



BOTANICAL SOCIETY

OF OTAGO



Newsletter Number 88
October 2019

BSO Meetings and Field Trips October 2019 - March 2020

Wednesday 9th October, 5:20 pm: Botanical art. The Botanical Art and Illustration Courses at Olveston began in January 2017. An Advanced Botanical Art and Illustration Course was later held beginning June 2018 and out of that course came the first Botanical Art and Illustration Exhibition at Olveston, which was held in December 2018. The classes have been hugely popular. The exhibition of original botanical artwork was of very high quality and created great public interest.

The courses are taught by Wayne Everson, who is an award winning teacher and practicing artist. He holds a Master of Fine Art degree from RMIT University, Melbourne, and has taught art at tertiary level for many years in New Zealand and overseas. Wayne Everson will give the talk, which will centre on the success of the classes at Olveston and their botanical focus.

19th – 20th October: Weekend trip to the northern Catlins. On this trip we will visit several stunning coastal sites in the northern Catlins, including Jacks Bay and blowhole, Pounawea Scenic Reserve, Cannibal Bay and Nugget Point. We'll encounter coastal rata forest, dune slacks with rare species, shrublands and herbfields. We will depart on Saturday morning and spend Saturday night at the Pounawea Motor Camp <http://www.catlins-nz.com/pounawea-motor-camp/> 2.5 km from Owaka. This tranquil camp has cabins and camping sites surrounded by native forest on the edge of an estuary. You are responsible for your own accommodation arrangements and catering. Please let John Barkla know if you are intending to come by Monday 14 October. Travel arrangements will be advised. Contact John Barkla jbarkla@doc.govt.nz Ph. 03 476 3686.

Saturday 2nd November, 8:30 am: Field trip to Andersons Lagoon. Andersons Lagoon is a sizeable wetland comprising a shallow lagoon resulting from the formation of a sand dune barrier limiting the egress of the waters of Stony Creek to the sea. The lagoon is contained in a steep-sided valley resulting in some narrow bands of vegetation types along the shore. The track to the lagoon passes through a QEII covenant which was planted with native trees some years ago. The dune system has led to an inland sand spit with primarily exotic species extending from the dunes towards the lagoon, where native wetland plants are more common. The embouchure at the northern end of the dunes is easily crossed and a stairway leads to the top of a cliff from where a pathway leads to the mouth of the Shag River. A seldom visited area and well worth the trip. Leave the Botany Department car park at 8.30 a.m. Any questions contact john.steel@otago.ac.nz.

Wednesday 13th November, 5:20 pm: Assessing the ecological consequences of extinction: are flightless birds important seed dispersers in New Zealand? Speaker: Jo Carpenter, Postdoctoral Researcher, Manaaki Whenua-Landcare Research. Understanding the mutualistic services that species provide is essential when assessing the consequences of their local or global extinction. New Zealand historically harboured ~27 species of flightless land birds, of which 67% are now extinct, and the mutualist services these taxa provided are still unclear. Five large-seeded endemic tree species (*Elaeocarpus dentatus*, *E. hookerianus*, *Prumnopitys ferruginea*, *P. taxifolia*, *Vitex lucens*) appear partially adapted for seed dispersal by flightless birds, leading to speculation that they may once have been dispersed by moa. However, coprolite (fossilised faeces) evidence demonstrates that moa actually functioned largely as seed predators. So who does disperse these strange seeds? My PhD research shows that a flightless rail, the weka (*Gallirallus australis*) may be a significant disperser for some of these plants. Weka moved *P. ferruginea* and *E. dentatus* seeds similar dispersal distances to kereru (*Hemiphaga novaeseelandiae*), yet the potential contribution of weka to forest regeneration is frequently overlooked by conservationists. Overall, my research demonstrates the importance of critically examining assumptions about which species conduct important ecosystem functions. More broadly, the Pacific has lost >450 rail species in the last 3000 years, which may represent one of the most widespread yet least appreciated losses of dispersal function ever recorded.

Wednesday 19th February, 5:20 pm: Eco-evolutionary stories about plant diversification in New Zealand. Speaker: Bill Lee, Manaaki Whenua-Landcare Research. Plant radiations are a feature of the New Zealand flora

and contribute endemic elements to many ecosystems. In this talk I explore what we are learning about the chronology, trait development, ecology and evolution of the modern flora by looking at woody and herbaceous lineages through time. This perspective focuses on distinct lineages and integrates time-calibrated phylogenies with the ecology and distribution of modern species. Immigration, abiotic and biotic selection and geography have all played a role in facilitating species-rich groups, especially after major extinction events and the appearance of new biomes. I will mainly use genera that have come out of the forest into open areas above and below treeline.

21st – 23rd February 2020: Weekend Field Trip to Invercargill. We are planning to visit Invercargill and explore sites of botanical interest there. These weekend trips have proved very popular in the past, especially for out of town members who do not get the opportunity to participate in local field trips. There is a lot of scope as there are many diverse natural areas close to Invercargill. We are planning to base ourselves at one of the local camping grounds. The preferred option at this stage is the Beach Road Holiday Park west of Invercargill, close to Oreti Beach. This is a preliminary notice until plans have been finalised. If you are interested in coming, contact David Lyttle (djl1yttle@gmail.com) ph (03) 454 5470.

Wednesday 11th March, 5:20 pm: New Caledonia: a Botanist's Paradise. Speaker: Peter Johnson, Manaaki Whenua-Landcare Research. "A Botanist's Paradise": so-claimed in an interpretation panel at the Noumea Aquarium. Indeed: a challenging Paradise for a young NZ botanist visiting New Caledonia 40 years ago, accompanying a group of NZ entomologists. My role was to collect plants of interest to the insect people, and get identification help from the resident (French) botanists. This had the additional challenge of understanding, for example, that 'Not-a-far-goose' was *Nothofagus* (5 spp. there). New Caledonia has a flora of some 3000 taxa, compared with c. 2400 in NZ, being mostly woody spp. of rainforest, dry forest, maquis (ultramafic shrubland), and savannah (mostly niaouli, a *Melaleuca*).

In 1978 I had a camera for black-and-white film, and another for a strict ration of 35mm colour slides. Revisiting New Caledonia in 2019 with a digital camera allowed for many more snapshots, even if winter meant a limited number of plants in flower. But more than enough for a picture show: some of the 13 spp. of *Araucaria*, one of the 95 *Pittosporums*, the only other (non-NZ) *Xeronema*, bracken fern that looks like bracken, filmy ferns that are not quite familiar ... and so on. Landscapes of misty montagnes, hillsides affected by mining, machetes, and the matchbox, localities with names like Riviere Bleue, Mont Koghi, and Dumbea. Plus road-signs, graffiti, markets, and cuisine ... all in French. Join me for a travelogue. Warning: we'll be driving on the wrong side of the road.

