NEW ZEALAND NUFFIELD FARMING SCHOLARSHIP TRUST

Catchment Management Strategies

New Zealand Nuffield Farming Scholarship
Paul Bernard McGill
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Disclaimer

Paul McGill
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Forward

I was brought up in rural New Zealand in a family whose outdoor interests were a perfect lead-in to a career in agriculture. I started to satisfy my thirst for agricultural knowledge by studying Agriculture at secondary school. Then, studying for a Diploma in Farm Management at Lincoln University allowed me to learn directly from agricultural scientists. I thrived in this learning environment and after graduating I set about starting my farming career.

I am passionate about NZ agriculture because it is seen as being world-leading. By developing sustainable farming systems that match the resources available to them, NZ farmers have increased productivity. Naturally my focus has been on doing the same.

Developing my farming knowledge and skills

I have experience of managing different farming systems including sheep and beef hill country, dairying, mixed cropping and lamb finishing.

I twice competed in the Young Farmer of the Year competition - at grand final level in 2003 & 2005 – which further developed my knowledge and especially my communication skills.

Mayfield - the farm I have managed for the past six years - won the prestigious Wairarapa Farm Business of the Year in 2008, and in 2007, the property received two awards for Nutrient Management and Crop Production in the Wellington Region's Ballance Environment Awards.

An AGMARDT Travel Grant award from the 2003 Young Farmer of the year contest allowed me to travel to the United Kingdom and Ireland in 2004. My focus on this trip was nitrogen (N) fertiliser use in pastoral agriculture. UK pastoral farms have been using high rates of N inputs for a long period of time and the trip gave me an insight into these farming systems and the research focused on them. The farms I visited were very productive, though, due to regulation from the European Union (EU) to improve water quality, many of the research organisations I visited were focusing on the environmental impacts of such systems.

My interest has always been focused on improving the productivity and profitability of NZ agriculture, and sustainability has been a parallel focus.

Environmental Impact

Over the past 20 years in NZ, the use of N fertiliser and other inputs has increased, especially on intensive lowland pastoral farms. Irrigation developments have contributed to this increase. Increasing the potential pasture production by using irrigation requires additional inputs to support pasture growth. During this period reports have been published showing declining water quality in some of our water systems, particularly in lowland catchments.

A comment I wrote in my 2004 travel grant report stated:

"The NZ agricultural industry needs to start to look at putting standards in place regarding the use of N inputs. The author would suggest that the impact of this would be less than will be the case if it is left to a group outside the industry to set these standards. If not managed sustainably the impact on the environment of present day N inputs will be seen by future generations."

The agriculture industry has made good efforts to improve environmental outcomes. The 2003 Dairy and Clean Streams Accord is an example, but industry standards will have to continue to improve if scientific reports show worsening effects on water quality are coming from agricultural sources.

I know that NZ farmers will respond to workable measures when required, to protect the land and water resources within their catchments. Farmers know that it is the advantages we get from these resources, along with the knowledge we have in managing them, that provides the quality of living available for them and all New Zealanders.

Any future irrigation development will need to have detailed plans not only for taking water but also for the way it is used and for any off-site catchment issues.

The Wairarapa Regional Irrigation Trust (WRIT), of which I am currently a trustee, is looking at irrigation possibilities on a regional scale based on storage systems. Being part of this process has further highlighted to me, the need to look at the issues at a catchment level

We must be proactive in developing standards. Other countries look to NZ as being a world leader. Catchment management issues concerning land, water and the ecosystems they support are already a very important focus globally.

My passion and involvement in NZ agriculture will require further investment of my time on this issue and the 2010 Nuffield Farming Scholarship year has been a significant part of this process.

Acknowledgements

This report is the result of a diverse range of opportunities that were available to be explored thanks to the prestige the Nuffield Farming Scholarships command internationally.

International Nuffield Scholars provided global networks, hospitality, knowledge and influential contacts related to the different subject areas. This network is an invaluable component for any Nuffield Scholar. I look forward to meeting more scholars in the future.

These opportunities would not be possible without all the people who support the New Zealand scholars while they are a long way from their personal and professional lives back home. In the case of the author a special thanks must be extended to his employers Jim and Lois Reynolds and all the many people involved in the farming operation at Mayfield Kingsdon Partnership.

It was said that completing a Nuffield Scholarship would be a life-changing experience. That comment is correct. It is also said that a Nuffield Scholarship never finishes - the year doing the scholarship is only one part. Hosting, and visiting scholars will continue for the rest of a scholar‟s life, so will the experiences and developments continue to be used by scholars in their professional and personal life. Long may the journey continue!

For this experience I will always be appreciative of the people involved in running the New Zealand Nuffield Trust and the sponsors of this organisation. Their personal involvement in the process made an intense situation both rewarding and enjoyable.

To Barbie Barton and Jim Geltch, thank you for all the organisational and logistical work you did during the year. Your support and contact through the year really helps the scholars stay focused on their requirements.

Thanks to all the wonderful people I met during this scholarship. I only hope I get to meet many of you again soon.

"It is the people that make the Nuffield Farming Scholarship such an awesome journey".

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Executive Summary

Irrigation and water storage

Factors outside a farm boundary, play a large role in the farming system. Irrigation water comes from the runoff from a whole catchment area. Water also leaves the farm and can have effects on the quality of waterways if nutrient and or sediment goes with it.

Water storage for future irrigation in New Zealand is being increasingly investigated where ground and surface water is under allocation pressure. This report gives examples of the irrigation schemes visited and the companies that manage the water use.

Irrigation schemes in Australia have considerable infrastructure. Investments to improve efficiency and add new technology have future benefits for irrigation consumers as well as for the environment within the catchment. Having a value on water, and the ability to trade the right to use this resource makes the economics of upgrading and modernising the infrastructure easier to finance.

All the irrigation schemes and farms visited used volume-based measures for water management. Although getting used to the terminology took some mathematical thinking, it soon became clear that volume-based measures make sense. It encourages Water Use Efficiency (WUE). Farmers have capital invested in Water Entitlements and fixed and variable costs are based on the volume of entitlements held and used.

Water allocated for irrigation in New Zealand is often measured on a flow rate basis and application described in depth. These measures make comparing actual volumes used difficult and therefore do not effectively encourage WUE. New Zealand has a national policy requiring future metering of the majority of water consents. This will be a good opportunity to look at volume based measures for managing water resources.

Water trading in Australia is based around the rights relating to how water is used rather than the purchasing or selling of the water itself. It is a fundamental difference to the management of the resource compared to New Zealand's consent-to-use approach under the 1991 Resource Management Act. It enables the value associated with its use to be invested in the resource that created that value. Effectively it is decoupled from the resource of land. Many irrigated farms have more invested in water assets than they have invested in land. This makes sense as it is the water that allows them to run their farming systems.

Conversely, New Zealand does not have an active water market or property rights attached to the use of this resource. Value created by water use in New Zealand is capitalised in land values where farm production is enhanced by water use, and that production is used to value the land. This could over capitalise land values out of reach for systems that have lower water requirements because the additional water cannot be traded. If water use is tradable it encourages investment in the resource that created the value.

