INTEGRATED CATCHMENT MANAGEMENT for the Motueka River

• ridge tops to the sea •

A Summary of Outcomes and selected formal publications from the Integrated Catchment Management (ICM) research programme:

2000 – 2011

Andrew Fenemor

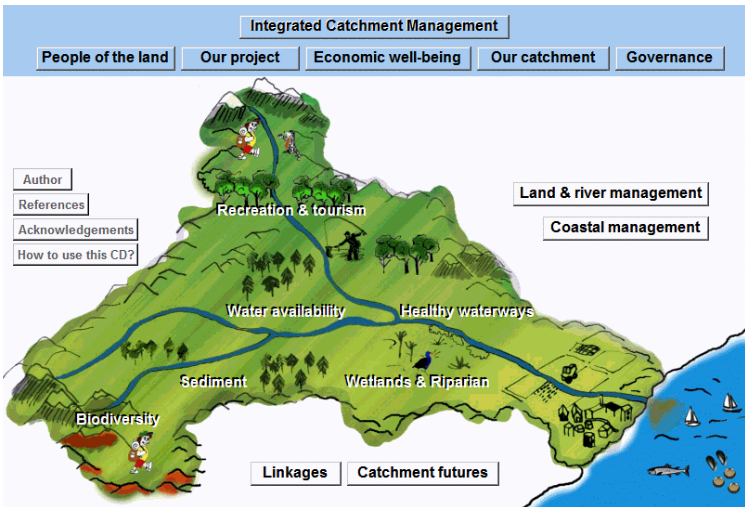
Programme Leader ICM

Landcare Research

2013

Research issues addressed

1. Allocation of Scarce Water Resources among Competing Land & Instream Uses



- How do local land uses affect the availability of ground and surface water over the entire catchment?
- What is the most defensible way to plan for the allocation of water resources among competing alternative uses?
- How much water is required to maintain instream values?
- How do economic returns affect landowners' and recreational uses of water?

2. Managing land uses in harmony with freshwater resources

- How is sediment mobilised to reach rivers, and what impacts does it have?
- What information is needed to best manage river gravel allocation?
- Why has the Motueka catchment trout population declined then partially recovered?
- How can water quality be maintained or improved with intensifying land use?
- Are there some fundamental solutions to water quality contamination?
- Is riparian re-vegetation the 'silver bullet' for improving water quality?

3. Managing Land and Freshwater Resources to Protect and Manage Marine Resources

- What are the risks to marine farming from activities on land?
- What are the factors that increase or decrease the production and values of fish and shellfish?
- Where are the faecal bacteria affecting marine farms coming from?
- What are the relative effects of river flows (especially floods) on scallop and mussel production compared to activities like dredging and marine farming?

4. Integrative tools and processes for managing Cumulative Effects

- What are preferred development pathways to ensure continued sustainable management at catchment scale?
- What are the opportunities for using modelling to predict cumulative effects of land use scenarios?
- How can models help decision-makers balance environmental impacts alongside social, economic and cultural benefits when planning for further development?

5. Building Human Capital and Facilitating Community Action

- What methods would best motivate environmental stewardship by catchment and community groups?
- What methods can we use to promote effective interaction between scientists, resource managers, and the community?
- How can iwi build their capability in the resource management process?
- What are some 'off the wall' examples of innovative and enduring community engagement that we could use to facilitate community action?

What has the ICM research programme achieved?

1. Allocation of Scarce Water Resources among Competing Land & Instream Uses

Water Allocation: Allocation of river flows for irrigation vs the nationally recognised trout fishery was a focal point of the negotiated agreement on the Motueka Water Conservation Order, gazetted in 2004. Water allocation limits were set for the Upper Motueka catchments in TDC's Resource Management Plan and are now being updated based on water allocation scenarios in GNS river-aquifer modelling (see below).

ICM research with the Ecologic Foundation and water stakeholders used the Motueka catchment as a case study to identify how water use flexibility can be enhanced and security of supply better understood, through changes to the RMA or regional council water allocation policy. Options include flow sharing and water quality management through catchment farmer groups, changes to water permit specifications and proposals to encourage transfers of water permits. This work addressed issues now relevant to the Land and Water Forum. Models predicting how in-stream habitat will change with flow have been used to assist flow management decisions.

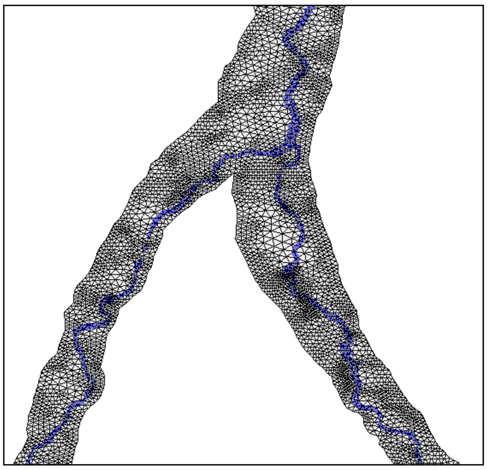
Water governance remains a priority issue for the new Government and the TDC. In 2008-09 we completed a survey of 56 stakeholders from 4 South Island regions and 5 catchments about their RMA water plan development process, and proposed a 'straw man' for improving RMA performance for water allocation and water quality management.

Contacts: Andrew Fenemor (Landcare Research), Jim Sinner (Cawthron Institute), Mary-Anne Baker (TDC)

Fenemor, A.D.; Neilan, D.; Allen, W.; Russell, S (2011). Improving Water Governance in New Zealand – Stakeholder Views of Catchment Management Processes and Plans. Policy Quarterly 7(4):10-19

Fenemor, A.D.; Davie, T.; Markham, S: 2006. Hydrological information in Water Law and Policy: New Zealand's devolved approach to water management. Chapter 12 in Hydrology and Water Law – Bridging the Gap (eds. J Wallace and P. Wouters). IWA Publishing London.

Groundwater Dynamics: Managing increasing demand for irrigation from groundwater in the Upper Motueka valley requires knowledge of how these alluvial aquifers interact with the Motueka and tributary rivers, and how groundwater pumping indirectly impacts aquatic ecology.