Meeting details: Talks are usually on Wednesday evening starting at 5.20 pm with drinks and nibbles (gold coin donation), unless otherwise advertised. Venue is the Zoology Benham Building, 346 Great King Street, behind the Zoology car park by the old Captain Cook Hotel. Please use the main entrance of the Benham Building to enter and go to the Benham Seminar Room, Room 215, located on the second floor. Please be prompt as we have to hold the door open. Items of botanical interest for our buy, sell and share table are always appreciated. When enough people are feeling sociable we go to dinner afterwards: everyone is welcome to join in. The talks usually finish around 6.30 pm. Keen discussion might continue till 7 pm.

Field trip details: Field trips leave from Botany car park 464 Great King Street unless otherwise advertised. Meet there to car pool (10c/km/passenger to be paid to the driver, please). Please contact the trip leader before Friday for trips with special transport and by Wednesday for full weekend trips. A hand lens and field guides always add to the interest. It is the responsibility of each person to stay in contact with the group and to bring sufficient food, drink and outdoor gear to cope with changeable weather conditions. Bring appropriate personal medication, including anti-histamine for allergies. Note trip guidelines on the BSO web site: www.bso.org.nz

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Chair's Notes

Gretchen Brownstein

Kia ora koutou.

After an unusually warm winter, it seems spring has blown in with its normal bluster and snow flurries. Back in July, I had a chance to look around the Clyde Railhead Community Eco-Nursery with Dhana Pillai and hear about some of restoration projects the group are supporting. I was really impressed with the range of species they are growing, everything from grasses and carexes to matagouri and totara. See Dhana Pillai's article in this issue on their very exciting MBIE funded Curious Minds Participatory Science Platform Project investigating Native-Plant Fungi Symbiosis. Really looking forward to hearing the final results.

The Baylis lecture this year was given by Dr Hamish Campbell. He gave us a wonderful geological tour of Zealandia, highlighting the connections between New Zealand, the Chatham Islands, and New Caledonia.

A bit of news from the BSO committee: A big welcome to Angela Brandt, our new BSO secretary! And a big thanks to Allison Knight for carrying out the secretary role so well for many years (happily, Allison is still serving as a committee member).

The 2020 BSO calendar is now out. Many thanks to John Barkla for once again putting together a beautiful and useful specimen of a calendar, utilising some of the photos from the photography competition. You can buy your copy now for \$15 at the BSO meetings or order them on the website. And remember; the calendar makes a great gift!

Also, due to the popularity of the botanical pun badges, Esther Dale has now produced botanical pun fridge magnets. These are for sale at the meetings for a \$1 each or a set of 6 for \$5.

As always, if you have any ideas for trips or talks or projects you think the BSO should do, let the committee know.

Happy botanising,

Gretchen

Secretary's Notes

Angela Brandt

I am grateful for the warm welcome from the entire committee, and especially the continued guidance and support provided by Allison Knight as I try to step into her very capable and knowledgeable shoes in my new role as BSO Secretary. I have certainly gained a greater appreciation for the efforts required (and generously given every day) by the committee to keep the Society's activities running smoothly and our botanical community well-informed.

As I now help manage the Society's correspondence and outreach, I have been impressed several times in just these few months by the impact we are able to have on our local community, the New Zealand botanical community as a whole, and even internationally. First, our June newsletter was highly praised by members of the Whanganui Museum Botanical Group, which celebrated its 50th anniversary last year - many thanks again to all who contributed to make this newsletter so notable, and to Lydia Turley for her ongoing stellar efforts as editor.

Second, the volunteer programme coordinator of Orokonui Ecosanctuary reached out to us in order to build on the already great relationships in place between many of our members and the Ecosanctuary. Multiple BSO members have provided advice for managing the Ecosanctuary's rare plants garden, and others already participate in their volunteer programme. The BSO committee has been brainstorming which other possible links to develop between the Society and the Ecosanctuary - such as holding a fungal foray field trip there next autumn - so watch this space! If anyone has ideas for workshops, field trips, or other events that might work well at the Ecosanctuary, please let us know.

Third, the botanical resources provided by the BSO are sought after from enthusiasts near and far. Two of the Society's publications - *Lichens of New Zealand: An Introductory Illustrated Guide* and *Mosses, Liverworts, Hornworts and Lichens: A Guide for Beginners* - have sold out and will soon be reprinted to meet continued demand as we regularly receive inquiries asking when they will again be available for purchase. Our website also received a "cyber thumbs-up" from a volunteer in a community

mentoring programme in the northern hemisphere who wrote to thank us for the links we have listed, which she used to help the children she mentors learn about plants.

Finally, another round of thanks to Lydia Turley for maintaining the BSO Facebook page. Posts on the page have been reaching up to 775 people per month, and the page provided a mechanism for people to vote on which botanical pun images would be best transformed into refrigerator magnets to be sold for fundraising (thanks to Esther Dale for organising this!). Photos are the best way to increase our community engagement, and social media platforms are a great way for us all to share photos from our wonderful field trips, so we encourage you to post photos from BSO events directly to the Facebook page or send them to Lydia, myself, or Sarah Kilduff to post as administrators of the page.

Editor's Notes

Lydia Turley

Hey hey, it's yet another busy edition of the newsletter, and the largest since I've been editor! I've dubbed this the moa edition since we've got multiple moa-related articles (who said botanists just study plants?), but there's lots of other cool stuff in these pages; for example, Angela has thoroughly documented her attempts to propagate bryophytes and Dhana has written about exciting work going on in central Otago looking at revegetation.

Many thanks to everyone who has contributed to this edition of the newsletter and I hope you all enjoy reading it!

If you've got anything you'd like published in the next edition, send it in – contributions are always welcome! We encourage stories, drawings, reviews, opinions, articles, photos or letters – or anything else you think might be of botanical interest to our diverse range of members. Copy for the next newsletter is due on **10 January 2020** and earlier submissions are most welcome.

Editor's guidelines: Try to aim for a 0.5–1 page of 14 pt. Times for news, trip/meeting reports and book reviews and 1–5 pages, including illustrations, for other articles. Electronic submission by email to lydiamturley@gmail.com is preferred. Send photos as separate files and remember to include photo captions and credits.

