

HYDROLOGY

Sediment yield estimates: a GIS tool

Murray Hicks

Ude Shankar

Alistair McKerchar

A GIS layer is now available for estimating long-term average suspended sediment yields from catchments throughout New Zealand.

How much sediment is a certain river or stream likely to carry over an average year? This information can be useful for a variety of issues. For example, planners might need to know how fast sediment might accumulate in a potential reservoir, or how vulnerable estuarine and coastal marine habitats are to sediment inputs from the land.

New Zealand-wide information is now available to help in cases like these. It is in the form of a geographic information system (GIS) layer of specific suspended sediment yield, or SSY, given in tonnes of sediment per square kilometre of catchment area per year ($t/km^2/y$). The layer – shown below – can be used to estimate the amount of sediment delivered from within any defined catchment boundary. So far, we have used the layer to estimate the suspended sediment yields to the coast from major rivers as well as the total yield to the New Zealand coast.

Getting the information

We obtained the information to build up the GIS layer from two sources.

First, the amount of sediment carried in rivers and streams was measured at over 200 river-gauging stations throughout the country.

Second, we used these measurements to calibrate a model that predicts suspended sediment yields from the rest of the country. The model relates SSY to mean annual rainfall and a so-called “erosion terrain” classification. Different erosion terrains were

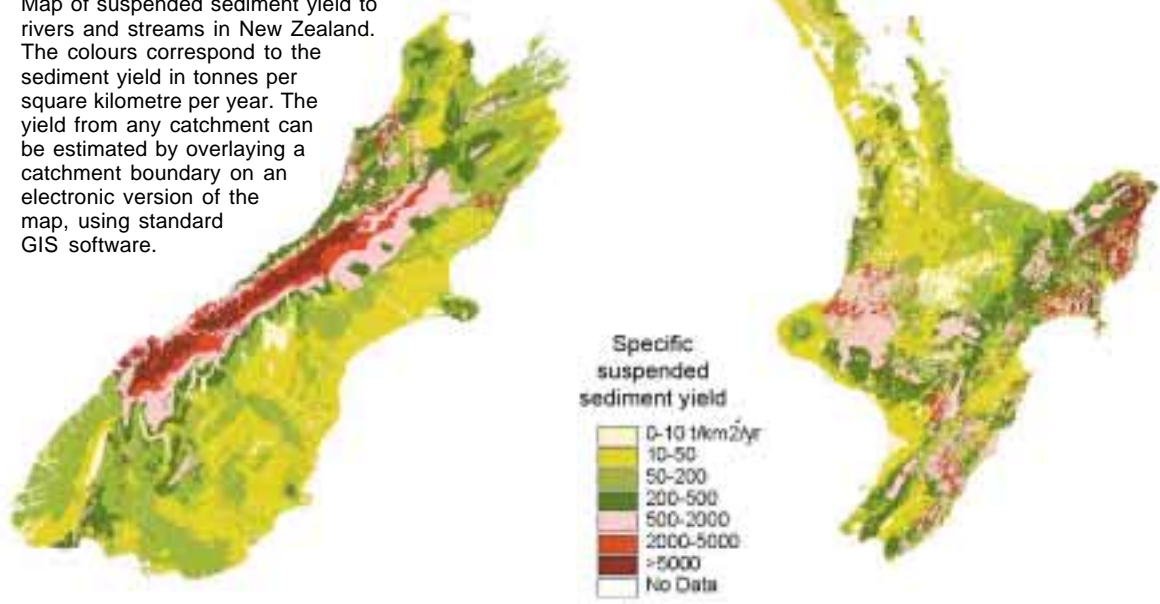
assigned according to how easily land is eroded. The terrains – defined by scientists from Landcare Research – were based on data on slope, rock-type, soils and dominant erosion processes, along with some expert knowledge. We calibrated the model by adjusting the predicted sediment yields to match the measured values at the 200 gauging stations. Therefore this is an *empirical model* – in other words, it is based on measured data.

