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Putting waste to work

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INSIDE THIS ISSUE

Enhancing ecosystem services in cities using wood wastes 2–3

Social and Cultural team update 3

Mānuka-dominated ecosystems to improve water quality 4–5

LTC 2017 Conference – Christchurch 5

Mānuka and kānuka for the land-treatment of municipal wastewater 6

Update from the Soil Science group 7

Update from the Ecotox team 8

UPDATE FROM THE PROGRAMME MANAGER

Kia ora and welcome to our Spring newsletter.

The big highlight for us this quarter has been the planting of 4 ha of mānuka dominated native plants along the shores of Lake Waikare in the Waikato. CIBR research shows that mānuka and kānuka root systems have unique properties that not only filter pollutants, but can assist in reducing leaching of nitrogen and pathogens. We have joined forces with local Iwi and the Regional and District Council to plant our very first field trial that is funded by the Waikato River Authority – very exciting. Turn to page 4 to read more.

In another first, the CIBR team is working with Lowe Environmental Impact and Horowhenua District Council to trial a purpose-made native ecosystem at an operational scale specifically for the irrigation and further treatment of wastewater. In a redevelopment of the Levin Wastewater Treatment Plant's irrigation system, 10 hectares of the current exotic pine forest at the site, locally referred to as 'The Pot', will be replaced with mānuka and kānuka trees as part of a five year trial to assess environmental benefits. This project is funded by the Ministry for the Environment Freshwater Improvement Fund. See page 6 to find out more.

The CIBR Social and Cultural team have published their excellent research on Tapu to Noa in the EPA Te Pūtara which is widely distributed to the Te Herenga (Māori National Network). Look out for the article entitled "Tapu and Noa – Critical constructs for management of biowastes in NZ".

Aerial view of 'The Pot' wastewater pond at Levin (photo credit Sian Cass)

Earlier in the year a large contingent from CIBR attended the Land Treatment Collective (LTC) conference in Christchurch – turn to page 5 to read about highlights from the conference. Congratulations to Gerty Gielen for winning Best Technical Paper (again!), Gerty was also awarded The Land Treatment Collective Award for Outstanding Services. Other CIBR highlights included a key note on "The land treatment of municipal effluent using NZ Native Species" by Brett Robinson; and CIBR/Lincoln University student Minakshi Mishra winning the "Best Presentation by a Young Professional". A great effort by team CIBR.

Last but not least in June we said goodbye to our wonderful colleague Alma Siggins. Alma and her family have returned to Ireland. We wish her all the best.

Jacqui Horswell

ENHANCING ECOSYSTEM SERVICES IN CITIES USING WOOD WASTES *Robyn Simcock*

The most common green spaces in our cities are mown pasture on road verges, parks and private lawns. We think adding biowastes to these ubiquitous green spaces could improve the 'ecosystem' services they deliver, for example retaining storm water (helping reduce flooding) and supporting pollinators (bees) and beneficial predator insects. Woody organic wastes and composted greenwastes are used in large volumes overseas to enhance degraded urban soils. Spreading and/or incorporating minimum depths and qualities of organic soil conditioners is now mandated in parts of USA and Canada through rules and policies[1] including Long Bay, North Shore City[2]. Poor quality urban pasture can have high ongoing financial costs (for mowing) and environmental costs when compacted, or intensively irrigated, fertilised and/or sprayed.

In 2015 a corner of old pasture at the Auckland Botanic Gardens (ABG) was divided into 49, 2 by 2 m plots. Two rates of coarse wood chip from macrocarpa trees, were spread over 14 of the plots. Five other treatments included a control (untreated) and additions of sawdust, sugar and nitrogen. A high rate (8 litres/m^2) was defined as the maximum ground staff considered was practical without smothering the turf or impeding mowing; we also used a half rate of 4 litres/m^2 9 (Fig 1). We wanted to maintain public use of the area and so didn't want to disturb the surface by rotary hoeing. Rotary hoeing is the usual way organic amendments are added, and happens at the time of turf renewal or renovation. We hypothesised that an annual addition of woody biowaste to the surface would:

- lower soil nitrogen levels and increase competitiveness of a variety of herbs, including ones used by beneficial insects (clovers, plantains and wild carrots)
- reduce turf growth, hence reduce the mowing frequency (saving $)
- increase infiltration rates as the wood chip broke down, reducing surface runoff and flooding, and improving drought resilience

Unfortunately, mowing plots with the high rate of coarse wood chip damaged mower blades, so in the second year we substituted a much finer biowaste (compost). An advantage of the compost was that rain could wash it down to the soil surface - this minimised visual impact, improving aesthetics compared with the coarse mulch.