Disclaimer: The views published in this newsletter reflect the views of the individual authors and are not necessarily the views of the Botanical Society of Otago.

New Members

A warm welcome is extended to James Crofts-Bennett, Nicole Bezemer, Ashlee Drummy, Lucy Heaton, Hamish Gray and Clay Gibbons. To our existing members, thank you for your continuing support.

Thank you very much to David Orlovich, Lucy Heaton and Clay Gibbons for their generous donations.

Correspondence and News

Obituary: Ian Atkinson

Bill Lee and Peter Johnson

On Friday 23rd August, 2019, Ian Atkinson died in Dunedin. Ian was an ecologist with Botany Division, DSIR, based for most of his working life in Wellington. In recent months he was being looked after by his daughter Toni at Warrington.

Ian was a mentor to many of us who joined DSIR in the 1970s, sharing his broad knowledge of NZ vegetation and his interest in the processes creating vegetation patterns and growth forms distinctive to our region.

Being in Dunedin, we had less of the close collaboration some of our northern colleagues enjoyed with Ian, but we shared many common

interests in soils, island ecosystems, vegetation history, kakapo habitat, mammal impacts, moa and divaricates, conservation and vegetation assessment.

In all these areas Ian made pioneering contributions that continue to shape our ecological understanding. He was an ecologist at heart and looked for mechanisms outside of climate to account for different patterns and forms in our vegetation. This may have originated during his PhD at the University of Hawaii where he investigated rates of ecosystem development on volcanic chrono-sequences while furthering his interests in rodent ecology on islands.

He always had thoughtful comments on any ecological topic, which we appreciated, and these often surfaced when he critiqued our draft manuscripts or reports. His talks were always fascinating as he took his listeners on a carefully crafted tour of a topic.

One of his major contributions was via the study of islands which he saw as natural laboratories, places for investigating invasions, human impacts, endemism, vegetation succession, and restoration processes and options. His thorough study of mammal invasion and impacts on NZ and South Pacific islands remains exemplary.

His work with Michael Greenwood on the effect of moas on the form and function of the NZ flora and ecosystems was revolutionary and bold. It represented a major shift in ecological understanding of plant-animal interactions, highlighting herbivory as a critical evolutionary factor. Ian then extended these ideas to explore rewilding or de-extinction possibilities, replacing missing functional species with ecological analogues from elsewhere. This idea was decades ahead of its time and represented much of Ian's thinking.

As young ecologists we always remember Ian as a happy, contemplative, thoughtful, insightful, and knowledgeable person who listened and discussed any ecological topic with great interest. In his patterned jerseys he was a frequent speaker at many ecological society conferences and attracted several notable international researchers to NZ, most remarkably Jared Diamond and Dan Simberloff.

Ian was farewelled on the 28th August at Warrington. It was a very special occasion where family and friends shared many fond memories of Ian. He was a remarkable person with a deep fondness for nature and New Zealand's plants and animals. He leaves a formidable legacy of publications and many shared experiences enjoying islands, volcanoes, and habitats around our country.



Ian Atkinson

Please don't lick the sexy pavement lichen!

Allison Knight

In 2010, I gave a talk on lichens to the Auckland Botanical Society and jokingly called *Xanthoparmelia scabrosa* 'the sexy footpath lichen', because it contains a Viagra-like chemical and grows profusely on footpaths all over New Zealand. It's all around the edge of the Botany Dept. car park, and very likely growing on a footpath near you. However, this lichen also contains toxic scabrosins, so I jokingly warned the audience not to go out and lick the footpath.

Now these two throw-away comments have come back to haunt me. The international common name of *Xanthoparmelia scabrosa* is now officially 'sexy pavement lichen', thanks to Dan Blanchon remembering my comment and Peter de Lange immortalising it on iNaturalist.

Last month, a Newsroom reporter was intrigued by the name and decided to investigate. She combined my two throw-away comments and titled her article "Please don't lick the sexy pavement lichen". This caught the eye of readers and news media all over the world, appeared on the front page of the Guardian,

and caused an amazing media frenzy. If you missed the storm in a teacup you can read the Newsroom article here:

<https://www.newsroom.co.nz/2019/08/14/745287/please-dont-lick-the-sexy-pavement-lichen>

I'll have to be careful what I say when I talk to the Nelson Botanical Society in September!

BOTANY!

There should be no monotony
 In studying your botany;
 It helps to train
 And spur the brain
 – Unless you haven't gotany.
 It teaches you does Botany,
 To know the plants and spotany,
 And learn just why
 They live or die –
 In case you plant or potany.
 You learn, from reading Botany,
 Of woolly plants and cottony
 That grow on earth,
 And what they're worth,
 And why some spots have notany.
 You sketch the plants in Botany,
 You learn to chart and plotany
 Like corn or oats –
 You jot down notes,
 If you know how to jotany.
 Your time, if you'll allotany,
 Will teach you how and what any
 Old plant or tree
 Can do or be
 – And that's the use of Botany!
 by Berton Braley

Science News Letter, 1929

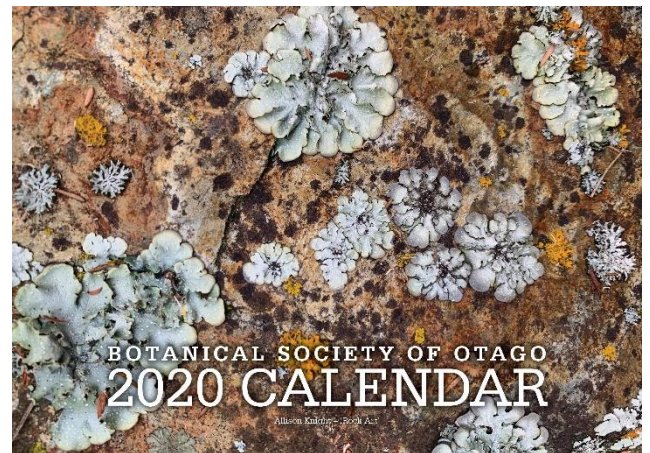
reprinted from Waikato Botanical Society newsletter No. 43, 12/18, via Wellington Botanical Society newsletter, April 2019, and Allison Knight.

Calendar

The Botanical Society of Otago 2020 Calendar is on sale now for \$15 each.

Available 1 - 3 pm from the Botany Department Reception, University of Otago (cheque or correct amount of cash only) and at Society meetings.