Max Fehring, an Australian farmer who is an authority on the subject says,

"The two most important aspects of irrigation are yield and security. Yield provides potential, and security allows potential to be achieved".

There are many overseas people with knowledge of water issues. New Zealand should draw on this when developing future policy direction for this key resource.

Catchment Management

Catchment management, especially policy and regulation around nutrient use, is part of farming in the European Union (EU). The EU has put pressure on member states to improve the quality of their water resources. Failing to deliver improvements could lead to fines and tougher regulation in the future.

The EU Nitrates Directive, part of the larger EU Water Framework Directive, focuses on the management of nutrient loading to protect water, both surface and ground, against pollution from agricultural sources. Increasing the amount of nutrients entering a water body can lead to eutrophication which affects the balance of organisms and water quality.

Biodiversity, water and air quality and farm profitability are all benefits from using nutrients more efficiently. Stakeholders involved in any catchment management plan must take a wider view than their individual situations if desired outcomes are to be achieved at the catchment level.

Benefits of research on nutrient use

Northern Ireland has taken a layered approach to look at nutrient use in agriculture. A national summary of nutrient use highlights where surpluses may lead to environmental impacts. Breaking it down into industry usage further identifies target areas. Research funding can then be applied to investigating possible outcomes that will improve nutrient use on-farm that are both economic and practical.

Farm system research in Northern Ireland has not only demonstrated that nutrient efficiencies are achievable, their research has been implemented at the farm level and has lead to measurable results.

Cattle wintering systems are becoming more intensive in New Zealand. Some farmers are even deciding to house their cattle over wetter periods. With these changes happening, it would be beneficial for New Zealand to research the impacts of different wintering systems. Included in this research should be the effects on soil structure, nutrient cycling of N and P as well as soil loss from erosion. Housing cattle adds cost and infrastructure both to house the livestock and to store the effluent produced.

Policy – The collaborative approach

All examples of successfully implemented catchment plans studied during this scholarship were based on delivering on national standards set by Governments. From this, state authorities set catchment policy and implement plans with collaboration from stakeholder input. Policies and plans are different as they relate to specific issues in a given catchment. Having measurable targets, plans that are workable with inclusive strategy and good working relationships between all stakeholders is important for successful implementation. Extension services that were well resourced with staff working directly with land and water managers displayed positive relationships. It was encouraging to be directed to policy officers by farmers who have direct contact with the people employed to manage natural resources at the catchment level. They were open with their opinions and respected each other's roles.

The New Zealand Land and Water Forum is an example of the collaborative approach to getting consensus on future governance around land and water resources. This approach needs to be adopted at lower levels once national policies are established. Adequately resourcing people to work with farmers and other stakeholders in implementing catchment plans will be required. Good working relationships are the key to successful outcomes being achieved to benefit all parties. The Natural Resources Conservation Service (NRCS) of Texas sums this up with their simple but powerful vision - ***"Helping People Help the Land"***.

Figure 1: NRCS Conservation Officers and 6666 Ranchers, 6666 Ranch, Guthrie, Texas

Introduction

As we enter 2011 there appears to be consensus building that some change is needed in the way we manage our land and water resources. New Zealand's foreign earnings have come largely from these resources, both directly and indirectly. This is still the case, and will continue to be as global population growth competes against the ability of these production systems to provide for this growth. The future prosperity of New Zealand will depend on how effectively we manage our natural resources, to provide for the needs of today without affecting the needs of tomorrow.

This should be looked at as an exciting period. Firstly, we have very capable human resources to plan and implement future requirements. Secondly, we have built up a good understanding of these resources and have developed systems that provide the standard of living we are fortunate to have.

So why are there calls for changes to be made around how we are managing our land and water use? We are always improving our understanding and continually developing systems to best use these resources. Some changes have happened quickly even in the short period (10 years) that the author has been managing agricultural production systems. Flow-on reactions from these changes can often take a lot longer to measure or visualise due to the biological complexity of the activity.

New Zealand agriculture has developed some very good measures that have enabled managers to measure their performance. Production and price are two such measures. They both can have true physical parameters attached to them and effective management can therefore be used to achieve desired results. What is also important is that New Zealand farmers have developed these measures and the management systems to fit, largely from experience and their knowledge of the available resources and the achievable outcomes.

Has New Zealand been somewhat complacent about setting measures around land and water use? New Zealand is in a better position than some of the countries we compare ourselves to. Our nearest neighbour Australia has greater water scarcity issues and in the United Kingdom biodiversity and water quality is under greater pressure than in New Zealand. Both, however, appear to be investing more resources into improving desired outcomes and New Zealand will benefit from exploring their knowledge.

"The big challenge will be for the real benefits of biodiversity and the hard costs of its loss to be included in our economic systems and markets." (Hilary Ben, the UK Secretary of State for Environment and Rural Affairs (BBC, 2010)).

Valuing the benefits of our water and placing a cost on its degradation will play a role in the future management of this important resource.

The relationships between central government setting national standards, regional authorities who set catchment policy and the land and water users who ultimately manage the outcomes are critical. Breakdowns have undesirable outcomes, no more evident than the situation with Environment Canterbury here in New Zealand. In 2010 the elected council of Environmental Canterbury was replaced by a government appointed commission due to dissatisfaction with the performance raised by local mayors and others.

The aim of this report is to raise suggestions that can be used to provide recommendations for catchment management in New Zealand. This will not be a wordy policy document. It is targeted at where action is needed, from national government through to the people who manage the land and water resources.

Water Supply

Water use for activities like irrigation relates to catchment management because that water is sourced from a catchment and is then used within a catchment.

Storage

Australia has several different types of storage systems for water. Differences between states exist for operating the storages and this can lead to different outcomes.

Without storage the amount of water available for use in Australia would be reduced severely. Many storage systems hold multiple years" worth of storage water such is the wide variation in climatic conditions experienced on this continent. For example the Murray Darling Basin Catchment receives an average annual rainfall of 530,618 Giga-litres. Of this, 94 percent will evaporate, two percent drains into the ground, and the other four percent becomes run-off. Even with the present scale of storage infrastructure in the Murray Darling Basin there are suggestions that still further storage infrastructure should be developed. It will be interesting to see in the coming years what approaches Australia takes.

May 2010 was a great time to look at irrigation in Australia. Many of the areas visited had been in drought for most of the past decade. Water available from storage during this drought period was often below 20 percent of the entitlements owned by farmers. However in spring and now in early summer (December 2010), flooding events throughout eastern areas of Australia have officially ended the drought. If additional storage was available it would have had significant inflows into its storage. The Murray Darling Basin Plan document is currently under consultation. One of the likely outcomes of the plan in its present form will see reductions of around 25 percent of current water available for consumption.

Australia requires storage for a large amount of its irrigation needs due to variation in annual rainfalls, river flows and evaporation.

Compared to Australia, NZ storage systems would only be needed to supplement river flows during low flow periods and therefore need not be as large as those in Australia.