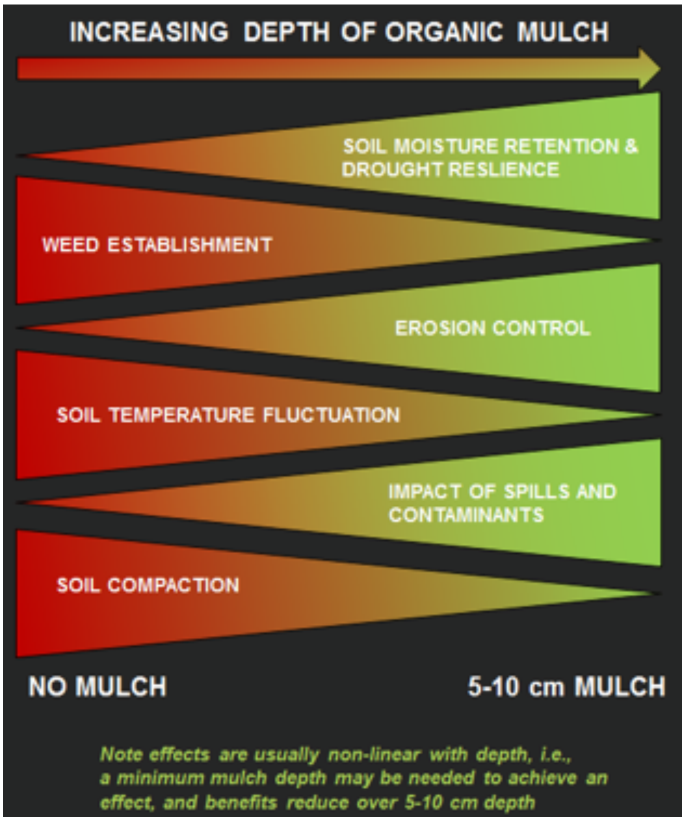
RESULTS

We measured foliar and soil nutrient concentrations, plant composition and soil infiltration rate. Foliar measurements indicated application of both levels of mulch had slightly reduced nitrogen concentrations in grasses (1.99 and 2.07 % N in high and moderate mulch treatments compared with up to 2.2 % N in control treatment) in the Autumn growth flush (April). This is because the high C:N ration of the mulch meant microbes removed nitrogen as they decomposed the mulch. Soil measurements confirmed both mulch treatments had lowered nitrogen concentrations, so less N was available for plant growth. The abundance of browntop (*Agrostis capillaris*), a thin-leaved, short grass adapted to low fertility increased in mulched treatments at the expense of ryegrass. These positive browntop-dominant swards require less frequent mowing and are usually more diverse. However at ABG, the composition of herbs did not change significantly over the first year, and neither did overall pasture biomass.

We measured infiltration rates in late 2016 in 5 of the 7 replicate plots for control and high-mulch treatments. Infiltration rates in both treatments were very good, over 280 mm/hr, with no plots less than 150 mm/hr. Low infiltration rates are typically less than 18 mm/hr, and bio-filtration devices (raingardens, bioswales, planters) are usually designed to have infiltration rates of 50 to about 400 mm/hr. This reflects the history of dense pasture cover and infrequent trafficking – there was no clear influence of adding mulch on infiltration. A high infiltration rate means high intensity rainfalls can soak in without surface runoff – helping to reduce flooding in downstream urban areas.

Applying up to 5 litres/m^2 is practical if fine mulch is used. A coarser mulch can also be used if mowing height can be increased to above 80 mm, and preferably 100 mm (our lawn mower blades couldn't be lifted higher than 80 mm). The trial helps support applying tree prunings from parks over grassed areas used for passive recreation (not playing fields) to avoid transport and disposal costs and is likely to deliver local ecosystem benefits; indeed, motorways now routinely spread mulched prunings straight back onto adjacent batters. Best results are likely

Figure 1: Macrocarpa mulch at the application rate of 8 and 4 litres/m^2



BENEFITS OF ORGANIC MULCHES

These benefits occur when applied over the soil surface at 50-100 mm depth but depend on underlying soil moisture, fertility and drainage conditions

- moderate soil temperature fluctuations (cooler in Summer, warmer in Winter)
- protect soils from compaction
- supress weeds (especially weeds growing from small seeds)
- improve plant establishment by helping conserve soil moisture, and enhance soil moisture storage once broken down (reducing vulnerability to drought) but will also keep dry soils from wetting up/ and wet soils from drying out)
- reduce runoff and erosion by absorbing water and preventing development of 'crusts' by physically protecting soil from raindrop impacts
- influence soil fertility (depending on the proportion of fines, C:N and C:P ratio)
- enhance contaminant removal (heavy metals, oils, greases)

with a fine mulch (e.g. higher mulch rotation speed) and where soils are compacted or have low initial water holding capacity. The soil physical conditions at our trial were pretty good to start with, so were hard to improve, and the plant diversity was relatively high!

Overseas research shows turf plant and soil communities take several years to respond to organic additions and changes in nutrients, so we plan to continue the trial, at least to see how soils may change, and include plant diversity if another University of Auckland masters student can be found to follow Curtis Lubbe[3] (who has started a PhD in the United States).

