Australian Nuffield Farming Scholars Association

2003 SCHOLARSHIP REPORT

Completed March 2004

Steven Jaeschke

Address PO Box 314 KEITH SA 5267
Phone: 61 8 8756 4256
Fax: 61 8 8756 4256
Email: jetskis@lm.net.au

Realising Potential by Modifying Sandy Soil

Sponsored By: MLA

MEAT & LIVESTOCK AUSTRALIA

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Modifying sandy soil by spreading clay or ripping clay to the surface, is a current and standard practise for large areas of Southern States of Australia. There are two key issues which drive the potential for increased production in clayed sand soils. They are an increase in water use efficiency and build up of soil organic carbon (SOC) in the soil, both of which are essential to using rainfall and environment to assist to prevent further degradation.

In addition, livestock feature as an integral part of this balancing of production systems, and farming systems incorporating livestock and grazing systems contribute to SOC build up, thereby utilising the soil resource and rainfall potential and supply lucrative meat and food market opportunities and economic sustainability. Direct tillage systems are contributing to SOC increases, and water use efficiencies.

The study topic was to consider what opportunities are available to continue to improve clayed sandy soils, both in water use efficiency and increased SOC levels, and consequent productivity, sustainability and profit. There are general and site specific management practises which can effect soil carbon reserves, in the context of both sequestration and fertility. Further research is essential to drive this carbon reserve.

Throughout the world, I experienced examples of reclaiming land, enabling better productivity. I travelled to New Zealand, to look at stock management and crop enterprises working together, utilising rainfall and seasonal markets, contributing to increasing SOC. I saw the 'humping and hollowing' and 'flipping' processes, which have allowed areas of very wet land to be rehabilitated, to be very productive, high value dairy land. In Canada and USA, I went to look at direct-drill tillage practises, which can contribute to soil management in very difficult physical situations and stubble retention. This included low rainfall areas around Lethbridge and Spokane, and Washington State, USA, where a long history of tillage has physically allowed soil to erode down into gullies. Work is being carried out to rehabilitate land in Canada by moving eroded soil back to its original place and implementing farming practices to prevent further erosion. I visited Minnesota to enquire about soil research into clay and OC relationships. In the Piedmont region in South Carolina and Georgia, I wanted to investigate degraded soil being put back to pasture rotations and animal production, to allow water infiltration and reduce water erosion, in order to sequester carbon and increase soil organic matter.

In the UK and Europe, I visited several Universities to consider precision agriculture principles.

I travelled to Israel to see sand being added to saline clay soils, to grow horticultural crops under irrigation. Out of season marketing opportunities into Europe and America, offer very lucrative opportunities, but modifying the soil first is required to achieve this. I briefly visited the United Arab Emirates to also look at what work is being done in sandy soil rehabilitation, and other development.

Although not all these examples are based on sandy soils, key principals follow. There is an economic increase in production, which can lead to improved profits, but most importantly, offer a sustainable future if rainfall or irrigation water is more usefully utilized, and soil fertility is maintained, or better, improved.

ACKNOWLEDGEMENTS

I would like to thank my immediate family, Robynne, Elise, Patrick, Bethany and Abraham for their continued support throughout the scholarship program. Robynne has encouraged me and supported me, and without her help, my trip would have been impossible to have achieved.

For my business partner and brother, Anthony, and our workforce Wayne, Craig and Jessame, a big thankyou.

Thank you to Nuffield Australia for the wonderful opportunity and education, and the financial support of Meat and Livestock Australia (MLA), who have sponsored me.

Thanks also to my mentors and referees, Ken Solly, Bruno Lablack and Brendon Smart who have encouraged and helped me for a number of years and have shown faith in me to be able to undertake this study program.

To those fellow Nuffield Scholars who I have got to know and travelled with, thank you for the wonderful time together during our core study tour, especially Arnaux Darrieux, Andrew Watters, Oliver Saxton and Mark Wales and the UK Scholars.

To those people who offered help, information, contacts and links to study areas, accommodation and support:

From New Zealand: Stewart and Angela Wright; Peter Morrison; Bruce Hamilton; Simon Osborne; Jacquie Johnstone and Mike Beare, Foundation for Arable Research (FAR); John and Betty Greenslade, winners Ballance Farming Environment Awards, New Zealand 2004; Paul Jarman and Denis Curtin, Crop and Food Research NZ; Glyn Francis; Terry McDonnel from Westport; Sam McIvor, Meat and Wool New Zealand; Graham Jarvis, Agresearch; Mike O'Connor; Stewart Ledgard; Miranda Hennesy; David Wheeler; Dave Fisher; Andy and Janet Fox; and Oliver Saxton.

From United States of America: Alan Olness, Dave Archer and Don Reicosky, United States Department of Agriculture, Agricultural Research Station (USDA ARS), Minnesota; Alan Franzleubbers, USDA ARS, Watkinsville; Phil Bauer, Geoff Novak, Warren and Marjory Busscher and Wayne Reeves, USDA ARS Florence, South Carolina, Bill Brush, Stalisnas Supply Company, Stalisnas County, California; Neal Kinsey Ag Consultancy; Michael McElhiney, USDA Natural Resources Conservation Service, California; John and Sharon Aeschlamin and Diana Smith, Pacific Northwest Direct Seed Association (PNWDSA); Mark Scheffels, Spokane.

From Canada: Rod and Shelley Bradshaw; Rob Dunn, Jill Clapperton, Conservation Cropping Specialist, Alberta Agriculture, Lethbridge University; Doug Wright; David Lobb, University Winnipeg Canada, Manitoba; Martin Entz; Ray and Leona Timmerman; Bill and Barb Toews; Carolyn and Rick Feurth; Jim and Ruth Clarke; Rob Lowe; Jack Rigby; Harold Rudy, Ontario Soil and Crop Improvement Group; Steven Eastop.