NZ's largest and only storage based irrigation scheme has 91GL of storage capacity in the Opuha Dam in South Canterbury.

Management of Storages

Multi-year Storage systems

In Victoria the companies that manage the storage systems are owned by the State Government. Goulburn-Murray Water (G-MW) was formed in 1994 and manages systems involving 70 percent of the State of Victoria's water storage, including all Victorian Murray River Entitlements set by the Murray-Darling Basin Authority. The 16 storages used by G-MW have a combined capacity of 9,000 gigalitres (GL). The Hume Dam is the largest storage reservoir of the Murray River system with a capacity of 3,036GL. It is managed as a multi-year storage system, which means that not all of the water will be released for use within one year.

Murray Irrigation Limited (MIL) in New South Wales was formed in 1995 and is situated across the Murray River from the G-MW irrigation area. Like G-MW, MIL is reliant on multi-year storages and even shares storage with G-MW. However, unlike G-MW, ownership in MIL was transferred to the irrigators. It is Australia's largest private irrigation company with each irrigator-landowner a shareholder in the company.

(Note: The New Zealand Government transferred ownership of the Rangitata Diversion Race (RDR) scheme to a user-owned company, the Rangitata Diversion Race Management Limited in 1990. The RDR is New Zealand's largest irrigation scheme, irrigating 66,000 hectares of land in the Canterbury region).

Security of water supply allows higher allocations to farmers within the G-MW irrigation scheme during drought years compared with farmers serviced by the MIL scheme. Permanent perennial crops like grapes as well as farming systems that need reliable water supply like dairy farming are more common in Victoria. Water use is more "opportunistic in New South Wales" (Fehring 2010). An example is the SunRice rice-processing mill out of Deniliquin, New South Wales. It is only operated when rice is produced in years of high water allocation, whereas Tatura Milk Industries Limited in Tatura, Victoria has been operating since 1907 and currently has 330 farmer suppliers.

Annual Storage Systems

Not all irrigation schemes in Australia are based on multi-year storages. The Macalister Irrigation District is managed by Southern Rural Water based at Maffra in Victoria. The main storage of this scheme is Lake Glen Maggie (177GL) which is run as a "fill and spill" scheme. The water which fills the lake in the winter period is used over the irrigation season. Macalister Irrigation District has 38,000 Hectares (Ha) of area under irrigation.

Looking from a catchment point of view, this could be used as a good comparison for potential New Zealand storage-based schemes which are currently under investigation. At the top of the catchment there are hills and native vegetation which capture rainfall, Lake Glen Maggie provides the storage. The middle of the catchment contains land suitable for a range of water uses from irrigated farmland and processing industries to residential townships. The lower catchment is the location of the internationally ecologically important Gippsland Lakes network. The largest of these lakes is Lake Wellington. Lake Glen Maggie storage is situated on the Macalister River. The river is used as part of the water distribution system to the town of Maffra before it is diverted to a channel via the Maffra Weir.

Urban Water Storage

Not far from Lake Glen Maggie is the Thomson Reservoir. It took 15 years to plan and build, with completion in 1984. Thomson Reservoir represents 60 percent of Melbourne Water's storage capacity which is 1,068 GJ or equivalent to twice that of Sydney Harbour. The state-owned company Melbourne Water manages the supply of this water to the urban areas around and including the city of Melbourne.

Thomson was designed to be Melbourne's "drought reserve" to stockpile water in wet years to be drawn down in dry years. It has been full three times; 1992, 1993 and in 1996. It has served its purpose well. From being full in 1996, storage levels dropped to just 16 percent by mid 2009. Fortunately the drought that lasted 14 years officially ended in the spring of 2010 and Thomson has recovered to 36 percent of capacity in December of 2010.

In the spring of 2009 the combined storages of Melbourne Water reached a record low of 25.6 percent of full capacity. To highlight Australia's rainfall variation, at 20th of December 2010, due largely to the current La Niña weather patterns in the Pacific Ocean, good rainfall across eastern Australia has enabled storage levels to reach 53 percent of capacity - a level not seen since 2006.

As a sign of current state policy Melbourne Water has decided it needs to diversify its water operations away from relying on rainfall. By diversifying it means creating the biggest construction project in Australia by building the Wonthaggi Desalination Plant. At a cost of $A3.5 billion and employing 3,000 people during construction this plant will produce 150 billion litres (150GL) of water per year. Household water bills for residents in Melbourne will reach $A 1,000 per annum in 2011.

In New South Wales and Victoria storage is the key component for irrigated farming systems. Storage is also an integral part of urban water supplies. They hold the water resource captured from runoff within large catchments to benefit multiple uses from rural irrigation to urban consumption.

How water from these storages is used is currently a very topical subject in Australia. The recent drought period through of the 2000's has had impacts on the environment. The Australian Government has been buying water from farmers to use for other uses. Water for protecting in stream and flood plain biodiversity has benefited from the government purchase irrigation water to be used for environmental flows.

Figure 2: Lake Glen Maggie, Macalister Irrigation District, Maffra, Victoria

Volume-based Measures

A difference between NZ‟s and Australia‟s water use, is the way it is measured. In NZ flow rates, i.e. litres per second (l/s) are the main way in which allocation and abstraction are described. Run-of-river irrigation schemes in NZ also use flow rate to describe their water take and demand. The flow rate of larger water takes are measured as cubic metres per second (m^3/s) and informally known as cumecs. In Australia all water allocation and storage observed during this study tour were measured as volumes usually expressed in megalitres (ML) or gigalitres (GL), where a ML is equal to one million litres and a GL is equal to one billion litres (1,000 MLs)

Using volume as a measure of a water allocation makes sense. Water users then state their allocation or entitlement by volume. They also use volume when describing application rates. In NZ it is more likely that water abstractors will tell you what the flow rate of their consent is. Continuing from this they may then state the depth in millimetres for the measure of application rate.

A NZ farmer, asked about his irrigation system for example, will likely state that he can pump 40 litres per second from his bore and that he applies 600 millimetres of irrigation per hectare over the season. An Australian farmer will state that he owns 700 ML of water entitlement and applies six megalitres per hectare (same as 600 millimetres per hectare).

If NZ's aim is to encourage the highest Water Use Efficiency (WUE) then using volume as the main way to measure water use is a priority. Firstly, this will aid the uptake of Australian research by New Zealanders, and secondly, it gives users measures to manage efficiency.

Resource Management Act consents need to be equably based and this is best done through volume measures being the main basis of any water allocation. Schemes which currently supply or charge for water using a flow rate or per hectare basis, should look at volume-based measures for charging. (This will be raised further under water trading.)

The NZ Ministry for the Environment has just passed a law that will require all consents over a minimum take of five litres per second to be metered. Data from this metering could be used to provide volume-based information about water use.