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2. However soil conditioning has been less used than raingardens and detention tanks. Wadan P, Clements O and Kettle D. 2013. Construction of low impact design solutions at Long Bay. 8th South Pacific Stormwater Conference and Expo. https://www.waternz.org.nz/Attachment?Action=Download&Attachment_id=799
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Table 1: Chemical properties of the mulches used, the soil to which it was added, and a common manufactured garden soil

Biowaste	Carbon % w/w	Nitrogen % w/w	C:N ratio	Phosphorus mg/kg
Wood chip [1]	50	0.41	120	453
Sawdust [1]	52	0.13	390	355
Compost	34	0.90	37	1421
Arborist mulch	48	1.14	42	1144
ABG Turf Soil [2]	6.2 ± 0.3	0.58 ± 0.01	11 ± 0.2	1032 ± 97
Garden Mix [3]	20	0.88	23	1645

[1] The source material in both cases was macrocarpa. The 'tipping point' for C immobilisation is C:N 25 to 27

[2] This is soil from the whole trial site, sampled in 7 blocks (each block has 1 treatment replicate)

[3] Garden mix is a manufactured product with tight quality control made from greenwaste-based compost and sand

SOCIAL AND CULTURAL TEAM UPDATE

Alan Leckie

Three members of the CIBR Social and Cultural team (Joanna Goven, Jamie Ataria and Alan Leckie) took part in an ohu or whānau (family) working bee one Sunday in July at Te Pā o Rākaihautū (Te Pā), a designated special character school in Christchurch that has a strong culture of creating transformational behaviour change including around environmental sustainability. They helped whānau prepare the māra kai (veggie garden) and erect a whare whakaata (greenhouse). The māra kai was weeded, dug over and mulched and will be spelled until the Winter weather has passed and seeds have been sown in the whare whakaata by pononga (students) for transplanting into the school's māra kai. This kai will supplement other fresh vegetables used in preparing breakfast and lunches at Te Pā for pononga. Kaitiakitanga or a Māori cultural sustainability ethos is practiced at Te Pā by management and forms a part of environmental education. The production of kai and composting green and other carbon wastes underpin a 'closing the loop' ethic which is very important for the future of this 'place-based learning' and which has become part of Te Pā's identity and culture. Students will see that the grounds of Te Pā will become their own 'place' within their greater community.

This initiative was part of the Social and Cultural team's collaborative working with Te Tautarinui (Board of Trustees) and Te Pā's staff to look at waste production and reuse, cleaning-chemical use and opportunities for composting waste streams, including biowastes. The team are examining chemicals used for cleaning and biowaste collection, reuse and impact. Vermicomposting and open-air composting methods are being discussed, and a visit has been planned to a commercial vermicomposting site to see how putrescibles are composted. Research to explore transformational behaviour changes initiated by students, and how best to capture these changes, has also been planned and is supported by CIBR over the next three years.

CIBR team members mucking in with Te Pā's greenhouse build. L-R: Joanna Goven, Alan Leckie and James Ataria (photo credit Keith Murphy).

Demand has been strong for the Social and Cultural team's two recent publications 'Community Engagement Framework' and the 'From Tapu to Noa' report, which were widely distributed last year to councils, Iwi and participants at the NZ Land Treatment Collective conference in Gisborne. Tapu is often understood to mean forbidden or restricted and noa, ordinary or free from restriction. This report provides a summation of many years of work with communities around New Zealand and is intended to guide non-Māori towards a better understanding of the right questions to ask in their conversations and engagement with local hapū and Iwi regarding biowaste and biosolids issues. It also is designed to support local government staff and engineers in better understanding and incorporating Māori worldviews into biowaste management negotiations and solutions. If you have not got a copy of either report for your use yet, paper copies can be obtained from Alan Leckie, Scion, alan.leckie@scionresearch.com or electronic copies can be downloaded from CIBR's website http://cibr.org.nz/news/cibr-reports/ .

Te Pā whānau weeding the māra kai (photo credit Keith Murphy).

MĀNUKA-DOMINATED ECOSYSTEMS TO IMPROVE WATER QUALITY AND PROVIDE ECONOMIC RETURN IN THE LAKE WAIKARE CATCHMENT

Maria Gutierrez-Gines

One year ago, Jacqui Horswell and Brett Robinson approached the Waikato Regional Council (WRC) proposing a collaboration to establish a field experiment using real life conditions. This would investigate the potential of mānuka and kānuka to reduce pathogens and nitrate leaching. The properties of these plant species were previously proven in laboratory and greenhouse experiments[1-3]. Now 10,000 plants are in the ground, with a further 30,000 to be planted late October. Funds were obtained from Waikato River Authority, WRC, and the Vision Mātauranga Capability Fund. With these funds a programme was created in collaboration with WRC, Waikato District Council, Nga Muka Development Trust, Te Riu o Waikato, Waikato-Tainui, Matahuru Marae, Nikau Farm Trust, and EcoQuest.

It has been a very intense and exciting year when lots of work, relationships and exciting projects came to life!

