the replacements are purchased as in-milk empty cows. They are aware of potential disease risks. They prefer to buy Jersey cows as they are less likely to have been with a Friesian bull so *M. Bovis* risk is lower. Paul believes that 70% of barrenness in cows is due to management and not disease. Therefore, they put these cows back in calf and sell them as spring

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calvers, which represents most of the New Zealand dairy industry. The cows are managed on a rotational grazing system. They are milked every 19 hours i.e 3 milkings in 2 days.

In the past 10 years dairy goats were very profitable, however since 2020 profitability has declined sharply. In the last 3 years revenue from the sale of goats milk has declined NZ$1.6 million annually. Thus the goat herd is been reduced from 1600 to 750. Previously the goats were producing 2,000 kg solids/hectare (worth NZ$20/kg solid) and costing NZ$10 to produce, leaving NZ$20,000 a hectare. Currently goat milk price has dropped to NZ$13/kg solids similar to the cost of production, thus minimum profitability. Whilst the goats are currently experiencing low revenues, Paul believes goat milk price will improve so they are not planning exiting the goat enterprise. The goats are housed full time to reduce/control internal parasite problems. Herbage from ryegrass and multi species swards is harvested daily with a zero grazer and delivered to the shed. There is a robotic pusher that moves the grass closer to the goats, as required. They receive 250g of concentrates at each milking. They are milked twice daily but are considering changing to 3 milking in 2 days. Breeds are predominantly Saanen, but there are also some Toggenburg and British Alpine. The goats are naturally mated (bucks were in the shed with the does when we visited) and most of the goat kids that are not kept for replacements are sold for breeding. The reduction in goat numbers (from 1600 to 700) will free up shed space, which will be used for housing the ewes when dry and for lambing. The goats are been replaced with dairy cows.

Currently they are milking 835 ewes and the flock is being increased to 1,050 ewes. The sheep are milked once daily since Christmas. When changing from twice to once a day milking milk volume reduced from 900 to 700 litres/day but solids increased from 18 to 20 %. The sheep (800) are milked in an hour in a 40-unit parlour. Initially when they started milking the ewes there were 10 people in the milking parlour, now this is reduced to 2. Peak milk yield is approximately 2 litres/ewe. The sheep are managed on a rotational grazing system of perennial ryegrass and perennial ryegrass/chicory swards. Currently the ewes are offered 200g concentrate at milking. In early lactation they receive 800g whole maize and this is reduced to 200g daily in late lactation. Paul assumes that the ewes consume approximately 4% of body weight (1.8 kg chicory, 1.4 kg grass). Minerals are provided through the plants; thus supplementation does not occur.

<u>Decision making process for getting technology</u>

When deciding what new technologies to use on farm, Paul bases his decision on the main drivers of milk price, which are labour, feed and energy. Therefore, a farm needs to be efficient on these three inputs. Other factors that are becoming important are environment and animal welfare issues and consumer behaviour. Paul claims NZ farmers are good with animals and the environment, so labour is the main area to improve efficiency. As farmers are getting older (mean age approximately 65) and share milking is not as attractive to new entrants, **Paul believes that the main reasons to use new technologies on his farm is to improve labour efficiency.** The introduction of new technologies into farming systems will hopefully improve work-life balance and the attractiveness of the industry.

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There has been a change in NZ farms over a number of years, from owner/operator, who knew ALL aspects of their business to owner/employees. This means less experienced staff, or staff whose main interest is not farming. Therefore, having technologies to help identify issues or warn about potential problems is useful. Paul believes that the main barriers to the uptake of technologies are cost, reliability and ease-of-use.

Paul and Kevin have kept their system simple and have adopted limited technology. The technologies adopted include:

1) EID - all cattle and sheep have EID tags. The goats have EID leg-bands and are also ear tagged.
2) EID stick-reader (wand)
3) Cow auto-drafter which can link with the mobile phone to draft cows after they have been through the parlour.
4) Robotic pusher to push the zero-grazed grass closer to the feed barrier for the goats.
5) They are considering automatic weighing and drafting of sheep to provide more data from his animals to help make additional management decisions.

The farm employs a total of 7 staff as follows:

1) 2 people on the cows (plus casual staff). Cows are milked 3 times every 2 days (19 hour milking interval).
2) 2 people on the sheep enterprise
3) 3 employees milking the goats.