For electronic payment, email the Botanical Society of Otago (bsso@otago.ac.nz) with your name, address, and whether you want to collect the calendar from Botany Department reception or have it posted (add \$2.50 for mailing).



Magnets

Following the popularity and success of the badges, Esther Dale has designed a set of botanical themed fridge magnets. We will be selling these at meetings for \$1 each, or \$5 for a set of six.





Magnet designs

Lichens of New Zealand:



An Introductory Illustrated Guide *Allison Knight*

A5, 56 pp, full colour, laminated cover. NZ\$20
 Published by the Botanical Society of Otago, using the Audrey Eagle Botanical Publishing Fund.

This introductory guide celebrates the extraordinary diversity of New Zealand lichens with full colour images of over 250 common lichen species, plus a glossary illustrating over 60 useful identifying features. Species are divided into 4 colour-coded ecosystems and displayed in order of the three main growth forms.

New Zealand is exceptionally rich in lichens and harbours around 10% of the world's lichen species. They are an important, yet often overlooked, component of every ecosystem from the seashore to the mountaintops and contribute over 2,000 taxa to New Zealand's biodiversity —nearly as many species as seed plants.

**2019 reprint with updated names
 (over 20% of the names have changed)
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 Only **CORRECT CHANGE or Cheques**, please.
Cheques payable to *Botanical Society of Otago*
 Or order in advance by **Internet banking**:
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Be sure to enclose or email your delivery address to:

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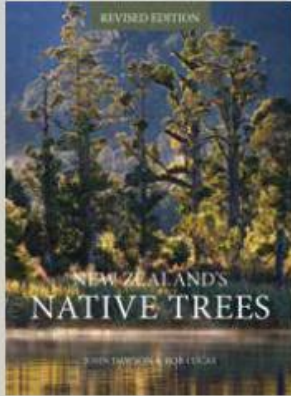
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Proceeds will go to the Botanical Society of Otago to replenish the Audrey Eagle Botanical Publishing Fund.

New Zealand's Native Trees

Revised Edition due October

Botanical Society special offer 20% discount



New Zealand's Native Trees is a landmark book, the kind that is published only once in a generation. It was Book of the Year in the 2012 NZ Post Book Awards. This revised edition has been completely brought up to date with a significant number of new species described or reclassified, and now has over 100 new pages, with a staggering 3200 photographs. It celebrates our unique and magnificent native forests, and describes and generously illustrates more than 350 species, subspecies and varieties.

Special price \$104.00

Retail \$130.00

John Dawson & Rob Lucas

310 x 229 mm, 688 pp

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colour throughout

Published: October 2019

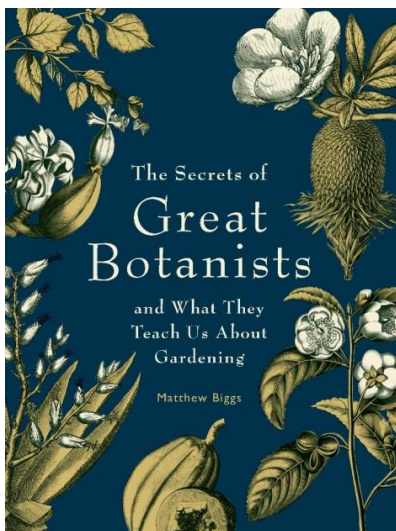
To receive 20% discount and free delivery in NZ, order online at pottonandburton.co.nz and use the coupon code **BOT19** at the shopping cart. Offer ends 20 December 2019.

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Advertisement: The Secrets of Great Botanists and What They Teach Us About Gardening

Author: Matthew Biggs



RRP \$34.99 Hardcover, published October 2019. The Secrets of Great Botanists is available from <https://exislepublishing.com/product/the-secrets-of-great-botanists/> When you go to the checkout, enter the voucher code OTAGOSOCIETY and you will receive 30% discount and free P&P in NZ.

Botanists have been the trailblazers in discovering how plants work to benefit our species, collecting many of the plant species we find in our gardens today from all around the world. This informative and beautiful guide presents the stories and reveals the secrets of 35 of these botanists, plant collectors and gardening pioneers of the past and present.

This includes Joseph Banks (James Cook's botanist on the Endeavour) and Georgiana Molloy (one of the first botanists in the Swan River Colony in Western Australia) highlighting the qualities that brought them success. Every botanist included in *The Secrets of Great Botanists* was, or is, passionate about their particular specialty. Whether they were searching for plants in wild places, prescribing herbal medicines or forming new structures of plant classification, they were driven by an insatiable desire to learn and discover, so that we, as humans, might benefit from improved crops, medicines or gardens.

Through the vibrancy of botanical photographs and beautifully illustrated period botanical watercolours, this book aims to teach readers about the observations, ideas, secrets and discoveries of these ground-breaking botanists. Their influence on gardening and the wider world will provide inspiration and practical guidance for budding gardeners of all levels and inspire readers to try these plants and tips at home.

Articles

Coproecology Reveals the Ecological Interactions Lost with the Extinction of the Little Bush Moa

Melanie Vermeulen

Each species forms ecological relationships as it interacts with its environment forming a network within an ecosystem which governs ecosystem processes such as nutrient cycling (de Ruiter et al., 1995). Species loss causes an extinction of an interaction that may have far reaching consequences, for example, high levels of plant species extinction (41-60%) had effects comparable to nutrient pollution on productivity and decomposition (Hooper et al. 2012).

Megafauna were once abundant and diverse in many ecosystems across the earth but are now severely diminished or lost from most landscapes (Koch and Barnosky, 2006). Megafauna have many ecological roles including shaping ecosystem physical structure through destruction or consumption of vegetation (e.g. Bakker et al., 2016); shaping vegetation composition through seed dispersal (Doughty et al., 2015) and promoting browsing tolerant species (Ford et al., 2014).

New Zealand's megafauna were the moa. Moa, of which nine species have been identified, were large terrestrial herbivores that ranged in size from 19 to 250 kg (Worthy and Holdaway, 2002). Coexistence between moa species is thought to have been facilitated by niche partitioning through differences in feeding height, bill morphology and gizzard development (Atkinson and Greenwood, 1989; Attard et al., 2016). Moa were once widespread throughout New Zealand with a population of 50,000-100,000 individuals but complete extinction occurred c. 200 years after human settlement (Holdaway and Jacomb, 2000; Perry et al., 2014).