With GNS and TDC, a FEFLOW spatial model has been calibrated to predict changing groundwater levels and river flows for the upper Motueka, based on geological mapping, river flow gauging and well monitoring. Soil moisture experiments on Korere and Waiwhero farms quantified the small contribution of hill slopes runoff to groundwater recharge. Dating the alluvial groundwater shows it has been underground only 1-3 years. Irrigation scenarios have been run through the FEFLOW model to understand how different levels of irrigated land use influence river flows and ecology, how climate change may affect river flows and groundwater yields, and what impact a changing river bed level might have on the groundwater table.

Contacts: Chris Daughney(GNS), Joseph Thomas (TDC), Andrew Fenemor (Landcare Research), Jagath Ekanayake (Landcare Research), Mike Stewart (GNS)

Gusyev M;Toews M; Daughney C; Hong T; Minni G; Ekanayake J; Davie T; Fenemor A; Basher L; Thomas J. (in press). Groundwater abstraction scenarios implemented in a transient groundwater-river interaction model of the Upper Motueka River catchment. J Hydrology (NZ).

Water Use Economics: Out-of-stream water allocation for irrigation is driven by returns for primary production. Paul White completed a 5-year survey of 17 agricultural users of groundwater in the Waimea Plains, to assess the economic drivers of groundwater use. This work shows the influence of lifestyle block demand and changes in apple prices on groundwater use.

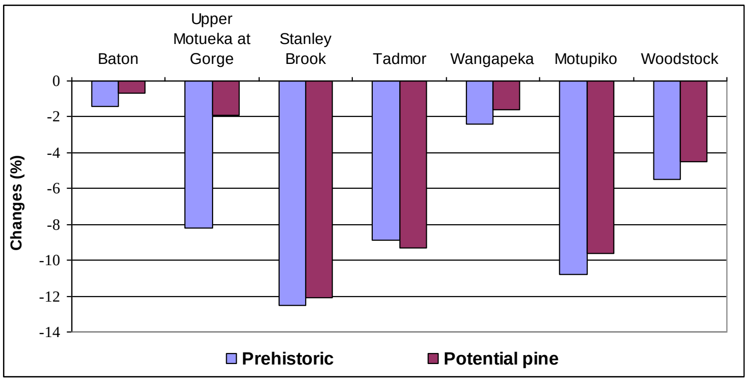
The costs and benefits of the Tadmor water augmentation scheme (Hope River diversion) were evaluated, and indicate net positive financial returns for irrigation water users of diverted water. A companion study of ecological costs and benefits concluded that the river diversion has not affected water quality or river ecology in the Tadmor River.

Contacts: Andrew Fenemor (Landcare Research), Paul White (GNS), Dean Olsen (Cawthron)

White PA. 2011. Economic drivers of land use and groundwater use by irrigators, Waimea Plains Nelson, New Zealand. New Zealand Journal of Marine and Freshwater Research 45:513-524

2. Managing land uses in harmony with freshwater resources

River and coastal hydrology: Changes and intensification of land use have impacted stream flows and water quality. Computer models help us understand why these changes occur. We have calibrated a SWAT catchment water balance model to compare the effects of different vegetation cover throughout the catchment on river flows. We have also developed a simple water balance model WATYIELD for unmonitored catchments to estimate how streamflows will change if land cover is changed (eg planting or cutting down forests).



The Motueka catchment SWAT flow and contaminant model showed that river flow at Woodstock is about 21% higher now than under prehistoric bush land cover, and with maximum possible afforestation would be about 16% higher. Nutrient flows down the river systems have been modelled using SWAT and bacterial inputs to the bay have been predicted using a faecal die-off model. Simulated Motueka river and contaminant flows feed into the Tasman Bay coastal circulation and ecosystem models to understand catchment impacts on the bay. Model results from the IDEAS model (see below) predict broad-scale in-stream and marine impacts of future land use and aquaculture scenarios.

At a more detailed scale, PhD graduate Kiran Kumar has shown that the average daily transpiration (February to April) rate of crack willows in the Waiwhero wetland was more than four times that estimated for pasture,

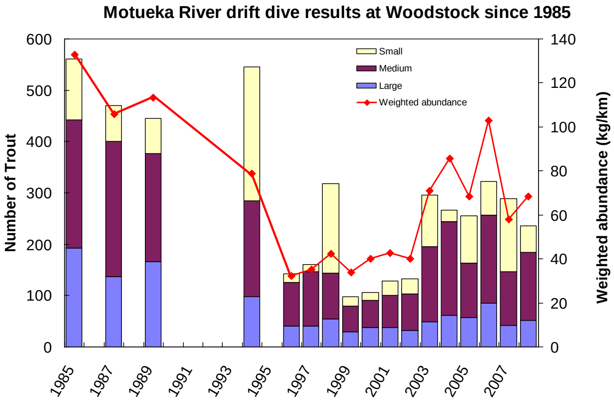
Contacts: Jagath Ekanayake (Landcare Research), Tim Davie (Environment Canterbury), Andrew Fenemor (Landcare Research)

Fahey, B; Ekanayake, J; Jackson, R; Fenemor, A; Davie, T; Rowe, L. 2010. Using the WATYIELD water balance model to predict catchment water yields and low flows. Journal of Hydrology NZ 49(1): 35-38.

Cao W, Bowden WB, Davie TJA, Fenemor A 2008. Modelling impacts of land cover change on critical water resources in the Motueka River Catchment, New Zealand. Water Resources Management, April 2008. SpringerLink

Sediment Impacts in River and Coastal Ecosystems: Sediment is blamed for deteriorating fish habitat in rivers, and has major impacts on scallop resources in areas off the river mouth in Tasman Bay.

Using a monitoring network of suspended sediment samplers in the catchment, set up in conjunction with TDC and NIWA, we have shown the importance of localised large, infrequent floods for sediment generation and dispersal and have also been documenting how sediment generation varies during the forest harvest cycle.



A 50 year storm at Easter 2005 in the upper Motueka/Motupiko raised sediment yields by 10 times in the affected area and by 2-3 times at the coast. This effect has persisted for the last 4 years with yields slowly returning to pre-storm levels. Heavy metals from a mineral belt in the upper catchment have been tracked from that storm down-river into the seabed sediments of Tasman Bay with their concentrations exceeding criteria for ecosystem health within the coastal river plume. These infrequent storms have a profound influence on long-term sediment yields.