From England and Germany: Peter and Linda Richardson; Adam Haylock; David Miller; Neal Rowe; Robert Lassiter; Gordon and Kathleen Spoor; Alison Lea; John Taylor; Dick Godwin, Silsoe University; John Taylor; Gavin Wood; Brian Reid, Norwich University; Thomas Bolte, Bremer Woll-Kammerei Ag, (BWK) Germany.

From Israel and United Arab Emirates: Moshe and Jona, Ariel and Mayaan Kitron; Dubi Segal, Netafim Israel; and Errol Fisher.

Without these wonderful people offering information, contacts and hospitality, my trip would not have been as successful or enjoyable as it was. To Matt Swain and George Thompson thanks for driving buses for us at certain times.

GLOBAL FOCUS TOUR

The Global Focus Tour undertaken as the introductory part of our study tour allowed a very comprehensive first hand view of issues which are facing agricultural producers throughout the world. It also introduced us to travel and associated challenges, was a useful link with research and development from the countries we visited and gave us background in areas including trade, Common Agricultural Policy (CAP) reform and support programs. We also met with past scholars, and travelled with and got to know current UK scholars.

COMMON GOALS

The areas which were likely to affect agriculture, in a common way throughout the world were:

- The water resource, whether used for irrigation, utilizing rainfall or snow-melt or excesses returning to waterways and the broader environmental issues. These were common themes in all continents.
- Urban impacts on agriculture, through either increased encroachment of urban development on agricultural land or the political and environmental expectations forced on rural communities by these enlarging urban developments, together with the challenge of climate change, having the potential for serious impacts. Research and development in assessing and dealing with these situations are very evident.
- World Trade and its impact on various markets and market opportunities. This showed to be very complicated in how policies are, and will continue to be, evolved and implemented and how trading partners are formed.

All countries we visited have extensive research efforts covering all of these issues.

SOIL REMEDIATION

Broad acre clay spreading of sandy soils didn't feature anywhere as specifically as that which is happening in Australia, except in the United Arab Emirates. However, utilizing rainfall, irrigation water, soil resources and other natural resources did. So, too, did the philosophies and changing attitudes to initiate such earthworks, other extension work, research and development and the resulting farming systems. Areas which had evidence of degradation were being preserved, remediated or improved by people who were passionate about this agricultural land and were concerned for their communities. At times, cost was not a consideration in the proposed works. Government organisations as well as private individuals, groups and organisations continue to conduct extension work and trial different ideas.

My study allowed me to look at ways to utilize rainfall and build the fertility of sandy soil, after the clay work has been done. There appears to be a need to gather information, collate and document best practise, especially that the results are variable. Of particular interest is the economics of this work, and the broader impact an increase in production can have on communities. I looked at crops, broadacre and horticultural and livestock situations.

LIVESTOCK

A consideration in this report is the innovative part livestock play in farming systems. Surprising was the high cost of meat products and the limited selection in supermarkets in European countries. This fact encourages me to think there will be continuing growth in market opportunities and potential for increased animal production here, providing rotation and alternative enterprises to balance production risks, but more importantly, for livestock enterprises to feature prominently in rotations to contribute to soil fertility and environmental sustainability.

Another issue which is gaining momentum and impacting on animal products, meat, wool and leather, is the animal rights groups and their influence on the public's perception of animal husbandry practices. There are some risks which may be very difficult to manage through in this area of livestock management or perceptions of management and education may take on a new urgency.

INTRODUCTION

SOIL POTENTIAL

Soil potential is defined as "The capacity of a specific kind of soil to function within natural or managed ecosystem boundaries, to sustain biological productivity, maintain environmental quality and promote plant and animal health" (Institute of Soil and Water conservation, Chinese Academy of Soil Sciences, Yarling, China). Soil quality is an all encompassing indicator of environmental quality, food security and economic viability.

In medium to high rainfall areas, where there are farms which contain land classed as sandy soils or sandy loam, some of the physical characteristics of the soil which are identified as holding back production, may be remediated in an economical way, by spreading clay, which also includes deep ripping or delving (erupting clay to the surface). Sandy soils have a low ability to hold water and nutrients. Thus plants which grow in sand, experience drought conditions after relatively short periods, if rainfall events are sporadic. This has the effect of reducing the productive potential and in this current economic environment, viability of the business can be compromised. Porous sandy soil has low cation exchange capacity which leads to inability to retain fertilisers and reduces ability for buildup of organic material, and contributes to lack of water holding capacity in the growing profile. Fertility is therefore affected by the wet/dry cycle of rainfall events

Organic carbon is important to all soil types, but very important to sandy soils and sandy loams, to create more stable soil aggregates, which allows gaps for water storage and movement and gaps and sites for fertility. It is the cornerstone of soil's structure and fertility. While fertilizers should be used to supplement the available nutrient supply, they are no substitute for a living system. The life beneath the soil far exceeds the life above the soil in terms of numbers of organisms. The various biotic forms living in and on the soil are mutually interdependent. Green plants use nutrients from the soil and carbon dioxide from the air to produce plant tissue. This plant material serves as food for life both in and on the soil.

The plant and animal waste and remains are returned to the soil where they are processed by insects, earthworms, fungi, bacteria and other living things. Eventually the cycle is complete and the nutrients and carbon dioxide are again available for plant growth.

Monitoring and assessing of both OC and rainfall utilisation are essential in an environment where both are limited. Benchmarking and measuring are useful tools which can be employed to monitor farm performances and extended to larger geographic areas, are capable of impacting on such things as water vertical recharge, erosion and desertification.

CURRENT ECONOMICS

While cropping traditional crops in these soils has been viable up til now, the need to consistently perform profitably is an expectation and fundamental requirement for a successful business operation. Poorer rainfall years or sporadic rainfall events can equate to inconsistent returns, because of the increasing costs of production, seasonal fluctuations, commodity price changes and potential climatic change and increased risk. Therefore a need arises to buffer these risks, by firstly influencing the soils productive potential and secondly by employing a management system which has several enterprises of production, namely, crops and livestock in a complementary way.