The ecological role of moa within New Zealand's ecosystem has been suggested as a disperser and as a driver of woody vegetation composition and structure (Clout and Hay, 1989; Lee et al., 2010). Numerous studies support the wire plant syndrome found in New Zealand to be an adaptive trait to

browsing pressure by large-bodied birds (Bond et al., 2004; Bond and Silander, 2007; Kavanagh, 2015; Lee et al., 2010). Recently moa have been suggested as dispersers of mycorrhizal fungi. Some species of mycorrhizal fungi have brightly coloured fruiting bodies (Beever, 1999). Mycorrhizal fungi form symbiotic relationships with particular plant taxa, for instance beech (Nothofagaceae) and therefore may have played an important role in the expansion of beech forest in New Zealand (Orlovich and Cairney, 2004). Boast et al. (2018) was the first to show evidence of the consumption of fungi by moa.

The state of knowledge on moa diet has changed greatly over time. Early accounts place moa as grazers, even going so far as to suggest they were functionally similar to cattle (as reviewed by Worthy, 1991), to suggesting that deer had fulfilled the lost ecological role of the moa, to the latest ancient DNA research that demonstrates the differences in diet and feeding ecology between moa and ungulates and the differences in moa diet at the species level rather than treating moa as a single entity (Wood et al., 2012 a, b; Wood and Wilmhurst, 2013; Wood et al., 2013).

My research aimed to expand the limited knowledge on the diet of the Little Bush Moa (*Anomalopteryx didiformis*). The Little Bush Moa was the smallest of the nine species, the adults ranged between 50-90 cm tall at the back and 19-73 kg (Tennyson and Martinson, 2007). Little Bush Moa had a New Zealand wide distribution and was primarily an inhabitant of lowland closed-canopy forests (Worthy, 1990). I used ancient DNA techniques on moa coprolites (desiccated moa dung) excavated from Mt Nicholas Station in Wanaka (deposited between 1521-1185 years BP (95% CI, calibrated age)) and Borland Burn in Southland (deposited between 6626-5721 years BP (95% CI, calibrated age)). First, I successfully amplified and sequenced moa DNA in ten coprolites of 35 coprolites to determine which moa species had deposited the coprolite. Second, I successfully amplified and sequenced the chloroplast *rbcL* gene and ribosomal 18S rRNA gene. My sample contained seven coprolites deposited by Little Bush Moa, two deposited by South Island Giant Moa (*Dinornis robustus*) and one deposited by Upland Moa (*Megalapteryx didinus*).

My research demonstrated that the diet of Little Bush Moa consisted predominantly of trees and shrubs as has been found in other studies and discovered eight new native plant genera: *Anemone*, *Carpodetus*, *Ileostylus*, *Hibiscus*, *Parsonsia*, *Raukaua*, *Pennantia* and *Pittosporum*. A number of species within these genera are listed as threatened. Potentially the most ecologically significant finding was the presence of the ectomycorrhizal sequestrate (truffle-like) family Tuberales in the coprolites of all three species and may be an example of fungi dispersal adaptation to native avifauna. Further studies using ancient DNA, pollen and macrofossils will aid in determining whether the new plants and fungi are actual diet or incidental feeding.

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Searching for Mycorrhizal Fungi in Central Otago

Dhana Pillai, Clyde Railhead Community Eco-Nursery, Haehaeata Natural Heritage Trust

Central Otago is one of the hottest, coldest and driest regions in New Zealand and has suffered devastating vegetation loss since the arrival of humans 800 years ago. Very small remnants of lowland vegetation are plagued by goats, possums and rabbits and a myriad of invasive weeds. Much work needs to be done to do put native vegetation back in the landscape.

The Haehaeata Natural Heritage Trust was set up just over 2 years to oversee the operation of the Clyde

Railhead Community Eco-Nursery. The nursery grows native plants from locally sourced seed for plantings on public and private land in Central Otago.

Concerned that the odds are against us in trying to re-establish woody vegetation in depleted Central Otago soils, we are always thinking about how to tip the balance in favour of establishing better nursery grown plants. Over cups of tea at the nursery a group of volunteers became increasingly interested in the role that mycorrhizal fungi potentially play in helping plants extract scarce mineral resources from the soil and survive drought conditions.

It is widely believed that most native plants have associations with mycorrhizal fungi, and that 80% of all these associations are with endomycorrhizal fungi. Unlike ectomycorrhizal fungi which have visible fruiting bodies such as mushrooms, endomycorrhizal fungi spend their entire life under the soil, are difficult to see and even more difficult to cultivate.

Following initial discussions with Prof. Kath Dickinson and Dr. Cathy Rufaut, we approached the Botany Department at Otago University to do a scoping project and then to become partners in a MBIE funded Curious Minds Participatory Science Platform Project investigating Native-Plant Fungi Symbiosis. Prof. David Orlovich kindly agreed to lead the scientific side of the investigation and Dr. Rufaut was appointed our project manager to provide essential liaison between the University and the Haehaeata Trust.

Funding was granted in July 2018 and the team decided to investigate an area on a working merino farm at Waikerikeri near Clyde. Three gullies on the southern end of the Dunstan Range at an altitude of about 300-400m were selected for the presence of native shrubland on one bank and thyme-dominated vegetation on the other. Like most of Central Otago, the area would have been extensively burnt by early Polynesian and European settlers. In the late 1860s the gullies were mined for gold with further vegetation loss and removal of soil. Since that time until the present, the land has been grazed by sheep and other browsing animals.

Field work to gather soil samples and survey the vegetation was undertaken in October 2018. We selected the relatively common native shrub *Olearia odorata*, the scented tree daisy, to centre our plots on in the native shrubland.



The soil under selected *Olearia odorata* shrubs (scented tree daisy) was sampled for DNA.



A volunteer tagging an *Olearia odorata* plot surrounded by matagouri.

Eight plots were randomly selected down each gully corresponding to a tagged *Olearia* shrub paired with a tagged thyme plant on the opposite bank. Surveying the native shrubland was a very prickly operation with briar, hawthorn and matagouri in most plots. Sometimes we were on our hands and knees because that was the only way to get to around.

Soil from under each of the 48 selected plots was sampled for chemical analysis and Botany Department scientists whisked subsamples for DNA

and RNA back to Dunedin to be stored at -82° before the dry ice in the sample chest melted.



A sampled gully with native shrubs on one side and thyme dominated vegetation on the other.

Haehaeata volunteers conducted a citizen science vegetation survey at each of the 48 plots. Every plant species present in 4m^2 quadrats was recorded and the cover of each vegetation class estimated. Volunteers had to brush up on their weed species identification as there were many more herbaceous and woody weeds present than native plants. From the three gully sites we found 14 native species and 59 exotic species.