Mastitis detection technology (Liam Kemshop – demonstrated on farm)

Only 4-5% of dairy farms in New Zealand have any mastitis detection and most don't have milk meters. Liam set up a company which is developing a product to measure somatic cell count (SCC). He is putting sensors in each cup of the milking cluster which measures conductivity plus a few 'other' (patentable) factors, to measure SCC and mastitis. The sensor is linked to a control unit higher up on the piping which will show a red or green light depending on the presence or absence of infection, allowing identification of infected animals immediately within the parlour. Each quarter is measured and any that are abnormal can be identified. Sensitivity currently is approximately 70% accuracy but as the measurements are undertaken at each milking more animals can be detected. The system has only been used on cows to-date, but Liam is working with the Schulers to see how adaptable the system is for sheep and goats.

The aim is that the product will be able to be purchased off the shelf, run on AA batteries (2-3 years battery life) and be simple for farmers to install, repair and service themselves.

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Spring Sheep dairy farm visit

Dairy sheep production is a new industry in New Zealand. There are approximately 30,000 dairy sheep in New Zealand. Spring Sheep started in 2015 and began with ca 2000 dairy sheep. Initially Spring Sheep started with a barn system but have now moved to an outdoor system farming 900 ewes on 50 ha. Currently the barn is only used to rear lambs. Genetic improvements have made to rapidly increase milk yield. Spring Sheep has developed their own breed, Spring Sheep Zealandia, by incorporating dairy sheep genetics from Europe; i.e. East Frisian, Lacaune and Manech. Zealandia sheep scan approximately 2.2 lambs per ewe. In 2015 mean lactation yield was 100 litres in 120days. Now the sheep are yielding 300 litres of milk/lactation

Spring Sheep has 3 nucleus farms and 14 supply farms. They aim to recruit 2 to 5 new farmers annually. Ownership of Spring Sheep farms is usually private. There is usually a waiting list to join Spring Sheep. All milk collected goes to the one dryer plant for the production of milk powder. The main market for the milk powder is infant formula. New farmers get advice but no financial support.

Spring Sheep have a protected genetics program and all Spring Sheep farms must use Zealandia sheep. They cannot sell animals (e.g. rams) outside the Spring Sheep community. All male lambs must be reared as castrates to protect their IP. During artificial rearing lambs receive artificial milk for 6 weeks by automatic feeders.

Any male lambs that are not retained for breeding are castrated. Lambs are EID tagged and DNA sampled and breeding values are available after 6 weeks. Up to 350 rams are retained annually from the nucleus herd for breeding from the first evaluation. Subsequently data from weight recording, udder scores, lameness and methane output are included before final selection of rams for sale to the supply farms. Rams are selected mainly from paper recordings, but also selected on foot score which is considered the biggest challenge.

Animals are recorded for udder score, foot score, temperament, methane breeding value, weight and body condition score, FEC and facial eczema. As some ewes were born in 2015 they are considering including longevity in their breeding goals.

Milk yield is the main focus in their breeding goals. Milk traits count ca 80%, and adult size, methane, lactation persistence account for the remaining 20%. The lactation performance is 300 litres/ewe, with some performing up to 450 litres/ewe. Top performance recorded ewe produced 730litres.

Laproscopic AI is used on all the ewe lambs as conception to cervical AI was as low as 30%. They use a CIDR programme of 9 days plus prostaglandin.

Ewes are weighed 3 times annually, for breeding purposes, to ensure not to breed for increased ewe weight. The replacement rate is 35% mainly to increase genetic gain. Target weight for ram lambs at mating is > 45 kg. Mating is undertaken in mobs with one ram per 75 ewes. Supplier farms lease rams,

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which must be returned to the nucleus farm, and join 1 ram per 50 ewes. Rams can be leased but there is a risk to taking them back.

The ewes' diet is mainly grazing ryegrass. Lucerne is grazed as it considered to protect against facial eczema. Winterfeed is normally purchased. During lactation milking ewes are offered 800g/day of concentrates; i.e. maize, mineral and protein pellets (protein, zinc, sodium etc). During lactation ewe receive approximately 200kg concentrates. During the winter ewes receive silage and are introduced to TMR diet approximately two weeks prior to lambing. Target BCS of lactating ewes is 4-4.5 because fat sheep produce more milk.

Mean ewe mortality is 6%. The following are the main health issues:

1) Facial eczema: they use fungacide spray on grass and include zinc in the concentrate feed (8mg/day, or Bolus).
2) Mastitis incidence is low: less than 3%.
3) Feet/lameness is the biggest health problem. Hoof trimming is done frequently and feet are checked every week.
4) "Pink eye" can be an issue in lambs.