In addition, sequestering atmospheric Carbon in agricultural soils is being advocated as a useful possibility to partially offset fossil-fuel emissions, offering another form of income. Vertical recharge may also be able to be reduced significantly, where that poses the problem of increased salinity and other forage and crop opportunities utilizing stored water will help control salinity.

At various places during the study program, I was able to look more closely at some of the ideals and reasons behind the physical remediation work being carried out, and to try to understand more of the processes we are participating in currently with clay spreading, and to consider what actions can be taken to continue our work in a positive fashion. This included visiting New Zealand, USA, Canada, England, Netherlands, Israel and United Arab Emirates.

STUDY RESULTS

The following report follows my path of travel. Many things were observed, some of which were not directly related to my subject, but which offered an informative background to aspects of production and markets. But the link is that all of these aspects of agricultural production are related to soil quality and environment.

THE NETHERLANDS AND FRANCE

INTERNATIONAL EFFORT

In Wageningen, the Netherlands, Dr. David Dent hosted me at the International Soil Reference and Information Centre (ISRIC). Its mandate is to collect and disseminate scientific knowledge about soils for the purpose of a better understanding of their formation, characterization, classification, distribution, and capability for sustained land utilization at local, national and global scales. Here an impressive display of most major soil types from throughout the world, helps describe the potential for fertility and water storage capacity. The Food and Agriculture Organisation of the United Nations (FAO) in conjunction with ISRIC is undertaking research and a knowledge database for Africa, so as to co-ordinate and stimulate learning and better water management by farmers there. There are also useful evaluations of all countries of the world, with maps and spatial data available.

WATER'S ROLE

The rainfall we receive on our land is the only water which is available for broadacre 'dryland' growing of either crops or pastures. That is winter and spring rain in the southern regions of Australia, with records indicating rainfall falling during the other months of the year, but not contributing to that growing season, but with potential for future use. The term used to describe that water which is the fraction of rainfall that is stored in the soil available for the growth of plants is called Green Water, as described by ISRIC. Runoff and deep drainage, recharging groundwater and feeding streams is referred to as Blue water.

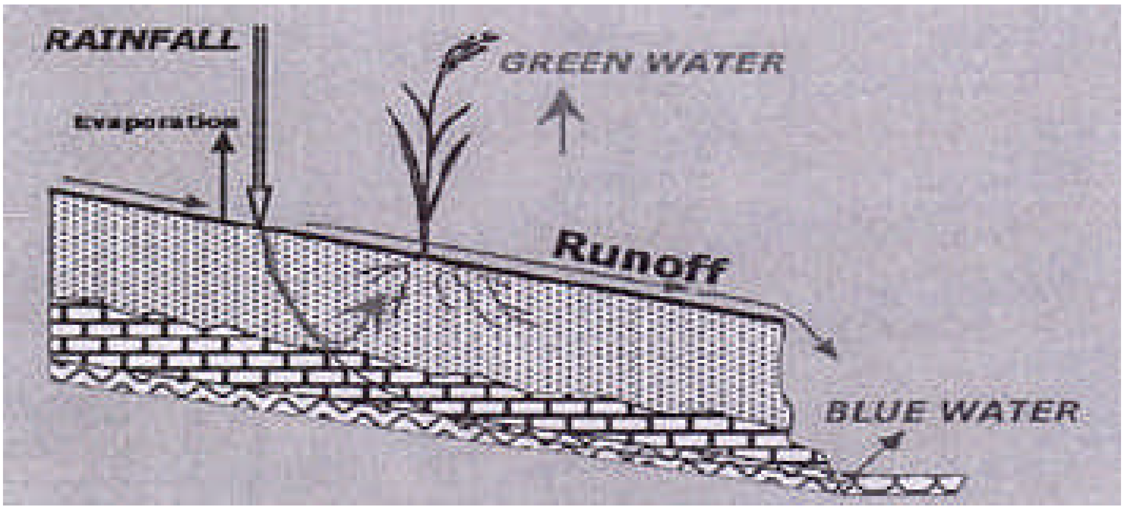

Fig. 1 – water cycle – ISRIC, Wageningen, Netherlands – Green Water description

Some dimensions of sandy soil can be managed to enhance its ability to generate storage capacity of water in that soil after evaporation, runoff and loss through the profile or green water usage. As seen in most Northern Hemisphere countries, rainfall appears to be more frequent, and in the growing season for arable crops, generally from 650mm to 875mm, lessening the need for soil water storage for plant growth. Soils in many regions are very productive under those climatic conditions, giving rise to organic carbon in excess of 3 and 4% and crop yields of from 8 tonne/Ha of barley, up to 80 tonne/Ha of sugar beet which is producing 12 tonne of sugar (P. Quignon, Amiens Fr. – per.con.).

Particularly sandy soils continue to be inefficient at holding soil moisture available as green water. A major result of water storage potential is an increase in organic material building up in the soil, because of better production which equates in time to soil fertility. Research has shown fertility is developed around 6 factors, 3 rather static: clay content, pH and organic matter content, and 3 variable factors: temperature, rainfall and bulk density. Soil Temperature and moisture has a significant effect on soil biological activity. So, too, does soil pH. Bulk density can be affected by makeup of the soil as well as soil particle composition, sizes and shapes and traffic over the paddock. Bulk density affects the amount of potential air space and water infiltration, and consequently water, fertilizer usage and biological activity.

ENVIRONMENT

Higher rainfall has some negative affects. While Northern Europe employs a strict monitoring of effluent disposal, the higher rainfall creates many potential problems with water source contamination. European Union (EU) rules allow nitrogen amounts of up to 168kg/hectare as a maximum level, which is then calculated back into Nutrient Units (NU) and livestock numbers. This same principle has been legislated in Ontario, Canada, although rather following along the lines of NU limits (1 beef cow and calf equals 1 NU, 8 meat breeding ewes and lambs equals 1 NU). A similar process is being implemented for New Zealand, evaluating animal carrying capacity and nitrates and phosphates applied or produced by animals.