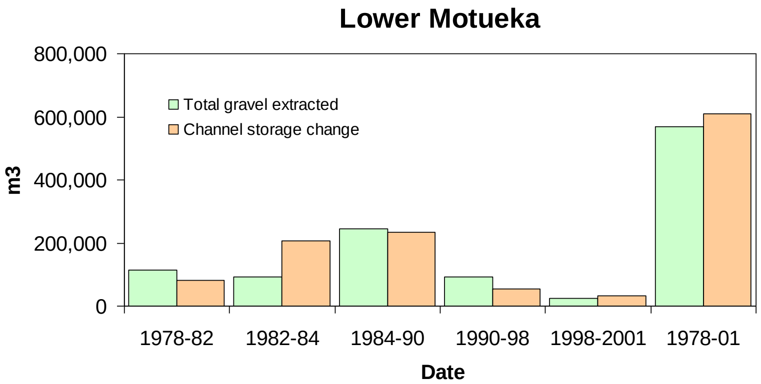
We have developed a riverbed substrate monitoring method to quantitatively link fine sediment occurrence with aquatic habitat suitability. It provides data on fine sediment abundance that complements biological surveys such as drift dives to measure trout numbers.

Contacts: Les Basher (Landcare Research), Murray Hicks (NIWA), Chris Cornelisen (Cawthron)

Basher, L.R., Hicks, D.M., Clapp, B., Hewitt, A. 2011. Sediment yield response to large storm events and forest harvesting, Motueka River, New Zealand. New Zealand Journal of Marine and Freshwater Research 45:333-356

Sustainable River Gravel Extraction: Catchment stabilisation works, revegetation since the bush clearance days and gravel extraction have led to a gradual decline in riverbed levels, and the need to limit gravel extraction from rivers.

An ICM study with TDC reviewed bed level changes based on 40+ years of river channel cross-section surveys in the Motueka river. It confirms the general degradation trends but finds that more information is needed on gravel transport mechanisms, especially during floods.



Periodic river cross-section surveys are the primary tool used by most regional councils to monitor river bed levels and to help set gravel extraction limits but these have significant limitations for accurately establishing gravel supply rates. Annual GPS surveys ('3 beaches') have better defined gravel volume changes, and are being used to assess how well the present river cross section network reflects bed level and gravel volume changes. They show that the cross sections under-estimate the changes in gravel volumes stored in the river bed, but the work confirms the continuing lowering of riverbed levels. This type of investigation can establish an average sustainable gravel supply that can be adjusted following large flood events. It also shows how constraining the width of gravel-bed wandering rivers leads to channel lowering and limits replenishment of the gravel resource on bars where gravel is typically extracted from.

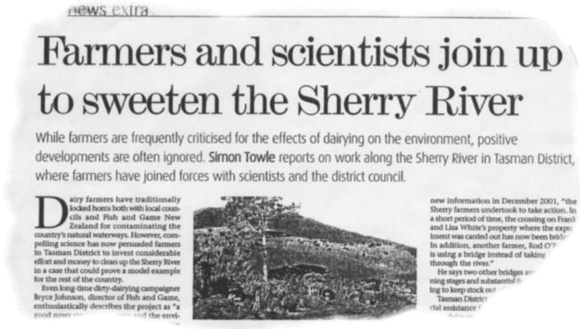
Contacts: Les Basher (Landcare Research), Ian Fuller (Massey Univ), Eric Verstappen (TDC)

Land Use Impacts on Water Quality: Early water quality research identified areas of concern in one part of the catchment, particularly related to the daily crossing of streams by cows.

Through working collaboratively with the dairy farmers, sheep and beef farmers, and forestry companies the bacterial water quality of the Sherry River has been improved by more than 50%, initially through bridging dairy crossings and forestry crossings. This work has been followed by further water quality sampling in conjunction with TDC which shows an improvement in river water quality, though not to swimmable standard at times.

Close ties with the local community and with the NZ Landcare Trust and TDC staff have built trust and a collaborative approach. A 2007-2010 SFF project assisted the Sherry Catchment Group to complete Landowner Environmental Plans now being implemented to improve water quality to a target 80% reduction in *E.Coli*.

Best management practices (BMP/GMPs) for the range of land use types in the Sherry were developed and a BMP library established on the ICM website http://icm.landcareresearch.co.nz. These were used in a partner project with TDC on whole catchment nutrient budgeting with landowners in the Motupipi catchment, funded through Envirolink. Water quality responses have been monitored by TDC and NIWA in the Sherry, and showed that floods transport most of the bacteria and phosphorus, but low flows carry most of the nitrate. Therefore different mitigation approaches are needed to manage both. At a whole catchment scale we have developed and calibrated a model that tracks faecal bacteria movement and die-off.


news extra

Farmers and scientists join up to sweeten the Sherry River

While farmers are frequently criticised for the effects of dairying on the environment, positive developments are often ignored. **Simon Towle** reports on work along the Sherry River in Tasman District, where farmers have joined forces with scientists and the district council.

Dairy farmers have traditionally locked horns both with local councils and Fish and Game New Zealand for contaminating the country's natural waterways. However, compelling science has now persuaded farmers in Tasman District to invest considerable effort and money to clean up the Sherry River in a case that could prove a model example for the rest of the country.

Even long-time dirty-dairying campaigner Bryce Johnson, director of Fish and Game, enthusiastically describes the project as "a good news

new information in December 2001, "the Sherry farmers undertook to take action. In a short period of time, the crossing on Frank and Lisa White's property where the experiment was carried out has now been brid[illegible] In addition, another farmer, Rod O'[illegible] is using a bridge instead of taking [illegible] through the river."

He says two other bridges [illegible] ning stages and substantial [illegible] ing to keep stock out [illegible]

Tasman Distric[illegible] cial assistance [illegible]

A farmer-maintained riparian restoration trial at Matariki has provided guidelines for farmer-friendly riparian restoration with native plants in weedy environments, aimed at providing stream shade and excluding stock from riverbanks. Aligned with the Sherry work is the database of the stabilising potential and growth characteristics of New Zealand's indigenous plants developed from 2 field trials in Gisborne.

Contacts: Andrew Fenemor (Landcare Research), Barbara Stuart (NZ Landcare Trust), Roger Young (Cawthron Institute), Rob Davies-Colley (NIWA), Chris Phillips & Mike Marden (Landcare Research), Lisa Langer & Nick Ledgard (Scion), Trevor James & Rob Smith (TDC)

Wilkinson RJ, McKergow LA, Davies-Colley RJ, Ballantine DJ, Young RG 2011. Modelling E. coli from livestock in the Motueka and Sherry rivers. New Zealand Journal of Marine and Freshwater Research 45:369-393

Smaill SJ, Ledgard N, Langer ER (Lisa) and Henley D 2011. Establishing native plants in a weedy riparian environment. New Zealand Journal of Marine and Freshwater Research 45:357-368

Shearer KA, Young RG 2011. Influences of geology and land use on macroinvertebrate communities across the Motueka River catchment, New Zealand. New Zealand Journal of Marine and Freshwater Research 45:437-454

Effects on freshwater fish of changing river flows: Decisions on water allocation are often made at a reach scale and neglect the fact that fish populations move throughout a river catchment. Flows that are adequate to protect ecosystem health in one part of the catchment at one time of the year may not be adequate at other times of the year or in other locations.