Water Guru - Max Fehring

While interviewing people in Victoria, the name Max Fehring often came into the conversation. Max Fehring is a dairy farmer in northern Victoria near the town of Cohuna. Max is also Deputy Mayor and a Councillor on the Gannawarra Shire Council. He holds directorships on the Geoffrey Gardiner Dairy Foundation Ltd as well as the Wimmera Mallee Water Authority. He is a former president of the United Dairy Farmers of Victoria, part of the Victorian Farmers Federation.

His name came up so often due to his involvement, at governance levels, with water issues in Victoria. In 1997 Max was awarded a fellowship by the Winston Churchill Memorial Trust where his study topic was on water sharing and disposal between agriculture, urban cities and the environment. The conclusions and recommendations of his report "Water=Key to Life" are still relevant today. Some of these recommendations are as follows:

- Set clearly defined levels of water security (the reliability of water supplied). This is the key to long term investment in water and sound water use.
- Identify water improvement projects and seek joint funding arrangements with State / Federal Governments and other interested parties.
- Raise the profile of water use and encourage research on responsible water use.
- Continue to pursue effective water use, otherwise society will be limited in the development of higher achievement in people skills, value added industries and social cohesion.
- Rural water authorities in Australian States should undertake work exchange programs and study tours to visit other irrigation systems of similar nature, interstate and overseas.
- Maintain contact and dialogue between water users, including cities, towns, environmental groups, catchment authorities, local government, rural water authorities and other state groups to maintain an integrated focus by all those with a vested interest in water.

This last point is very important. NZ has started a collaborative approach with the Land and Water Forum. It is important that this approach is used not only at the high level as in the case of the Land and Water Forum but right throughout the policy and management of water in NZ.

An important take home message from Australia came from a statement made by Max.

"The two most important aspects of irrigation are yield and security. Yield provides potential and security allows potential to be achieved".

"Security encourages confidence to invest," Max says. Victoria has been more conservative with water allocation and therefore has higher reliability within the government-controlled water companies. NSW water is managed privately, yield is higher but security is lower. This has lead to systems where opportunistic water use is evident, for example annual crops such as rice being grown in years where water availability is higher.

The Fehring family knows the value of land and water. These resources are key to the operational activities and the financial viability of their business. That is the reason why they are the biggest assets in the business. Their 180 hectares of dairy farm land is valued at $A 450,000 along with water rights of 720ML valued at $A1,400,000.

One of the roles for the NZ Government commission appointed to run Environment Canterbury is to develop a Water Strategy for the region. Max Fehring's knowledge of water management and his governance experience is an example of the international expertise available to help develop water strategies for NZ

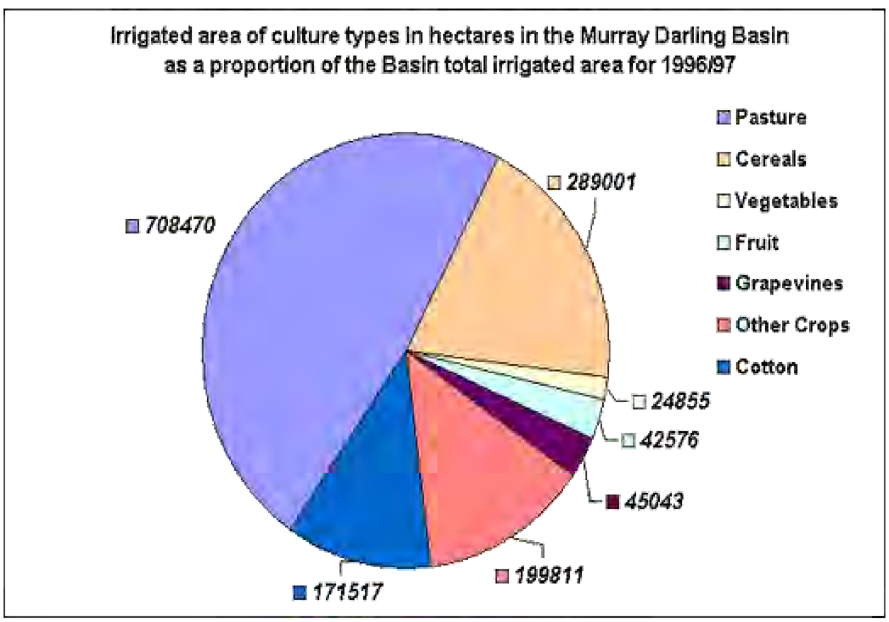

Figure 3: Irrigation in the Murray Darling Basin
Source: ABC AgStats 2007

Water Trading

Water trading in Australia is based around the buying and selling of water entitlements or allocations on either a temporary or permanent basis. What is being traded is the rights relating to how the water is used rather than the purchasing or selling of the water itself.

What was interesting from visiting irrigated farms in both Victoria and NSW was that they had clear values, separately, for both their land assets and their water assets. Australia decided in 2002 to separate water and land property rights. In Victoria, land entitlements are recorded in the Victorian Land Register, water entitlements are recorded in the Victorian Water Register. Investment can therefore be directed to where the value is created.

NZ's current approach, where resource consents for water are structured under the 1991 Resource Management Act, has lead to what is described as a "first in, first served" approach (Lange) which is a very individualistic way of managing a public good.

This approach has also lead to the economic value created by the resource of water being capitalised in the land value, as there is no active market for trading water in NZ. Value should be associated with the resource where the value is created to provide a platform for the best long term sustainable management of that resource. The current approach is not sustainable as future water requirements will put pressure on both the surface and the ground water supply to meet this need.

It is my belief that water trading is already happening in NZ. When irrigated land is sold or purchased on the basis of its productive returns, then any of the production generated by the use of water allocation therefore carries a capital value that is expressed in the land value. This needs to change so that that value is decoupled from the land value, effectively what Australia has done. Below are reasons that this report suggests lend support to the development of a water-trading market in NZ.

Hillary Benn's BBC statement (Ben, 2010)

"Perverse subsidies and the lack of value attached to the services provided by ecosystems have been factors contributing to their loss. What we cannot cost, we don't value - until it has gone".

NZ's current first in, first served approach to water allocation is fast putting pressure on water resources in some NZ catchments.

Water Requirements

NZ Research shows that plants that receive irrigation when under water stress, respond to that irrigation by producing more biomass. One research paper showed a response of 20 kilograms of dry matter production per millimetre of irrigation applied per hectare to a mixed rye grass and clover pasture (Moot, 2006). Different plant production systems require differing amounts of irrigation for differing periods of time. For example, a pasture system growing through the spring, summer and autumn period may receive 6ML of irrigation per hectare over the irrigation season. A winter sown cereal system will receive less irrigation as its water requirements are lower and, being an annual crop, water will not be required after grain-fill in early summer. This system is likely to receive around 2ML per hectare.