How much sediment reaches our coasts?

We have used the GIS layer to estimate how much sediment is washed out to the New Zealand coast each year, and where it comes from. The total estimated – 209 million tonnes per year (Mt/y) – is approximately evenly split between North and South Islands (91 and 118 Mt/y , respectively).

The highest yields from the North Island are to East Cape. It's easy to see why erosion is so high here. Rainfall is moderately high. The mudstone and sheared argillite rocks are easily eroded. The area is prone to earthquakes, which tend to expose broken rock. Finally, the native forest cover is almost completely removed. These factors combine to give specific suspended sediment yields of up to $20,000 t/km^2/y$. This amounts to an average

Map of suspended sediment yield to rivers and streams in New Zealand. The colours correspond to the sediment yield in tonnes per square kilometre per year. The yield from any catchment can be estimated by overlaying a catchment boundary on an electronic version of the map, using standard GIS software.



Murray Hicks, Ude Shankar and Alistair McKerchar are based at NIWA in Christchurch

lowering of the land surface in the region by approximately 7.5 mm each year. The East Cape region is 6% of the area of North Island, but accounts for 58% of the sediment yield. The Waiapu River alone delivers 35 Mt/y. In contrast, the relatively low-relief areas of the northeastern North Island generate comparatively little sediment (for example, only 0.35 Mt/y is delivered to the Hauraki Gulf).

In the South Island, the highest SSYs are from the western flanks of the Southern Alps in south Westland. There, a combination of steep slopes, heavy rainfall, high uplift rates along the eastern side of the Alpine Fault, and easily eroded schist result in specific yields up to 32,000 t/km²/y. The regional yield is 62 Mt/y. This represents 68% of the South Island yield from just 8% of the land area.

In contrast, and despite heavy rainfall, sediment yields in Fiordland are only

1.3 Mt/y. This reflects the hard, glacier-scoured, gneiss rock, and almost complete forest cover below the tree line.

Sediment trapped in lakes

Lakes trap sediment that would otherwise be washed out to sea. Estimates from the GIS layer indicate that the large natural lakes of the South Island trap some 15 Mt/y of suspended sediment, while natural lakes in the North Island trap less than 1 Mt/y. So how much difference have man-made hydro-lakes made to the sediment yield to the coast? Well, hydro-lakes in the South Island's Clutha and Waitaki catchments intercept 2.4 Mt/y, while dams on the Waikato and Rangitaiki Rivers trap some 0.4 Mt/y. In total, natural lakes trap 15% of the potential sediment delivery to the New Zealand coast, while hydro-dams have reduced the natural suspended sediment yield to the coast by 1.3%. ■

This study was partly supported by the Foundation for Research, Science and Technology under Contract C01X0024.

For further information, contact Murray Hicks or Ude Shankar (m.hicks@niwa.co.nz, u.shankar@niwa.co.nz).

Teachers: this article can be used for NCEA Achievement Standards in Geography (3.1), Agricultural/Horticultural Science (1.3, 1.5). See other curriculum connections at www.niwa.co.nz/pubs/wa/resources