Movements of radio-tagged trout throughout the Motueka were characterised by Cawthron ICM researchers to understand more about habitat requirements in different parts of the river. A 50+year flood upset the study to some extent, but resulted in an interesting finding – more than half of the adult trout population in the tributary most affected by the flood perished during the flood. The results indicated the importance of flow and water temperature for controlling fish movement, the importance of deep pools for providing refuge from low flows and warm water temperatures, and also the dramatic effects of that large flood on adult trout survival.

Many fish species move throughout catchments to complete their life history, especially those that require access to and from the ocean. ICM research has confirmed the potential of using fish otolith microchemistry – the chemistry of fish earbones - for tracking how fish have moved throughout a catchment. It is now possible to distinguish between fish reared in different parts of a catchment and to determine where a fish has been throughout its life by looking at the chemical signatures laid down in its otoliths. We also conducted a test of a 2-D hydraulic model (River 2D) for defining how habitat availability for different species will vary with flow at several sites throughout the catchment including in some small streams where traditional models have proved problematic. These studies provided advice on appropriate environmental flows throughout the catchment.

Contacts: Roger Young & Joe Hay (Cawthron Institute), Ricky Olley (Otago Univ), Trevor James (TDC), Neil Deans (Fish & Game NZ)

Olley R, Young RG, Closs GP, Kristensen EA, Bickel TO, Deans NA, Davey LN, Eggins SN 2011. Recruitment patterns of brown trout identified by otolith trace element signatures. New Zealand Journal of Marine and Freshwater Research 45:395-412

Doehring K, Young RG, Hay J, Quarterman AJ 2011. Suitability of Dual-frequency Identification Sonar (DIDSON) to monitor juvenile fish movement at floodgates. New Zealand Journal of Marine and Freshwater Research 45:413-422

3. Managing Land and Freshwater Resources to Protect and Manage Marine Resources

The Condition of River Delta Habitat: River outflows to the coast affect the stability, productivity and ecosystem health of the river delta, and this has a flow-on effect on marine fisheries and aquaculture potential. A national protocol for monitoring barrier-enclosed estuaries has been adapted to include river delta systems. Both broad-scale mapping on GIS, and fine-scale assessment of seabed habitats of the Motueka River delta have now been completed for comparison with future repeat surveys.

Contacts: Paul Gillespie (Cawthron Institute)

Catchments Extend Offshore: Our research has shown that the Motueka 'Catchment' effectively extends offshore encompassing more than 400 km^2 of the marine environment of Tasman Bay. Physical and chemical (nutrient) characteristics of the water column within the plume have been shown to stimulate the growth of micro-algae upon which shellfish (including farmed mussels) depend for food.

Suspended sediment from the river mouth has been shown to generate chronic high turbidity conditions in near-bottom waters that can interfere with the feeding of scallops and potentially other commercially and ecologically important benthic suspension feeding animals. This mechanism has been suggested as a major contributor to the poor performance of the Tasman Bay scallop resource in recent years.

Of this 400km^2 of catchment influence, about 180 km^2 of seabed has a demonstrable terrestrial signature arising from the river outwelling plume. Naturally high heavy metal levels (Ni, Cr, Cu) within the sediment flushed from the Red Hills at the head of the catchment may be affecting marine and freshwater life, because they are beyond ANZECC levels for ecosystem health. These catchment-coastal connections demonstrate that management of coastal ecosystems, fish and shellfish resources needs to take account of activities across the entire land/sea continuum comprising our redefined "catchment". This is a major deviation from current coastal management practice.

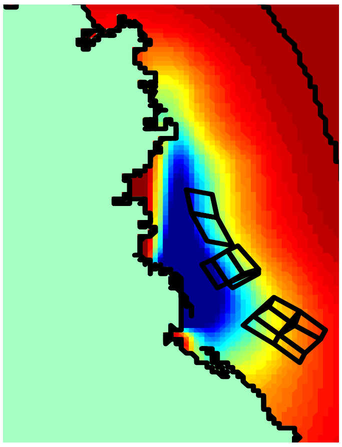
Contacts: Paul Gillespie & Chris Cornelisen (Cawthron Institute)

Gillespie PA, Forrest RW, Peak BM. Basher LR, Clement DM, Dunmore R, Hicks DM. 2011a. Spatial delineation of the depositional footprint of the Motueka River outwelling plume in Tasman Bay, NZ. NZ Journal of Marine and Freshwater Research 45:455-476.

Gillespie P, Forrest R, Knight B, Cornelisen C, Young R. 2011b. Variation in nutrient loading from the Motueka River into Tasman Bay, New Zealand, 2005–2009: implications for the river plume ecosystem. NZ Journal Marine and Freshwater Research 45:497-512.

Effects of the Motueka River Plume on Aquaculture Management Areas:
Water quality and productivity in the 4200 ha of designated Aquaculture Management Areas off the Motueka river mouth is affected by the river discharge, particularly during large floods. The extent and magnitude of freshwater effects on seawater temperature, salinity, density, chlorophyll-*a*, water clarity and nutrients has been mapped to provide a basis for understanding the nature and spatial extent of catchment effects on wild, enhanced and farmed shellfish resources.

Information generated through the ICM Programme proved critical to consenting of a large offshore mussel farm in western Tasman Bay. The first stage of development achieved marketable product size/quality within seven months. High mussel growth rates occurred during spring and autumn 2008/09 with a slowdown, particularly in the upper water column, during summer. This is consistent with predicted chlorophyll-*a* maxima and minima and water column stratification characteristics that are influenced by the river plume. Mussel growing conditions and catchment implications are being tracked over time using long term *in situ* data and nutrient load estimates.



Harvest conditions were developed by the mussel industry using ICM data demonstrating elevated concentrations of faecal indicator organisms after a rainfall event within a plume extending at least 7 km offshore. Using Cawthron's new microbial source tracking (MST) technology, contaminant sources were linked to ruminants using genetic markers. This was the first observation in New Zealand of ruminant faecal contamination from a river plume extending well offshore.