Due to the high degradation of Lake Waikare, this was a great setting and a challenge for carrying out field experiments with mānuka and kānuka. Lake Waikare is the most degraded and contaminated lake in the Waikato Region. Inputs of nutrients, pathogens and sediments from the surrounding farming activities, the deforestation of natural vegetation, and the Flood Regulation schemes since the 1960s, are the main drivers that led to the low quality of the lake. The strategic importance of Lake Waikare and the Whangamarino wetland as the lungs and kidneys for the Lower Waikato Region are recognised by local Iwi, since in the past the lake was a source of sustenance for the whānau (family) of the region.

CIBR, in collaboration with Ngā Muka Ltd, Te Riu o Waikato Ltd, Matahuru Marae and the WRC, obtained 5-year funding from Waikato River Authority (WRA), and co-funding from WRC and CIBR, to plant 4 ha – 40,000 plants on farming land with NZ native vegetation (50% with mānuka) in the margins of Lake Waikare. Two experimental plots located in Nikau Farm will allow us to study the potential mānuka and other native vegetation has to reduce sediment, pathogen and nitrogen run-off from farms into waterways. Due to the interest to improve water quality and the natural values of Lake Waikare, other stakeholders joined the project in the following months: Waikato District Council, EcoQuest, and Waikato-Tainui.

After performing an extensive study on natural vegetation in riparian and wetland ecosystems in Lower Waikato Region and Meremere basin, and having the expert advice of WRC and other stakeholders, we designed the floristic composition of the plots. The selected plant species are distributed in the plots depending on the water regime and their water requirements (Table 1). The two plots have different characteristics. The so called "Slope plot" is a 1 ha plot located in a high productive paddock with a gentle slope towards one of the drains that arrive to the lake (Photo 1). The slope in this plot will be ideal for doing the research about infiltration and run-off in pasture compared with native vegetation cover. The 3 ha plot called "Swampy plot" is a flat low productive paddock that is flooded for a large part of the year.

From 22 to 27 June, 10,600 plants arrived at Nikau Farm, and were planted with the help of more than 50 volunteers including members of the local community, friends from the collaborating organisations (Waikato Tainui, WRC, and CIBR), students and staff of EcoQuest, and students of Te Kauwhata College and Te Wharekura o Manurewa. The remaining 30,000 plants will arrive and will be planted from 25 to 31 October – please lock those dates in your calendars!

With the establishment of run-off collectors, soil pore water samplers and the periodical monitoring of soil, rhizosphere soil, and plants, we will generate enough data to demonstrate the potential of mānuka and other native plants to improve the water quality of waterways impacted by farming activities.

Due to several stakeholders who have interest in restoring the health of Lake Waikare, and the numerous plantations of native vegetation that WRC and the local Iwi are undertaking in the margins of the lake, we decided to further explore how these riparian plantings could contribute to their general expectations. We obtained a project funded by the Vision Mātauranga Capability Fund – MBIE, to measure the benefits of riparian vegetation restoration on the health and wellbeing of Lake Waikare for the whānau hapuu Iwi and communities of the Lower Waikato Region.

Drain in the Nikau Farm around which the experimental plots are being planted (photo credit: Brett Robinson).

CIBR team members involved with the planting programme. L-R (back): Brett Robinson, Maria Gutierrez-Gines, Jymal Morgan, Jamie Ataria, Vikki Ambrose. L-R (front): Izzy Alderton, Libby Harrison (photo credit: Jacqui Horswell).

The first objective of this project is to explore the expectations and objectives of all the stakeholders and collaborators – including local communities from different generations - about the restoration of Lake Waikare. The second objective of the project, which will also be the main deliverable, will be the creation of a monitoring system to measure and demonstrate the direction riparian plantations develop and whether they address those expectations. In order to do this, both ecological, and socio-cultural indicators will be created and measured in various restoration plots, and in remnants of vegetation.

On 17 August the last hui took place regarding the creation of a programme that includes both projects, and addressing the broader view concerning the restoration of Lake Waikare. This programme has brought together a great multidisciplinary group, joining many institutions: CIBR, Ngā Muka Ltd, Te Riu o Waikato Ltd, Matahuru Marae, Nikau Farm Trust, Waikato-Tainui, WRC, Waikato District Council and EcoQuest. This already is a great success for the project, but we also expect to generate enough scientific and social evidence to demonstrate the benefits of riparian plantings to improve the water quality and increase ecological values in agricultural landscapes. This evidence will guide and help further restoration projects around the country.

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Table 1: Native plant species for the two plots at Lake Waikare