Indexes to Water & Atmosphere, Volume 11

Author index

Baker, C.; Boubée, J. Using ramps for fish passage past small barriers. 11(2):12-13
 Bodeker, G. The WMO/UNEP 2002 ozone assessment: a New Zealand perspective 11(4):pull-out section
 Booth, J.; Chiswell, S.; Bradford, R.; Bruce, B. The ups and downs of rock lobster larvae. 11(2):17
 Brown, M. New ocean current studies. 11(3):5
 Bruce, N. Giant marine bulldozers. 11(3):4
 Burgess, J. Ministry of Fisheries' Antarctic research. 11(3):9
 Carter, L.; Manighetti, B.; Neil, H. From icebergs to penguins: Antarctica's ocean link with New Zealand. 11(3):30-31
 Cummings, V. Assessing biodiversity on the Antarctic sea floor. 11(3):10-12
 Dunn, A.; Andrew, N. The chaotic world of our reefs. 11(2):18-19
 Ellwood, M.; Kelly, M. Sponge "tree rings": new indicators of ocean variability. 11(2):25-27
 Goring, D. Tides in the Ross Sea. 11(3):26-27
 Green, M. Mangrove management guidelines. 11(1):5
 The dance of the turbid fringe. 11(2):20-21
 Hall, J.; Cumming, A. Flow cytometry in aquatic science. 11(1):24-25
 Hanchet, S.; Horn, P.; Stevenson, M. Fishing in the ice: is it sustainable? 11(3):24-25
 Haskell, T. What's so important about sea ice? 11(3):28-29
 Hawes, I. Kyoto conference discusses effects of climate change on the world's lakes. 11(2):7
 Hawes, I.; Howard-Williams, C. Pond life on the McMurdo Ice Shelf, one of the world's strangest ecosystems. 11(3):18-19
 Hawes, I.; Schwarz, A.-M.; Sutherland, D.; Howard-Williams, C. Aquatic ecosystems of the McMurdo Dry Valleys – the edge of survival. 11(3):16-17
 Hicks, M.; Shankar, U.; McKeerchar, A. Sediment yield estimates: a GIS tool. 11(4):26-27
 Hicks, M.; Westaway, R.; Lane, S. A bird's-eye assessment of gravel movement in large braided rivers. 11(1):21-23
 Howard-Williams, C.; Andrew, N.; Poulter, M.; Robertson, D.; Murdoch, R. Editorial: NIWA's science in Antarctica. 11(2):7
 Howard-Williams, C.; Davey, F. SCAR – a lesson in national and international cooperation. 11(3):8-9
 Hume, T.; Swales, A. How estuaries grow old. 11(1):14-15
 Jeffs, A. Global lessons from Maori success in fisheries? 11(2):4
 Jellyman, D.; Lambert, P. The how and when of catching glass eels. 11(4):22-23
 Kelly, M. The science of waka kopapa. 11(1):4
 Kelly, M.; Grieve, J. The ocean's own "tuatara" discovered. 11(4):5
 King, D. Inventory of New Zealand greenhouse gas emissions. 2001. 11(4):6
 Kreher, K.; Johnston, P. NIWA makes atmospheric measurement in Arctic Norway. 11(2):4
 Lamarche, G. Huge undersea avalanche dwarfs New Zealand's biggest landslide. 11(3):6
 Le Gonidec, Y.; Lamarche, G.; Wright, I. Using sound waves to sort out seafloor sediment types. 11(4):10-12
 Lefale, P. Seasons in Samoa. 11(2):10-11