HEALTHY COUNTRYSIDE

There is a more obvious and urgent push in the Netherlands to have control of the environmental impact from farming and deliver cheap food of high quality. Attending a ‘Future for the European Countryside’ Seminar in Wageningen in April, allowed an opportunity to experience, firsthand, people’s interest and passion towards food production being not only ‘food-safe’, but also safe to the countryside, and how they can contribute to this ‘balanced landscape’. There was some discussion about the accession of countries into EU and farm size affecting family farm stability. In 1950 the average area of land was 10 – 30Ha for 2 – 3 people and their families. In 2005, this average is 100 – 200Ha for 1 working man and his/her family (Trygve Sundt, Consultant Sundt/Thomassen, 2005). Family farms are important to the Dutch, German, Polish and Hungarian culture and there was an obvious passion to see farm stability continue.

FOOD MARKETS

Meat was expensive in this region and quite scarce compared to dairy products. Supermarket prices of New Zealand lamb equated to AU$13.00/kg, with beef half that amount again. This varied quite a bit across the countries I travelled, but the most expensive I experienced was AU$55.00/kg as I travelled into Poland. Meat and animal production in such an environment would seem to be difficult, given the environmental constraints with regard to excesses of surface water and seasonal freezing conditions, high land costs and dense human population.

Organic cheese, milk and beef were again products being pursued to utilize available livestock production. While meat products appeared to be in short supply, dairy and cheese products were not. Consumers' preference to cheese consumption, offered a lot of opportunities for marketing into a high value dairy food markets. While I was in the Wageningen area, I also visited a very successful operator involved in organic farm and cheese production, selling into a niche market which was based on top quality product at a high price of around AU$12 – 14/kg.

NEW ZEALAND

CROPPING

Near Christchurch, in New Zealand, Denis Curtin has worked on a three year trial program, carried out at Crop and Food Research, to determine the state of OC in a minimum tillage cropping situation. This trial also had livestock included, to determine different rotational influences on OC. With direct drilling, 3 years of trial data were indicating a small reduction in organic carbon. Denis' research indicates almost all OC in soil is located within pores between mineral grains, either as individual particles or as molecules absorbed onto the surfaces of mineral particles. So the pore spaces within the soil are very important to holding that potential organic matter. Adequate oxygen and water are required also to optimize the decomposition and mineralisation of organic material. Compressed soil also affects pore space, and research shows carbon mineralisation is slowed under these less porous conditions. This trial work also was including grazing trials, to again determine OC buildup.

LIVESTOCK

In the Lincoln area, on the Canterbury Plains, a continuous pasture rotation, since 1838, has 15% organic material levels, which would equate to around 8% OC. Evidence of mycorrhiza fungal activity is quite visible in the sod which was dug up. Soil on other areas of the farm is very productive in crop production and rye-grass seed. Wheat yields range from 10t/Ha up to 13t/Ha. And ryegrass seed yields, after grazing, of up to 1.5 tonne per hectare. Other grain crops included in this rotation are peas, herb crops and linseed.

Livestock include only sheep and lambs, and the heavy stubbles in this system are broken down well within the time required for next season's crop. On the surface many small stubble feeders, slaters, beetles, worms and fungi were obvious. It was pointed out that together with sheep they are an integral part of breaking down the stubble in time for cropping. Because ryegrass is included in the rotation for seed production, the sheep are important to control rank growth, encouraging seed production. The root growth of this crop, under a grazing regime is contributing to OC buildup. (Simon Osborne, per.con. July 04)

ENVIRONMENT

New Zealand has an environment, which offers diverse opportunities for different grazing systems. The management of forage crops during the autumn and winter period was utilizing rainfall from that time of year, and capitalising on market opportunities for livestock. A healthy trade of store stock was benefiting from this extra pasture crop's growth. These stock were lambs for export, dairy heifers for export to China, and dairy cows for agistment out of milking season. Crops included in various grazing regimes were white clover, oats, chicory, linseed, radish, swedes, turnip, pasja and kale.

Dairy cows being pastured during their 'dry' season, were being agisted and fed on autumn-sown cereal oats and clover feed. The price of this feed was determined by the calculated weight of dry matter in that paddock, rather than a cents-per-head charge. The paddock inspected on Paul Jarmen's property, was returning about $800.00 per hectare, on this basis.

The meat and wool growers levied Monitor Farm Programme (MFP) has been very successful in monitoring spectacular production and financial results of farms throughout New Zealand. This type of programme has generated camaraderie within the community as well as helping farmers to realise the potential they have, and the confidence to pursue it. Linked to this is practical experience of successful farmers who are achieving better than average returns for their livestock enterprises. (Sam McIvor, Meat and Wool NZ, MFP).

SEVERE DISRUPTION

The ‘Flipping’ process has transformed ‘Pakihi’ soils on the west coast of South Island, as seen on Terry McDonnel’s property. This process involves mixing peaty topsoil and sandy subsoil to lift dairy cow carrying capacity by 1 cow/Hectare, and allowing better drainage, by breaking up a hard pan. The process, although costing between \$1000 - \$3000/Ha and very disruptive, is proving to be profitable, and providing returns on investment from 8 – 37%. Up to 5 tonne of Lime, 1 tonne of superphosphate per hectare, urea and potash are applied throughout the first year after having been flipped. With rainfall infiltration improving markedly, and much less waterlogging, production is much increased. (Ministry of Agriculture and Forestry, NZ; publication Oct. 2004)

‘Humping and hollowing’ also featured as a production increasing, but very disruptive process in enhancing production in waterlogged soil. Drainage lines are dug into a landscape in a ‘street’ fashion, with fall to lowest valleys, forming the base of the hollow, and the humping of the soil occurs between these drainage lines using excavation machinery, with the consequent landscape proving to be well drained and productive. Sowing grass-seed and application of fertilizer complete a transformation to productive dairy country.

