ENVIRONMENT SOUTHLAND

SCIENCE SYMPOSIUM

Evolution of Knowledge

Value – Change – People

BILL RICHARDSON
TRANSPORT WORLD

INVERCARGILL
26 SEPTEMBER 2018

environment SOUTHLAND
REGIONAL COUNCIL
Te Taiao Tonga

Longridge North, Northern Southland (PHOTO: LES LADBROOK)

Environment Southland is proud to host the first

ENVIRONMENT SOUTHLAND **SCIENCE SYMPOSIUM**

at Bill Richardson TRANSPORT WORLD

ENVIRONMENT SOUTHLAND

Our Vision *– A thriving Southland – te taurikura o Murihiku*

Our Mission *– Working with our communities to improve Southland's environment*

Welcome

GRAHAM SEVICKE-JONES, DIRECTOR – SCIENCE AND INFORMATION

We're proud to be presenting the results of our four-year Southland Science Programme to you today and very pleased to be welcoming you south to our beautiful region.

Graham Sevicke-Jones

Some of you have been involved in various parts of the Southland Science Programme, and we sincerely thank you for your contribution. We couldn't have achieved what we have without you.

The theme today is the 'Evolution of Knowledge'. The programme essentially summarises and showcases what has been learned and how it adds to the evolving foundation of knowledge that is important for sustainable management, and for the Southland community.

The foundation of knowledge that has been built up over hundreds of years of Māori and then European occupation, alongside Environment Southland's years of monitoring data and research information, helps manage resources in the region today.

Environment Southland's past science programmes were either long-term 'state of the environment' monitoring, or more focused short-term investigations.

With the advent of the National Policy Statement for Freshwater Management making it mandatory for regional councils to establish freshwater objectives and to set limits for both water quality and quantity, it was time to review Environment Southland's science programme.

The review identified that the structure of the programme would probably not provide what was needed to inform policy development and then manage freshwater within limits or constraints.

And so, the Southland Science Programme was established and saw Environment Southland partnering with a number of research organisations and stakeholders. The programme was in addition to continuing the existing monitoring programmes.

The purpose of the new programme was to provide a strong conceptual understanding of natural and socio-economic system functions in Southland, to provide the when and where context for community engagement and better management – and specifically to prepare for setting limits under the national policy statement. This was a significant new level of investment by the Council in science, and in working together with other organisations to build a coordinated, integrated knowledge base.

As you know, research is about discovery, and our knowledge has evolved in a way that means new questions have arisen. While some of the original questions were only able to be partly answered, we have also learned things that we hadn't anticipated.

This Symposium offers us an opportunity to reflect on this as we move forward. I hope you enjoy the Symposium, and we look forward to your continued involvement.

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Oreti River, Northern Southland (PHOTO: LES LADBROOK)

A little about Southland

Southland is New Zealand's southern-most region and has a total land area of 3.2 million hectares (or 12% of New Zealand). Of this total area, 59% is land in indigenous vegetation – 42.3% of this is in Fiordland and on Stewart Island.

Southland is shaped by some of the country's most complex geology and it has one of the widest assemblages of soils. The region's northern boundary is marked out by the Livingstone, Eyre, and Garvie Mountains (in Southland) and the Blue Mountains (in Otago). The Southland Syncline (formed by geological faulting) is a geological fold in the earth's surface that creates a thick 'belt' running on a north-west to south-east axis from Lumsden through to the Catlins coast, and is partially buried beneath the Southland Plains.

Around 96,500 people call Southland home. Invercargill is the only city in the region and has a population of around 50,000 people. Other main townships include Gore in eastern Southland, Riverton along the southern coast, and Te Anau, near Fiordland in western Southland. Just over 30% of Southland's population live in rural areas, compared with 13% nationally. The relatively high proportion of people living rurally reflects Southland's reliance on primary sectors, particularly agriculture.

Southland contains a large amount of freshwater, both as surface water and groundwater. The region has six of New Zealand's 25 largest lakes (as measured by surface area), including Lakes Te Anau, Manapōuri, and Hauroko (which are also New Zealand's three deepest lakes). There are also tens of thousands of kilometres of rivers and streams, including the Waiau, Aparima, Ōreti and Mataura Rivers. Together the catchments of these four rivers drain 1.85 million hectares or 62% of the Southland mainland.

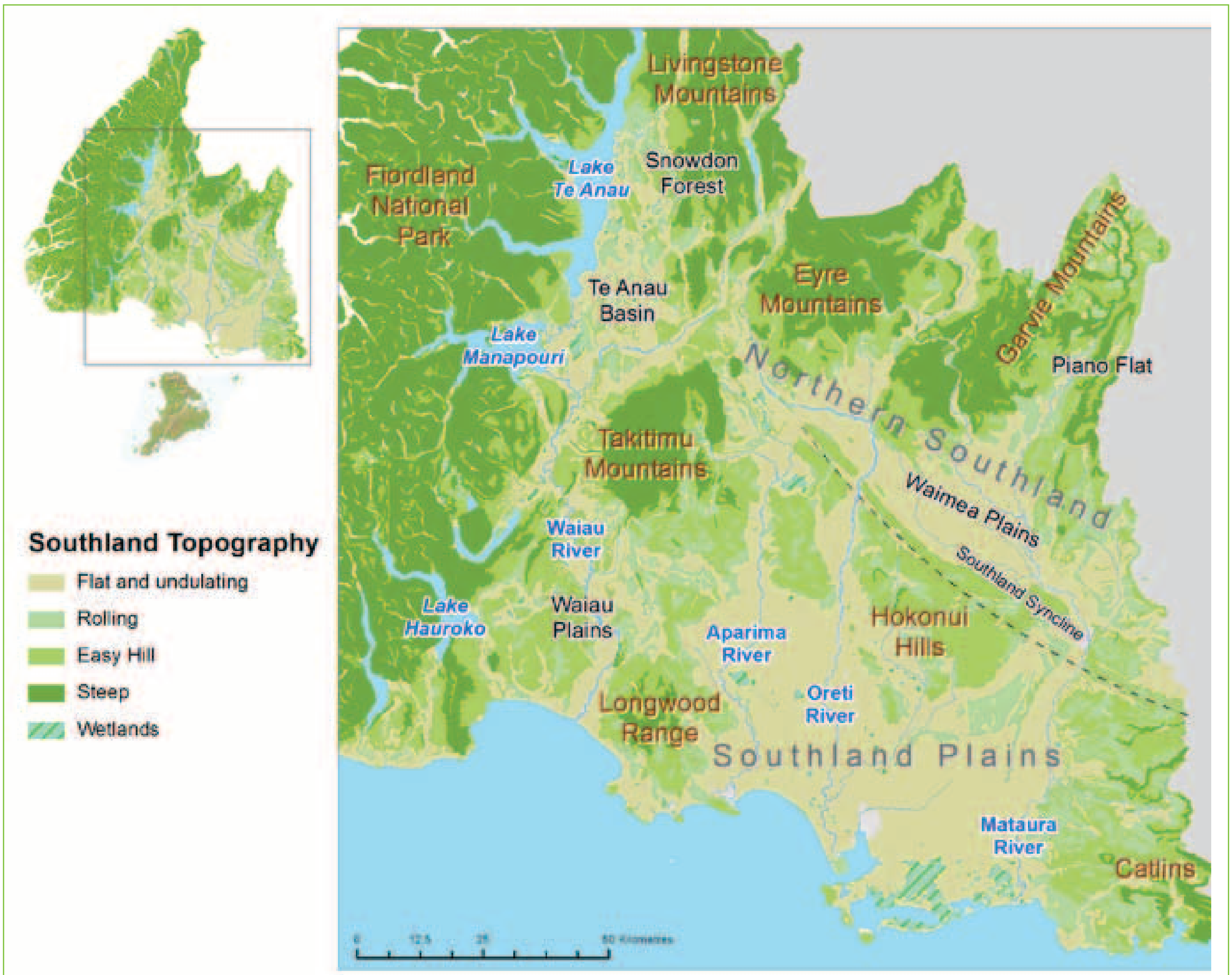
Before Māori arrival, around 268,500 hectares of land in Southland were in wetlands and swamps, most of it across the Southern Plains. Wetlands perform a significant cleansing role in the environment and are also important connectors between surface water and groundwater. Since 1840, it is estimated that the area of wetlands on privately owned land reduced from around 220,000 hectares to 8,486 hectares (or 3.2%) by 2015. The installation of tile and mole drains to enable farming has created direct channels (or pathways) for losses of nutrients to enter surface water, bypassing some natural processes.

Southland has a mosaic of unconfined, shallow groundwater aquifers that exchange groundwater to surface water relatively quickly. Approximately 47% of all of the water in Southland streams is groundwater from these aquifers.

The shallow groundwater table, together with a cool humid climate, mean that groundwater within unconfined aquifers is young, with an average residence time or age of less than 10 years.

Eventually, the regions fresh water flows into 23 estuaries before entering Foveaux Strait and the Southern Ocean.

Southland's water and land is highly connected in comparison to other regions. The environment has influenced the development of agriculture and forestry and, in turn, it has been altered by the expansion of these sectors. Modification of Southland's environment, combined with its natural short lag times, means that water (and the substances that are carried in it) now flows more quickly through the landscape, with fewer opportunities for attenuation.



The Environment Southland science story: evolution of knowledge

Purpose of the Symposium

We would like to:

i) Celebrate the completion of the four-year Southland Science Programme (2014-18) with many of its participants and Environment Southland's partners and stakeholders;

ii) Summarise and showcase what has been learned and how it adds to the evolving foundation of knowledge that is useful for sustainable resource management and for the Southland community; and

iii) Signal where we are going with the next evolving phase for Southland Science, and to welcome your continued involvement.

Where have we come from?

Environment Southland has many years' worth of monitoring data and research information. In combination with the foundation of available knowledge built up over hundreds of years of Māori and then also European occupation, this helps us to manage natural resources in the region today.

Pre-2014, Environment Southland's science programmes were either long-term 'state of the environment' monitoring of state and trends, or short-term investigations into specific issues. In 2013, a science review identified that these types of programmes did not always provide well for the type of science needed to inform policy development. In particular, the National Policy Statement for Freshwater Management (NPSFM) in 2011 made it mandatory for regional councils to establish freshwater objectives and to set associated limits to resource use for both water quality and quantity. This requirement placed considerable additional demands on science to identify the total capacity of catchments for cumulative resource uses, rather than continuing to assess the effects of multiple case-by-case specific issues. It was clear that our science programme needed to adopt a new approach.

Southland Science Programme 2014-18

In 2014 Environment Southland partnered with several research organisations and stakeholders to embark on a comprehensive new four-year science programme. This body of work was undertaken in addition to our existing monitoring work. The purpose of the new science programme was to provide a strong conceptual understanding of the functioning of natural and socio-economic systems within Southland. We used this understanding to provide a spatial and temporal

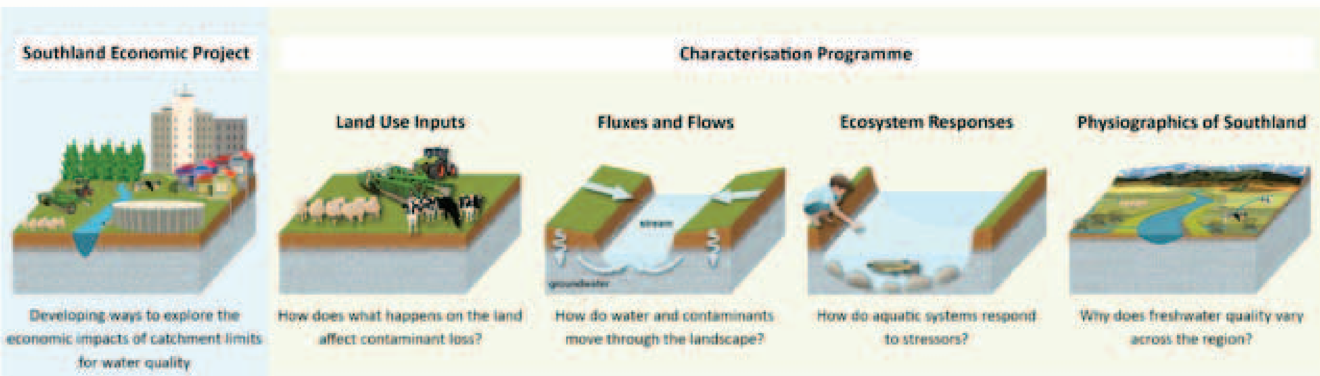


Figure 1: Southland Science Programme (2014-18) comprising the Southland Economic Project and the four components of the Characterisation Programme.