The management applications of our river plume monitoring buoy have strengthened over time with the trialling of new and more robust components. Seasonal and flood-related events shed light on the variability of food for mussel and scallop growth and can now be linked directly to aquaculture responses. Nutrient loading from the catchment to Tasman Bay (reported annually to stakeholders) varies seasonally and between years with resulting ecosystem implications. In the absence of ongoing research funding, Cawthron is self-funding real-time data collection to further develop capability for advising shellfish industries on bacteriological water quality, the fluctuating prospects for successful spat collection/survival, and food availability for shellfish.

Baseline data described above has been applied in models of hydrodynamics (currents and tides), water quality distribution across the bay and with depth, phytoplankton growth and decline (chlorophyll-*a*), and the marine foodweb from algae up to finfish. These models allow evaluation of trade-offs between large-scale land use change onshore and aquaculture scenarios offshore.

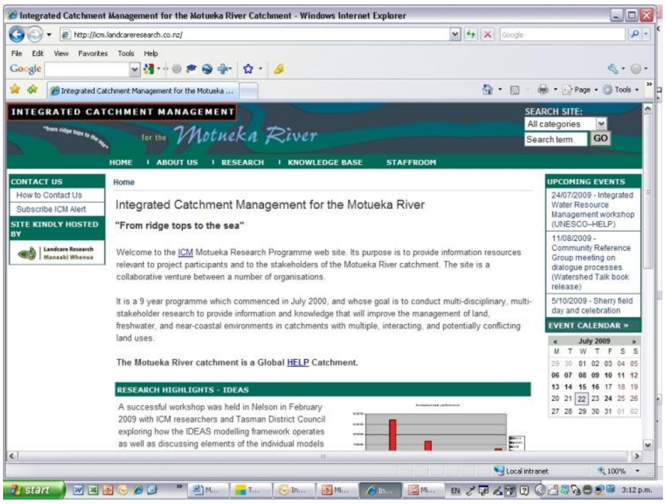
Contacts: Paul Gillespie & Chris Cornelisen & Ben Knight & Weimin Jiang (Cawthron Institute), Neil Jackson & Steve Markham (TDC)

Cornelisen CC, Gillespie P, Kirs M, Young R, Forrest R, Barter P, Knight B, Harwood VJ. 2011. Motueka River plume facilitates transport of ruminant faecal contaminants into shellfish growing waters, Tasman Bay, New Zealand. NZ Journal of Marine and Freshwater Research 45:477-498.

4. Integrative tools and processes for managing Cumulative Effects

Knowledge Base: Establishing a baseline of what we know already is important in any catchment management programme. The ICM programme has published "The Motueka Technical Report, a comprehensive summary of knowledge about the Motueka and Riwaka catchments". ICM research results, findings, and all reports, presentations, and published articles are still available on the programme website http://icm.landcareresearch.co.nz.

The ‘Motueka Toolbook’ CD-ROM has also been developed. This integrates existing and new knowledge of the catchment and links it to global catchment management knowledge. The CD-ROM is dominated by figures and photos, rather than text, and is designed to spread the ICM message to a variety of audiences.



The ICM research programme was the subject of *Country Calendar*, shown on primetime television (TV1) on 21 June 2008. This highlighted ICM as an organising concept for land and water management, and also the benefits of scientists, landowners and communities working together. Research results have been made available through the ICM newsletter *Catchment Connections* with over 700 subscribers (a final edition is possible 2012-13), and a series of videos on ICM topics is available through YouTube or the ICM website.

Contacts: Chris Phillips & Andrew Fenemor & Les Basher (Landcare Research)

IDEAS Modelling: Catchment-scale modelling offers an opportunity to provide councils and sector groups with strategic advice on scenarios which assess impacts not only of future land use mixes, but other types of development impacts as well (e.g. population growth, subdivision), and is being used by Canterbury’s zone committees.

The first foundation for this research was an integrative Triple-Bottom-Line modelling approach trialled using a participatory process (Influence Matrix) with the ICM Community Reference Group. The process identified these critical factors likely to affect the group’s vision for future sustainability of the catchment:

- Nature and extent of primary industries,
- Measures of water quality and supply, and
- Available mix of policy-plans-rules-legislation.

The process and its results raised awareness of the value of such tools which may be useful for informing Long Term Council Community Plans, and for framing up ratepayers’ own perspectives on sustainability.

The second foundation was development of component models: catchment water yield and water quality, catchment transport of faecal pathogens and sediment, exchange of water between rivers and groundwater, coastal productivity and foodweb models, an ‘agent-based model’ which simulates peoples responses to policies, and the Motueka Futures economic input-output model with associated population growth module.

Together these models provided the third foundation, a large-scale modelling framework called IDEAS (Integrated Dynamic Environmental Assessment System). The IDEAS scenario modelling system allowed us to assess cumulative effects of broad-scale development (eg. land use changes) over a 20-50 year timeframe and do this by looking not only at environmental outcomes (eg water quality) but also social (eg. employment), economic (eg. GDP) and cultural (eg. biodiversity) consequences. An IDEAS stakeholder group and the ICM Community Reference Group identified and prioritised the types of issues they see for the catchment in future, and these formed the basis for 6 Motueka catchment scenarios. These were: (1) pre-human (2) present land use (3) present land use with best management practice (4) very intensive agriculture (5) very intensive agriculture with best management practice, and (6) continued present growth until 2020.

IDEAS was applied to assess and compare the environmental and socio-economic impacts of these scenarios, based on the concept of environmental intensity (ratio of environmental impact over economic output). Concept development also included a new indicator of Maori cultural values developed by iwi.

Contacts: John Dymond & Andrew Fenemor (Landcare Research), Ben Knight & Roger Young (Cawthron), Anthony Cole (Pansophy), Oscar Montes de Oca (AgResearch) & Steve Markham (TDC)

Dymond, J.R., Davie, T.J.A., Fenemor, A.D., Ekanayake, J.C., Knight, B.R., Cole, A.O., Montes de Oca Munguia, O., Allen, W.J., Young, R.G., Basher, L.R., Batstone, C.J. 2010: Integrating environmental and socio-economic indicators of a linked catchment–coastal system using variable environmental intensity. J. Environmental Management 46: 484–493.