Lohrer, D. Burrowing by heart urchins: an important function in soft-sediment ecosystems. 11(4):13-14
 Lorz, A.-N.; Grieve, J. A manager for the NIWA marine biology collection. 11(3):6
 McDowall, R.M. The key to climbing in the koaro. 11(1):16-17
 McKenzie, R. Spectacular effects of Australian bushfires seen in Central Otago. 11(1):6. What's the UV today? 11(4):4
 Morrison, M.; Parkinson, D.; Francis, M.; Timperley, M. The hunt for small snapper. 11(2):6
 Nodder, S. Deep-ocean experiments suggest summer food shortages. 11(2):5
 Oliver, M. The high-tech world of lobster surveillance. 11(4):5
 Parkyn, S.; Davies-Colley, R. Riparian management: how well are we doing? 11(4):15-17
 Parkyn, S.; Wright-Stow, A.; Quinn, J. Photo survey: do people like riparian management on farm streams? 11(4):20-21
 Pelly, L.; Fisher, G. Energy problems: are they the same elsewhere? 11(2):8-9
 Penny, G. Energy, industrial ecology and the cost of change. 11(1):26-27. Supply and demand at the papakainga: a flax-roots approach to distributed renewable energy generation. 11(2):6
 Pickrill, R.; Barnes, P. Managing the seabed with multibeam mapping: learning from Canadian experience. 11(4):7-9
 Quinn, J. Environment Watch in CD: Promoting healthy farm and forest streams. 11(3):5
 Renwick, J. Award for NIWA climatologist. 11(4):6
 Richardson, J.; Boubée, J. Does stream restoration work? 11(4):18-19
 Richardson, J.; Jowett, I. Location, location, location! Predicting fish communities in New Zealand streams. 11(2):14-16
 Riis, T.; Biggs, B. Stream vegetation and flow regimes. 11(1):18-20
 Robertson, D. RV *Tangaroa*: a research ship for all seasons. 11(3):13
 Sanson, L. Antarctica New Zealand supporting quality science. 11(2):8
 Schwarz, A.-M. Life in the dark: plant growth beneath the sea ice. 11(3):14-15. Spreading mangroves: a New Zealand phenomenon or a global trend? 11(1):8-10
 Smith, B. NIWA Identification Workshops: just ask the experts. 11(1):4
 Smith, P.; Hauser, L.; Adcock, G. Overfishing leads to loss of genetic diversity in Tasman Bay snapper. 11(1):7
 Swales, A.; Oldman, J.; Radford, J.; MacDonald, I. What happens in estuaries during floods? 11(1):11-13
 Thrush, S. Voyage on the *Italica*. 11(3):12
 Tracey, D.; Neil, H.; Gordon, D.; O'Shea, S. Chronicles of the deep: ageing deep-sea corals in New Zealand waters. 11(2):22-24
 Turner, R.; Renwick, J.; Schroeder, S. How good are New Zealand weather forecasts? 11(4):24-25
 Wood, S. Winter science at Scott Base. 11(3):4
 Wood, S.; Lowe, D.; Connor, B.; Kreher, K.; Nichol, S.; Bodeker, G. The Antarctic atmosphere: barometer on a changing world. 11(3):20-22.

Subject index

air quality 11(1):6
 all-sky images 11(1):6
 Antarctic and Southern Ocean Science Strategy 11(3):8
 Antarctica 11(3):4, 7-31
 Antarctica New Zealand 11(3):8
 aquatic plants 11(1):18-20
 atmospheric measurements 11(1):6
 atmospheric research 11(1):6, 11(2):4, in Antarctica 11(3):4, 20-22, 11(4):pull-out section
 awards, honours 11(4):4, 11(4):6
 BioRoss research programme 11(3):9
 bioturbation 11(4):13-14
 CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources) 11(3):9, 11(3):24-25
 climate research and indigenous knowledge 11(2):10-11
 climate/energy research 11(2):8-9
 coastal ecosystems, Antarctic 11(3):18-19
 conferences/workshops, aquatic plants 11(1):4, macroinvertebrate identification 11(1):4, Solutions to Pollution 11(1):5, 3rd World Water Forum, Kyoto 11(2):7
 corals, ageing 11(2):22-24
 Environment Watch (CD) 11(3):5
 estuaries 11(1):8-10, ageing 11(1):14-15, flood effects 11(1):11-13, sediment in 11(2):20-21
 fish communities, freshwater 11(2):14-16
 fish passes 11(2):12-13
 flow cytometry 11(1):24-25
 freshwater ecosystems, Antarctic 11(3):16-17
 genetic studies 11(1):7
 GIS (geographic information systems) 11(4):26-27
 glass eels 11(4):22-23
 greenhouse gases 11(3):20-22, emissions in 2001 11(4):6
 heart urchins 11(4):13-14
 hydrology 11(4):26-27
 ICECUBE (Coastal Underwater Benthic Ecosystems) project 11(3):10-12
 identification workshops 11(1):4
 IMBER (Integrated Marine Biogeochemistry and Ecosystem Research) 11(4):4
 industrial ecology 11(1):26-27
 instruments, benthic lander 11(2):5, EM300 multibeam 11(4):7-9, 10-12, flow cytometer 11(1):24-25, real-time UV display 11(4):4, Vemco Radio Acoustic Positioning System 11(4):5
 International Polar Year 11(3):7
 IPCC (Intergovernmental Panel on Climate Change) chair 11(2):5
 isopods 11(3):4
Italica (research vessel) 11(3):12
 kelp 11(2):18-19
 kina 11(2):18-19
 lakes and climate change 11(2):7
 lobsters, rock 11(2):17, spiny 11(4):5
 mangroves 11(1):5, 11(1):8-10
 Maori fishery businesses 11(2):4