The following technology is available on the farm

1) DeLaval automatic feeders are used to rear the lambs. One hundred lambs per feeder.
2) Tru-Test is used and it links animals with milkmeter yield. It is simple to use and sends data to the computer.
3) DeLaval milkmeters: Milking is for max 3.5 minutes, and flow determines when milking ends. A light flashes if milk yield is less than average. This is useful. Information from milkmeters is often under utilized.
4) DTRIO data management software is used (before it was excel and dropbox = no good). It is developed in NZ for Spring Sheep. Abacus in Dunedin is the software developer. All farms use this. In the software they can highlight animals, find animals, group animals, make an alarm 'do not milk' etc. Software records death, lambing information etc. Unfortunately, there is no link between Tru Test and DeLaval. Tru-Test data is downloaded to CSV file and loaded into DTRIO.
5) An autodrafter is available but not in use. They prefer to use a stick reader and draft manually.

Their wish list for technology is the automation of udder and foot scoring

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Day 12. – Friday 10th February: Gallagher and Ruakura workshop

Gallagher

Gallagher is a privately owned company that was formed 85 years ago and now supplies 160 countries. Their main markets are New Zealand, Australia, USA, Canada, Europe and Latin America. The company is a market leader in electric fencing, weighing and EID systems for livestock. Gallagher products can be grouped into 3 groups as follows

1) animal fencing
2) animal performance and traceability
3) land and water care

1) Animal fencing: The system consists of an energizer, earthing, lead-out cable and fence. Currently, they sell more than 100,000 units worldwide annually. Other components discussed include the solar range, series system, connectivity and data services. The first number indicates the power (joules) of unit and the 'I' series indicate the land range and power of the unit e.g. a M12,000i has 12 joules and a range of 1000 acres. New fences include blue tooth and wifi to inform the operator what is happening to the fence via an app on their phone.
   Gallagher cater for both permanent and portable fences. They sell 1.2 million portal posts, 100,000 reels and 850,000 insulator strainers annually.

2) Animal performance and traceability:
   The main components and/or criteria linked to animal performance and traceability criteria are:
   a) Load bars which weight from 1500 to 5000 kg with an accuracy of +/- 1%. The load bars are wireless as wires are prone to damage and dampness. The battery in the load bars have a life expectancy of 10 years.
   b) Weigh scales which have touch screen technology.
   c) Handhelds EID readers (2 models, HR4, HR5) which have a read range of 0.3 m.
   d) Software, some of which is free. The software enables creation of mobs/groups/breeding groups etc. The software enables editing of data and has an annual charge of approximately €300NZ.
   e) Animal Intelligence solutions.

   There was a discussion around compatibility issues with a diversity of different and specific existing farm software management packages (interoperability), as well the services that are free (related to the acquired equipment) and those which are charged for by Gallagher (i.e. when further analyses are requested at the mob or flock group level, or when additional data management interpretation and analyses are demanded).

3) Land and water care

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Products and equipment for auto metering water, pump controls, water tank level, visual flow meters to aid finding water leaks, etc. were also presented. Good nature traps for vermin were also presented.

Future farm

Gallagher's vision is driving a quantum leap in sustainable pastoral farming through technology. The ultimate aim is to manage each animal individually e.g. when to move, cull, mate etc. New products being developed include:

a) remote pastoral weighing e.g. based on front weight,
b) camera vision technologies to weigh, count and herd animals,
c) farmote system: a precise pasture measurement and management system using sensors e.g. use 5 sensors per 250 ha surface with LoRA. Has an annual cost of approximately $12000 i.e. $5/ha/month,
d) hands free real time data collection with voice to data platform where the farmer wears a wearable tablet and talks the data into it.

More of the technologies conceived and commercialized by Gallagher are for cattle. The question about technology adoption and the impact on the sheep industry was discussed, and Gallagher concluded that they use innovations and not a lot of technology. Thus, a lot of effort is required to get advance in the technologies used in small ruminant sectors while being more creative in order to add value of different potential advantages for the sector.

eShepherd

eShepherd, is the virtual fencing system produced by Gallagher. This system involves cattle wearing collars and not passing a virtual boundary, which is controlled by computer. **eShepherd is only adapted for cattle.** The hardware elements, the web application, the mobile application for deciding questions such as "where to go…" or "which portion of pasture to graze were presented.