Fenemor, A.D; Deans, N.A.; Davie, T.J.; Allen, W.; Dymond, J.; Kilvington, M.; Phillips, C.; Basher, L.; Gillespie, P.; Young, R.; Sinner, J.; Harmsworth, G.; Atkinson, M.; Smith, R. 2008. Collaboration and Modelling – Tools for Integration in the Motueka Catchment. Water South Africa 34(4):448-455

Modelling Catchment Futures: The Influence Matrix research described above was extended into an ecological economics model of the whole catchment, founded on an economic input-output model. Using benefit-transfer, non-market valuation methods it was shown that natural ecosystem services annually contribute non-market (indirect) goods and services of $163M, more than half annual catchment gross product. The model, in conjunction with the agent-based model ENVISION, is part of the IDEAS framework, allowing a quadruple bottom line evaluation of various catchment-scale development scenarios.

Contacts: Anthony Cole (Pansophy), Oscar Montes de Oca (Landcare Research)

Cole A.O., Allen, W., Kilvington, M., Fenemor, A. and Bowden, B. 2007. Participatory modelling with an influence matrix and the calculation of whole-of-system sustainability values. International Journal of Sustainable Development 10(4): 382-401.

5. Building Human Capital and Facilitating Community Action

Collaborative learning: Management is a distinctly human process. Social research is developing tools and approaches which can be used by research groups, agency staff and other community leaders to support more effective multi-stakeholder processes for learning and decision-making. Topics worked on include knowledge management, integration, stakeholder analysis, social capital, evaluation and cross-case learning. For example, we developed a methodology labelled Social Spaces for evaluating collaboration among different groups in integrative projects, and for the Auckland Regional Council we applied a logic model to evaluate ICM plans across multiple timescales – an 'Orders of Outcome' approach. A Sediment Learning Group helped stakeholders reach a common understanding of sediment loss and impacts in rivers.

A community resilience project called *Watershed Talk* explored what different people care about and feel a sense of responsibility towards in the Motueka catchment. Often there is a set of practices or values that underpin our wanting to leave the land in better shape, whether it is the people who work and live, who manage or who do science about this place. The *Watershed Talk* project distinguished how resilience approaches to problem solving differ from traditional approaches (eg of some RMA statutory processes), and the 2009 book from Manaaki Whenua Press on this project documents techniques for cultivating ideas and community action for better stewardship of the environment.

Contacts: Will Allen & Margaret Kilvington (social researchers), Maggie Atkinson & Andrew Fenemor & Chris Phillips (Landcare Research)

Allen WJ, Fenemor AD, Kilvington M, Harmsworth GR, Young RG, Deans NA, Horn C, Phillips CJ, Montes de Oca O, Ataria J, Smith RA 2011. Building collaboration and learning in integrated catchment management: the importance of social process and multiple engagement approaches. New Zealand Journal of Marine and Freshwater Research 45(3): 525-539

Kilvington M, Allen W, Fenemor A 2011. Three frameworks to understand and manage social processes for integrated catchment management. New Zealand Journal Marine and Fresh Water Research 45(3): 547-561

Kilvington M, Atkinson M, Fenemor A 2011. Creative platforms for social learning in ICM: the *Watershed Talk* project. New Zealand Journal Marine and Freshwater Research 45(3): 563-577

Atkinson, M; Kilvington, M; Fenemor, A. 2009. *Watershed Talk* - the cultivation of ideas and action. Manaaki Whenua Press. 45pp.

Communicating Research Findings: Design and facilitation of community engagement processes is an important Council function, and vital for catchment research to make a difference. One major method has been through ICM Annual Meetings held at the council and in the catchment around October-November, and including public participation.

Summary of the ICM AGM programmes

2003:	Stakeholder Workshop: *Improving Community Engagement;* Public Field Trip: A Day in the Catchment, Science Workshop: *Delivering the Vision through ICM Research*; Open Workshop: *Creating an ICM art-science collaboration*
2004:	Workshop: *Linking ICM Research to Management; Planning the Motueka ICM Toolbook*; Public Field Trip: A Day in the Lower Motueka; Science Workshop: *Linking Research into TDC Policy*
2005:	National ICM Workshop: *Tools, techniques and lessons for ICM; Pacific HELP Symposium*: Hydrology for the Environment, Life & Policy. International ICM symposium sponsored by Landcare Research and UNESCO; ICM Coastal Workshop: *The river plume ecosystem of Tasman Bay*.
2006:	ICM Stakeholder Workshop: *Gravel and River Channel Dynamics;* Tasman Bay ICM Field (Boat) Day: Land-Marine Interactions; Open Workshop: *How are we doing on the 4 BIG ICM research issues?*
2007:	Public Workshop: *Celebrating ICM Success;* Stakeholder Workshops: *Integrated Catchment Modelling IDEAS*. Team Workshop: *ICM2-What are the outstanding issues for integrated land & water research across NZ?*
2008:	Hosted and ran the NZARM National Conference: *Integrated Catchment Management – are we wiser than we were?* Themes: *Bold governance; Committed Communities; Out of the silos, into the landscape – science for ICM; Catchment Futures – Wisdom for the Transition*. Motueka catchment field trip.
2009:	Interactive ICM Science day at TDC with US guest Dr Breck Bowden. Integration workshop – *ICM as a process; Motueka Futures Model hands-on*. Field trip…understanding the river
2010:	National ICM workshop: 26-28 April 2010. *Integrated Catchment management – Connecting Research and Practice*. Nelson. With guest Dr Gene Likens, Director Cary Institute for Ecosystem Studies, New York. Comprising: (1) Stakeholder engagement workshop 26 April: *Mobilising-Moderating-Motivating: Engaging People in Collaborative Environmental Management*. (2) Café Scientifique: '10 *Scary & Wonderful Discoveries about Catchments*' 26 April. (3) ICM Research summary workshop 27 April: *The Legacy of ICM Science from the Motueka catchment*. (4) Ridgetops to the Sea: ICM Field Trip, Motueka catchment. 28 April.

Contacts: Andrew Fenemor & Chris Phillips (Landcare Research), Roger Young (Cawthron), Steve Markham & Rob Smith (TDC)

Phillips CJ, Allen W, Fenemor A, Bowden B, Young R. 2010. Integrated catchment management research: Lessons for interdisciplinary science from the Motueka Catchment, New Zealand. Marine & Freshwater Research 61:749-763.