IMPRESSIVE RESULTS

Statistics for animal production in NZ have shown impressive gains. This was seen by the farmers’ attention to detail in their livestock operations, particularly sheep and lamb, resulting in National productivity trends for lamb showing increases of lamb kilograms per sheep, of 4% per year, since 1990/91. The result is that total national production of lamb in kgs has increased by a net 10%, while at the same time there are 32% fewer sheep. Dairy cattle numbers have increased by 53% since 1990. (Meat and Wool Innovation, Economic service).

UNITED STATES OF AMERICA

CLAY INFLUENCE

Soil organic carbon has many functions in the soil. Perhaps one of the most important functions as related to crop production, especially in a rainfall deficient environment, is its effect on plant available water capacity. While this affect varies, depending on soil texture, generally available water capacity increases with increase in OC. (Olness and Archer). As suggested, arid regions can experience obvious gains by increases in water holding capacity, but this was seen to be the case in areas where water was typically not limiting. Again, intermittent drought conditions can cause yield loss. At the USDA ARS Morris, Minnesota, a study survey was compiled to value the soil organic carbon as a drought mitigation tool. The conclusion indicated the most benefit for short-term dry periods, as experienced in Australian conditions, not so much from year to year, but dry periods between rainfall events.

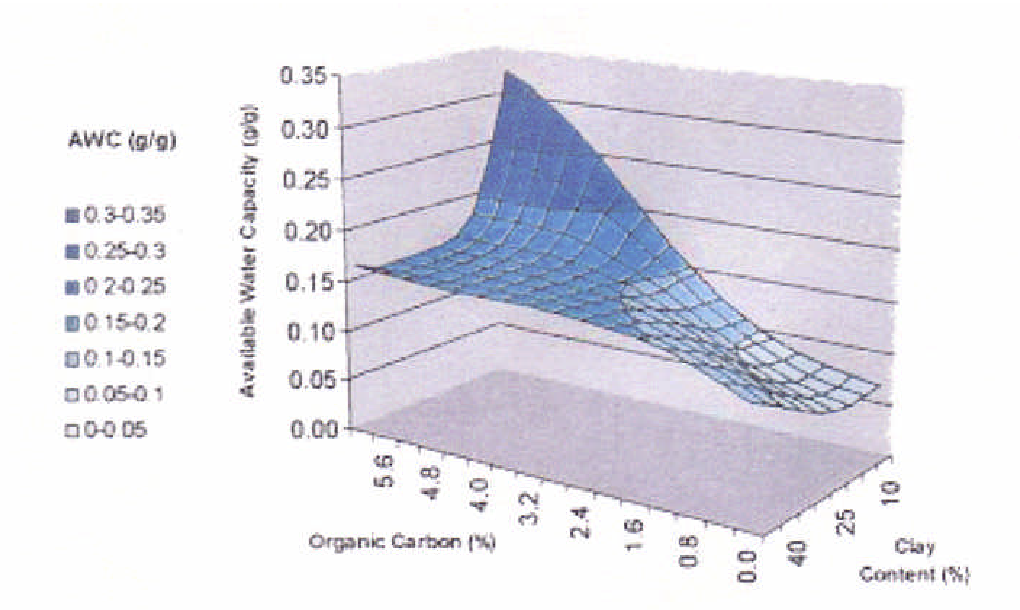

Figure 2 – Function relating soil organic to available water capacity for varying clay content and a silt content of 30%.

What was of particular interest was the relationship between clay content and soil organic carbon and the ability to store water. The graph above shows the relationship between clay content, organic carbon and available water. This is a key finding and this description supports the need for research to determine what is an optimum, achievable amount of clay to target. It also supports that the clay we are adding to the soil, given an increase in organic carbon, has the potential to dramatically increase the water holding potential of this soil.

STUBBLE RETENTION

Some of Washington State, in the North West of United States, has Loess soil types. The soils have high production potential, and a variable rainfall, ranging from 250mm to 500mm. Very steep slopes of up to 50 degrees, on these Loess soils threaten damage by water erosion. Traditionally fallowed, this productive soil is responding to stubble retention, both from a biological perspective, but also physically, contributing to erosion prevention. John Aeschlamin, the president of Pacific North West Direct Seed Association, (PNWDSA) whose farm I visited, showed me modified machinery which was used to farm on these steep slopes. He is employing a conservation and direct-drill system, to prevent erosion, and build organic material in the soil. While some of the more extreme slope land was being placed back into conservation grassland, yields of grain for their 500mm rainfall area were good. With wheat yielding up to 10 t/Ha (140 bushels/acre) (averaging around 4 – 5t/Ha) and dryland corn included in the rotation, but only on low lands around the same yield, (J Aeschlamin, per.con.) their rainfall is being used efficiently.

CARBON CREDITS AND COMMUNITY

What is of particular interest was the success of the PNWDSA operating collectively, using carbon which is sequestered into the soil by no-till practises, being contracted and leased as carbon credits in a deal between farmers and an energy consortium from southern USA, Entergy. While there are obvious gains, in the sense of production potential in fixing OC, this movement towards focussing on sequestration is a welcome one indeed, with OC becoming a ‘tradeable’ commodity.

Yet another aspect of the PNWDSA, was their passion to be working together for their farming communities, in a way which preserves the family farms and bolsters rural communities. A recent oilseed forum, promoting new cropping systems and oilseed production, is focussing on oilseed production for biodiesel. This, in turn will have the benefit of creating and maintaining jobs and production stability and growth for the local community.