marine biodiversity 11(2):22-24, 11(2):25-27, 11(3):4, in Antarctica 11(3):10-12
 marine biology collection 11(3):6
 marine ecology 11(2):18-19, 11(4):13-14, in Antarctica 11(3):14-15
 marine fisheries 11(1):7, 11(2):17, 11(3):24-25
 marine geology 11(3):6, 1(4):7-9, 10-12
 McMurdo Dry Valleys 11(3):16-17
 McMurdo Ice Shelf 11(3):18-19
 meteorology 11(4):24-25
 modelling, digital elevation model (DEM) 11(1):21-23, estuaries 11(1):11-13, gravel movement 11(1):21-23, reef communities 11(2):18-19, sediment in rivers 11(4):26-27
 multibeam mapping 11(4):7-9, 10-12
 native freshwater fish 11(2):14-16, eels 11(4):22-23, inanga 11(2):12-13, koaro 11(1):16-17, redbfin bullies 11(2):12-13
 NDSR (Network for Detection of Stratospheric Change) 11(2):4
 ozone depletion chemistry 11(3):20-22
 ozone hole 11(3):20, 11(4):pull-out section
 palaeoecology 11(2):25-27
 physical oceanography 11(2):5, 11(3):26-17, 11(3):28-29, currents 11(3):5, 30-31
 pond ecology, McMurdo Ice Shelf 11(3):18-19
 publications order form 11(1):6, 11(2):7, 11(3):6, 11(4):6
 renewable energy 11(2):6, 11(2):8-9
 research vessels, *Italica* 11(3):12, *Tangaroa* 11(3):13
 resource management 11(1):8-10, 11(4):15-17, 18-19, 20-21
 riparian management 11(4):15-17, 18-19, 20-21
 riparian zone (defined) 11(4):15
 river hydraulics 11(1):21-23, 11(4):26-27
 rivers, gravel-bed 11(1):21-23
 rocky lobster 11(2):17
 rocky reefs 11(2):18-19
 Ross Sea 11(3):10-12, Ministry of Fisheries' research in 11(3):9, tides 11(3):26-27
 Samoa 11(2):10-11
 SCAR (Scientific Committee on Antarctic Research) 11(3):9
 sea ice 11(3):28-29, effect on benthic productivity 11(3):14-15
 seafloor mapping 11(4):7-9, 10-12
 sediment, in estuaries 11(1):11-13, 14-15, 11(2):20-21, in rivers 11(4):26-27, marine 11(4):10-12, yields 11(4):26-27
 snapper 11(1):7, 11(2):6
 spiny lobsters 11(4):5
 sponges, ageing 11(2):25-27, "living fossil" 11(4):5
 stream ecology 11(1):18-20, 11(2):14-16, 11(4):15-17, 18-19, 20-21
 sustainable development 11(1):26-27
Tangaroa (research vessel) 11(3):13
 Tasman Bay 11(1):7
 Te Kuwaha research 11(2):6
 tides 11(3):26-27
 toothfish 11(3):24-25
 UV Index 11(4):4
 waka kopapa 11(1):4-5
 wakaopona bomb 11(1):11-13, 11(4):24-25
 weather forecasting 11(4):24-25