Community Input to Sustainability Decisions: The ICM Community Reference Group was a touchstone for our research direction and research findings. These 8 catchment residents met every 3-4 months. Memorable topics included 'Futures' modelling, and a review of ICM marine research with a vigorous debate about the effects of scallop dredging and catchment runoff on the recent decline in scallop production. The CRG provided their insights into sustainability of the Motueka catchment described above for the IDEAS scenario modelling.

Contacts: Andrew Fenemor (Landcare Research) & Will Allen (social researcher)

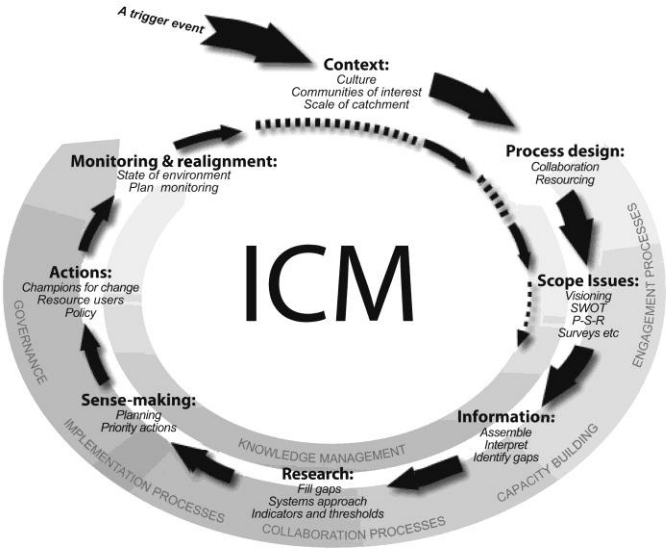
Iwi Values in Integrated Catchment Management: Motueka iwi Te Atiawa, Ngāti Rarua, Ngāti Tama through Tiakina Te Taiao Ltd have a keen interest in building information systems for addressing catchment and economic issues. The programme built a relationship with these iwi, and developed guidelines for iwi consultation. The iwi identified their issues as information collation for iwi management plans, defining the process for undertaking Cultural Impact Assessments of development proposals under the RMA, improved input needed in resource consent decisions, and contaminated sites management. The 3 iwi through the ICM programme have developed GIS-based information systems for environmental management, now used daily. They have also begun to involve their young people in ICM projects relating to water quality, coastal issues and kaimoana.

Cawthron researchers developing new indicators of river ecosystem health. Comparative work between scientific indicators of river health and cultural indicators of river health determined by local iwi is ongoing in the Motueka and Riwaka catchments (and was profiled in a TVNZ *Rural Delivery* programme in October 2007). It shows that scientifically and culturally–based monitoring and assessment can provide an enriched and complementary understanding of freshwater systems. Each approach offers a slightly different worldview and can be used side by side by local government, community, iwi and hapū, and research agencies – for example in TDC's State-of-the-Environment monitoring of rivers.

Contacts: Garth Harmsworth (Landcare Research), Kura Stafford & Dean Walker (Tiakina Te Taiao), Roger Young (Cawthron), Trevor James (TDC)

Harmsworth GR, Young RG, Walker D, Clapcott JE, James T 2011. Linkages between cultural and scientific indicators of river and stream health. New Zealand Journal of Marine and Freshwater Research 45:423-436

Decision-making processes in resource management agencies: Decisions on resource consents and RMA plans do not necessarily follow an objective process utilising all available information. A group within TDC worked with us to develop an institutional learning approach to improve science uptake and information flows. Organisational structure, personal relationships, political influences, decision-making processes and access to information all influence resource management decisions. Improving hard information systems like GIS and databases will not by themselves necessarily result in better decision-making. Insights from this work have been applied in collaborative processes on NZ environmental management issues.



Contacts: Glen Lauder (Common Ground), Rob Smith & Steve Markham (TDC), Andrew Fenemor (Landcare Research)

Fenemor AD, Phillips C, Allen WJ, Young RG, Harmsworth GR, Bowden WB, Basher L, Gillespie P, Kilvington M, Davies-Colley RJ, Dymond J, Cole A, Lauder G, Davie T, Smith RA, Markham S, Deans NA, Atkinson M, Collins A (2011). Integrated Catchment Management – interweaving social process and science knowledge. NZ Journal of Marine and Freshwater Research 45(3): 313-331

Art-Science Collaboration: Most effective among the social learning methods designed and trialled with stakeholders and catchment groups was the *Mountains to the Sea* art-science collaboration. The *Travelling River* exhibition that resulted from this work combined over 250 community photographs, science images and stories from 60 contributors in the Motueka catchment attracting more than 2500 visitors. It built understanding of ICM science and encouraged people to think about how their environment has been modified by human and natural actions.

Travelling River was exhibited at Nelson's Suter Gallery and throughout the catchment, and has received national (Creative NZ) and international recognition (plenary presentations at Dartington/Schumacher College UK; and a US Art-Nature-Culture conference).

Contacts: Margaret Kilvington (social researcher), Maggie Atkinson & Andrew Fenemor (Landcare Research), Suzie Peacock (Nelson Marlborough Institute of Technology)

Atkinson, M.; Peacock, K.; Fenemor, A.D. (eds) 2004. *Travelling River* – a collaboration of artists, scientists and the people of the Motueka River catchment. Catalogue for the *Travelling River* exhibition. Published by the Mountains-to-the-Sea project, Landcare Research, Nelson.

An overview of the Motueka catchment

Motueka River Basin Physical Features

- Total basin area 2,170 km^2
- Located between 41^{o}00' S and 41^{o}45' S latitude

Motueka River Physical Features

- Elevation: sea level at Tasman Bay to 1800 m in alpine headwaters
- Length: 110 km
- Delivers 62% of the freshwater inflow to Tasman Bay

Climate and River flows:

- Average annual precipitation: 1040 - 4030 mm measured across the catchment
- Annual sunshine hours: ~2400 h
- Annual days of air frost: 31-92 days
- Mean annual flow: 58.1 m^3 s^{-1}
- Mean annual 7-day low flow: 10.1 m^3 s^{-1}
- 50-year flood event: 2050 m^3 s^{-1}