LIVESTOCK CONVERSION

In Southern USA, in the southern Piedmont region of South Carolina and Georgia, research to measure fixation of SOC using grazing systems, after extensive degradation from cropping, is showing success. Long rotations including soybean, cotton, tobacco and corn have degraded the fertility of these soils, and with the quite severe weather, in terms of rainfall and humidity, SOC is proving difficult to sequester into these sandy soils. This area shows considerable similarities to our own area, with respect to sandy soil over a clay layer, but with much higher rainfall and SOC around 1 - 2%. In Watkinsville, Georgia, the Southern Piedmont Conservation Research unit, Allan Franzleubbers' research indicates useful buildup of SOC under trial grazing systems. Cropping is proving to be unsustainable, both in terms of yields and consequent returns and the pasture establishment is contributing to cleaner water runoff management.

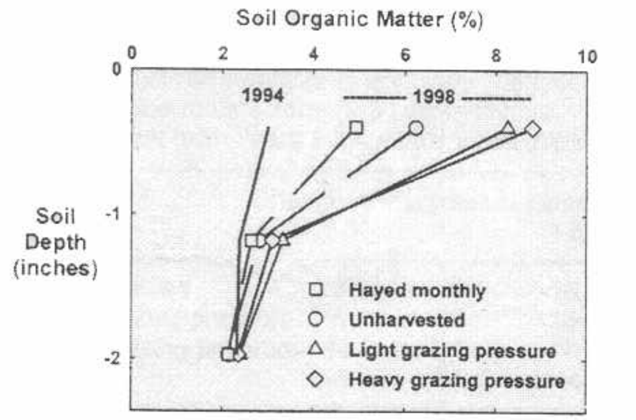

Fig. 3 – Relationship between soil organic matter and forage systems, Franzleubbers, A. 1998

CARBON CYCLE

The USDA ARS researchers are focusing on the relationships between carbon and nitrogen cycling. Sequestration of carbon into agricultural systems is dependent in part on the availability and cycling of nitrogen because the organisms, which capture and cycle carbon require nitrogen as well. This may impact the decisions of crop and pasture crop rotations in attempting to build organic material in the soil. Long-term grazing research show affects on not only their rangeland health, but increases in OC. Their research also supports that grazing increased soil OC levels more compared to non-grazed pastures.

NOVEL MARKET

As some of the area has the enterprises changing from cropping emphasis, to stocking, it was interesting to see a farmer exploiting a 'new' market producing grass-fed beef, in Darlington, South Carolina. His approach was a low input grazing system, also allowing an organic certification. His marketing strategy was to advertise using 'flyers' to people, who in turn were placing forward orders. He was experiencing difficulty keeping up with the demand for his beef.

NEW TECHNOLOGY

While in California, I met with Michael McElhiney, who has a long history in soil conservation in his county. He spoke about and demonstrated Polyacrylamide (PAM), in flocculating solids out of irrigation water. Research on a new formulation of this product is continuing, especially in trying to prevent soil runoff in irrigation situations, and therefore improve cleanliness of runoff water quality. Research has shown that 10ppm of PAM has the ability to stabilize existing soil structure, to prevent erosion in water. There may be some use of a product like this in stabilizing sandy soils.

CANADA

DIRECT DRILLING

Direct drilling of arable crops and some summer crops is very successful in dry conditions of Canada's Lethbridge area. Here, crops are making full use of available moisture by full stubble retention, enhancing organic buildup and providing a physical cover for the soil with crop residues, preventing wind erosion and moisture to dissipate. Crops such as flax and sunflower are being sown in a cereal-canola-pea rotation, with a great deal of success from an economic perspective, and also from a weed control perspective. With rainfall not falling in abundance, about 250mm of rain plus snow melt, these rotations appear to be utilizing ground water which may otherwise be lost from the profile.

ENVIRONMENT CONTROLS

Water loss, through the soil as well as runoff is also a problem for other areas of Canada, like Ontario. These more densely populated areas have implemented laws which obligate farmers to monitor and document their nitrate and phosphate use, as well as limit the number of animals they can run on that land, as mentioned earlier. Restrictions also apply as to time of the year to apply or spread effluent, in response to frozen seasonal conditions. The response to this requirement is seen as a part of a Nutrient Management Strategy (Ontario Ministry of Agriculture and Food) implemented in a step-by-step way, allowing farmers' systematic uptake of a Nutrient Management Plan (NMP), with some immediate compliance based on size or changes of current operations. If, for example, a person is likely to generate 300 or more nutrient units, then a NMP must be implemented. Some funding incentives are available to help farmers comply with the NMP implementation requirements. Their livestock units are a measure of volume of effluent, relative to land area available. Steve Eastop in Ontario provided an excellent opportunity to view the implications of such legislation, with a fully implemented farm monitoring and management system, requiring documentation of all chemical use, stubble residues, chicken litter disposal and pig effluent management (limited spreading volume per acre), and human movements in and out of his farm. A license is required to dispose of dead animals into the composted solids. OMAF also provide publications for information regarding carbon sequestration, greenhouse gases, and modifying production systems to reduce GHG emissions.

TOPSOIL RELOCATION

Dr. David Lobb, University of Manitoba, Winnipeg, is conducting trials in topsoil relocation, following a long history of tillage erosion, where again the physical tilling of the soil over a long period, has pushed soil on knoll-tops to move down the slopes and was looking at some very profitable returns, for the expense. This project is only in its evaluation infancy, with the Timmerman farm, about 60km east from Winnipeg, having been selected for this work to be carried out. The soil transportation carried out so far, is indicating a good increase in crop production. Not a lot of specific detail is available here, but preliminary research and trial work is showing potential.

The research is also looking at the weed burden, but the main area of production increase is in fertility, and more even crop production over the whole field area. The crops were lodging in the low lying areas (3 – 4 tonne/Ha estimate), while the tops of the knolls were quite poor, (2 – 3 tonne/Ha estimate). The work is predicting much more even crops and a buildup of organic carbon. There is a considerable area which can be remediated in this fashion throughout Canada and USA, and current trials will support this work with real data on cost versus production increases. Even in Minnesota, USA, this process was happening on a local scale, and with improvement in crop performance. Laser bucket machines were the machines being used to complete the job.