The woody native species present were *Muehlenbeckia complexa* (small-leaved pohuehue), *Coprosma propinqua* (Mingimingi), *Discaria toumatou* (matagouri), *Olearia odorata* (scented tree daisy) and *Melicytus alpinus* (porcupine shrub). These are all common components of the so called “grey scrub” community. That's the informal name given to the native woody vegetation we see growing around the Central Otago hills. The native shrubs present in the study area represent the pioneer species i.e. they are able to spread easily and colonise bare ground.



Ranunculus amphitrichus one of the native herbs present in a boggy section of a gully.

Native forb and graminoid species were represented by *Acaena buchananii*, *Crassula sieberiana*, *Oxalis exilis*, *Hydrocotyle microphylla*, *Ranunculus amphitrichus*, *Prasophyllum colensoi*, *Carex berggrenii*, *Carex breviculmis* and *Asplenium flabellifolium*.

Most of the exotic species encountered were forbs and grasses with a few woody weeds, the main ones being briar, hawthorn and thyme. Out of the 59 species of exotic plants the most common was the introduced herb *Anthriscus caucalis* (burr parsley) a plant of the carrot family, native to Europe. It was present in 100% of the *Olearia* plots and 40% of the thyme plots.



Anthriscus caucalis (burr parsley) was the commonest out of 59 exotic species present.

Interim results were presented at a seminar at Dunstan High School last June which generated much interest from the community and demand for a follow up seminar when full results are available.

The extraction of the genetic material has involved much time and effort by OU Botany scientists. The current project is looking at the DNA present in the soil, which will give us an indication of what fungi species have been present. The researchers have also extracted and preserved RNA (ribonucleic acid) for analysis in the future when further funding allows. RNA can reveal which fungi are currently living in the soil. We await the final results with interest.

The core volunteer team Bill Nagle, Corinne Ebisu and Dhana Pillai are grateful for the encouragement of Dr Craig Grant (Participatory Science Project, Otago), the financial support from Curious Minds and MBIE, the ongoing help from Botany

Department scientists, the partnership with Mokihi Trust and permission from the Attfield family to access their land.

Central Otago readers who want to volunteer at the nursery or get involved in community plantings can contact Dhana at nursery@haehaeata.org.nz. Our weekly nursery working bees are held on Thursdays; 9am to 12pm in summer and 1-3pm in winter. Visitors are most welcome and our morning/afternoon teas are well catered for.



Otago University scientist and Haehaeata volunteers gathering data in the field.

Taking on the Challenge of Experimenting with Bryophytes

Angela Brandt, Manaaki Whenua – Landcare Research

When I was preparing to apply for grant funding for the first time as a project lead and busily brainstorming ideas of pressing ecology questions I would be most keen to answer, Bill Lee suggested that I consider working with bryophytes (mosses, liverworts, and hornworts) as they are often overlooked by plant community ecologists. With David Glennie of Manaaki Whenua – Landcare Research's (MWLR) Lincoln office and David Burritt of the Dept. of Botany as collaborators, I could learn to identify mosses and liverworts, and to explore their physiological responses to different environmental conditions and to interactions with each other. However, as I knew well from experiments I had previously done with vascular plants in both the glasshouse and the field, I would likely need a large number of plants to have the statistical power to test how species responded to a variety of conditions. I also realised that I needed to be able to reliably keep those plants alive and healthy

before beginning any experiment, and as a baseline to compare with a physiological stress response to an imposed condition. The key question, now that I had received some funding to test my ideas, was whether I could set up conditions that would allow me to grow multiple species to use in experiments.



Fig. 1. *Sciadocladus kerrii* lining the Pipeline Track in the cloud forest of Swampy Reserve.

I first needed to find local sites from which I could collect a variety of common species to use in growth trials, focusing on species predominantly occurring in forest. We are lucky here in Dunedin to have many easily accessible areas of native forest close to the city, and I sincerely thank the Dunedin City Council (DCC), Kelvin Lloyd, and Orokonui Ecosanctuary for accepting my proposals to collect bryophyte material from their lands to use for various parts of my research project. For my initial growth trial, I chose to collect plants from along the Pipeline Track in the Swampy Reserve managed by the DCC (Fig. 1) because many common species are abundant here and public access to the site makes it less suitable for conducting field experiments on bryophytes *in situ*. At the end of November 2018, I collected large clumps of 14 species in total: 10 mosses (*Achrophyllum quadrifarium*, *Atrichum androgynum*, *Cyathophorum bulbosum*, *Dicranoloma dicarpum*, *Echinodium hispidum*, *Ptychomnion aciculare*, *Sciadocladus kerrii*, *Thuidiopsis furfurosa*, *Weymouthia cochlearifolia*, and *Weymouthia mollis*) and four liverworts (*Leiomitra lanata*, *Marchantia foliacea*, *Plagiochila arbuscula*, and *Porella atrax*; Fig. 2). If the species' rhizoids (structures that anchor the plant in a substrate) were anchored in the soil, I collected a thin layer of topsoil in addition to the aboveground plant

biomass to ensure I was collecting the entire plant and hopefully causing it minimal stress. For epiphytic species, I attempted to collect specimens on bark that had sloughed off a trunk and fallen to the ground where possible, but again, I collected the whole plant, including a thin layer of bark if its rhizoids were anchored. I put these collections in plastic sealable bags to keep the bryophytes moist until I could put them into planting trays.



Fig. 2. The 14 species of bryophytes I collected from the Pipeline Track in Nov 2018.

Initial challenges and failures

Perhaps needless to say, my mentors, collaborators, and colleagues ranged along a spectrum of scepticism to eager optimism about my chances for successfully growing bryophytes in an artificial setting. Regardless, everyone helpfully offered ideas, suggestions, space, and resources to assist with this trial, with Susan Mackenzie (Technical Assistant in the Dept. of Botany) being a particular champion. I split my collection of each species in half to trial the different spaces available to house them at the Botany and MWLR glasshouses. I placed each set of plants on top of a layer of potting soil in a small planting tray directly after collecting them from the field (Fig. 2). The potting soil was meant to both keep certain species like *Cyathophorum* and *Sciadocladus* upright and to hold moisture to help prevent the bryophytes from desiccating and going dormant.