		Slope plot	Location of species in this plot	Swampy plot	Location of species in this plot
Total number of plants		11,000		29,000	
Plant species	**Vernacular names**	%		%	
Leptospermum scoparium J.R.Forst. & G.Forst.	Mānuka	17.3	Moist and dry areas	59.4	Everywhere
Leptospermum scoparium J.R.Forst. & G.Forst.	Swamp mānuka	33.6	Moist and swamp areas	0.0	
Kunzea robusta de Lange & Toelken	Kānuka	4.5	Dry areas	0.0	
Cordyline australis (G. Forst.) Endl	Cabbage tree	6.4	Moist and swamp areas	7.4	Everywhere
Phormium tenax J.R. Forst. & G. Forst	Flax, harakeke	6.4	Moist and swamp areas	7.4	Everywhere
Coprosma robusta Raoul	Karamu	6.4	Moist and dry areas	7.0	Everywhere, far from submerged areas
Dodonaea viscosa Jacq.	Akeake	1.8	Upper	0.0	
Podocarpus totara D.Don	Totara	1.8	Moist and dry areas	1.4	Everywhere, near the drier areas
Pittosporum tenuifolium Sol. ex Gaertn.	Black matipo	1.8	Dry areas	0.0	
Dacrycarpus dacrydioides (A.Rich.) de Laub.	Kahakitea	1.8	Moist and dry areas	1.2	Everywhere, near the drier areas
Pittosporum eugenioides A.Cunn.	Lemonwood/tarata	1.8	Dry areas	0.0	
Veronica stricta Banks & Sol. ex Benth.	Koromiko	3.6	Moist and dry areas	2.9	Everywhere, near the drier areas
Austroderia fulvida (Buchanan) N.P.Barker & H.P.Linder	Toetoe	1.8	Moist and swamp areas	2.0	Everywhere
Carex secta Boott	Purei	0.9	Swamp areas and border of the drain	2.7	Submerged areas
Carex virgata Sol. ex Boott	Swamp sedge	0.9	Swamp areas and border of the drain	2.7	Submerged areas
Machaerina articulata (R.Br.) T.Koyama	Jointed twig rush	0.9	Swamp areas and border of the drain	2.9	Submerged areas
Schoenoplectus tabernaemontanii (C.C.Gmel.) Palla	Kuawa	0.9	Swamp areas and border of the drain	2.7	Submerged areas
Coprosma rotundifolia A.Cunn		1.8	Swamp areas	4.9	Everywhere, near wet areas
Coprosma propinqua A.Cunn	Mingimingi	3.6	Swamp areas	5.3	Everywhere, near wet areas
Coprosma rigida Cheeseman		1.8	Swamp areas	4.5	Everywhere, near wet areas
Coprosma tenuicalis Hook.f	Swamp Coprosma, hukihuki	0.0		4.5	Everywhere, near wet areas
Agathis australis (D.Don) Lindl. ex Loudon	Kauri	0.2	Moist and dry areas	0.1	Everywhere, near the drier areas
Myrsine australis (A.Rich.) Allan	Red matipo	0.5	Moist areas	0.6	Everywhere, near the drier areas

LTC 2017 CONFERENCE – CHRISTCHURCH

Bronwyn Humphries

The NZ LTC Annual Conference was held in Christchurch from the 29 - 31 March, with a theme of "Resilience and Innovation".
A total of 94 delegates attended, from a range of backgrounds including research, industry and regulatory authorities. The conference was opened by three local keynote speakers who really set the scene for the Christchurch area. Mike Bourke (Christchurch City Council) discussed the resilience of Christchurch following the earthquakes, Brett Robinson (Lincoln University) presented his research on the use of native plant ecosystems for land treatment, and Andrew Dakers (EcoEng) outlined the current state of on-site wastewater management practices.
Over the next two days, we were treated to talks on a range of topics including: Regulation, Environmental Impacts, Emerging Contaminants, On-site Wastewater Treatment, Plants and Land Treatment and Infrastructure & Strategy. On the last day we had a field trip, where 55 delegates visited the Pines Wastewater Treatment Plant, the Aranui Vacuum Station, the Bromley Thermal Dryer and the ESR field site at Kaiapoi.

The recipients of the Best Conference Paper, Best Technical Paper and Best Student Paper were Rob Potts (LEI), Gerty Gielen (Scion) and Minakshi Mishra (Lincoln University). Bronwyn Humphries (University of Canterbury) and Minakshi Mishra (Lincoln University) both received student scholarships to attend the conference.

The well-deserved recipient of the LTC award for Outstanding Services to the NZLTC was Gerty Gielen from Scion. Those of you who have been involved with NZLTC for some time will know what a fantastic advocate Gerty has been for NZLTC over a number of years. Gerty has a direct role in the management of NZLTC as a member of the Technical Committee, and has had a significant indirect role as a guiding hand to previous Technical Managers and a volunteer for any and all jobs at many previous NZLTC annual conferences and workshops. Furthermore, Gerty has been a consistent presenter at the annual conferences and the quality of her research and presentations has been recognised by her receiving the Best Technical Paper award on a number of occasions.

The planning is well underway for the 2018 LTC conference. It is to be held in Rotorua from 7 - 9 March 2018. The venue, international speaker and field trips will all soon be confirmed.

Conference venue at the Christchurch City Council (photo credit: Jacqui Horswell)

Conference dinner and awards

Pines Wastewater Treatment Plant, NZ LTC Conference field trip 31 March 2017

MĀNUKA AND KĀNUKA FOR THE LAND-TREATMENT OF MUNICIPAL WASTEWATER

Maria Gutierrez-Gines

Recently the CIBR team at LEI, ESR, University of Canterbury and Northcott Research Associates, obtained funds from Horowhenua District Council (HDC) and the Ministry for the Environment's Freshwater Improvement Fund to carry out an exciting real world large-scale project using mānuka and kānuka dominated ecosystems to reduce the impacts of the land-application of treated municipal wastewater (TMW) on the Waiwiri Stream.