LIVESTOCK HEALTH

Livestock operations in Canada were reeling from the trade restrictions of cattle export markets, as a result of the BSE detection in United States being traced back to Canada. This was causing considerable difficulty for Canadian cattle farmers, not knowing what markets were going to be available to them with cattle they had for sale and with winter closing in. There are many cull cows, which have been re-mated, but until the markets open again, things will continue to be very difficult for cattle farmers in Canada. This situation illustrates the importance of animal traceability in Australia, so that in the event of a disease outbreak, a trace back can be implemented and restrictions put in place.

An outbreak of avian flu on the West coast of Canada back in April while we were travelling in Ontario, again suggests the vulnerability of livestock production systems and supports the importance of maintaining sanitary phytosanitary restrictions and traceability systems.

UNITED KINGDOM

WATER HOLDING CAPACITY

In the Fens, in North East England, drainage works allowed some poorly drained soils to become very productive. This peat soil has only become productive since the area was drained, from the seventeenth century onwards.

As the soil was dried, it has shrunk, up to 4 metres, leaving drainage channels high above the soil level, requiring pumps to continue to drain the water. Some of this land was deep ripped and delved to bring clay material to the surface and bring mineral into the peat soil.

The Norfolk breckland (a tract of heathland country) area of East Anglia, with the Fens to the West and good clay 'uplands' to the East, is a sandy, traditionally poor soil of England. This area has had a chequered history of rabbit plagues, grazing by livestock and erosion. It has poor water holding capacity, as Dr. Brian Reid of Norwich School of the Environment, Norwich University explained. He talked about the sandy soil's water potential characteristics for plant extraction of water for growth, compared to clay soil. The field capacity is the amount of water the soil can hold against the pull of gravity. The soil water potential changes with content of clay within the soil.

While this concept may seem to be unsupportive of sandy soil, this soil type does not have the restriction of 'holding onto' water tightly away from plants, as higher clay content soil does. Again, if organic matter is present in the soil and if the sandy soil has stable aggregates and texture, the makeup of this type of soil will hold a much larger volume of water available for the plant and release its water content much easier than high content clay soils, while still maintaining a healthy plant available water capacity (PAW). Sensors are available to measure this potential water in soil, either by a heat dissipation method, or electrical resistance.

Both in the Fens of Eastern England and in South Carolina, research demonstrates the difficulty of plants to extract moisture from higher content clay soils, as opposed to sandy soils, where the particles within the soil allow the plant to utilise that moisture more easily.

ISRAEL

MARKETS

In Israel, lucrative export markets offered some very attractive options. One of these included sunflower seeds for human consumption, with an export to Spain as well as domestic use. I experienced harvest being carried out at night, of a crop of these sunflowers, which allowed less grain loss from shattering in the cooler night weather. Israel has a mild winter which provides an opportunity to grow some specialty crops. Water is not a plentiful resource, so careful planning of use of water resources, for which Israel is well known.

SAND ON CLAY

Another crop being grown was peppers or capsicums, growing in the Southern Arava Valley region near the moshava (a village of private farmers), Iddan, in the south of Israel. The soil in this particular area is highly saline and has high clay content. Its historical origin is Dead Sea sea-bed. In locations where horticultural crops are being grown, the soil is having 3000 cubic metres of sand per hectare spread on it, using tipping trucks and loaders, effectively mined from a quarry. The sand is spread and prepared for planting, with dripper tape laid down for irrigation. Net-houses, nets completely covering over the crops, serve two main purposes; to keep pests out, as this also forms part of the USA import protocol and to provide shade and shelter from the sun and wind. Other crops grown in this 'sanded clay' were onions, grapes and cut flowers. Fertilizers were put through the watering systems, which were mainly dripper tape and monitoring done by soil and tissue testing. Water is pumped from a deep aquifer and reticulated locally. The aquifer is replenished by rainfall runoff from the Jordanian mountains, which when heavy rain occurs, water runoff is banked up, and pumps direct that water below the surface, into the aquifer.

In Moshav, Hutseva, research is looking to grow peppers hydroponically, in a bid to reduce the expense of carting and spreading suitable sand, which is becoming difficult to find in locations adjacent to the plots. This research work is assessing stem thickness measurement to measure water flows within the plant.

LIVESTOCK

Kibbutz En Hishovet has a large beef importing program for Israel. Their own herd comprises about 1000 cows, with by far the majority imported live. Around 18000 beef bulls and another 50000 dairy bull beef go into the feedlot, mainly from Australia, but with extra numbers sourced from South America. Quarantine costs from Australia are around $80.00/head and South American cattle were favourable because of cost and numbers available. Beef consumption is around 17kg/person, compared to 46kg/person of chicken.   Customers are now being educated about beef quality. There are some cattle and sheep, apart from goats, which were run in 'traditional' grazing systems. Sheep, too, were being kept in feedlots.

This looked like a very inefficient and uneconomical way to be breeding and growing sheep, but with downgraded horticultural products as part of their ration, they were able to utilize some of these waste feed products. Opportunities exist here to continue to import animals.

As this country has demonstrated, arid land can still be developed to supply lucrative markets, even with adverse weather conditions. Research continues in production and irrigation systems, but again, labour of sufficient quality is becoming more difficult to attract to farming.

UNITED ARAB EMIRATES

CLAYED SAND

Unfortunately, being held up in Tel Aviv for an extra two days, interfered with travel plans for The United Arab Emirates (UAE). Their weekends span Thursday and Friday, so my planned weekend trip turned out to be only a short one afternoon drive down to areas where extensive clay spreading is being carried out. The wealth of UAE is obviously driven by oil, and spending is without limit. This offers a good opportunity to see without restriction, what can be done with remediation of a landscape. Errol, my host, told me of the dozens of bulldozers pushing sand hills flat, spreading clay on the area, and developing these areas into horticultural areas, which are turned over to the local people to farm crops. The development is a way of redistributing the wealth of the country. Of particular note, were the numbers of Pakistani people labouring in the country.