I first put my two sets of trays into the Botany glasshouse under a shade frame (Fig. 3a) and outside the MWLR glasshouse inside several bins (set on top of frames to prevent them lying in standing water) that I then covered with shade cloth (Fig. 3b). However, I quickly realised that neither situation provided sufficient humidity to keep the species active or, in some cases, alive, although I watered the plants and shade cloth covering them daily. I have since noted that some of these species start to appear

desiccated at relative humidity <90% in the field (both at 10-12°C on the Pipeline Track and 16-19°C in a bush patch near Waitati [measurements taken directly adjacent to bryophytes *in situ* using a Memory Hygrometer/Thermometer, Traceable® Products, Webster, TX, USA]). Thus, what I needed to have a chance to successfully grow these bryophytes was an automated watering system that could operate more than once a day, especially as it was now summer and the days were getting warmer.



Fig. 3. (a) Bryophytes under a shade cloth frame in the Botany glasshouse.



3. (b) Bryophytes in bins outside the MWLR Dunedin glasshouse.

Second attempts

Once again, I benefitted from the generous and knowledgeable botanical community of Dunedin. I moved the bryophytes I was keeping in the Botany glasshouse into the fernery established by John Steel (Fig. 4), which is shaded and receives 8 min of watering from overhead sprinklers three times a day. With the help of Gretchen Brownstein, I moved the bryophytes outside the MWLR glasshouse into portable shade frames built for a previous project and set the watering system to douse them for 5-8 min three times a day (Fig. 5). Both new set-ups looked promising after the first week or so, and I settled in to let the bryophytes grow as they would.



Fig. 4. (a) The fernery near the Botany glasshouses.



4. (b) Nine of the 14 bryophyte trays nestled among the ferns.



Fig. 5. (a) Two portable shade frames housing bryophytes outside the MWLR Dunedin glasshouse.



5. (b) Bryophyte trays and automated sprinklers under a shade frame.

Ultimate successes...for some species

Fast forward to July and the automatic watering systems continued to be essential for keeping my bryophytes alive given the number of dry days we have had, even during winter (for example, the MetService website shows no rainfall recorded for Dunedin on 10 days between 26 July and 26 August, with less than 1 mm recorded on an additional six days). It was also anecdotally clear that the fernery provided the best setting for growing bryophytes (Fig. 6) and certain species were more amenable than others to growing in these quasi-experimental conditions.



Fig. 6. The 14 trays of bryophytes (same set as Fig. 2) after approximately seven months in the fernery, and after significant weeding of adventive plants from the trays.

Thuidiopsis thrived in both settings, and *Ptychomnion* also grew well overall, which matches with their expected tolerance for drying out and preference for high light availability (D. Glenney, pers. comm.). Species that grew particularly well in the fernery compared to under the portable shade frames were *Atrichum*, *Cyathophorum*, *Leiomitra* (Fig. 7), and *Plagiochila*. Overall, the species that did most poorly were *Achrophyllum*, *Dicranoloma*, and *Weymouthia*, though both *Weymouthia* spp. (especially *W. mollis*) survived and grew better under the portable shade frames (Fig. 8a) than in the fernery (Fig. 8b). This contrast to the general trend may be due to *Weymouthia* spp. being epiphytic and thus growing better in conditions with greater air flow, less water saturation, and higher light.



Fig. 7. (a) *Leiomitra lanata* filling approximately half the tray (at the MWLR site) at planting in Nov 2018 (note: the tray kept in the Botany fernery was similarly half covered at planting),



7. (b) having died by July 2019 under the portable shade frame (with adventive moss colonising the bare potting soil), and



7. (c) thriving in the fernery in July 2019.

Next steps

While challenging, this trial of growing different bryophyte species was truly informative for helping me plan the next steps in my research project, particularly which species to use as a focus for experiments. As might have been predicted, certain species, like the epiphytic *Weymouthia*, would not be suitable for a conventional “pot experiment”.

However, I would not necessarily have predicted the liverwort *Leiomitra* to be as easy to work with in this type of setting as I have found it to be – and it is now a focal species in my first growth chamber experiment of the project. I also learned that I would need at least a year to grow significantly more bryophyte material than that initially collected, even for the most successful species (matching the experiences of other New Zealand bryophyte ecologists), which confirmed I would need to focus current experiments on highly-abundant species that I can collect from the field.



Fig. 8. *Weymouthia mollis* (a) still green and growing under the portable shade frame vs.



8. (b) brown and apparently dead in the fernery.

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Hungry Moas and Divaricating Shrubs

John Grehan

During my childhood, I first encountered the moa at the Wellington Museum where a 'stuffed' giant moa was on display. I was impressed by its size and felt a sense of loss knowing that it was no longer around because of human hunting. Moas, along with kiwis, have assumed an almost iconic quality in the study of New Zealand's evolutionary history. Along with the ostrich (Africa), elephant bird (Madagascar), emu (Australia), cassowary (New Guinea and Queensland), and the rhea and tinamou (America), these birds have figured prominently in the debate over the origins of animal and plant life in New Zealand. Since modern ratites are flightless (or almost so in the case of the tinamous), there was a general consensus that a former land connection was necessary to explain the distribution range which includes New Zealand. With the wide acceptance of plate tectonics, the now-disjunct ratite groups could be seen as an example of vicariance caused by the breakup of Gondwana.

Various other animals and plants have also been widely regarded as 'ancient' elements of the New Zealand landscape with origins in Gondwana. But a pioneering study by Robin Craw showed that while the distribution of ratites might conform to the expectations of a Gondwanan distribution, the native frogs and the southern beeches did not. The latter groups are absent from major Gondwanan regions such as Africa and India, and only peripherally present in the Americas. Craw (1985) pointed out that the overlap between these two distribution types in New Zealand was correlated with the region's