The aims of the eShepherd technology include improved grassland management and animal wellbeing, reduced labour, storing more carbon in the soil, soil fertility restauration, biodiversity conservation.

Ruakura workshop

A Sm@RT tech workshop was held at Ruakura McMeekan Centre involving members from the Sm@RT delegation, AgResearch and commercial industry. Twenty two people took part. The following is a brief summary of the presentations:

1) James Turner (AgResearch) demonstrated ADOPT

   ADOPT (adoption, diffusion and outcome) is a web-based tool, developed by CSIRO and is freely available on line, or NZ$~35 for advanced level access where more detailed reports are available. Aimed at researchers, stakeholders, farm advisors, to think about and analyse how a farm practice will be adopted by a population of farmers. It can be used to:

   a. predict the level and time to peak adoption,
   b. consider the influence of a structured set of features,
   c. engage researchers and stakeholders in exploring adaptation/uptake,
   d. consider the typically long-time frame to peak adoption.

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There are 22 factors considered (which will turn into questions), based around the risk to farmers and the technology itself, with groups into those that affect

1. the farming population
2. characteristics of new practices (or tech).

Tech works well when it matches the characteristics of the population.

The delegates present at the workshop completed an interactive demonstration of ADOPT, using mentimeter to survey the group on most suitable answer. EID and weighcrate was the technology considered for the demonstration and the target population was European sheep farmers. Results from our demonstration suggest that peak adoption would be 25.9% of farmers and peak adoption occurs after 13.7 years.

References:
Kuehne et al 2017 Predicting farmer uptake. Agriculture systems 156: 115-25
For underpinning info: Pannell 2006 Animal Production Science 46, 1407-1424

2) Claire Morgan Davies (Sm@RT – SRUC, UK) presented the Sm@RT project giving an overview of the project's aims, methodologies and outputs to-date.

3) Gosia Zobel (AgResearch) Insights into small ruminant behaviour and welfare research
Three components of welfare, for goats in particular, are biological functioning and health, natural living and affective states. Gosia looked at the affective states of goats i.e. how does the goat experience its life. Gosia undertook studies with goats to see how fast they find food based on their emotional state (had they been grazing, had they been given food, and had they been in the rain) and goats in rain took longer to find the food. The conclusion was that decision making is more rapid after a positive stimulus. She presented examples of technologies used in goat and sheep research as follows:
    a) Examples of technology used in goat research:
        - accelerometer on legs to identify health issues (Zobel et al., 2015 a,b)
        - could detect pregnancy toxemia by the lying behaviour (they laid down an extra 3 hour/d)
        - could detect overgrown hoofs – at kidding, they laid longer (Zobel et al., 2016)
        - they developed a tool to identify overgrown hoofs: looked at 6000 photos and developed a scoring system – also started machine learning based on 343 photos, and developed an app. (Deeming et al, 2019, Animals, 9(11). Takes 1 photo at a time, at the moment only identifies a hoof 50% of time, but when hoof is identified hoof shape scored correctly 88% of time.

    b) Examples of sheep research:
        - looked at behaviour and experience (active, reactive, food-orientated). Use a feeder which deploys puff of air once animals head has been in feeder for 1 second. Camera records how quickly animals move away/react.
          Can manage based on their reaction

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- automatic tracking using off the shelf package (with manual correction): different social zones and food zones. More active lambs have a lower daily weight gain. Dam reared lambs had positive association: more 'reactive' lambs had a higher daily weight gain. Artificially reared lambs had negative association: more reactive had a lower daily weight gain.

4) Laura Hunter (AgResearch) – Wearable sensors used in animal behaviour and welfare research

Sensor technology enables facilitates to record

a) things we are unable to observe e.g. brain function, heart rate etc.
b) remotely
c) with less labour
d) at night
e) with fewer disturbances to animals

Challenges with sensors include

a) adapting tech not developed for animals
b) deploying in the field and pastoral system
c) steep learning curve
d) data storage and uploading to the cloud
e) data accuracy/validation
f) potential welfare issues caused by the tech itself.