Table 1: Returns per volume of water - NZ

Gross economic returns gained from irrigation on a volume basis between different farming systems

Crop / Farming System	Response per ML of Irrigation	Upper level response per hectare	Economic Value (2010) per ML
Pasture - Dairy farming	1,500kgdm pasture (100kg Milk Solids)	6 ML during the growing period	**$700.00** (based on $7.00 / kg Milk Solid)
Milling Wheat - Cereal Cropping	2,500kg grain	2 ML during growing period	**$800** (based on $320 / tonne Milling Wheat)
Rye Grass - Seed production	250kg of dressed seed	2 ML during growing period	**$500** (based on $2.00 / kg of Dressed Seed)

Source: Paul McGill 2010

The table above shows that although the economics are similar on a per volume basis, the upper limit of application is three time higher on the pastoral system allowing for a higher per hectare increase in gross income. When this is capitalised in land value, it limits the opportunity for that land to return to a system that requires a lower water use per hectare even though the margin on a volume basis may be similar.

Value the Resource

Not only will water trading value the resource, it will allow investment to aid in its long term management. There are many discussions on how NZ needs to invest in water storage. The current Minister of Agriculture has stated that it is not that NZ is short of water it is just that it often falls in the wrong place and at the wrong times. However, it is the cost of building suitable dams and of servicing the capital that is restricting these developments. Federated Farmers of NZ has called on the Government to invest in the infrastructure for the economic benefit of NZ. Investment will be needed from many sources including the water users. There needs to be returns for all parties involved before any new developments will occur.

If NZ had a water market to value water use, capital for upgrading, further development and new schemes might be easier to finance. Water storage would realise further irrigation yield and enhance the security of future irrigation developments. Storage is a more expensive option than the current individual approach based on surface or ground water allocation. Until they are valued appropriately regionally-based schemes incorporating a storage component will be at a cost disadvantage.

Modernisation

Open channel water schemes for domestic and stock water requirements are an inefficient way to deliver water. A water market may at some point value the resource, and it would then make sense to modernise the scheme and trade the surplus water requirements. This was the case for the funding partners for piping the Wimmera Mallee Domestic and Stock Channel System. Most of the water savings are being returned to the environment while still allowing for some additional growth within the scheme.

Although these are some of the reasons why water trading could be beneficial for the long term management and efficiency of use, it will not solve all the issues going forward. Not everyone will agree that water should be tradable and there may also be issues around The Treaty of Waitangi between the Crown and Maori. For an overview on the pros and cons of water trading in NZ a useful resource to read is “Water Trading in NZ - Grappling with the Issues” (Lange).

Nutrient & Catchment Management

'A focus of European Union Water policy'

One of the key benefits of the Nuffield Farming Scholarship is the opportunity for one-on-one interviews with people. They share their knowledge in a way that somehow allows the brain to file a key message that is easy to recall. Two such statements from different people will make a good lead into this section.

"Nutrients are the oil of the 21st century. The nation which looks after and re-uses them, will prosper both economical and environmentally. It will never hunger".
Prof. Julian Cribb, Nutrients and the future of Australia - Nutrient Discussion Paper (Cribb, 2010).

"Lost energy is wasted energy as it is less concentrated and therefore less useful. Pollution is not useful as it degrades other useful resources".
Prof. John Ikerd, speaking at the Nuffield Contemporary Scholars Conference, Washington DC, March 2010 (Ikerd, 2010).

Often nutrient management is focused on reducing the environmental impact of losses to the environment. The comments above mention it in the context of energy. Good nutrient management practice will improve environmental outcomes, farm production and the direct and indirect efficiency of resources. The approach to catchment management should be seen in the same way. Improvements to water quality and the ecosystems it supports will improve on-farm efficiency both financially and biologically.

Regulation like the EU Nitrate Directive and Regional Plan Variation 5 in the Lake Taupo catchment here in NZ, indicates that future policy concerning nutrients entering water bodies will become a focus of future policy.

The two main nutrients used in global agriculture for plant production that can have significant impacts on water quality at a catchment level are nitrogen (N) and phosphorus (P).

It is common for one of these to be the limiting nutrient in aquatic ecosystems. Where this is the case additions of that nutrient can lead to eutrophication and its resulting effects on the ecosystem. P and N can enter water systems in various ways so policies and management need to account for this. Improvements in water quality in a given catchment may be best achieved by focusing on the limiting nutrient of the two, as policies in different member states of the EU show. The ability to focus on the main issues when looking at catchment management and water quality is important. However, because they are complex biological systems, solutions need to be structured at the catchment level.

Eutrophication

Eutrophication is the process whereby excess nutrients in the water, in particular N and P, result in an over-abundant growth of algae and plants, which affects the balance of organisms, and water quality. Eutrophication in fresh water arises mainly from excess inputs of P from sources such as farming, industry and sewage. Excess inputs of nitrates also contribute to eutrophication especially in saline waters i.e. estuaries, coastal and marine waters. Algal blooms can be associated with eutrophication. P is normally in short supply in fresh water so it is sometimes referred to as the „limiting nutrient" and the same applies to N in salt water. However studies have shown that both nutrients, either together, or in turn can be the limiting nutrient in both types of water.

Two significant global cases of these events during 2010 were a blue-green algal bloom in the Baltic Sea covering 377,000 square km. The BBC reported that this was the largest bloom since 2005 and was partly due to lack of winds and high summer temperatures. The article added that fertilisers from surrounding agricultural land washed into the sea had exacerbated the problem" (BBC, 2010).

The summer flooding in Eastern parts of Australia has lead to concerns with "black water" events in the Murray-Darling river systems. Black water is eutrophication caused by a rapid breakdown of leaf litter and the nutrients thereof entering the water. The lower oxygen levels make the water go a black colour. Hundreds of the Murray Cod, a native fish species have died as a result (ABC, 2010).

EU Nitrates Directive (91/676/EEC)

The Nitrates Directive was first introduced in 1991 and is designed to protect water against pollution across Europe by preventing nitrates from agricultural sources polluting both ground and surface waters. The directive is the part of the Water Framework Directive (WFD) which focuses on agricultural practices. The primary emphasis is on the management of nutrient loading from animals, manures and other Fertiliser.

Water sources that are used or intended to be used for drinking water, which have a nitrate concentration greater than 50mg / litre are defined as polluted. Natural waterways, both fresh and saline, that are eutrophic, or at risk of becoming eutrophic, are the other water pollution areas that the directive is aiming to reduce. Member states must designate "Nitrogen Vulnerable Zones" in catchments where polluted waters, or waters at risk of pollution are present. Codes have now been established for farmers to take measures aimed at reducing pollution including:

- limiting when fertilisers including manures can be applied to match plant needs
- taking care how they are applied around water ways
- having minimum storage capacity requirements for livestock manure
- managing the winter cover of land to limit leaching during wet seasons
- achieving an Organic Nitrogen Loading (ONL) less than 170kg per hectare (derogation available to grassland out to 250kg per hectare).

Prescriptive Policy

Farmers find much of the policy within the Nitrate Directive to be prescriptive. An example of this is the calendar approach to when slurry and manures can be spread. In recent years there have been periods in late winter when conditions suited spreading but farmers were restricted from doing so only to find that wet conditions in the spring further delayed application.

Another example of a prescriptive measure is the set level of the ONL. This level was set more for countries like Holland where intensive farming systems occur with dense populations. When farmers cannot calculate how a measure is arrived at they find it hard that the measure can be just forced upon their way of farming.