Table 1: Summary of the purpose and high-level research questions of the five components of the Southland Science Programme (2014-18)

Southland Economic Project	*To work collaboratively to develop ways of understanding the economic impacts of setting catchment limits for water quality in Southland. In particular, the economic impacts of dealing with discharges to land or water from agriculture and towns.* • What are the economic impacts of different policy options that satisfy the requirements of the NPSFM? • How will impacts on sector(s) flow through to the rest of the economy? • How might costs to the economy have social and cultural impacts on our local communities
Land use inputs	*To identify and fill critical knowledge gaps in the field of contaminant sources, loadings and transport associated with rural and to a lesser extent, urban land use. A longer-term priority includes conducting or facilitating research into high contaminant loss land uses or landscapes to help improve catchment models and a conceptual understanding of land use losses and pathways of losses.* • Where do contaminants come from and how has this changed over time? • How much nitrogen, phosphorus, microbes and sediment is leaving the land and entering waterways? • How are contaminants attenuated along different pathways?
Fluxes and flows	*To identify the origins of water and the different flow paths, quantify the interactions between groundwater and surface water, assess the role hydrological processes play in the attenuation and transport of contaminants, develop robust conceptual and numerical models, and apply the models to explore different options for managing water and land, and evaluating forecast climate change scenarios.* • What does Southland's sub-surface geology look like in three dimensions? • What does Southland's steady-state and transient groundwater flow look like? • How much nitrogen, phosphorus and microbes are being transported by aquifers, rivers and streams?
Ecosystem responses	*To characterise and understand the ecological responses to contaminant stressors. The main stressors considered were elevated sediment, faecal and nutrient concentrations and loads to a range of receiving environments.* • Is periphyton growth a problem in Southland? If so, where and when? And what in-stream nutrient concentrations are needed to achieve compliance with the National Objectives Framework periphyton state bands? • What is the state of Southland's macroinvertebrate community, how does this vary across the region, and has it changed over time? • Can stable isotopes of carbon and nitrogen in aquatic food webs be used to establish where nutrients entering freshwater systems are coming from? • How much nutrient and sediment is transported by Southland's rivers to different receiving environments? • What condition are Southland's lakes in and how do they function relative to anthropogenic stress? • What are the relationships between load and ecological response in estuaries? • What are the main water and contaminant sources for the New River Estuary? How do water, nutrients and sediment move within the estuary? • Is it safe to use our region's waterways and swimming spots for recreation?
Physiographics of Southland	*To develop a better understanding of the evolution of water across Southland. By understanding where water comes from and the processes it undergoes as it moves through the landscape, we can better understand the reasons for different water quality outcomes across the region.* • Why does water quality vary across Southland, even under similar land use? • Can we use a spatial classification system to better manage the effects of land use on water quality?

information context for community engagement and better resource management, and in preparation for setting limits under the NPSFM. This was a significant new level of investment by the Council in science and in working together with other organisations to build a coordinated and integrated knowledge base.

The Southland Science Programme comprised two main research areas known as the *Characterisation Programme* and the *Southland Economic Project* (Figure 1). The Characterisation Programme sought to understand Southland's physical geography, how natural systems interact, and the causes of variable water quality. It comprised four components, each of which contained numerous individual research projects: Land Use Inputs, Fluxes and Flows, Ecosystem Response and Physiographics of Southland (Figure 1). The Southland Economic Project sought to understand and test the economic and social impacts of potential policy decisions on industry, businesses and the wider economy (Figure 1). The purpose of each of the five components of the programme and their main high-level research questions are shown in Table 1.

With the Southland Science Programme (2014-18) nearing completion we now have information, at various levels of detail, to answer the research questions listed in Table 1.

We will be presenting some examples at the Symposium and further detail is provided in the numerous programme outputs listed in the symposium handouts.

However, as we know, research is about discovery, and our knowledge has evolved in a way that means new questions have arisen. While some of the original questions were only able to be partly answered, we have also learned things that we hadn't anticipated. It is timely to reflect on all this as we move forward.

Where are we going?

Our focus is now shifting from characterisation and preparation to the next steps for setting water quality and quantity limits. Most importantly, we recognise that resource management needs to nest policy development with action on the ground. To support this shift, our science programmes are now moving away from a 'business as usual' approach to an 'outcome, people and solutions' focus. The intent is to build on existing knowledge and partnerships and better explore evolving areas, such as social science and Mātauranga Māori.

Figure 2: Environment Southland's 10-year vision.

The original intent of the Characterisation Programme was reasonably broad in that it aimed to develop a strong conceptual understanding of the natural systems in Southland and to provide the information needed to policy-makers, land managers and communities. However, there has been a tendency for discussions to more narrowly dwell on the needs of limit-setting policy development. This is perhaps at least partly because that is where the focus of conversation has been nationally and regionally since the gazetting of the NPSFM in 2011 and with the regular NPSFM updates in 2014 and 2017.

As knowledge and conversations in Southland and nationally have evolved since the first NPSFM in 2011, it has become increasingly apparent that limit-setting is just one part, albeit an important one, of land and water policy development. In turn, policy development is just one important part of achieving sustainable resource management. At the heart of effective resource management are people – and people need knowledge, willingness and motivation to act to achieve the desired outcomes expressed in policy.

The evolution of knowledge and understanding described above is reflected in our revised strategic intent, documented in our *Long-term Plan 2018-2028.* We have a vision of a *thriving Southland … te taurikura o Murihiku* (Figure 2). To achieve this vision, all programmes now demonstrate linkages to one or more of our four outcomes.

By 2028:

- Managed access to quality natural resources;
- Diverse opportunities to make a living;
- Communities empowered and resilient;
- Communities expressing their diversity.

People, Water and Land programme

Through the *Long-term Plan 2018-2028*, we are embarking on a new People, Water and Land programme. This programme seeks to put people at the heart of environmental management for a thriving Southland. It includes Environment Southland's response to limit-setting and is underpinned by the concept of 'action on the ground'. Action on the ground recognises that people and institutional structures require time to change; therefore, outcomes can be achieved more quickly if regulation and action on the ground occur in parallel.

The People, Water and Land programme is a partnership with Ngāi Tahu ki Murihiku and aims to maintain and improve Southland's water quality, ultimately helping the Southland community to achieve its goals for our region's water. It is an integrated programme of regulation (including the setting of limits for water takes and discharges), and on-the-ground action that will require people, businesses and organisations to significantly change their activities that affect land and water and take a ki uta ki tai (mountains to the sea) approach (Figure 3).

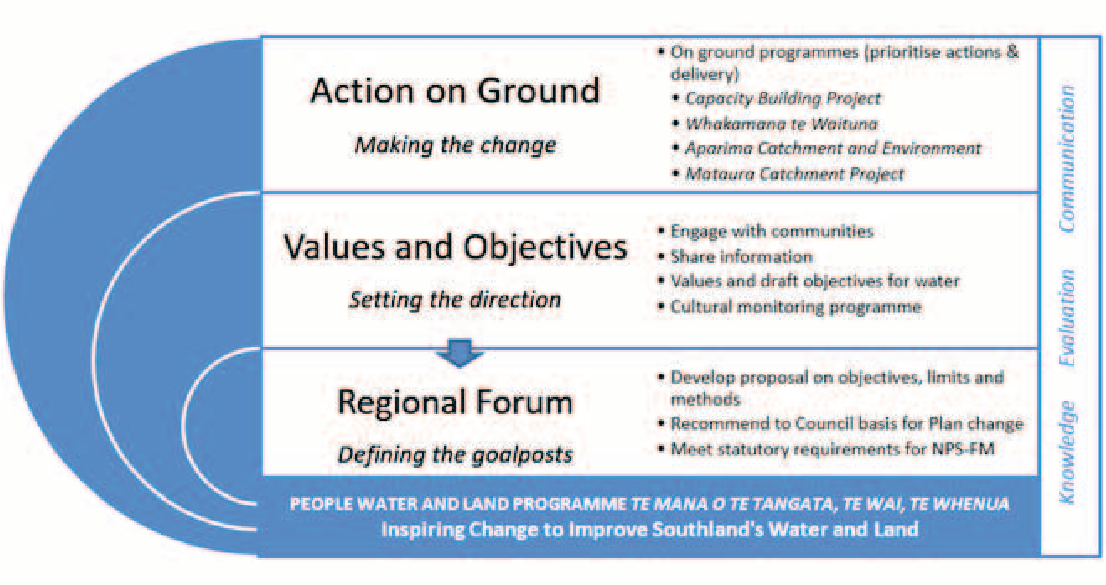


Figure 3: People, Water and Land programme framework.

Southland science and monitoring strategy (Southland Science Inc.)

As part of the move away from a 'business as usual' approach, we have initiated a project to develop our next science and monitoring strategy. This involves working collaboratively with a cross-section of people to form a project group, including those who use our science and monitoring as well as our research partners. At its first workshop in early 2017, the project group proposed broadening the project to a 'Southland Incorporated' strategy. The project group is now looking to develop a a multi-agency approach to deliver on the science and monitoring needs of the region.

Southland Science Inc. will lay the groundwork for a greater emphasis on co-development and co-delivery of science for the region. Environment Southland will look to increasingly become knowledge 'brokers' to deliver science for the region and programmes like People Water and Land. This transition will require science to be brought together and packaged so that information is accessible to a range of audiences, uses and knowledge systems. The approach will require scientists to increasingly broaden their role from 'deliverers of facts' to also be participatory knowledge producers and facilitators of learning.

Evolution of knowledge – where are we at today?

Everything is connected – land, water, air, people

We know everything is connected, both in terms of the physical direct and indirect linkages between land, water, air and people in a system (e.g. mountains to the sea depicted in Figure 4). We also acknowledge the conceptual linkages between knowledge systems, such as traditional science and mātauranga Māori. Also included are the complex causal linkages whereby people's activities in one part of the system, potentially many kilometres away or even in a different region or country, may influence changes within the Southland sub-system. Environment Southland science is continuing to increase emphasis on thinking about whole systems as well as their tangible parts.

Evolution: in each of many disciplines

The Characterisation Programme has produced knowledge advances in many areas depicted in Figure 4. These advances have built on the knowledge generated over several hundred years of Māori and then European occupation. The programme was organised around the five main project components of land use inputs, fluxes and flows, ecosystem responses, physiographics, and the Southland Economic Project (Table 1). However, advances

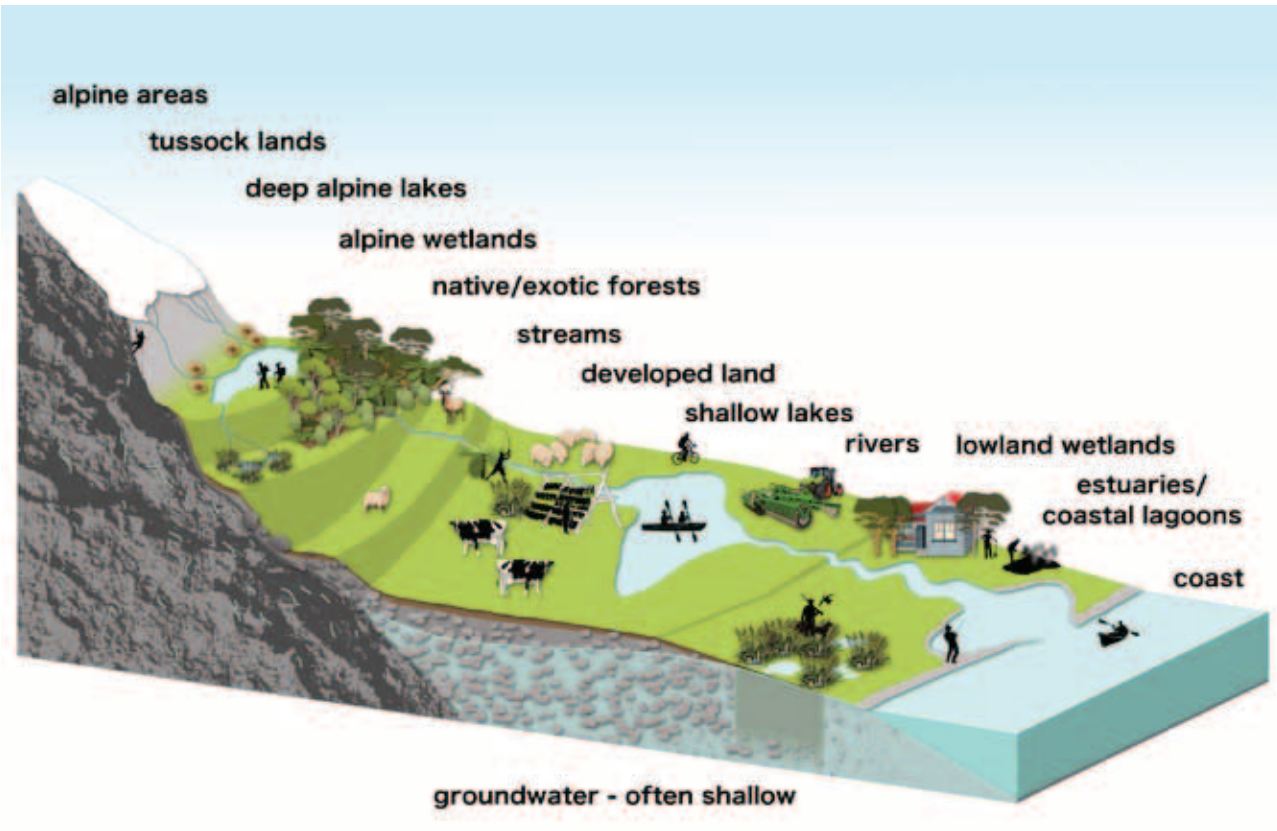


Figure 4: Some biophysical parts of the Southland system and some interactions of people within that system, directly relevant to land, water and air resource management in Southland.

have also been made in many technical discipline areas including:

- History of human behaviour/interventions
- Economics and social sciences
- Mātauranga Māori
- Climate
- Hydrology
- Air
- Soils and land use
- Biodiversity and pests
- Water quality – rivers, lakes, estuaries
- Water and contaminant transport
- Ecology – terrestrial, rivers, lakes, estuaries
- Stressors – of land and water use
- Variable sensitivity and capacity – e.g. physiographics
- Variable responses – e.g. environmental gradients
- Multiple stressor interactions and people

The large volume of work and learning across these areas is reflected in the table of programme outputs provided with the Symposium handout material and on the website. The Symposium oral, poster and video presentations give selected snapshot examples of the learnings from across these areas.