Water quality in the Waiwiri catchment is mainly impacted by pastoral land use, the quality of water released from Lake Papaitonga, and land discharge of TMW from "The Pot". "The Pot" is the local name of a 7 ha pond where wastewater from the Levin wastewater treatment plant (WWTP) is stored in, before being used for irrigation of 40 ha of exotic pines. Nutrients from The Pot and the land-application of TMW into the pine plantations, enter the Waiwiri Stream via drains and subsurface flows. This, along with nutrient loads from elsewhere in the catchment contributes to the degradation of water quality of the Waiwiri Stream, and exacerbates the loss of biodiversity on the Horowhenua coast near the stream outflow[1]. This area is already depauperate in NZ native species through the development of agriculture and forestry practices. In particular, the Waiwiri Stream and surroundings are an important habitat for the endangered native land snail (*Powelliphanta* spp.), native fish including the brown mudfish (Neochanna apoda) and longfin eel (Anguilla dieffenbachia), and plants such as the rare leafless mistletoe (*Korthalsella salicornioides*)[2-4].

The poor water quality in the Waiwiri Stream has been flagged as a significant issue for local Iwi, who have noted the disappearance of mahinga kai (food gathering places). Moreover, the presence of human waste derivatives in waterways is considered abhorrent by Iwi[5]. The Waiwiri Stream is a notable historic fishing site, and significant historical Māori events have occurred at the source of the Waiwiri Stream at Lake Papaitonga. Preliminary investigations carried out by the Department of Conservation (DOC) have indicated that local Iwi wish for the fishing capabilities of the stream to be restored.

The resource consent for the irrigation scheme at The Pot requires renewal and this offers the opportunity to revise the design of the irrigation scheme, with input from key stakeholders including Iwi, DOC, Regional and District Councils. The revised design has the scope to incorporate the most up to date irrigation technology, including utilising recent research discoveries on the abilities of mānuka/kānuka native ecosystems to provide enhanced treatment of wastewater.

Research by ESR/Lincoln University has demonstrated that the root systems of mānuka/kānuka have unique properties that do more than just filter pollutants; they actively inhibit nitrification and enhance the die-off of pathogenic bacteria. The antimicrobial properties of those species have been shown to kill soil-borne pathogens associated with the land application of treated human wastes[6]; and alter nitrogen cycling in soil, leading to a significant decrease in nitrate leaching[7]. These species also inhibit the emission of the greenhouse gas nitrous oxide[8]. Moreover, the growth of these species is significantly enhanced following the land-application of organic waste[9].

In this project, we will replace 10 ha of pine forest with native ecosystems comprising 40-60 % mānuka and kānuka. The mānuka/kānuka will form a contiguous mosaic interspersed with other native species that were common in this area before the land was cleared, especially kahikatea, pukatea, rimu, tawa and swamp maire[10]. Borders of the drains and wet areas within the site will be also be planted with mānuka/kānuka and other suitable riparian species to limit contaminants entering the drain and subsequently the Waiwiri Stream. Existing links with mana whenua will facilitate advice on taonga species (species of interest/treasured) that can be re-established in these areas.

Kānuka, to be planted around The Pot.

Aerial view of 'The Pot' wastewater pond (photo credit Sian Cass)

This project poses a great opportunity for the researchers at CIBR for investigating the first full scale application of TMW on NZ native vegetation in the country. The applied research component of this project is twofold, first we can provide validation of the benefits of mānuka/kānuka-dominated ecosystems to enhance the land treatment of land applied wastewater in an operational environment. Secondly, we will collate information on the accumulation, fate and effects of emerging organic contaminants in wastewater applied to land. This is a knowledge gap for both councils and communities and HDC have been asked to provide key stakeholders with information on the impacts of emerging organic contaminants in the environment. System improvements will be monitored using existing groundwater monitoring piezometers, and installation of soil pore water samplers and water flux meters to quantify the benefits of the new system in reducing the leaching of nutrients, pathogens and other contaminants. Monitoring the site will enable the performance of the first 10 ha to be assessed, with scope for further areas of pines to be replaced with functional native ecosystems.

The data obtained will be used to enhance decision support tools, for the suitable species and likely environmental benefits of planting adjacent to waterways or land-application of biowaste schemes. Globally, there is only limited information on the effects of indigenous vegetation on nutrient and emerging organic contaminant removal and no information on using plants to attenuate pathogens in biowastes. New knowledge obtained from this project on the effects of native plant systems to mitigate emerging organic contaminants and pathogens in treated human wastewater will make a significant contribution to national and international research in the field of land treatment of biowaste.