This is not only a European Union issue. Horizon Regional Council in NZ tried to implement policy on nutrient restrictions for land uses. Known as the "One Plan," farmers were alarmed at the proposed measures and have put huge pressure on the council to change the policy.

Due to the Common Agricultural Policy and associated Single Farm Payments, it is easier for the EU to implement regulation on farming. Uptake of policy is required in order to receive payments. NZ does not have this option. Therefore, any policy will need to be implemented in collaboration with the regional authorities and those responsible for achieving the desired outcomes. Agreement on setting of measures to achieve the desired outcomes will always be a hard point between the parties involved. If they are too restrictive farmers will find it hard to agree to them and it could put considerable economic pressure on their businesses. Although, if set too low, measures that lead to better environmental outcomes will take too long to show results if at all. This will then, only lead to tougher requirements at a future time.

Figure 4: Slurry Spreading, AFBI, Hillsborough, Northern Ireland

Northern Ireland

Both Northern Ireland and Ireland have designated their whole territory under nitrogen Vulnerable Zones. Although P is the main issue with water quality in Ireland and Northern Ireland, the Nitrate Directive applies, due to eutrophication and risk of eutrophication of water bodies. Northern Ireland successfully gained derogation for intensive grassland farms as a phase in period for the Nitrate Directive. In order to receive derogation, Northern Ireland agreed to undertake research activities aimed at measures that could be adopted by farmers as best practice to improve the water quality of catchments.

Northern Ireland is a good place to look at catchment management for a number of reasons. Lough Neagh, the largest lake in the United Kingdom, is situated there. Lough Neagh and its out-flowing river the Lower Bann drain 38 percent of Northern Ireland catchment area as well as some from Ireland.

In terms of water quality the lake‟s status is hypertrophic containing 120 micrograms (mg) phosphorous (P) / litre. According to Bob Foy, research scientist at Agri-Food and Bio-science Institute (AFBI) in Belfast, Lough Neagh contained less than 20mg P / litre one hundred years ago. It reached 140mg P / litre in the 1990s and will have to continue to fall below 80-90mg P / litre before any change will be seen in water quality. A lower limit of 35mg P / litre is used to define eutrophic lakes (Foy, 2010).

Agriculture is said to be the source of 62 percent of the P-loading entering Lough Neagh and 75 percent of the nitrogen-loading (Foy, 2002). According to the Department of Agriculture and Rural Development, Northern Ireland, 58 percent of P losses to inland waters in NI were from agriculture prior to the implementation of the Nitrates Directive in 2007 (DARDNI). Therefore agriculture will have to play a key role if water quality is to continue to improve from its current state.

Phosphorous losses

In the period post World War II, compound fertilisers containing both N and P were commonly applied to grassland to increase production. Excessive use then, has elevated soil P levels above that required for agronomic optimum under a grassland system. Under derogation one measure put in place for Northern Ireland was to limit P use both from fertiliser and feed inputs. For P fertiliser to be applied there has to be a shown need from a soil test. If P is applied as fertiliser, the surplus over what is exported off the farm in products must be kept to less than 10kg P per hectare per year.

Currently P fertiliser use in Northern Ireland has reduced to 1935 levels and the average surplus is 8kg P per hectare per year (Foy, 2010). This compares to a surplus of 16kg P per hectare per year prior to the implementation of the Nitrates Directive in 2007. Livestock systems where high rates of concentrates (meal, grain etc) are fed, find it hard to keep P surpluses below 10kg per hectare even if no fertiliser P is applied. The P-loading is coming from the concentrate feed inputs on these farms.

P mainly enters water attached to soil. Soil erosion from slopes or as overland flow will enable P to enter waters. Large animals accessing waterways also cause erosion and sediment disruption, therefore acting as another source for P to enter into waters. Another source for loss is from P contained in animal manure when it is applied to pastures during wet periods. This is one of the reasons that closed periods for applying manure and slurry to land is enforced in Europe.

AFBI research farm at Hillsborough in County Down, Northern Ireland has completed and is currently undertaking research work that aims to reduce P losses from farming, especially from intensive grassland systems. Management strategies from one such research paper (Ferris, 2002) include:

- reducing the use of Fertiliser P
- reducing stocking rates
- reducing the P content in inputs of feeds.

Nitrogen Losses

Regulations concerning N use and nitrates in ground water are more of an issue in Britain than in Ireland. These need to be addressed under the Water Framework Directive and improvements by 2015 will need to be shown in order to avoid facing fines and tighter regulations on farming and industry.

ONL is a measure of the amount of N either excreted directly by the animal or applied as slurry and manure from housing. Rates of N produced by animals used as guidelines for Northern Ireland are shown in the table below.

Table 2:

Nitrogen Produced by Livestock on the Farm (Sheep and Cattle), Northern Ireland

Type of Livestock	Total N produced / yr / unit (kg N / yr)
Cattle	
Dairy Cow (550 kg)	**96**
Dairy Cow (450 kg)	**76**
Cattle 12-24 months (400 kg)	**58**
Bull Beef 6-12 months	**23**
Sheep	
Sheep	**9**
Finishing Lamb (6-12 months)	**3.2**
Finishing Lamb (0-6 months)	**1.2**

Source: Nitrates Action Programme, Northern Ireland

The table shows that even with derogation stocking rates, a dairy system would need to be less than 2.5 cows per hectare to stay under the 250kg ONL per hectare per year. Otherwise additional land would need to be used to reduce the ONL by exporting some of the farms stored effluent. Sheep and/or beef farms are mainly less intensive grassland systems so typically fall below the 170kg ONL per hectare.

Northern Ireland has a collaborative approach not only to catchment issues but to agriculture in general. Being a small country may make it easier to identify and work with different stakeholders, also, the Department of Agriculture and Rural Development co-ordinates funding for agriculture centrally. This avoids some of the duplication that occurs in other countries, including NZ.

Figure 5: Dr Conrad Ferris (left) **explaining a dairy systems trial. AFBI, Hillsborough, Northern Ireland**

Nutrient Summary

Northern Ireland takes a layered approach to identifying nutrient usage and losses. This information shows where issues are present and what the key areas are that need to be addressed.

National Level

An agricultural summary of inputs and outputs of each nutrient identifies potential surpluses that could contribute to losses from farming systems.

For example, a summary for P use for Northern Ireland in 2000 (Foy, 2002) showed inputs from fertiliser of 9,601 tonnes and another 9,310 tonnes from animal feed inputs. Outputs of P in arable, milk, beef, sheep, pig and poultry products combined amounted to 6,062 tonnes exported of farms. This therefore leaves a surplus of 12,849 tonnes of P. Although most of this surplus accumulates in the soil, a small proportion enters rivers and lakes affecting water quality. As surpluses increase soil P levels the chances of losses to water also increases.

Industry

From the national nutrient summary agricultural industries are able to identify their contribution and educate farmers accordingly.