Evolution: integrating multiple disciplines

While knowledge has progressed in many disciplines, we have importantly also improved our understanding of the way these inter-relate. This understanding is helping us to build an integrated, multidisciplinary picture of the Southland system, and it is happening in several ways. First, our scientists are interacting and working across technical disciplines, both within Environment Southland and with other knowledge providers such as iwi, Crown research institutes, government, non-government and industry stakeholder organisations. Second, our scientists are actively seeking opportunities to share knowledge and thus broaden their own and others' interdisciplinary appreciation, even when working on projects with a narrow technical focus.

Some of the projects have been designed from the outset to be integrative, such as the Southland Economic Project. Economics tends to be an integrative discipline, bringing in elements of the behaviour of people and their connections with places and choices about resources. Other examples include the Physiographics of Southland Project, which initially integrated learnings from the fields of chemistry, geology and hydrology, before also integrating elements of spatial planning. The Streambank Erosion Project started with a narrow focus on better informing part of the requirements of models that help predict stream-bank sediment erosion (e.g. SedNet). However, this project evolved to consider the entire post-human history of land use and drainage interventions, and the consequence of these for stream-bank erosion. All of this work is now helping to inform us about the implications of alternative management futures (e.g. scenarios) for the whole system. These are just a few of many examples and are elaborated on in Symposium talks by Emma Moran, Ewen Rodway and Dr Tim Ellis.

Evolution by themes: value, change and people

Cutting across all the knowledge disciplines mentioned above and interwoven with all the multiple strands of the Southland system and beyond, are the Symposium themes: Value, Change and People (Figure 5). The Symposium oral, poster and video presentations are organised under these themes; although in reality each of our projects is relevant to many or all of these themes:

Value: how we are providing better scientific value for money. This includes data worth and integration sub-themes.

Change: how our understanding of environmental changes has improved. This includes environmental gradients and resilience sub-themes.

People: how our science is better informing people. This includes building connections and behavioural change sub-themes.

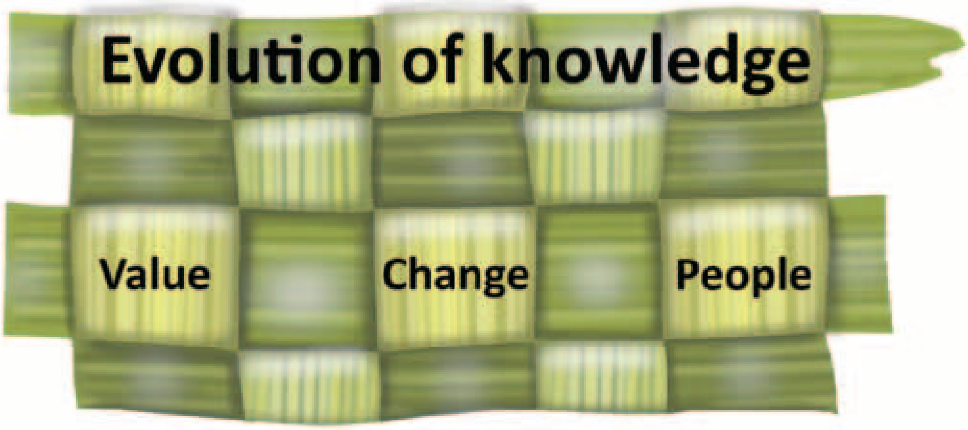


Figure 5: Evolution of knowledge themes for the 2018 Southland Science Symposium.

Value – data worth and integration

Arguably, all well-gathered data has an actual or potential worth now or sometime in the future, even though we often don't realise the full worth until later. We cannot be certain that we'll make the most efficient decisions today on data worth and gathering effort to inform tomorrow's resource management questions; that involves anticipating the future. However, we can strive to be better informed and smarter about the data we gather and how it is used. Money and staff time are always finite and thus decisions are constantly required to prioritise effort.

One way of informing the prioritisation of effort is to regularly analyse the data we are gathering and check that it is still fit-for-purpose for answering the intended questions, even when the surrounding context may have changed since gathering began. An example is the investigation into a revised sampling design for Southland's periphyton monitoring programme. After several years of greater sampling effort (e.g. more frequent and paired sampling) the results showed that our estimate of current state periphyton biomass was not what we previously thought. Roger Hodson will elaborate on this in his Symposium talk. Given the potential importance of periphyton state monitoring to test whether we are meeting community aspirations for river quality (i.e. regional plan periphyton objectives and national bottom lines), and to identify what management actions might be needed (e.g. nutrient limits and farm environment plans), decisions around what sites to monitor and how often, are important. The periphyton monitoring work informed these decisions on data gathering priorities in Southland and could have broader application in other regions.

Another way of improving the worth of finite data is to combine data and techniques from one technical discipline with data and techniques from others. This generates a worth that is greater than the sum of its parts. Sometimes the data and techniques in other disciplines are pre-known and built into an integrated project design, but sometimes they are discovered along the way during the science and knowledge gathering process.

The Physiographics of Southland Project initially set out to utilise existing datasets gathered under multiple technical disciplines such as water chemistry, geology, geography and hydrogeology. Some of these data were gathered years ago for other purposes, certainly well before the project's new purpose of investigating why hydrochemistry varies across Southland. The Physiographics of Southland Project achieved that purpose but has since also created considerable spin-off value for evolving knowledge in other technical disciplines and in resource management. For example, an output was a water quality risk assessment tool, comprising nine mapped physiographic zones, that has been used in policy development in the Southland Water and Land Plan and for informing consent decision-making. The broader physiographic science package has worth well beyond this, reaching out into several other areas such as informing models (e.g. CLUES and SAM), rationalisation of monitoring networks, land use suitability, and as a basis for community engagement and identifying place-specific, efficient options for mitigating poor water quality. The Physiographics of Southland Project is thus relevant to several Symposium themes; Ewen Rodway will give an overview on this subject in his Symposium poster and his talk under the Behavioural Change theme.

The Coastal Lakes Project has integrated state of environment monitoring data and land use observations to help characterise poor water quality and ecological health in some of Southland's coastal lakes. This led to development of the Lake Vincent Catchment Management Proposal, a joint initiative by Environment Southland's Science, Compliance and Land Sustainability teams, along with landowners in the Lake Vincent catchment. The goal was to reduce nutrient and sediment losses to the lake and demonstrate improvement in water quality and ecological health through continued monitoring of this relatively small case study catchment. In a related but broader scale project Environment Southland has mapped land use change and estimates of associated changes in nutrient losses from land across the whole region. In combination with river water quality monitoring this has enabled estimates of nutrient losses and receiving water loads and how these have changed through time in different catchments. Keryn Roberts and Karen Wilson will describe the Lake Vincent case study and regional scale nutrient loads work respectively in their Symposium talks.

Environment Southland's biosecurity team has generated valuable data and built collaborative connections with numerous groups of volunteers that have formed across Southland to implement coordinated pest control for conservation outcomes. The biosecurity team conducts regular monitoring of rodents, possums and birds, then feeds the data back to the groups so they can respond with informed adjustments to their pest control and other conservation efforts. The pest monitoring shows how well control effort is working, while the bird monitoring demonstrates successful outcomes. The data thus helps motivate volunteers' actions; the groups communicate with Environment Southland directly by email and can adjust their effort and celebrate success together as results come to hand in near to real time. Tom Harding will describe this positive interaction further in his Symposium talk.

Change – environmental gradients, and resilience

We know that change is inevitable, whether it be natural or caused by people. Understanding change and disentangling natural changes and variability from those caused by people, is a fundamentally important part of informing the community about what the future could look like, and thus the choices we face about the way we behave and use resources. If science can inform these things well, then potentially better societal decisions can be made that increase the chances of a sustainable and perhaps resilient future.

The Waituna Lagoon Modelling Project has described the seasonal and interannual variability changes that occur to the lagoon water level under the current climate situation and current operating regime. People have historically drained surrounding land for farming and now artificially control the water level according to a rule-based, lagoon-outlet opening regime. The model can produce asimulated time series of the lagoon water level and can thereby generate statistics about the amount of time the lagoon is above or below specified levels of interest for ecological values. The model also estimates periods of time that surrounding farmland is compromised by high water. Furthermore, the model can simulate how the situation may change under future climate scenarios, with either the current operating regime or under any future alternative management options being considered.

The Waituna Modelling Project is thus nicely situated to inform about the possible implications of management choices; even more-so when combined with the parallel knowledge of other disciplines such as ecology, the social sciences and economics. For example, in a separate project, the area and rate of decline of Southland wetlands has been quantified and the associated loss of intrinsic, biodiversity and ecosystem services value has been described. In combination these projects can contribute to informed decision-making on options. Symposium talks by Chris Jenkins and Mark Oster will describe these projects in more detail.

The Estuaries Project sets out to apply an ecological condition gradient (ECG) approach to defining the ecological state of either a series of estuaries along a continuum from 'natural' to 'degraded', or changes in state within estuaries over time. The condition gradients can then be correlated with other changes that may have occurred in the catchment over time, such as changing use by people (e.g. as indicated by changing nutrient and sediment loads) and/or differences in catchment characteristics between different estuaries. These correlations can be combined with other parallel lines of evidence such as examining the mechanisms that cause ecological responses (e.g. nuisance algae and sediment anoxia) to increase in sediment and nutrients. The project also considered the differing estuary sensitivities and resilience due to hydrological factors, to predict the relationship between nutrient and sediment loads and ecological state.

In the separate but connected Streambank Erosion Project, the sources and causes of streambank erosion in Southland were explored with a view to contribute in part to quantifying changes in sediment loads over time and in response to management action such as riparian planting stabilisation. The Streambank Erosion Project evolved to identify the importance of considering the wider historic physical and socio-economic context when estimating sediment loads from multiple sources; the project is thus relevant to 'environmental gradients', 'resilience' and 'behavioural change' themes.

The Estuaries and Streambank Erosion projects are thus now well placed to inform, in parallel with other knowledge disciplines, on management options such as setting limits for nutrients and sediment and/or other management, education and community environmental enhancement initiatives. The environmental gradient approach helps provide information about options (e.g. condition points along the gradient) and the resource use constraints likely needed to achieve each option under alternative possible futures (i.e. scenarios). The Symposium talks and posters by Nick Ward and Dr Tim Ellis will give more detail on these projects.

Another project that investigated change (or gradient responses) to resource use is the Net Rate of Energetic Intake (NREI) Bioenergetic Modelling Project which, in simple terms, predicts the response of drift-feeding fish to change in river flow. River flow is affected by water abstraction and use. The terminology used in the eco-hydraulics discipline often refers to predicted 'relationships' between flow and ecological response indicators, rather than 'environmental gradients'; however the concept is the same. This example illustrates why it is useful to share knowledge among disciplines, identify common concepts and different language, and enhance the worth of multidisciplinary knowledge. The very same water abstractions being considered in the NREI project have consequences for not only drift-feeding fish, but amount and type of land use that may generate contaminants (e.g. nitrogen and sediment) and thus estuary ecological condition, as well as social and economic well-being for abstractors and their communities. Everything is connected and these projects in combination can inform across these connections. The Symposium talk by Lawrence Kees will give more detail and context for the NREI project.