Geology

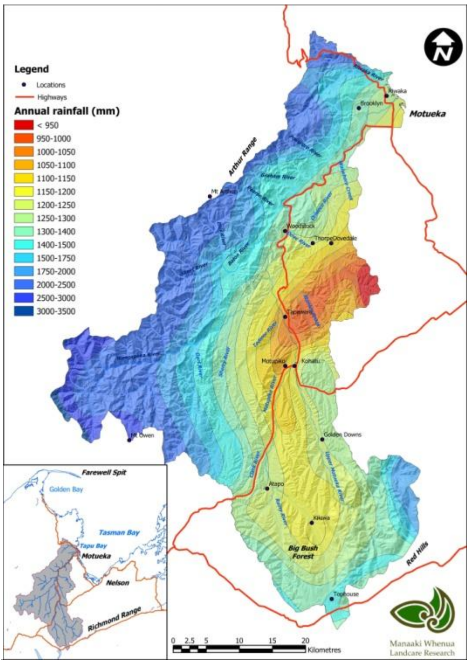
- complex limestone, marble, and calcareous mudstone (Mt Arthur Group), igneous rock (Riwaka complex) formations in the western headwaters
- clay-bound Pliocene-Pleistocene gravels (Moutere Gravel) dominant mid-basin
- erodible Separation Point granites (mid-basin)
- ultramafic rocks (Dun Mountain formation) and sandstone-siltstone (Maitai Group formation) in the southern headwaters
- small areas of young alluvial gravels (mainly coastal area and mid basin)

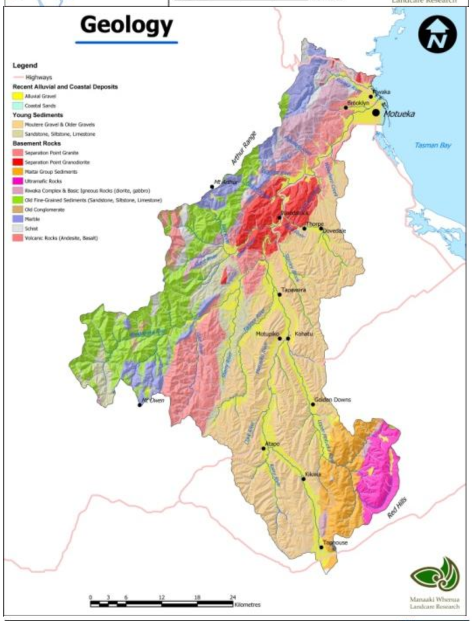
Topography and soils

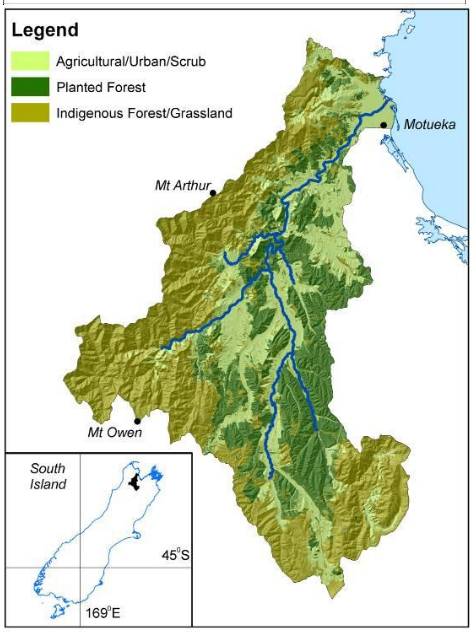
- Flat alluvial plains at mouth, sea-level, young relatively fertile soils
- Rolling and steep hill country in lower basin, low-fertility soils
- Flat alluvial terraces in upper basin valleys, young relatively fertile soils
- Rugged mountainous terrain in headwaters, with a wide range of fertility and permeability

Land-use & Land cover

- Native forest, scrub and grassland in headwaters: southern beech (*Nothofagus*), podocarps (40%)
- Commercial forestry on steeplands and hill country: radiata pine, Douglas fir (25%)
- Dry land pasture and scrub: pasture grasses, sheep
- Valley bottom riparian areas: berry crops, hops (35%)
- Coastal plains: fruit trees, hops







Freshwater resources

- Nationally important blue duck habitat, karst and wild & scenic features in Kahurangi National Park
- Nationally important recreational trout fishery in the Wangapeka, Lower and Mid-Motueka rivers
- Regionally important whitebait fishery
- Water supply for irrigators and townships
- The Water Conservation Order (Motueka River) was formally gazetted by the Minister for the Environment in April 2004
- TDC's Tasman Resource Management Plan (Ch 31) sets water allocation limits in the water management zones throughout the Motueka and Riwaka catchments

Marine resources

- Extensive delta system linking land, freshwater and marine ecosystems
- Internationally recognised birdlife (e.g. bar-tailed godwits, pied and variable oystercatchers on Motueka sandspit)
- Nationally significant oyster and (enhanced) scallop fisheries
- Intertidal cockle fishery
- Rapidly expanding aquaculture : mussel farming
- Recreational and commercial fin fisheries
- Associated nationally important coastal recreation areas (e.g. Abel Tasman National Park)
- Marine reserves: Horoirangi (rocky shore and soft sediment habitats), Tonga Island (marine mammals habitat)

Population

- Sparsely populated: less than 1 person per km^2
    - ~12,000 in catchment, mostly in the town of Motueka
    - ~41,400 in Tasman District (2001 NZ Census)
- One of the fastest growing populations in the country

History of settlement in the Motueka River Catchment

Archaeological evidence suggests that Maori groups first settled the Motueka River area before 1350 A.D. and more permanent camps and fortifications (pa) were gradually established. Settlement was largely restricted to the coastal areas, although Maori travelled through the catchment in search of valued "pounamu" or greenstone and argillite. Inter-tribal conflicts decimated the local iwi in 1828-1830, about 10 years before the first European settlers arrived. Early European settlers were largely interested in sheep grazing land and in gold. Gold operations existed in the area until the early 1900's.

A major flood in February 1877 transformed the shape of the catchment, as a consequence of widespread mass wasting. This event has left a legacy that is important even today. Subsequent flooding prompted local river boards to construct stop banks in the lower river in the 1950's.

Introduction of tobacco in the 1920's brought a period of growth and prosperity. Decline in the tobacco industry in the 1950's was followed by a rise in fruit tree, berry fruit, and hops and by a rise in commercial forestry. Plantation forests – stocked primarily with exotic species such as Monterey pine (*Pinus radiata*) and Douglas fir (*Pseudotsuga menziesii*) were established on less-fertile, steeplands abandoned and purchased from farmers. More recently, vineyards, marine farming, and tourism have added substantially to the diversity and productivity of the local economy, and lifestyle blocks are increasingly being developed.