The data for the year 2000 shows feed inputs used by the dairy industry contained 3,025 tonnes of P, with outputs in milk amounting to 1,539 tonnes. This showed that even before P inputs from fertiliser were included the average dairy farm had a P surplus.

Research

Given the surplus identified above, research trials were approved and funded to see if the amount of P fed to dairy cattle could be lowered to improve efficiency of use, animal health and environmental outcomes. Trials at Hillsborough Research Centre lead by Dr Conrad Ferris (Ferris, 2002) and the dairy team there have shown that markedly reduced P levels in concentrates fed to lactating dairy cows reduced the rate of excreted P with no effect on milk production, quality or cow fertility.

Research on nitrogen usage also helps to set the organic nitrogen loading figures in Table 3 for the Nitrates Directive in Northern Ireland.

Animal

Research like that mentioned above shows why it is often said that the risk of nutrient loss is higher from the animal than from the application of nutrients as fertiliser. Levels of both P and N fed to livestock exceed that required by the animal. Therefore, even though pastoral production increases, the animal in many cases will not require the additional nutrient levels consumed.

Soil

Many soils in the United Kingdom and Ireland have soil P index levels in excess of crop requirements. Much of this is due to the period of large increases in fertiliser use and food production in the 30 year period post World War II. As part of the Nitrate Directive implementation in Northern Ireland restrictions have been imposed on P fertiliser use where P surpluses are happening and soil indices are too high. This has resulted in fertiliser P inputs significantly reducing to levels not seen since 1935 (Foy, 2010).

NZ also has a farm level nutrient budgeting computer model called 'Overseer'. This model was developed by Agresearch and is proving a valuable tool for farmers and fertiliser industry representatives alike. As part of the 2003 NZ Dairying and Clean Streams Accord a national performance target has been set of 100 percent of dairy farms to have in place systems to manage nutrient inputs and outputs by 2007. This has been implemented largely due to good collaboration between the dairy and fertiliser industries.

This report supports the layer approach adopted by Northern Ireland as a stock-take on where the NZ agriculture nutrient summary stands at present. Correlation of Overseer nutrient budgets from different farming operations spread throughout NZ could be of great value in this process. That is of course provided that it is available for use in this manner.

Wintering systems

One of the main differences between NZ livestock systems and those in many European Countries is the different approach taken to wintering livestock. In NZ livestock are mainly wintered outside on pasture and crops, while in Europe they are mainly wintered inside and feed silage, straw, grain and other supplements. This is said to be an advantage to NZ farming due to our temperate climate. There has been uptake of outdoor wintering of cattle on crops in the UK, while some NZ farmers have started to invest in housing for cattle during winter and other wet periods.

Two dairy farmers visited during this research tour were wintering cattle outside, one in northern Wales and the other in southern Scotland. Both of these properties were situated in areas of the UK that are not designated as Nitrogen Vulnerable Zones under the Nitrates Directive. Currently 62 percent of England and Wales is currently designated as Nutrient Vulnerable Zones (EA, 2008). If intensive cattle farming continues to increase in areas not designated as Nutrient Vulnerable Zones and outdoor wintering use continues it is likely that the Environment Agency will be placed under pressure from the EU to increase Nutrient Vulnerable Zones.

Cattle numbers and intensive pastoral farms that support these animals are increasing in NZ. Specialist farming operations that produce supplement feed and grazing for these cattle have increased also. Wintering these cattle on brassica crops enables high yields of available feed for utilisation during this period.

Visiting Debbie McCall's research work on minimising P losses from Dairy systems at Hillsborough Dairy Research Centre, Northern Ireland, raised some questions about some of NZ's cattle wintering systems. Debbie presented some management strategies for minimising P losses, they were:

- improve soil structure to minimise overland flow
- minimise areas of exposed soil
- improve slurry spreading techniques.

Questions raised:

- How do New Zealand research findings of our different wintering systems for cattle measure up against Debbie's management strategies for P losses?
- What does the nutrient cycle under this management practice look like?
- How sustainable and fit for purpose are these systems at a catchment level looking forward?

Lough Melvin Catchment Management Plan

In order to develop and implement an effective catchment management plan it is necessary to have background information on the actual sources affecting the catchment. As Bob Foy says (Foy, 2010),

"The best way to understand the issues of a lake is to turn your back to it".

This is likely to be the source of the issue. Once the issues are identified a plan must be inclusive and taken up by all parties to incorporate a catchment-level strategy that deliveries the required outcomes.

Lough Melvin is a 2,206 hectare lake with a catchment covering 22,000 hectares. The lake is situated in Co. Leitrim and Co. Fermanagh, Ireland.

The Lough Melvin Nutrient Reduction Programme (Emer, 2008) has been developed to protect this important lake which has been designated as a Special Area of Conservation (SAC) under the EU Habitat Directive. It supports a diversity of habitat and species including unique fish like the Gillaroo and Ferox Trout.

The phosphorous concentration of the lake was around 20mg P / litre during the early 1990s. However, during the early 2000s P levels have been at levels around 25mg P / litre. Due to its SAC designation a nutrient plan has been developed to try and reduce P levels to around 20mg / litre. Like many freshwater bodies in Ireland, P is the limiting nutrient. To achieve this, the P-loading entering the lake will have to be limited to 12 tonnes per year. While agriculture is the single largest source, other significant loadings come from forestry and housing wastewater treatment systems.

Stakeholder Involvement

The nutrient reduction plan was developed with stakeholder participation (Doody, 2010) and this participation process is increasingly becoming accepted as a component of effective policy. This participatory approach worked by developing methods to achieve outcomes. From this, surveys and interviews were carried out with stakeholders in the catchment. Then a preliminary list of measures was presented at a workshop. The agreed measures from this were then evaluated for cost effectiveness, before a final list of measures was developed to form the policy of the Lough Melvin Nutrient Reduction Plan.

This catchment plan is an example which shows that a collaborative approach can work at an implementation level. The Land and Water Forum will report back to the NZ government in March 2011. Hopefully their experience with a similar approach has been seen as positive also.

Policy Extension

Extension services were a key feature in forming positive relationships between land and water managers and the people involved at policy level, in Northern Ireland, Australia and in Texas. When tension exists, there are never any winners in the long term and progress is slow and often expensive. Furthermore the mindsets that develop are often difficult to breakdown. There are different ways to implement these services. Giving them the required resources, and ensuring positive relationships are built, enhances stakeholders desire to play their role for the greater good of the catchment.

Two examples of organisations that nurtured good relationships with farmer stakeholders visited during this Nuffield Scholarship.

Murray Catchment Management Authority (CMA), NSW, Australia

The Murray CMA is one of thirteen CMAs working with farmers and other stakeholders to address resource management issues relevant to their catchment in NSW. The role of the CMA is to ensure communities have a say on how natural resources are managed. They prepare catchment plans and are a key link between the latest scientific information and the knowledge and experience of the local people. NSW CMAs report to the State Minister of Climate Change and the Environment. It was great to be referred to different CMA representatives by the farmers who have a regular working contact with this authority. The discussions about the key issues within the catchment showed that the parties both had awareness of the plans operating and a positive relationship by being open about each other's opinions.