People – building connections, and behavioural change

Environment Southland's science is about better informing people and we're doing this in several ways. We're building connections, not only with a wide variety of science and other knowledge provider organisations, but also with the wider Southland community. We do this by listening and seeking the input of community-held knowledge to our work, operating collaboratively with others where practical, designing relevant research investigations, and communicating knowledge in a way that tries to make it relevant to everyone's world and future.

In some cases, our science informs people as part of formal processes designed to make important strategic resource management decisions, such as regional policy statements, plans and resource consenting. In other cases, our science informs people about the current state of the environment, causes of improving or deteriorating trends, risks of human activities and practical things people can do to solve problems and achieve desired outcomes. Sometimes we inform with our own research and sometimes we act as knowledge brokers by putting people into contact with knowledge held by others. In all cases we strive to make our information credible, objective and uncertainties transparent. This helps build trust, which is essential for positive connections and influencing behaviours for better outcomes. We are also trying to avoid debates about blame for historical degradation. Instead we strive to share the burden of past decisions and of future uncertainty while seeking solutions going forward.

By example, the Southland Economic Project has studied the connections between people and place, between essential infrastructure, between town and country, and between towns, country and the environment. The project also studied factors that influence people's behaviour. By building collaborative connections with relevant stakeholder organisations such as DairyNZ, Beef and Lamb NZ, the Department of Conservation, Ministries for the Environment and for Primary Industries, Southland Chamber of Commerce, Te Ao Marama and farmers in the community, the project has been able to develop locally relevant, credible information on the effectiveness and impacts on profitability of managing nutrient losses within farming systems.

The Southland Economic Project also worked with the Gore District, Invercargill City and Southland district councils to develop credible information on the financial costs of further managing contaminants in discharges of treated wastewater from municipal schemes. Both these sub-projects contributed to building a dynamic model of Southland's regional economy with the purpose of being able to explore the impacts of management options (e.g. including limits for water quality) on the main economic sectors and flow-on effects through the rest of the economy.

The Southland Economic Project has also highlighted the role of Southland's environment in the settlement and development of towns and industry and how this, in turn, has modified the environment through history. There are synergies here with the long-running modification of drainage and agricultural land use assessed in the Streambank Erosion Project, and the variable response of different physiographic zones to modified land use and mitigation options identified in the Physiographics of Southland Project, both already mentioned above. In combination all of these projects highlight the significantly modified existing environment and the complexity of connections within Southland's environmental and socio-economic system, as context for making choices about the way we behave and use resources in future. The symposium talks by Emma Moran, Ewen Rodway and Dr Tim Ellis touch on some of these connections, choices and the behaviour changes that might be needed.

In a final example, Environment Southland's air quality science has helped characterise the dominant source of emissions affecting air quality in Southland towns (i.e., domestic heating). This work was used along with numeric national standards based on good evidence about the health effects of emissions, to inform the development of changes to the Regional Air Plan (2016), and to also subsequently launch community education initiatives. However, it has been recognised that technical evidence, regulation and education alone may not be the most efficient path to achieving behavioural change and outcomes. Environment Southland is now specifically researching the drivers of behavioural change for this case. There are perhaps learnings to be drawn from air quality management, which is ahead of land and water resource management in setting compulsory national numeric standards. The air quality experience suggests it may be useful to think about implementation and the drivers of behaviour change at least at the same time as developing the regulations, if not before. Owen West's symposium talk will elaborate further.

Concluding remarks

The four-year Southland Science Programme (2014-18) has been highly fruitful, both in terms of knowledge generated and the relationships built with partners and stakeholders.

We have built on the knowledge that has evolved from the historical Māori and European occupation of Southland. We've advanced data and knowledge across multiple technical disciplines while growing our appreciation of how everything is connected. We know we need to think about whole systems and to integrate the pieces of knowledge we have.

We've generated more data, with greater worth and at better value for money. We've better characterised the way our environment responds to change; to human use of resources, natural variability and climate change. This knowledge can undoubtedly help better inform societal choices about the way we decide to behave and the objectives and limits we set for utilising land and water resources into the future.

Environment Southland has a strategic vision of a *thriving Southland … te taurikura o Murihiku.* The People, Water and Land programme is designed in partnership with Ngāi Tahu ki Murihiku to help take us there. This will consolidate on previous knowledge but bring greater emphasis to partner and stakeholder relationships, co-generation of knowledge and thinking about whole systems to find solutions.

We hope you enjoy the Symposium, get involved in the discussions and feel motivated to contribute. We welcome your continued involvement with science in Southland.

Programme

10.00 – 10.30am	Registration and morning tea
10.30 – 11.30am	Welcome and science overview – ***Evolution of knowledge***

VALUE

	DATA WORTH (Room A)	INTEGRATION (Room B)
11.30 – 11.45am	***Periphyton – improving our understanding of Southern slime*** Roger Hodson, Environmental Scientist – Surface Water Quality	***A case study: linking catchment land use management to lake water quality*** Keryn Roberts, Environmental Scientist – Estuaries and Lakes
11.45 – 12.00pm	***Number crunching for community conservation*** Tom Harding, Biosecurity Officer - Information	***Nutrient losses, loads and loadings*** Karen Wilson, Team Leader – Science, Strategy and Design
12.00 – 12.15pm	***Worth of data in hydrological modelling*** Lawrence Kees, Environmental Scientist – Water Resources	***Where does microbial contamination come from?*** Nick Ward, Team Leader – Ecosystem Responses
12.15 – 12.30pm	Activity/discussion	Activity/discussion
12.30 – 1.30pm	LUNCH	

CHANGE

	ENVIRONMENTAL GRADIENTS (Room A)	RESILIENCE (Room B)
1.30 – 1.45pm	***Estuaries: what's the difference?*** Nick Ward, Team Leader – Ecosystem Responses	***Modelling Waituna Lagoon response to change: climate and management*** Chris Jenkins, Senior Hydrologist
1.45 – 2.00pm	***Bioenergetics to balance water takes and instream habitat*** Lawrence Kees, Environmental Scientist – Water Resources	***Evolving freshwater management in the face of increased demand and climate change*** Ewen Rodway, Environmental Scientist - Chemistry and Groundwater Quality
2.00 – 2.15pm	***Establishing reference conditions to support habitat assessment in citizen science*** Roger Hodson, Environmental Scientist – Surface Water Quality	***Southland's scattered wetlands: the results from a regional inventory*** Mark Oster, Biodiversity Programme Leader
2.15 – 2.30pm	Activity/discussion	Activity/discussion

PEOPLE		
	BUILDING CONNECTIONS (Room A)	**BEHAVIOURAL CHANGE (Room B)**
2.30 – 2.45pm	***Location, location, location*** Emma Moran, Senior Policy Analyst/ Economist	***Emission characterisation, interventions and community response in the face of health-related evidence*** Owen West, Air Quality Scientist
2.45 – 3.00pm	***Streambank erosion in Southland and thinking more broadly about sediment*** Tim Ellis, Senior Science Coordinator	***Physiographics: utilising science to effect positive change*** Ewen Rodway, Environmental Scientist – Chemistry and Groundwater Quality
3.00 – 3.15pm	***Ecosystem fragments – protecting the 'little guys'*** Ali Meade, Biosecurity and Biodiversity Operations Manager	***Economics is a behavioural science*** Emma Moran, Senior Policy Analyst/Economist
3.15 – 3.30pm	Activity/discussion	Activity/discussion
3.30 – 4.00pm	AFTERNOON TEA	
4.00 – 4.30pm	Poster and video session	
4.30 – 5.15pm	Discussion panel – ***Is there a role for environmental science in resilience thinking?***	
5.15 – 5.30pm	Wrap up	
7.00 – 10.30pm	Dinner with guest speakers: Dean Whaanga and Dr Jane Kitson – ***Cultural health monitoring***	

Biographies of Speakers

Roger Hodson

Roger Hodson

Environmental scientist – surface water quality

Roger worked with the Living Streams programme at Environment Southland, before taking his current role in 2012. Key components of Roger's role include state and trend reporting, monitoring network design, and working with community groups.

Roger oversees the monthly river water quality monitoring programme, ecosystem health monitoring programmes and continuous river water quality monitoring. Recent optimisation work has enabled resourcing to be directed toward a new programme of monthly periphyton monitoring. Roger's reviews of biological monitoring programmes have resulted in increased spatial alignment between ecosystem health and water quality monitoring in the Southland region and the inclusion of assessments of deposited sediment and stream/river habitat. Roger has also driven the increased use of continuous monitoring equipment for suspended sediment and nitrate load assessment programmes.

A University of Otago graduate, Roger gained a Bachelor of Applied Science (1st Class Hons), majoring in environmental management. His time as a student included a semester at the University of British Columbia in Vancouver, Canada. Roger also worked as a glaciology field technician for the University of British Columbia, carrying out glacial mass balance measurements and alpine hydrology work. Returning to the University of Otago, Roger then completed an honours dissertation on the snow melt and snow surface albedo of the South Island's Brewster Glacier.

Roger enjoys the affordable lifestyle Southland offers, including access to uninhabited coastline, marine reserves, national parks and mountains.

Dr Keryn Roberts

Environmental scientist – estuaries and lakes

A native of Melbourne, Keryn has been enjoying the Southland lifestyle since October 2017. Her love of the outdoors was enough to lure Keryn over the Tasman to take up the position of environmental scientist at Environment Southland. Keryn's role involves overseeing the State of the Environment monitoring networks for lakes, lagoons and estuaries.

Keryn gained a Bachelor of Environmental Science (Hons), majoring in environmental chemistry and marine and freshwater biology from Monash University, Australia. Continuing at Monash, Keryn's PhD focused on nutrient cycling in the Yarra River Estuary. Subsequent work as a postdoctoral fellow concentrated on both environmental and anthropogenic factors that influence nutrient pathways including, but not limited to, oxygen dynamics, benthic macroinvertebrates, algal and cyanobacterial blooms and pharmaceuticals and personal care products. Keryn's research spanned estuaries, lakes, lagoons and wetlands.

Being close to the coast is a good fit for Keryn, who enjoys snorkelling and diving. However, Southland temperatures aren't always conducive to spending much time in the water. Investing in a drysuit may be Keryn's next purchase.

Dr Keryn Roberts

Tom Harding

Biosecurity officer – monitoring and information management

Tom's role in the biosecurity team is to manage and coordinate monitoring programmes. He also ensures that the information and data produced by the biosecurity team is managed correctly. This involves dealing with both pest and native species (plants and animals), so there is plenty of variety.

Born in Hawera and raised on a rural block on the outskirts of Hamilton, Tom didn't expect he'd ever find himself living in Invercargill, and nor did he expect he would enjoy it so much. Like many at Environment Southland he enjoys the great outdoors but also spends much of his time at ILT Stadium Southland where he competes in basketball and men's netball.

Tom has been interested in wildlife from a young age. He later combined his passion for the natural environment with his knack for dealing with numbers and completed a Bachelor of Science and a Post Graduate Diploma in Science majoring in biology and statistics at the University of Auckland. Prior to working at Environment Southland Tom worked as an ecologist at Auckland Council, educating landowners on how to best care for and enjoy their private blocks of forests and wetlands.

Tom enjoys the practicality of his role's biosecurity focus and being involved at the forefront of conservation.

Tom Harding

Karen Wilson

Karen Wilson

Team leader – science, strategy and design

A born and bred Southlander, Karen is a familiar face at Environment Southland. Karen's current role as science, strategy and design team leader is a new one, reflecting the change in focus for the science team and Environment Southland as a whole. Karen's broad knowledge base and experience in both the sciences and Council activities makes her a perfect fit for this strategic role.

Karen gained a Bachelor of Science from the University of Otago, majoring in geography. She then spent 15 years at Environment Southland working her way up from field technician to principal scientist. During this time Karen worked extensively across the organisation, for example with the consents team and in the planning and policy space, gaining a broad understanding of both science and how Council functions. Karen was also involved in the establishment of Environment Southland's groundwater programme. Her institutional and science knowledge is invaluable to the organisation.

Karen then took an opportunity to spread her wings, spending time in the United States. Upon returning to New Zealand, Karen worked for Landpro Ltd, a consultancy firm based in Cromwell. As a senior environmental scientist for LandPro, Karen was involved in ground and surface water quantity and quality projects in Southland and Otago. This included technical assessments for consent applications, planning processes and assisting community groups. During her time at LandPro, Karen also had a key role in Environment Southland's Physiographics of Southland Project.