Laura presented examples of technologies she had used previously as follows:

a) physiological sensors:
   - heart rate monitors (Polar belt + watch, Polar optical HR sensory, Zephyr bio-harness)
   - electroencephalography (EEG) and electromyography (EMG)
   - body temperature (internal & external) – star oddi/ibuttons
b) behaviour sheep:
   - standing/lying: Hobo & IceCube
     - Tried to adapt for sheep
     - Ice-cube as good as hobo
     - Issue of Hobo rubbing on leg, especially if non woolly
c) Behaviour (cows):
   - for grazing/rumination she used CowManager (for cows)
   - GPS – Oyster 3
   - vocalisation (Olympus WS-853 digital voice recorder)
   - RFID ear-tags – interactions with resources (UHF)
d) Other tech used: SmaXtec rumen bolus (temperature), E-Shepherd (GPS only), Afi Milk Collar, SmartShepherd (proximity between ewe & lambs)

5) Gavin McEwan – CEO of FARMAX and FarmIQ

Gavin has 30 years experience in agritech, primarily software. Interested in adoption of software and economics. Gavin's views are:

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- How can software designed for agriculture be used as a tool to improve the farm business? Farmax is a modelling tool and farm IQ is a data base to record data. Now a greater need to record data for compliance.
- AgriTech has failed agriculture in NZ
- Softwares are not uptaken widely

FarmIQ is a database to record historical information from the farm. It is great for compliance, auditing and decision-making. Farmax is a modelling tool for pastoral farms. It predicts what will happen in the future. It does not tell you what to do but is a decision support tool and informs the farmer. Farmax and FarmIQ merged as there are too many software packages were available which can confuse farmers.

In New Zealand approximately 50% of greenhouse emissions (GHG) comes from agriculture and the average farm emits 6 tonnes CO2/ha. At the moment, GHG is a big issue in NZ so AgResearch has added a GHG calculator in Farmax. The calculator helps farmer to balance 3 points on their farm (production/financial viability/environmental viability). If balance is not right, people will leave the industry.

There are approximately 20,000 commercial farmers (dairy, beef, sheep, deer) in New Zealand. Farmax and Farm IQ tools are adopted by 5 to 10% of New Zealand farmers. The low adoption rate is due to:

1) many farmers are still old school and like notebooks
2) many farmers are time-poor, they need to learn the tools and how to input data.
3) farmers willingness and capability to learn IT skills
4) poor linkage between different software packages

Farmer owns the raw data, but the processed data is owned by the company.

6) Katherine Tozer (AgResearch) – opportunities for virtual fencing in New Zealand hill country

New Zealand is 40% hill country (approximately 4 million ha) with slopes greater that 15%. Opportunities exist of virtual fencing including the following:

a) tree establishment – to keep stock out of planted areas. Traditional fencing is very expensive
b) grazing management including stock exclusion, deferred grazing, increase stocking pressure to remove rank forage after the deferred period etc.

7) Claire Morgan Davies (Sm@RT – SRUC, UK)

Claire presented details on the Sm@RT project, focusing how we gauge the barriers to technology uptake via national workshops, training days and transnational workshops. Testimonies of the project's innovative farmers were also presented.

8) Brid McClearn (EuroSheep – Teagasc, Ireland)

Brid presented details of the EuroSheep project and the use of the multiactor approach to identify needs and provide solutions to sheep farmers regarding sheep nutrition and health management.

9) Claire Morgan Davies (TechCare – SRUC, UK)

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Claire presented the TechCare project, which aims to find innovative and precision livestock farming tools to manage welfare in small ruminant systems. She presented the different steps of the project, including welfare issues prioritisation, PLF tools inventory, pilots, welfare assessments and testing on large scale commercial farms, and its planned outcomes for the industry.

10) Sue McCoard (AgResearch): background

Sue presented some of her current project as follows:

a) Pen-side tests:
   - Glucose monitoring
   - Thermal imaging

b) US mammary gland to predict lactation performance

c) Automatic feeders for lambs with EID (lamb collars) to avoid competition at feeders

d) Development of lamb-rearing guide which can be downloaded on the phone whilst in the field (www.agresearch.co.nz/lamb-rearing-guide).

11) James Turner (AgResearch) – realising the promise of smart technologies in agriculture

James presented research an uptake of smart technology in agriculture (ref: Zambon et al., 2019.). Barriers to technology adoption are interconnected and impact multiple stakeholders in different ways. It is a holistic work from 1) the product to 2) smart product, 3) smart connected product, 4) product system and 5) system of systems.

(Eastwood et al., 2023. A review of multi-scale barriers to transitioning from digital agriculture to a digital bio-economy. *CAB review International)*

The day closed the whole NZ visit. The Sm@RT participants thanked the NZ team, in particular Sue McCoard, for their help and fantastic programme.

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Day 13. – Saturday 11th February: Travel to Auckland to return home

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