These labour units were cheap, but available. With the amount of development actually happening, a large amount of labour is required.

The UAE have visited Australia to investigate the claying process here, and are applying it to their own situation.

After 12 weeks away, I was very tired, but excited about what I had seen and excited to be home again.

CONCLUSION

Soil remediation can occur in three ways – physically, chemically and biologically. Clay is the catalyst to improving water holding capacity, consequent growth and production of crops and livestock as a result of increased natural fertility. Rainfall and other water resources are a most precious resource, especially in naturally deficient landscapes. To make the best use of inputs, the physical and chemical characteristics of the soil may need to be modified in a way which helps increase biological activity, representing long term sustainable fertility, to continue to improve the soil. This is the best likely outcome in farming systems, where water use is a priority. The only logical place to store moisture is to store it in the soil.

MANAGEMENT

This modification process also includes management practices, using different enterprises, such as livestock and horticulture crops, and using various fertilizer regimes. Different species of plant can contribute to varying degrees of microbial activity and organic material in the soil profile.

The content of clay in the soil is important. This prevents erosion or other forms of degradation, but importantly enhances the potential for increased production. Texture and structure are important aspects of this resilience of the soil. This affects the water retention and release characteristics, and so affects the crops growing under drought conditions.

The biological aspects are also many and varied, but less understood. Building organic carbon in the soil, natural fertility, is of paramount importance, especially for clayed or modified soils. The type of crops chosen in rotation, whether grazing is used, or including grasses or clover pastures, how stubble is conserved or whether green manure crops are grown, all have an influence on the biological aspects of the soil.

Observations made on this trip, indicate the need to get more information of what things farmers and researchers do and don't know about the soil which has been treated with clay, and the various treatments and how these new soils behave differently.

To promote the environmental benefits these management decisions has on carbon and nitrogen fixation as well as the water 'conservation' potential this has, is also important. The vertical recharge resulting in salinity being slowed as a result of clay applications on a large scale is a good example of unknown impact. A micro-climate may even be developed in this large scale application.

The influence on the broader community's economic and social status needs to be considered as a result of changes to management practises and consequent increases in production.

Consideration needs to be given to the energy required to complete soil remediation works. If we consider the fossil fuel and time to complete earthworks, maybe the immediate gains are consumed by the cost of the process. The long term gains must be considered, particularly with regard to Carbon sequestration. Current rising prices of fuel increase the urgency to complete such investigative work.

RECOMMENDATIONS

Clay is a catalyst to help create biological and chemical fertility. This in turn is essential to water holding capacity and influential on water use efficiency. Because there is modification of clay content, and chemical changes of sandy soil, trial work and data collection form the basis to understanding optimal performance of these modified soils. Particularly rotations of different crops, application of various fertilizers, both chemical and organic based, as well as trialling different enterprises, aimed at utilizing, protecting and enhancing the natural resources associated with these landscapes would be a logical step forward from here. Having a more extensive understanding of the impact on our environment as in carbon sequestration and prevention of vertical recharge, are also very important factors for long term sustainability. The clayed soils are unique, and sandy soils are difficult to manage.

There is a need to soil test more accurately down the different horizons those areas which are currently being clayed, delved and ripped, in order to establish a much more specific understanding of where the biological activity is likely to be happening and capable of contributing to long term fertility. We need to understand what can be achieved in terms of biological fertility, and what optimal performance for a given rainfall is. Water loss through the system also needs to be analysed, as well as evaporation potential.

The physical aspects of soil temperature, pH, rainfall and water content of soil need to be measured more accurately.

For farmers and researchers, there is a need to co-ordinate all of this specific information currently in practise, and made available in a form which is easily readable and 'consumable' by as many people as possible within the farming industry.

More work by promoting pasture alternatives, not only from a production perspective, but importantly fertility and include specific cultivar species which contribute to various areas of sustainability.

The energy cost of achieving these changes, especially the clay spreading, should be evaluated more closely.

FINAL COMMENT

I am fortunate to be rewarded by very responsive outcomes by using a process which physically remediates sandy soil. I will continue to be challenged by adapting to further advances in knowledge. As environmental challenges and market demand will play a huge part in Australian Agriculture in the future, we must be adaptable and prepared.

Information is plentiful, affordable and instant. Knowledge is select, expensive and requires time. As Agribusiness Managers, the challenge remains for us to gather and apply the correct knowledge.

REFERENCES

Meat and Wool New Zealand

Curtin, D. Crop Rotation and tillage impact on carbon sequestration in Canadian prairie soils, Soil and Crop Research 74, (2003) 81-90

Dent, D. International Soil and Reference and Information Centre, Netherlands

Clapperton, J. The real dirt on No-till Soil, Rhizosphere Ecology Research Group, Lethbridge Research Centre, Canada

Krull, E. Baldock, J. Skjemstad, J. Soil Texture Effects on Decomposition and Soil Carbon Storage, CRC for Greenhouse Accountancy, CSIRO Land and Water, 2001

Franzluebbers, A. Soil Organic Management, Southern Piedmont Conservation Research Unit, Watkinsville, Georgia, USA, 2003

Olness, A. Factors affecting microbial formation of nitrate-nitrogen in soil and their effects on fertilizer nitrogen use efficiency, The Scientific World, 2001

Lobb, D. Restoration of Eroded Landscapes: Agronomics and Environmental Impacts, Manitoba Zero-Tillage Research Association, 2003

Archer, D. Olness, A. Valuation of Soil Organic Carbon as a Drought Mitigation Tool, USDA, Agricultural Research Service, Morris, Minnesota, 2004

Aeschliman, J. Pacific North West Direct Seed Association, 2004

Foundation for Arable Research (FAR), New Zealand.