Looking to broaden her work focus, Karen re-joined the team at Environment Southland in 2016 as a senior science coordinator, before taking her current role.

Lawrence Kees

Environmental scientist – water resources

Lawrence's role at Environment Southland ranges from characterising groundwater and surface water interactions (from the alpine zone to wetlands), and eco-hydrology to allocate the region's water. A key part of his role involves overseeing the development of robust conceptual and numerical models that can be used to explore different options for managing our region's freshwater resource. The breadth and scale of Lawrence's work has required him to work collaboratively on projects with a range of external organisations. The diversity of his role also allows Lawrence to balance field work with the theoretical aspect of understanding the hydrological cycle.

During his undergraduate degree Lawrence developed an interest in glaciology and the cryosphere. After measuring the hydrological wonders of the West Coast as a hydrology technician at NIWA, Lawrence then obtained a Masters in Science from the Antarctic Research Centre at Victoria University, Wellington. For his thesis, Lawrence used geophysical techniques to estimate seasonal precipitation across the Southern Alps.

After spending time in the North Island as a student and working for the Hawkes Bay Regional Council, Lawrence then looked for opportunities to move back down south. Originally from Christchurch, Lawrence's affinity for being in the outdoor environment brought him to Southland to join the science team at Environment Southland.

Lawrence Kees

Nick Ward

Team leader- ecosystem response

Nick has been in his current role overseeing State of the Environment monitoring and investigations for estuaries, lakes, coastal science, marine science, aquatic ecology, and freshwater science for about five years. A key part of his role is to provide technical advice both within Environment Southland, (e.g. the consents team) and externally, including technical advisory groups. Nick can also be found imparting his extensive knowledge to schools and community groups.

Born in the United Kingdom, Nick obtained a Bachelor of Science (Hons) in environmental geology from the University of Leeds. Before moving to New Zealand, Nick had a diverse and interesting work history, ranging from working in cooperative housing in London to teaching English as a foreign language in Mexico, to working on an organic farm in Spain.

Interested in learning more about New Zealand, Nick moved initially moved to Auckland, then to Wellington where he completed a Post-Graduate Diploma in marine ecology at Victoria University.

Nick enjoys the outdoors lifestyle Southland has to offer and considers it a great place to raise a family. A self-confessed 'hobby botanist', Nick and his family also propagate native plants and edibles for a regenerative project on their property.

Nick Ward

Chris Jenkins

Chris Jenkins

Senior hydrologist

Born in Lancashire, England, Chris moved to Invercargill with his family in 1973 and hasn't moved far since. Chris enjoys the laidback affordable lifestyle of Southland.

Chris started work at Environment Southland's predecessor the Southland Catchment Board in 1986 fresh out of school. Chris gained a NZCS in Water Science in 1992 through the Technical Correspondence Institute and followed this up with a Bachelor of Science in geography from Massey University. In 2011 Chris completed a Post Graduate Diploma in geography with a thesis on El Niño Southern Oscillation and its influence on the magnitude and frequency of flooding in Southland.

In his spare time, Chris enjoys playing music, reading, photography and is interested in new technology. He enjoys creating models that mimic our environment and is interested in the effects of climate on our hydrology.

Ewen Rodway

Ewen Rodway

Environmental scientist – groundwater quality

A born and bred Southlander, Ewen started at Environment Southland as a groundwater technical officer in 2013, before moving to his current role as groundwater quality environmental scientist a year later. Ewen is responsible for groundwater quality State of the Environment monitoring and investigations. His role also involves providing technical advice to other divisions within Council in the areas of geochemistry, water quality and nutrient management. Ewen is also involved with the Southland Economic Project, providing expertise in the areas of land use and contaminant losses.

Ewen gained a Bachelor of Science from the University of Otago, majoring in geology. Staying at Otago, he then completed a Masters of Science in geology/geochemistry. His thesis looked at using geochemical techniques to assess the provenance of sediments in the western Southland basins. Ewen has also obtained qualifications in advanced nutrient management from Massey University.

Upon completing his Masters, Ewen was briefly lured across the Tasman to work as a hydrogeologist for an environmental consultancy company in Brisbane. Ewen has had a lifelong connection to Southland's mountains, rivers and coastline through the many years spent whitewater kayaking, hunting and spearfishing.

Mark Oster

Biodiversity programme leader

Mark came down to Invercargill from the North Island for a holiday in 2004, and has been here ever since. He left behind a farm and poplar nursery near the central North Island town of Taumarunui.

Whilst in Southland, Mark formalised his passion for education with a Bachelor of Education from the University of Otago (Invercargill Campus). From there Mark was able to utilise both his degree and love of the outdoors as a community relations ranger, then education ranger at the Department of Conservation. These roles involved working with community groups and volunteer programmes associated with a range of biodiversity and restoration projects.

In 2012 Mark started at Environment Southland as an environmental education officer. This role involved working with preschools and schools on projects ranging from developing plant nurseries, undertake planting projects and pest control. He also worked as an Enviroschools facilitator and held numerous workshops for teachers. About 70% of Mark's role was out in the field, providing 'hands-on' real world experiences for children (and their parent helpers).

Mark has worked in the broader education field for over 20 years, including being on the national executive for the New Zealand Association for Environmental Education.

Mark continues to share his extensive knowledge and insights with Southlanders through his new role as biodiversity programme leader.

Mark Oster

Emma Moran

Senior policy analyst/economist

Emma has a Masters in Applied Science (Hons), majoring in ecological economics, from Lincoln University. While at Lincoln she worked in the Agribusiness and Economics Research Unit.

She has been in the policy and planning team at Environment Southland since 2011 and for the last four years has been the project manager for the Southland Economic Project. This project is a great example of what can be achieved when people are given a real opportunity to work together and do things a little differently!

Owen West

Owen West

Air quality scientist

Originally from Marlborough, Owen took the opportunity to move south to Invercargill in 2012. A role as air quality scientist at Environment Southland caught his eye and he hasn't looked back. Owen is tasked with leading Environment Southland's regional air quality monitoring programme, which includes PM_{10} and $PM_{2.5}$ monitoring, and evaluates progress towards achieving the National Environmental Standards for Air Quality.

Owen studied at the Otago University, completing a Bachelor of Science in geography, Bachelor of Arts in film and media studies, and a Postgraduate Diploma in environmental science before going on to complete a Master of Science majoring in geography. Owen's thesis research focused upon the temporal and spatial variations in particulate matter in Alexandra, Central Otago. Owen is now well accustomed to Southland and it's air quality challenges, but also has a background in resource consenting and plan development. More recently, Owen has enjoyed working towards understanding the mechanisms required to influence behaviour change and reduce anthropogenic particulate emissions.

In his downtime, Owen enjoys Southland's great outdoors.

Dr Tim Ellis

Dr Tim Ellis

Senior science coordinator

Tim has recently taken up the role of senior science coordinator at Environment Southland. This role involves supporting the development and implementation of science, research and monitoring strategies; providing strategic direction to the division; and coordinating the transfer of scientific information to the wider organisation, stakeholders and the community.

Following several years of farm experience, in 1987 he completed a Bachelor of Engineering (Agriculture) and then took a lecturing position at Roseworthy Agricultural College and the University of Adelaide until 1994. There he undertook research on crop root growth as affected by soil compaction from agricultural machinery. Subsequently, Tim completed his doctorate in 2001 (University of Adelaide) on the ecohydrological effects of agroforestry on groundwater recharge. He then worked as a research scientist at the Commonwealth Scientific and Industrial Research Organisation (Australia) until 2013 and then as a senior researcher with the International Water Management Institute in Ghana, West Africa, before joining Environment Southland in 2015 as team leader, soils and freshwater, and taking up his current position in 2018.

Ali Meade

Biosecurity and biodiversity operations manager

As biosecurity and biodiversity operations manager, Ali is responsible for protecting Southland from harmful species, and finding ways to maintain and protect the region's indigenous biodiversity.

Ali grew up in the Uniited Kingdom and studied natural sciences at Durham University, specialising in biology and biological anthropology. Following university, Ali carried out research into the parasitic disease schistosomiasis in Malawi. Ali led the expedition to Malawi, which was supported by the Malawian Government, Danish Bilharzia Lab and the Natural History Museum. Ali then completed a Masters in science in contaminated land Remediation at Lancaster University and worked at coal mine restoration sites for the Royal Society for the Protection of Birds. The work involved restoring old open-cast coal mines and spoil heaps from underground mining into habitats and wetlands for native species.

After moving to New Zealand in 2009, Ali worked as a weed control specialist in Auckland. She then took a role with the Auckland Council as a senior ranger conservation, responsible for the Southern Regional Parks conservation programmes, including biosecurity and biodiversity programmes. Ali was lured south in 2016 to join the Environment Southland team as the biodiversity programme leader. She has recently moved into the manager role.

Ali Meade

Rachael Millar

Strategy and partnerships advisor

Rachael began working for Environment Southland in 2001 in the policy and planning team. As principal planner, she led the development of the Regional Water Plan, before moving across to the science team in 2014 to support the coordination of the Environment Southland Science Programme. In 2015, she stepped into the science manager role through to the completion of the programme in early 2018.

Rachael has recently taken on a cross-organisational role, as strategy and partnerships advisor, but continues to work closely with the science team to ensure that knowledge that has been gained informs decision-making. Rachael has a Masters of Professional Studies (environmental management) and a Bachelor of Resource Studies (Hons), both from Lincoln University.

A born and bred Southlander, Rachael loves living on a family sheep farm with her husband and two small children, and spending time out enjoying our fantastic lakes, beaches and forests.

Rachael Millar

Graham Sevicke-Jones

Graham Sevicke-Jones

Director – science and information

Graham initially worked in the primary sector as an industrial chemist for the meat processing industry before taking on the role of environmental scientist for firstly the South Canterbury Catchment Board, Environment Canterbury, and then the Hawkes Bay Regional Council.

In these roles he principally managed freshwater and marine water quality and ecological programmes and worked closely with communities on establishing limits to assist in resource management through statutory processes.

Graham spent 15 years working in science management for the Hawkes Bay and Greater Wellington regional councils prior to moving into the position of director - science and information at Environment Southland. Graham has been involved in enabling collaborative processes for limit-setting to meet national and community outcomes at the regional scale. Graham has extensive knowledge on environmental monitoring programmes, transfer of science into policy and effective measurements.

Graham has been involved in numerous national steering groups (including the National Environmental Monitoring and Reporting project), contributed to the National Environmental Monitoring and Reporting forums (and its successor EMaR) and has provided feedback on the RMA changes and proposed Bill on Environmental Monitoring and Reporting.

Graham has also participated in the government appointed Land and Water Forum and Ministry for the Environment National Objectives Framework provisions for the NPS-FM amendments.

Previously Graham was the convenor of the Surface Water Integrated Management Group, (a regional council special interest group) for 10 years. This special interest group, consisting of regional council policy staff and freshwater scientists has a strong emphasis on integrated and collaborative science processes. Graham is also past president of the Hawkes Bay Branch of the Royal Society of New Zealand.

Dr Jane Kitson

Director, Kitson Consulting Ltd

Jane is an ecologist and environmental scientist who has previously worked for Te Waiau Mahika Kai Trust, Environment Southland, Te Ao Marama Inc. (the Ngāi Tahu ki Murihiku natural resource management agency), Te Rūnanga o Ngāi Tahu and currently runs her own environmental consultancy company.

She has worked on a range of research and management projects including doctoral research on traditional ecological knowledge and harvest management of tītī/muttonbirds; microbial food webs in lakes; research on kanakana/lamprey, coastal and freshwater environmental science; and managing the State of the Environment reporting on the freshwater and coastal marine environments. The projects she has enjoyed most are the ones where she has been able to work with whānau to bring science and mātauranga together.

Jane hails from Murihiku and is a member of the Ōraka-Aparima Rūnanga and has whakapapa links to Waihōpai and Awarua Rūnanga. Jane is married to Zane and they have two sons Luke (12) and Trent (10). Her family has a strong interest in hunting and mahinga kai pursuits e.g. trout and salmon fishing, duck and deer hunting, kaimoana gathering and tītī/muttonbird harvest.

Dr Jane Kitson

Dean Whaanga

Kaupapa taiao manager

Ko Motupohue te Maunga
Ko Te Ara a Kiwa te Moana
Ko Awarua te Whenua
Ko Te Rau Aroha te Marae
Ko Tahu Potiki te Tangata
Ko Ngāi Tahu, Ngati Kahungunu me Rongomaiwahine nga Iwi
Ko Dean Whaanga ahau

Dean is kaupapa taiao manager for the Ngāi Tahu ki Murihiku environmental consultancy, Te Ao Marama Inc.