Natural Resources Conservation Service (NRCS), Texas, USA

The NRCS celebrated 75 years of operation in 2010 and was created at the time of adversity during the "Dust Bowl' of the 1930s. The NRSC is an organisation of the United States Department of Agriculture. It was such a pleasure to be hosted by the NRCS in Texas for a week during the Global Focus Tour of the Nuffield Scholarship. Visiting the Texas Panhandle seven decades after the devastation caused by the dust storms highlighted why this organisation was such a positive network of people. Texans are proud people, and the Texan NRCS was proud of the involvement they have in the organization's mission –"Helping People Help the Land." Such a short phrase, but one that really sums up what catchment management is all about. Land is very much ingrained into the culture of Texas. "Texas!" - a play held in the summer months in Palo

Duro Canyon really highlights the history, culture and passion of the relationship between people and the land.

In each district visited the local NRCS District Conservationist would board our tour bus and give an overview of the distinctive features and farming types in the area. When visiting a farming operation, the local District Conservationist and the farmer would both actively convey how great it has been to work together towards a conservation outcome. 90 percent of Texas is privately-owned. The only option for helping the land is to work with land owners to protect their natural resources.

Texas is a large land mass and the NRCS services this area with 217 field officers, one for almost every county. The field officers look after the Texas Soil and Water Conservation Districts and are backed with the NRCS teams of agronomists, biologists, economists, engineers, foresters, hydrologists, range specialists, resource conservationists and soil scientists. The aim is to work at the community level to help landowners and managers improve and conserve natural resources.

Given the mission of the NRCS it was no surprise that Don Gohmert, the State Conservationist of Texas was a man for the people. He is in charge of a large organisation with a very important role. Don and his staff dedicated a lot of resources to ensuring our tour in Texas would be memorable. It was very obvious from our tour that the people of the NRCS in Texas are equally dedicated to working with landowners to develop conservation plans and manage the natural ecosystems they work within.

"Helping People Help the Land"

Figure 6: Don Gohmerts (back, left) **NRCS State Conservationist of Texas**

Recommendations

New Zealand is making progress on managing land and water resources. Catchment management is an important part of this process, especially within agriculture. Farming in this country is built around the advantages that these resources provide. All stakeholders, including farmers will benefit from policy that protects these resources for the future prosperity of New Zealand and its people.

Governance and Policy

Central government must give priority to setting national standards for the protection of our water bodies. This is also a recommendation of the Land and Water Forum. These standards need to be measurable.

Regional authorities should use a range of instruments including developing catchment plans to achieve these national standards.

An extension service should be developed that will work with stakeholders, such as farmers, to aid implementation of catchment plans. This service could be a role within an existing government agency like the Ministry of Environment, Ministry of Agriculture or Regional Authorities. It could be a role of a new Ministry for Water if that is proposed.

It is important that a collaborative process that includes stakeholder involvement is used when developing policy.

Water

Volume should be the basis used to measure water. This will then change the language used to describe water abstraction and encourage efficiency of use. Water charges should also be based on volumes rather than flow rates or per hectare charging.

Water needs to be given economic value. It is an asset and the value created by using it should be invested in it. Water-trading through an active water authority such as Australia has, needs further investigation. This will decouple the value of water from the value of land.

The current codes that restrict cattle access to water bodies needs to be amended to include all animals that have an affinity for water, on all types of properties, where practical. Where this is not currently practical any future development should try to achieve this outcome.

Nutrient Loss

A National Nutrient Summary should be compiled showing nutrient inputs in the form of fertiliser and feed inputs against outputs from farm produce. Northern Ireland uses these to highlight areas to focus research around.

Nutrient budgets successfully implemented by the dairy industry under the Dairying and Clean Streams Accord should evolve to include set limits on nutrient loss.

Management Plans in sensitive lake catchments like Taupo and Rotorua need to be assessed for their usefulness in other sensitive catchments around New Zealand.

Research

Farm system research needs to focus on all parts of the farming system. Demonstration and research farms have been successfully developed for milking platforms. Hopefully, in the future, funding will become available to extend this to include farm systems that provide support to these farms in the form of grazing and feed.

Research to compare different wintering systems for cattle should also be funded. Cattle numbers on intensive pastoral farms are increasing. Their impacts on land and water within catchments need to be assessed.

Relationships

Structures that encourage good working relationships between the people who are responsible for policy, and the stakeholders who manage the resources, will be critical to successful catchment management strategies.

One highlight of this Nuffield Scholarship study was seeing positive interactions between farmers and extension services working together on catchment, conservation or irrigation improvement projects.

I recommend that relationships like these are facilitated and distributed widely throughout all New Zealand catchments.

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Abbreviations

AFBI - Agri-Food and Bioscience Institute

CMA - Catchment Management Authority

EU - European Union

GL - Gigalitre

G-MW - Goulburn-Murray Water

GWM - Grampians Wimmera Mallee Water

Ha - Hectare

MID - Macalister Irrigation District

MIL - Murray Irrigation Limited

NSW - New South Wales

ONL - Organic Nitrogen Loading

ML - Megalitre

SAC - Special Area of Conservation

UK - United Kingdom

WMPP - Wimmera Mallee Pipe-line Project

WUE - Water Use Efficiency

Appendix

Itinerary

6th of March - 14th of March:

Washington DC & Pennsylvania, USA
Contemporary Scholars Conference (CSC)

6th of May - 4rd of June:

Victoria, New South Wales & South Australia,
Australian Irrigation & Catchment Management Studies

4th of June - 17th of July:

6 week Global Focus Program

Canberra, Australia. Ypres / Brussels, Belgium. Cambridgeshire, UK. Ireland.
Washington DC, USA. Alberta, Canada. Texas, USA. China. Philippines.

18th of July - 1st of September:

England, Wales, Scotland, Ireland & Northern Ireland
Catchment and Nutrient Management Studies

Global Focus Program (GFP) - Tour group

Alan Redfern - Cotton and Grain grower, New South Wales

Ben Hooper - Apiarist, South Australia

Desiree Reid - Dairy farmer, South Island, New Zealand

Brad Stillard - Tomato grower, New South Wales

Ben Tyley - Cray-Fishermen, Kangaroo Island, South Australia

Helen Thomas - Sheep Farmer, South Australia

Paul McGill - Arable and Sheep farmer, North Island, New Zealand

Ed Cox - Dairy farmer, Western Australia.

The only way to put this experience in any form of context would be to go to a farming conference for a week and get an idea of the learning and networking opportunity they provide your business and personal growth. Well, the Global Focus Program is like that except at the end of the week you do not go home, you go to another area of the world and meet some more amazing people, visit different farming systems and continue the knowledge-sharing.

"Our differences make us interested in each other, our similarities provides comfort with one another" - Paul Ford (Gardiner Foundation, Victoria, Australia).

Figure 7: GFP Tour Group at American Cotton Growers Denim Mill, Littlefield, Texas