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UPDATE FROM THE SOIL SCIENCE GROUP

NITROGEN (N) INPUT FROM BIOSOLIDS APPLICATION INCREASED CARBON SEQUESTRATION IN A RADIATA PINE PLANTATION FOREST AT RABBIT ISLAND

Jianming Xue, Mark Kimberley and Russell McKinley

Beneficial use of biosolids as a supplemental fertiliser and soil amendment is one of the most common options for biosolids management. In New Zealand, application of biosoilds on forest land is preferred than on agricultural land because it can reduce the risk of contaminants entering the human food chain and it can also increase tree growth and subsequent economic returns. Treated biosolids from the Nelson Regional Sewage Treatment Plant have been applied to a 1000-ha radiata pine forest plantation at Rabbit Island near Nelson City since 1996. A research trial was established on the site in 1997 to investigate the long-term effects of biosolids application on soil and groundwater quality, tree nutrition and growth. Biosolids have been applied to the trial site every three years (1997, 2000, 2003, 2006, 2009 and 2012) at three application rates: 0 (Control), 300 (standard loading rate) and 600 (high loading rate) kg N per hectare. Tree nutrition status and growth are monitored annually, groundwater quality quarterly and soil properties every three years to determine both the risks and benefits and sustainable application rates as well. The latest radiata pine tree growth measurement and wood core sampling at the Rabbit Island biosolids research trial were completed in 2015 (Fig. 1). The effects of N input from biosolids application on forest carbon (C) sequestration were quantified using the C-Change model from annual plot measurements of stand density, stem height and diameter, and annual breast height wood densities obtained from increment cores.

Figure 1: Effect of repeated biosolids application on tree growth (left) and taking wood density measurements (right) of radiata pine at Rabbit Island in Nelson

Here we update our recent findings on the impact of N input from biosolids application on carbon sequestration in a radiata pine forest.

At age 24 years (2015), the *P. radiata* trees treated with the standard biosolid loading rate had sequestered significantly more carbon than untreated trees but there was no additional increase in sequestration for trees receiving the high loading rate (Table 1). The total carbon sequestered in fertilised trees averaged 260 ± 10 t C ha^{-1} (mean of standard and high loadings with 95% confidence interval) compared with 220 ± 13 t C ha^{-1} in unfertilised trees, a difference of 40 ± 16 t C ha^{-1} or 18 ± 7 %. Stem volume of fertilised trees was 23 ± 7 % higher than unfertilised trees but stem wood density of fertilised trees was 11 ± 8 kg m^{-3} or 2.5 ± 1.9 % lower than unfertilised trees. Thus, in terms of carbon sequestration, the positive effects of N addition from biosolids application on stem volume growth greatly outweighed the negative effects of reduced wood density. As is typical in young *P. radiata* stands, the great majority of carbon is sequestered in the above and below ground biomass pools with only a small component in dead wood and litter pools (Table 1). Annual treatment means for carbon sequestration are shown in Fig. 2.

Table 1. Carbon stored in the P. radiata trees, stem volume and stem wood density at age 24 years by treatment. Carbon is shown for AGB (above ground biomass), BGB (below ground biomass) DWL (dead woody litter), and FL (fine litter). Values in a column followed by the same letter do not differ significantly (LSD test, α=0.05).

Biosolids	Carbon (t C ha^{-1})					Stem volume	Stem wood density
loading	Total	AGB	BGB	DWL	FL	(m^3 ha^{-1})	(kg m^{-3})
Control	220 a	175 a	36 a	1 a	8 a	595 a	418 a
Standard	259 b	206 b	43 b	2 a	10 b	716 b	413 a
High	261 b	207 b	43 b	1 a	9 b	744 b	403 b

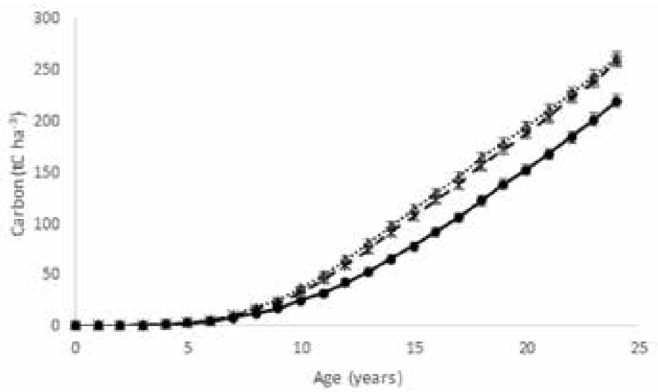

Fig. 2. Annual means by biosolids treatment showing total carbon sequestration. The following symbols and lines are used for each biosolids loading rates: Control - dots and solid line; Standard rate – stars and dashed line; High rate – triangles and dotted line. Error bars show standard errors.

In summary, trees applied with biosolids had sequestered 40 t C ha^{-1} more than unfertilised trees, an increase of 18 %. Biosolids application increased stem volume by 23 % but reduced stem wood density by 2.5 %. Most of the increased C sequestration occurred between age 6 when the trial commenced and age 17 years, and the standard rate gave the same increase in C sequestration as the high rate. This suggests that 2-3 applications of the standard rate would have been sufficient to achieve the increased C sequestration, implying an applied N to C conversion ratio of 43-65 kg C kg^{-1} N, similar to ratios estimated from forest fertiliser trials in the Northern Hemisphere. This suggests that N input from biosolids application accelerates the rate of increase of needle mass in the developing forest canopy of *P. radiata*, but does not necessarily affect the final level of foliage mass in the closed canopy. It is likely that N fertilisation will become more widespread under the New Zealand Emissions Trading Scheme which encourages forest management practices that improve C sequestration in young forests.