He is born and bred in Bluff and has a strong affiliation with his Ngāi Tahu whakapapa. He presently is kaiwhakahaere for the local Runanga Awarua.

"I believe being brought up in Bluff and working for my Iwi has allowed me to experience and gain many skills and knowledge within Te Ao Māori, sharing and passing on some of these understandings is important and necessary".

He believes the Māori world view of our natural environment and the Western view of science have synergies and are able to combine for the wellbeing of all things.

Dean Whaanga

Dr Marjan van den Belt

Dr Marjan van den Belt

Ecological economist

Marjan van den Belt is an ecological economist, holding a PhD in marine estuarine environmental science from the University of Maryland, USA and a Masters in business economics from Erasmus University Rotterdam, Netherlands. She is currently working as an independent expert on sustainability and serves on the New Zealand Treasury's Tax Working Group. Previously, she was the assistant vice chancellor (sustainability) at Victoria University of Wellington, where she used the Sustainable Development Goals (SDG) as an organising framework. She is a co-author in the global *Sustainable Development Solutions Network (SDSN) Guide for Universities on the SDGs* (2017) and convened the inaugural cross-sectoral New Zealand Summit for SDGs on 23 April 2018.

Until 2016, she was associate professor and director of Ecological Economics Research New Zealand at Massey University, where she was a science leader on nationally funded programmes, using stakeholder participatory processes guided by model building and scenario development. She is the author of *Mediated Modelling; a system dynamics approach to environmental consensus building*, Island Press (2004). Her transdisciplinary research interests span land (e.g. urban, agricultural and conservation) and water (e.g. rivers, coast and marine) as they relate to human well-being.

She has used an ecosystem services approach for 20 years and is a co-author on the seminal article in Nature on the 'Value of the world's ecosystem services and natural capital' (Costanza et al. 1997) and lead editor of the treatise *Ecological Economics of Estuaries and Coasts* (2011) featuring an ecosystems services approach.

Appointments include:

1) Pool of experts for the United Nations World Oceans Assessment;
2) Expert member of Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES);
3) Editorial board of the journal 'Ecosystem Services', and
4) Assessor of MBIE Research Investment.

Her governance experience includes appointments to the Sustainable Business Council Advisory Board and the Board of NZ Global Studies Trust.

She arrived in New Zealand in 2009 from Vermont, where she ran an independent consulting business (Mediated Modelling Partners, LLC) bringing together diverse stakeholders to co-design practical, systemic solutions. During this time, she also taught at the University of Vermont and co-founded a cohousing/ecovillage (Champlain Valley Cohousing). In the 1990s, she worked for five years in Stockholm, Sweden, on waste reduction and systemic challenges with businesses and NGOs. She is native to the Netherlands.

She has given over 300 public talks, including a recent TEDx on 'Overcoming addiction to economic growth' (available on www.youtube.com).

Dr Nicky Grigg

Senior research scientist, CSIRO Land and Water

Dr Nicky Grigg works in interdisciplinary teams on a diverse range of projects exploring impacts of and responses to global change in social-ecological systems. Nicky has worked on the development and testing of a framework for putting concepts of resilience, adaptation and transformation to work to design pragmatic actions towards sustainability goals (https://research.csiro.au/eap/rapta/). The framework provides guidance for working with diverse stakeholders to describe and assess their system and use this information to design intervention options and implementation pathways. These decisions and actions cannot wait for certainty in a world of rapid, novel and unpredictable change, and so the approach fosters deliberative learning across sectors and disciplines to design actions that build flexible future options.

Other recent projects have involved working with Emergency Management Australia to explore Australia's vulnerability to natural hazards, working with ecologists, hydrologists and social scientists to characterise societal benefits from water management, and developing a systems view of water quality issues in Pakistan as part of the Sustainable Development Investment Portfolio (https://research.csiro.au/sdip/).

Dr Nicky Grigg

Dr Ken Hughey

- **Chief science advisor for the Department of Conservation**
- **Professor of Environmental Management – Lincoln University**

Dr Ken Hughey is chief science advisor for the Department of Conservation and professor of Environmental Management at Lincoln University.

Ken works with Natural Resource Sector Government agencies, with regional councils and science providers to increase the amount, and relevance, of science contributing to the resolution of long running conservation and broader environmental management issues.

He is an active researcher and leads Lincoln University's ongoing triennial environmental perceptions surveying, is involved in freshwater research particularly around braided rivers and their birdlife, undertakes research into introduced ungulate policy, and is involved in aspects of sustainable tourism. He supervises PhD students and is on the Board of the Waihora Ellesmere Trust, the Hanmer Springs Conservation Trust, and is a foundation member of the Hurunui Waiau Water Zone Management Committee.

Dr Ken Hughey

Lian Butcher

Lian Butcher

Director – aquatic, Department of Conservation

Lian Butcher is the director of aquatic at the Department of Conservation. The purpose of the aquatic unit is to provide leadership in the conservation of New Zealand's freshwater, estuarine and marine ecosystems and species. The team is highly focused on achieving conservation outcomes through their partnerships with others.

Lian has degrees in marine biology and fisheries science and her career originally started in the Falkland Islands, where she worked as a scientist for Falklands Fisheries, and later for Falklands Conservation, where she worked closely with the Fisheries Department on the impact of fishing on penguin species. After she returned to Wales, she began a 10-year career in the Environment Agency, where her main focus moved to freshwater and estuarine biodiversity.

She moved to New Zealand nine years ago, where she first started in the Ministry for the Environment as the senior analyst for water. She then moved to Greater Wellington Regional Council, where she moved into leadership roles. The main focus of her work there was how collaboration and integration can build better outcomes for the environment, and it was particularly focused on how to better integrate catchment management.

Lian has been the director of aquatic at DOC for eight months, and is very excited about the portfolio of the team. She is keen to continue the great work that has been done in partnership for better conservation outcomes.

Science Abstracts

VALUE

DATA WORTH

Roger Hodson

Periphyton – improving our understanding of Southern slime

Periphyton is a collective term for the complex community of algae, cyanobacteria and heterotrophic microbes that can be found attached to the submerged surfaces of aquatic ecosystems. Periphyton is important in stream communities, forming the bottom trophic level of the aquatic food chain. However, at high levels periphyton can compromise ecosystem health, recreational and aesthetic values. Periphyton is the primary food source for many aquatic invertebrates, which are in turn food for higher order consumers such as fish. Benthic chlorophyll a (chl-a (mg m-2)), ash free dry weight (AFDW (g m-2)) and percent cover of periphyton are used as an indicators of stream health.

Environment Southland has been collecting data on benthic periphyton as chl-a, AFDW and percentage cover as part of our long-term environmental monitoring programme. Specifically we have collected periphyton chl-a, and AFDW data annually since 2001 at up to 103 sites from 55 different streams and rivers (74 sites retained for analysis, n≥6), and on a monthly basis from 30 sites located on 27 different streams and rivers since 2015. In addition the monthly monitoring has included estimates of percentage cover. Analysis of monthly data illustrated a better state of ecosystem health with respect to periphyton than previous assessments from annual data only.

Analysis of monthly benthic chl–a showed that 100% of the 30 sampling sites were likely to be within the National Objectives Framework (NOF) band range of A – C, above the national bottom line. While none of the sites were in the band D category (below the national bottom line), seven sites had an upper 95% CI value in the D band.

In contrast, assessment of annual chl–a showed 88% of the sampling sites were within the NOF band range of A – C. However, 12% of sites from eight different streams and rivers, were in the band D category and failed to meet the national bottom line.

Comparison of estimates of biomass from annual data vs monthly data showed that estimates based on annual data were on average 1.6 times greater than those from monthly data. Of 19 sites with monthly and annual frequency data, eight had significantly ($p<0.05$) different mean biomass. Ten of the 19 sites were classified as being in a worse state based on annual data than monthly, while three were classed as being in a better state. Based on these results we conclude that estimates of periphyton state from annual data tend to be biased towards a worse state, while monthly data produce more reliable state estimates. Understanding this is important for planning and funding future monitoring programmes, particularly given the potentially significant resource management implications of negatively biased periphyton state reporting.

Analysis of the AFDM and percentage cover of periphyton data from 19 monthly monitoring sites demonstrated that 68% and 21% of sites were compliant with respective periphyton standards defined in the Southland Regional Water and Land Plan (2018).

Tom Harding

Number crunching for community conservation

Throughout Southland, there are numerous groups of volunteers that have formed with the same goal in mind – to protect and enhance the biodiversity in the natural environment. Environment Southland's biosecurity team works closely with a number of these groups to help maximize the efficiency of their pest control to get the best conservation outcomes. One particular way this is done is through regular monitoring of rodents, possums and birds. Monitoring has been undertaken to help the community volunteers since 2004. Data from these monitoring programmes are fed directly back to the groups, to help them make decisions on what the next step should be in their conservation efforts.

The Bluff Hill/Motupōhue Environment Trust (BHMET) and the Omaui Landcare Charitable Trust are two examples of the groups Environment Southland works with that have seen significant positive benefits from the use of the monitoring data. For example, the BHMET has actively responded to spikes in pest numbers by increasing its use of toxins. The Omaui group has added a huge number of rodent traps to its programme after realising that existing methods were not maintaining low rat numbers. While bird monitoring hasn't revealed any overall changes in abundance or diversity over the past 10 years, there are exciting patterns hidden in the data. One of the most interesting of these in recent times has been the establishment of kakariki populations at both sites.

Lawrence Kees

Worth of data in hydrological modelling

Models represent environmental processes in an idealised way. The conceptual understanding of a catchment must include sufficient and accurate data to adequately represent system processes. A key phase of catchment model development was to ask why modelled predictions depart from observed catchment behaviour. By investigating such discrepancies we can explore the data used in hydrological and catchment modelling to improve our knowledge of what and where data should be collected, and at what temporal resolution. Such exploration is necessary to trust in the decisions that we make from the results of catchment models.

Environment Southland, NIWA and GNS, have developed catchment-scale hydrological models that integrate catchment hydrological, hydro-geological and hydro-chemical characteristics. We aim to provide models as a basis for integrated freshwater management, and to improve the assessment of cumulative anthropogenic effects. Using broad-scale but high resolution data sets, we aim for a scalable approach that can be applied to answer a wide range of questions.

We present the findings and explore the worth of data in environmental predictions from the catchment modelling in the Waimatuku and Mataura catchments. This work was undertaken as part of the collaborative (GNS and NIWA) research programmes of Fluxes and Flows, and Smart Aquifer Management.

The Waimatuku example describes the increase in predictive reliability of a surface water flow model using a physically based hydrological model (TopNet). Catchment discharge predictions were made using both a 'standard' national model and associated data inputs, and a regionally specific model that incorporates detailed soil, climate, terrain and river networks. We found that the uncalibrated revised model predicted with a similar level of accuracy to the calibrated original version. Further exploration of model results suggests the extent of the role that subsurface drainage plays on catchment hydrology.

The Mataura example explores different techniques for smart aquifer management by testing and comparing catchment models to advise on whether a management decision based on a model output may change depending on the model and model inputs used. We also looked at how model predictions might be altered by directly exploring the worth of the model input data used by changing the temporal frequency and spatial distribution of environmental measurement. By testing models in this way we can describe the predictive reliability of a model output to provide confidence in model predictions and environmental decisions.

Environment Southland can use the findings from the modelling and data worth investigations to: better design monitoring networks; improve the benefit of where we spend money in different parts of the modelling process; assess fit for purpose model use; and assess appropriate level of effort required to inform community decision making in order to meet the challenges of limit-setting.

INTEGRATION

Keryn Roberts

A case study: linking catchment land use management to lake water quality

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Environment Southland has been monitoring three coastal lakes (Lake George, Lake Vincent and The Reservoir) since 2015, as part of a wider Lakes and Lagoons State of Environment monitoring programme. These shallow lakes are located in catchments extensively used for agriculture and have been showing signs of degraded water quality. Specifically, we have seen increased incidences of algal and cyanobacterial blooms.

Catchment land use practices in Southland such as stock wintering on forage crops, feed pads, silage storage and vegetation clearing, can increase nutrient and sediment loads in our coastal lakes. If these land use practices are not managed effectively they can indirectly impact lake health. The Lake Vincent catchment provides a case study that highlights the linkages between lake health, catchment land use, and lake water quality management. The water quality in Lake Vincent significantly degraded in 2016 when compared to 2004 (Schallenberg & Kelly, 2012[1]). The concentrations of Total Phosphorus (TP) fell within the 'C band' and Total Nitrogen (TN) was below the 'national bottom line' defined in the National Policy Statement for Freshwater Management. These changes were linked to poor land use practices within the catchment.

In late 2016, a 'Lake Vincent Catchment Management Proposal[2]' was developed by Environment Southland to reduce nutrient leaching and improve water quality. This proposal involves an ongoing joint effort between Environment Southland's Science, Compliance and Land Sustainability teams, along with the landowners in the Lake Vincent catchment. Outcomes to date have included a step change reduction in point source discharges to the lake and improved land use management, including riparian fencing and planting, the lining of effluent ponds and capture of silage leachate. Monitoring showed lower TN and TP concentrations for 2017 compared to 2016, however given the land use changes are recent, more time is required to determine a trend.

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Karen Wilson

Nutrient losses, loads and loadings

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Managing excess nutrients is one of our most challenging environmental problems. The nutrient status of a receiving environment, such as an aquifer, stream, lake or estuary, usually reflects the land use of the upstream catchment. Water quality becomes a key concern when land use is intensified or if water quality objectives are not being met. To protect water quality we need to better manage increased contaminant loss from the land, contaminant loads moving through aquifers, streams and rivers, and subsequent loadings into downstream receiving environments like estuaries.

Contaminants can be measured or estimated at different points and expressed in different units as they move through the landscape. Here we use 'losses' to refer to the mass of contaminants lost from a given source area and time period (mass/area/time); these are sometimes also referred to as yields and when summed for a given catchment area as 'source loads'. 'Loads' describe the mass of contaminants being transported past a given point over time, for example, via a stream monitoring point (mass/time); these are sometimes also referred to more specifically as receiving environment loads, or 'in-stream' loads. The difference between the 'source' load and 'in-stream' load for a given catchment assessment point is the catchment attenuation. We use areal 'loadings' to refer to the mass of contaminants applied or received by an environment of interest over a given area and time period (mass/area/time); for example the mass of contaminant received per hectare of an estuary or the mass of fertiliser applied per hectare of farmland. These measures are all related to one another but are distinctly different and easily confused if care is not taken when integrating work from different scientific disciplines. Our understanding of contaminant sources can vary depending on the method and metric we use.

In order to better understand nutrient losses, loads, loadings and their linkages, Environment Southland has undertaken several work streams. We have mapped land use changes, and estimates of the likely associated changes in nutrient losses from land use over time. Since 2014, our water quality monitoring has included continuous monitoring of nitrogen, phosphorus and turbidity (a proxy for suspended sediment) to enable more accurate calculations of in-stream loads at multiple sites and time scales. Additional high flow event sampling has been carried out since 2016 to help describe loads over a larger flow range. We have also undertaken modelling in some receiving environments to better understand how loadings and contaminant sources vary at different locations and time.

Land use mapping shows us that the total area of agricultural land in Southland hasn't changed much for decades, but land use has been intensified and this increases potential losses (Pearson and Couldrey, 2016). However, Southland's catchments are not homogenous and different combinations of soil and geology can attenuate these losses by varying amounts. That is, the same land use will likely have a different loss in different locations and these variations affect subsequent stream loads. Further attenuation can occur in the stream before loading of receiving environments. Therefore, our estimates of losses, loads and loadings, depend on the knowledge and the methods we use.

New River Estuary is an example where different methods for establishing loadings gave different results. For example, hydrodynamic modelling by NIWA (Measures, 2016), which uses in-stream measurements, suggests rivers are the main source of nitrogen while wastewater is the main source for phosphorus. However, results from catchment loss estimates suggest wastewater contributes only 13% of phosphorus loss. Differences in results may be explained through attenuation and other factors, but this illustrates the importance that understanding all metrics can be important depending on what information is being used for.

By being clear about the differences between losses, source loads, receiving environment (e.g. in-stream) loads, attenuation and areal loading rates, we have a much clearer and fuller (integrated) picture about contaminant sources, movement and the potential for mitigation. We can use this information to develop and implement effective management solutions for our region's waterways. The differences and relationships between losses, loads and loadings are particularly important considerations for limit setting and implementing limits.

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Nick Ward

Where does microbial contamination come from?

Faecal matter from agricultural animals and wildfowl can contribute to the microbial contamination of water, crops and food. Such contamination is also a pathway through which human-relevant pathogens enter the environment. Understanding the source of microbial contamination and how it moves through the landscape is an important part of managing surface water quality.

Animal faeces contain the faecal coliforms *Escherichia coli* and *enterococci*, which are used globally as 'indicator' organisms for the presence of faecal pollution. Although these bacteria provide a useful indication of the general presence of microbial contamination, they are common to many host species and have limited application in identifying specific faecal sources (e.g. cow vs sheep).

However, faeces also contain a range of other microorganisms that are specific to different host animals. An alternative approach for identifying the source of faecal matter is to extract total DNA from a water sample and examine the sample using polymerase chain reaction (PCR) and genotyping. These techniques provide a form of 'genetic fingerprinting' by amplifying the DNA from water samples and then identifying the source of-specific organisms it has come from.

Environment Southland embarked on an extensive programme with Environmental Science and Research (ESR) to characterise the extent of microbial contamination issues in Southland waterways. PCR and genotyping were used to provide genetic markers for species-specific campylobacter for sheep, cattle, humans and wildfowl. This allowed us to identify the source/s of faecal matter for a particular site and point in time.

Knowing the source of faecal contamination only gives us part of the picture. We also need to understand the pathways of contamination movement. To provide a greater understanding of a particular site, contextual information needs to be collated around land use, point source discharges, water quality data and local knowledge. This approach can be and target efforts towards improvement, whether via policy mechanisms or otherwise.

Nick Ward

Estuaries – What's the difference?

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Environment Southland is taking an Ecological Condition Gradient (ECG) approach to determining catchment nutrient and sediment load limits, required to meet community and stakeholder defined expectations regarding estuary condition. In order to inform nutrient and sediment limits we need to understand what is happening to our region's estuaries. For example, we need to answer the following questions:

- In the New River Estuary;
  - Why has the 'high density' (>50% cover) opportunistic macroalgae cover increased by ~800% since 2001 and ~100% since 2007?
  - Why have eutrophic areas in the estuary increased ~1400% since 2001 and ~600% since 2007?
- Why have other similar estuaries, such as Jacobs River (Riverton), had a >600% increase in eutrophic area from 2008 to 2016?,
- Why do other similar estuary systems show relatively little change over the same period?

To begin to answer these questions we need to compare the systems against each other. The ECG involves defining the ecological state of either a series of estuaries along a continuum from 'natural' to 'degraded', or changes in state within estuaries over time. Each ecological state is then correlated with the associated matching catchment sediment and nutrient loads. These correlations can then be used, along with other lines of evidence such as examining the mechanisms that cause ecological responses to sediment and nutrients, to predict the relationship between contaminant loads and ecological state.

The ECG approach could inform decisions on whether any given estuary should be maintained or improved to a 'healthier' location on the continuum by maintaining or reducing contaminant loads according to the predicted relationships. However, to increase confidence in our predictions we need more information about the contributing contaminant loads and the hydrology of each system, which both influence the sensitivity of catchments to nutrient and sediment inputs. We acknowledge that the process of refining knowledge is on-going and will progressively improve confidence in our predictions to inform limit setting.

Additional factors affecting estuary health, such as legacy effects from sediment and complex positive feedback mechanisms are also important. By looking at these additional hydrological factors and monitoring data it may be possible to add further to the story informing limit setting processes and to establish some ecological thresholds.

Lawrence Kees

Bioenergetics to balance water takes and instream habitat

Water allocation in Southland is nearing a fully allocated status in some catchments. A balance is required whereby we are able to provide enough water to farms and industry, whilst maintaining sufficient fish habitat. Stream flow is particularly important for drift feeders such as trout, which rely the continuous supply of drifting invertebrates. If stream flow is disrupted or insufficient, drift feeders have less to eat, resulting in fewer fish and/or changes in species size classes.

Methods of stream flow allocation generally revolve around setting a minimum flow and an allocation limit in a regional plan. Decisions on these limits are typically informed by Instream Flow Incremental Methodology (IFIM), utilising River Hydraulic and Habitat Simulation (RYHABSIM) and Generalised Habitat Modelling, amongst other things. A limitation of these models as traditionally applied in the IFIM, is the assumption that physical habitat alone (which includes water depth, velocity and substrate composition) determines fish habitat selection.

Net Rate of Energetic Intake (NREI) bioenergetic modelling was applied to three main-stem representative reaches of catchments in Southland to assess the response of drift feeding fish to instream variations in flow. A key finding of this work was how sensitive drift feeding fish are to changes in flow between 7–day mean annual low flow (MALF) and the median flow. The NREI model predicted that feeding opportunities, growth and carrying capacity would keep increasing as flow increases, through the mean annual low flow and beyond into mid-range flows. In comparison, RHYHABSIM predicted an optimised amount of habitat below or just above the MALF, depending on the choice of habitat suitability curves used.

Advances in physical habitat modelling, and comparisons between hydrological measurements and modelled flow estimates, are now being made to investigate the applicability of current flow allocation regimes in light of recent findings on bioenergetics demand.

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Roger Hodson

Establishing reference conditions to support habitat assessment in citizen science

Community initiated catchment groups have expressed considerable interest in undertaking citizen science initiatives to assess water quality and stream health in Southland. With robust study design, such initiatives have the potential to make a meaningful contribution to the management of our region's aquatic ecosystems. Environment Southland has been collecting a reference condition data set from Southland streams. Quantifying reference conditions can support citizen science initiatives, in interpretation and contextualisation of their monitoring efforts.

Healthy, resilient aquatic ecosystems depend on physiochemical water quality, ecosystem processes and stream habitat quality all being provided for. However it may not practicable or cost-effective for community groups to monitor multiple aspects of stream health. Physicochemical water quality indicators (such as nitrate) are important indicators of aquatic ecosystem health. However, successful monitoring requires a commitment to regular long-term monitoring and consistent methods to characterise diurnal, seasonal, inter-annual and climatic variability. Such monitoring is costly and time consuming to execute and interpret. Similarly, indicators of ecosystem function (e.g. organic matter decomposition, primary productivity) are relatively costly and complex to measure and interpret, and many require specialised monitoring equipment and skills.

In contrast, a visual, low cost assessment of stream health can be achieved through application of a habitat assessment such as Rapid Habitat Assessment (RHA). RHA involves assessing ten components including bank vegetation, buffer width and shading, bank stability and erosion, sediment deposition, and flow types. With training RHA assessments can be carried out in approximately 20-30 minutes per reach, meaning a large number of sites can be assessed relatively quickly to facilitate both spatial and temporal comparisons.

The interpretation of RHA scores is most robust when scaling to relevant reference condition. There is a paucity of relevant reference condition information available. To address the shortcoming, Environment Southland is carrying out work to quantify reference conditions in Southland streams. Potential reference sites were identified in a desktop exercise, subsequent filed work has included the collection of macroinvertebrate taxa, physiochemical water quality and completion of a RHA score. Preliminary results from 37 of 101 identified sites illustrate a median reference condition RHA score of 86.5, range 63 - 97.

There is opportunity to support Southland community groups use of the RHA to: provide a baseline assessment of stream habitat; prioritise restoration activities within and between locations; assess changes in stream habitat over time. Additional benefits to community group involvement in monitoring efforts include: developing trusted relationships; building common understanding and ownership of issues and management solutions; and increased data collection capacity.

Chris Jenkins

Waituna Lagoon: exploring management solutions for maintaining lagoon health whilst providing for land drainage

Located 40 km south east of Invercargill, Waituna Lagoon is one of the most natural examples of New Zealand's coastal lagoons. The surrounding wetland and its flora and fauna is of international significance and is valued for its recreational, cultural and scientific values. The catchments that contribute to the lagoon are intensively farmed and there are concerns that the health of the lagoon and its tributary waterways is under stress.

In a 'healthy' state, the lagoon should be dominated by aquatic macrophytes such as *Ruppia* spp. Current management of the lagoon allows mechanical opening to the sea to provide drainage for surrounding farmland when the lagoon reaches a depth of two metres above mean sea level. However, if the lagoon is open for extended periods, the influx of salt water may compromise the growing conditions required by *Ruppia*. An ideal management solution would satisfy the requirements for land drainage whilst also maintaining growing conditions for *Ruppia*.

To assess different the impacts of different potential management regimes, a hydrological model of the lagoon has been developed to model the response of water level on surrounding farmland. Specifically, the model will be used to assess the effects on neighbouring landowners, under several alternative scenarios where the existing opening criteria are varied from 2.2 to 3.0 metres. Increasing the lagoon level opening criteria will increase the amount of time that land is submerged, however the magnitude of this is unknown. Mechanical opening is currently only permissible between 1 May to 31 July in any given year.