UPDATE FROM THE ECOTOX TEAM

Louis Tremblay

Many members of the CIBR team continue to work on the initiative of raising the profile of emerging contaminants in New Zealand. An increasing number of signs indicate that it has become a significant issue. At a recent Regional Council Special Interest Group strategy meeting, Regional Councils agreed that ecotoxicology and emerging contaminants were areas that need greater attention and was part of their top priority list. Recent publicity around the presence of triclosan in widely used consumer products is another reminder that there is a need to better characterise the risks of emerging contaminants so that they can be better managed. Chris Arbuckle (Aspiring Environmental) has made good progress with the National Strategy to manage emerging contaminants. The document will be completed by the end of September.

We are also working with colleagues Rai Kookana and Anu Kumar from CSIRO on another exciting emerging contaminants initiative. We are planning to hold the next of the conference series '*What's in our water*' (WiOW 2018) in Canberra at the Discovery Centre, Tuesday 30 October to Thursday 1 November 2018. The first two days would be for the conference followed by a workshop on the third day. The workshop would be to revisit the Black Mountain declaration that was signed by a scientists in 2007 to highlight the importance to better assess the risk of emerging contaminants. We are exploring options for the Black Mountain Declaration to underpin the development of an Australasian Directive Framework to manage emerging contaminants based on the European Union model. Such agreement would facilitate exchanges and collaborations across Australasia.

CIBR is working closely with Olga Pantos from ESR on the planning of a workshop to discuss risk and management of plastics. There is much interest and concerns around the risk of plastics including increasing media coverage, e.g. Auckland Council are looking at developing policies and other groups like Gisborne District Council would like more info. Olga will use an approach similar to the emerging contaminants workshop held in Wellington last December. She has secured internal ESR funding and we are currently working to explore other funding options. We are identifying key people that should be approached to attend the tentative workshop next December. David Weller (EPA) and Sarah Fish (MfE) are contributing to the process and have vested interest in the risk of plastics. There are many community driven initiatives. Andrew Jeffs (U Auckland) has interactions with Sustainable Coastlines, a community group trying to reduce plastic pollution and with strong community engagement in Auckland. Plastics can be considered an emerging contaminant with multiple implications, so it would be good to identify priorities and ensure cohesion across the different groups.

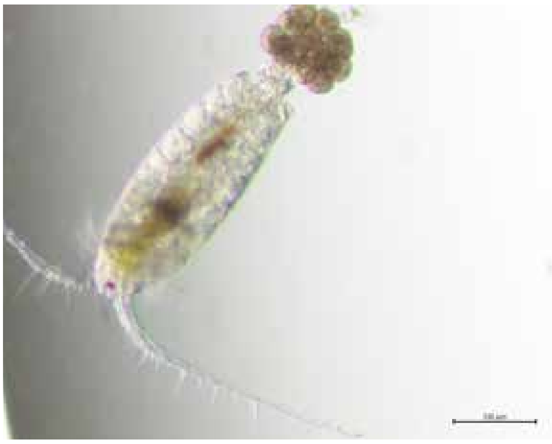

Figure 1: Photo of a female Gladioferens pectinatus with the egg sack.

French visiting student Anais Guyon completed her research project on the pelagic copepod Gladioferens pectinatus at Cawthron that lives in the water column in the marine environment (Figure 1). The key objective of the project was to assess whether this copepod species is a suitable ecotoxicology model for studying the effects of an organism that is in contact with a small dose of a pollutant over a long period of time (Figure 2). Anais successfully conducted a long-term exposure experiment where the copepod were placed in the presence of non-lethal low doses of the UV blocker benzophenone and the anti-inflammatory drug diclofenac. The time of exposures covered a total of six generations, i.e. from new born to adult stages. At the end of the experiment, Anais found that the copepods had become more tolerant to the chemicals than the non-exposed animals. That demonstrates that the stress from the chemicals led to some level of adaptation. She also measured the level of DNA methylation in the copepod as an indicator of epigenetic mechanisms. There were some significant differences across the treatments suggesting that this could explain how the copepod became more tolerant and this is an exciting result as it could explain aspects of the adaptation. We will follow up with those experiments with more in-depth investigations on the epigenetic and metabolomic profiles with colleagues from Griffith University to further advance our understanding of the subtle effects of micro-pollutants on the health of our environment.

Figure 2: Experimental set up for the copepod multigenerational experiment.

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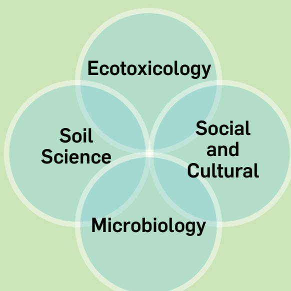

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