The model utilises 39 years of long-term flow record from the nearby Waihopai catchment, which has a strong correlation with the flow in Waituna Creek. Local data for precipitation, evaporation, groundwater input and barrier seepage are used to complete the water balance for situations where the lagoon is closed to the sea.

Probabilities for the lagoon closure in a given month have been estimated from historic records of the natural closings and mechanical openings.

For each opening criteria scenario, Monte Carlo models have been used to generate 30 simulated datasets of lagoon water level based on randomly selected closing conditions followed by mechanical openings. A distribution analysis and event counter have been used to predict the amount of time neighbouring land is submerged per year under each scenario. These predictions can inform discussion and a decision process around the merits of alternative lagoon level management solutions.

Modelled lagoon levels for different climate scenarios showed that the annual average number of days above 2.0 MSL increased from 2.7 under current climate conditions to 4.0 for future modelled rainfall conditions. Spring to autumn openings currently average 0.16 openings per year, but could increase to 0.36 with climate change. However, winter openings are expected to remain generally unaffected. In one climate scenario, the average number of days the lagoon was open to the sea increased from 118.6 days to 131.3 days. In summary, these results indicate that land use and lagoon health will be affected with changes in climate.

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Ewen Rodway

Evolving freshwater management in the face of increased demand and climate change

The ongoing intensification of urban and rural land use in Southland brings challenges in terms of maintaining freshwater quantity and quality. Historically, Southland has had modest pressure on usage so there has been an apparent abundance of available water. However, increasing water demand and variation in recharge patterns requires a more advanced approach to freshwater resource management.

To date management of freshwater has relied on the assessment of resource use applications on a broad scale and somewhat isolated basis. This methodology has been to the detriment of effectively assessing the cumulative effects of multiple users. Reduced seasonal recharge in the last two years has highlighted the vulnerability of water resources in some areas of Southland. The integrated understanding of these hydrological systems could be improved to reduce negative impacts on resource users and dependant ecosystems.

Along with NIWA and GNS, Environment Southland has developed catchment-scale geological and hydrological models. When combined with management tools such Hydro-GeoAnalyst and Cumulative Hydrological Effects Simulator (CHES), these models provide a basis for integrated ground and surface water management and improved assessment of cumulative effects. Using broad scale but high resolution data also allows for a scalable approach that can be applied to answer a wide range of questions.

Improved aquifer and hydrological characterisation provides the basis for more sustainable allocation even with changing climate and use. By obtaining knowledge of system boundaries and operating sustainably within these we can build resilience into the communities and industries that rely on them.

Mark Oster

Southland's scattered wetlands; the results from a regional inventory.

Wetlands are an intrinsic part of the landscape and a critical part of a healthy environment. Despite their importance they have been subject to wide scale drainage and destruction. Wetlands are now amongst the most threatened ecosystems in New Zealand. In Southland it's estimated that just 11% of our original wetland areas remain.

Wetland areas continue to decline in Southland. They are sensitive to environmental change and are vulnerable to the effects of human activities including changing land use and water regimes, invasive weeds and animal pests. Environment Southland sought to better understand recent wetland loss by comparing aerial photography from 2007 and 2014/2015. Results showed a continued decline of wetlands on private land.

The continued decline risks not only further loss of the intrinsic value of Southland's wetlands but also further loss of priority ecosystem services such as water quality, flood abatement and carbon sequestration, as well as biodiversity values including rare flora and fauna.

Environment Southland has been working with landowners and community groups to help them to understand and better manage our natural wetlands. The creation and development of artificial wetlands is also a key tool in wetland protection. Environment Southland provides support and research into how to create sustainable wetlands to provide ecosystem services.

PEOPLE

BUILDING CONNECTIONS

Emma Moran

Building connections – Location, location, location

In Southland, a relatively large proportion of people live rurally (twice the national average) and towns are service centres for their local area. As a result, many Southlanders tend to live closer 'to the land' than other regions and there are strong connections between 'town and country'. The supply of essential services, such as wastewater management, is a sizeable investment for local communities but they make it possible for people to live and work together. These services form part of a local community's natural and built assets or 'wealth' and, where they are delivered sustainably (in all of its components), they contribute to a community's wellbeing.

Water is vital to life but many towns have an uneasy relationship with water, in terms of its quantity and its quality. Most towns and settlements lie on valley floors near rivers and streams, and in some cases also lakes. Towns are often one of a series or chain within a catchment, connecting the headwaters of a river, or one of its tributaries, with an estuary.

The Urban and Industry Report brings together research on municipal wastewater, involving Southland's four councils: Gore District Council, Invercargill City Council, Southland District Council, and Environment Southland. Eight towns across the region were included as case studies and their wastewater treatment systems were modelled with upgrade scenarios: Te Anau, Ohai, Nightcaps, Winton, Gore, Matāura, Bluff and Invercargill. The towns were selected to cover as wide a range of different circumstances as possible, and together represent over 70 percent of Southland's total population. The report is one of the main outputs of the Southland Economic Project, which was set up to develop robust ways of understanding the possible socio-economic impacts of achieving 'limits' for fresh water in Southland.

The aim of this research was to develop information on the financial costs of further managing contaminants in discharges of treated wastewater from municipal schemes. Specifically, investigations focused on:

1. the current performance of municipal wastewater treatment systems in terms of the waste substances in their wastewater discharges; and
2. the effectiveness of modelled scenarios to further improve their discharges and the financial costs of these scenarios.

Research results will be used in a regional model of Southland's economy, which will trace transition pathways (or routes) for the economy as it evolves over time in response to limit-setting for water. The model will be used to test the economic impacts of different 'what if' policy scenarios. This testing will help develop our understanding of how Southland's economy works, which is needed to inform decisions on how to achieve freshwater limits.

Tim Ellis

Stream bank erosion as a result of socio-economic goals

Tim Ellis, Janet Hodgetts and Jane McMecking

Excess sedimentation of our waterways is a major environmental issue in New Zealand. In Southland, stream bank erosion is thought to be a broad-scale source of excess sediment in some of our waterways. Environment Southland was asked by the Ministry for the Environment to contribute to the national understanding of stream bank erosion and its mitigation.

We reviewed available knowledge on stream bank erosion processes and modelling capability, as well as the history of human influences on the geography and hydrology in Southland and their implications for stream bank erosion. We then examined the question of how to inform decision making for mitigating problem sediment from stream bank erosion.

Simulation models can make important contributions to resource management decision processes, however their utility can be limited without an understanding of catchment history and broad-scale drivers. We present the case that the overall drivers of excess stream bank erosion, and erosion excess generally, are socio-economic factors and that they are typically omitted or inadequately considered within decision-making processes.

In addition, we propose that popular methods for on-site stream bank erosion mitigation, such as riparian planting, address *symptoms* rather than the *causes* of stream bank erosion. Further, these mitigation methods may ultimately fail, or make matters worse, unless the main drivers are simultaneously addressed.

We conclude that stream bank erosion is an emergent property of a self-organising, complex system and a holistic approach, with a blend of systems thinking and simulation models, is required to address sediment problems in general. We recommend that a good understanding of social, economic and ecological histories, drivers and trajectories is needed, supported by simulation models if appropriate, and not the other way around.

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Ali Meade

Ecosystem mapping: a stocktake of Southland's biodiversity

Environment Southland's vision for biodiversity is that 'The full range of Southland's indigenous ecosystems and species are maintained in a healthy and fully functioning state'. However, to do this we first need to understand what the region's biodiversity looked like before humans arrived, the extent of the biodiversity loss and health and the significance of what we have left.

Southland's four councils have commissioned a regional stocktake in the form of a series of maps. These maps use historical information, biotopography and soil data to determine potential ecosystems. Mapped data were then compared to recent ecological reports and aerial photography to determine where ecosystem types exist today.

The work covers terrestrial, freshwater and marine ecosystems, and has identified over 80 regional ecosystems. The largest change in biodiversity has occurred across the Southland Plains and many ecosystems are now only found in small, widely dispersed fragments.

The next stage of the project will be to ground-truth the mapping data and then prioritise areas that need intervention, management and protection.

BEHAVIOURAL CHANGE

Owen West

Emission characterisation, interventions and community response in the face of health-related evidence

Environment Southland has monitored ambient PM_{10} since the early 2000s and currently monitors three sites across Southland. High PM_{10} concentrations are regularly recorded during the cool, calm winter months. Establishing a thorough understanding of the temporal and spatial sources of PM_{10} has enabled Environment Southland to develop local regulations to support national, health-based standards. Other measures to tackle the issue have included education and more recently engagement with affected communities.

Analysis of PM_{10} sources included an emission inventory that estimated on an average winter's night domestic heating accounted for 95% and 97% of PM_{10} emissions in Invercargill and Gore, respectively (Wilton, 2015). Further source characterisation work completed by GNS Science reinforced the dominance of domestic heating as a primary source of PM_{10} and also provided an understanding of natural source contributions (Ancelet et al., 2015). Temporal variations in sources were also assessed by GNS.

PM_{10} source analysis was used to support the changes to the Regional Air Plan 2016 and the subsequent education initiatives. However it has been recognised that technical evidence, regulation and education alone may not be the most efficient path to achieving desired outcomes. Community engagement is now being explored in partnership with the Institute of Environmental Science and Research in an attempt to understand the key drivers of behaviour change necessary to meet the health standards and other community outcomes in Southland's regional plans.

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Ewen Rodway

Physiographics: utilising science to effect positive change

The Physiographics of Southland encompasses a large body of science developed at Environment Southland over several years. The project began as an investigation into the reasons why hydrochemistry varies across the Southland landscape often contrary to expectation based on land use (Rissmann et al., 2016).

The initial delineation of the 'drivers' of hydrochemical variation evolved into the development of a qualitative water quality risk assessment tool for use in the Southland Water and Land Plan (Environment Southland, 2016). The tool relates to nitrogen, phosphorus, sediment and *E.coli* and consists of nine physiographic zones and eight variants or subclasses. These zones and variants describe areas with similar characteristics that determine water quality risk.

Physiographic zones have been incorporated into the Southland Water and Land Plan in two distinct ways. Firstly, the zones are used at a region-wide policy level to provide landscape specific direction on how to mitigate water quality risk. Region-wide policies also provide direction to discourage high contaminant loss activities in high risk zones. Secondly, it is required that the zones are considered in all farm plans. Their use in this context focuses on identifying farm specific water quality risks and complementary mitigations or good management practices. The zones have provided a good basis for community engagement and stimulating thought about regional variation in water quality risk.

The broader physiographic science package has been used extensively in supporting consent decisions and data interpretation as well as an input to models and projects such as CLUES, Smart Aquifer Management (SAM), monitoring network rationalisation and land use suitability assessments.

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Emma Moran

Economy, understanding and resource management

This talk is about economics, how it fits with the Resource Management Act, and the thinking behind the Southland Economic Project. When people talk about economics most people focus on everything financial. In reality, economics is about understanding choices, particularly when something is scarce. These 'somethings' could be money, skilled labour, water, or soil. They can even be pollen. In general, there are two basic types of economics: positive economics, which describes what is going on, and normative economics, which prescribes what to do about it.

The RMA is all about economics and, in this context, the things that are scarce are usually natural resources. The point of the RMA is to manage our resource use in ways that give us opportunities to live the lives we want now while making sure that our children and grandchildren will have similar opportunities later. For resource use to be sustainable, which just means 'on-going' or sustained, we have to make choices based on value, and that is where economics comes in. This value is both market and non-market. It is also changes spatially and temporally.

Through the Southland Economic Project, we have invested in understanding how the real world works, not some optimised or idealised view of it. It is all about behaviour – people actions, reactions, and the incentives that they face – through policy and other factors. It recognises that the economy sits within, and is part of, the wider environment. Everything is Southland closely interconnected and the region operates as a system.

The Southland Economic Project was set up to create ways of agreed understanding of the possible socio-economic impacts of setting limits on the use of fresh water under the National Policy Statement for Freshwater Management (2017). It's a joint venture with many partners invested in creating robust datasets for the agriculture and municipal sectors.

Case studies were developed for 95 farms and eight towns across Southland. The aim of this research was to develop information on the effectiveness and financial impacts of further managing waste products. Data collated from these studies are being used in the Southland Economic Model for Water. By tracking resources through the economy, the model will have the capability to report on both direct impacts and wider impacts across the region.

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Next steps

Thank you for attending the Environment Southland Science Symposium. All the posters and videos from today will be online in the next few weeks at www.es.govt.nz/science-symposium18.

For further information on our next steps and how you could be involved, please have a chat to:

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