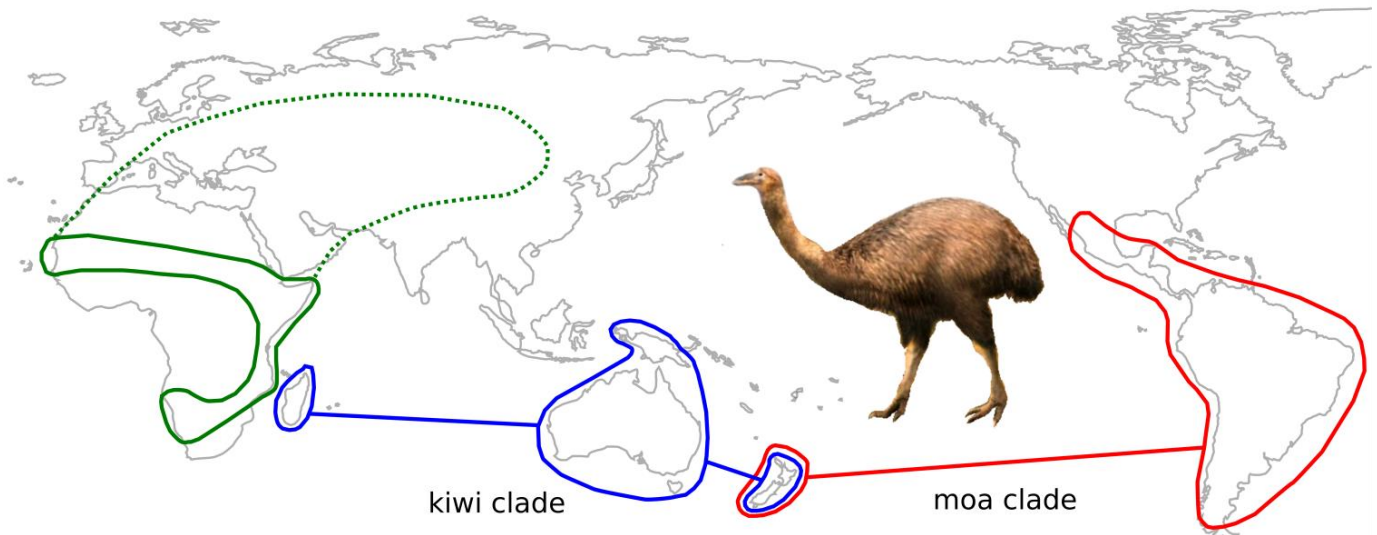


Fig. 1. Biogeography of extant (living within human history) ratite birds: ostriches (green outline, dotted for fossil range), elephant birds, emu, cassowary, & kiwis (blue outline), and moas, tinamous, and rhea (red outline). Simplified from Heads (2014, fig. 3.21). Note the overall allopatry of the three main lineages, with overlap occurring only in New Zealand.

geologically composite origins, in which Mesozoic Gondwanan and Pacific terranes came together to form what is now New Zealand.

Ideas on ratite phylogeny have varied in recent morphological and molecular studies, but there is support for the view that kiwis and moas are each more closely related to other ratites outside New Zealand than to each other. A molecular study by Smith *et al.* (2013) classified ostriches as sister to all the other ratites, while the remaining ratites formed two further subgroups. One of these comprised moas along with the New World rheas and tinamous, and the other comprised kiwis along with the extinct elephant birds of Madagascar, emus of Australia, and cassowaries of New Guinea and Queensland. The three groups of ratites are all allopatric with the exception of New Zealand, where the two subgroups overlap (Fig. 1). The overall allopatry is consistent with the idea of an ancestral ratite that was widespread and diverged over different parts of its range into three descendant groups, followed by local range expansion of two of the subgroups in New Zealand. There is evidence from fossils that some ratites were able to fly (Faux & Field 2017). While this means of dispersal may have been involved in the establishment of the ancestral range, it does not explain allopatric phylogenetic differentiation.

The initial phylogenetic separation of the ostrich lineage from all the other ratites corresponds with a

mid-Jurassic (160-120 Ma) tectonic break between Africa and Madagascar, and an early Cretaceous (100 Ma) break between Africa and America. While kiwis belong to a group that is distributed across the Indian Ocean (and in this respect has a conventional Gondwanan range), the moa has its closest affinities with the New World. The overlap of these two ratite groups in New Zealand may have been the result of tectonic events involving the Rangitata orogeny in Late Jurassic-early Cretaceous time, before rifting of the Tasman and southern Pacific basins began at about 85 Ma (Heads 2014). In this context, the origin of the moa has more in common biogeographically with Pacific groups such as the native frogs and southern beeches than with the typically Gondwanan distribution of kiwis and their closest relatives. This two way split between trans-Indian Ocean and trans-Pacific Ocean groups of ratites is seen in the wider affinities of many New Zealand animals and plants (Heads 2014, 2017). Various molecular clock approaches have proposed younger ages for ratites, but these ages are fossil calibrated and therefore only represent minimal dates that do not conflict with the earlier dates estimated by spatial correlation between tectonics and biogeography.

Divaricating shrubs (Fig. 2) are a major group of plants that were browsed by moas (Wood *et al.* 2012). They are small leaved plants with short shoots (brachyblasts, with much reduced internodes) and

long shoots with abortive apices (and determinate growth). The orientation of the shoots is variable and may be horizontal, vertical, or mixed (Heads 2017). Even though divaricating plants are not monophyletic, they have a distinct geographic range, as most occur around the southwest Indian Ocean, southwest Pacific and south Atlantic basins, while they are rare in other regions such as New Guinea, the central Pacific, and West Africa. As with the kiwi clade of ratites, the diversity of divaricates is centred on the Indian Ocean. But instead of forming a single group as with the ratites, the divaricating growth form encompasses many different lineages.



Fig. 2. Example of divaricating growth form: *Coprosma rhamnoides* (Rubiaceae).

<http://www.nzplants.auckland.ac.nz/en/about/seed-plants-flowering/rubiaceae/coprosma-rhamnoides.html>

Parallelism or convergence of a single feature (such as divaricating growth) in different clades within a particular geographic range is often explained as the result of some common selection pressure. As the diversity of divaricates in New Zealand, Australia, and Madagascar coincides with the distribution area where ratites, rather than ungulates, are the main browsers, the origin of the growth form is regarded as a defence mechanism against ratite browsing. There are problems with this idea, however. For example, divaricates in Patagonia are exposed to both ratites and ungulates, and in southern and eastern Africa ungulates are the dominant browsers. Even though ratites are widespread in New Guinea, divaricates are almost entirely absent from that region (Heads 2017).

Thus, while ratites and divaricates occur together in many areas, biogeographic evidence contradicts the idea that browsing caused the divaricating growth form. Selection-pressure narratives presuppose that

no other mechanism is possible, although the fields of developmental and molecular biology have generally recognized the existence of other mechanisms of evolutionary change (such as biased gene conversion) (Heads 2017). Selection narratives assume that random mutation can create any structure that is needed by the organism, and so this approach suppresses interest or curiosity in the structural nature of adaptation. In the case of divaricates, the selection model (whether moas or some other environmental variable) avoids investigating the growth pattern itself. Heads (2017) has pointed out that evolution of the divaricating growth form is not simply a reduction of leaves and stems, but a replacement of one growth form by another – the replacement of an original vegetative system of indeterminate growth (that occurs in most plants) with one that has determinate growth like that of an inflorescence. This may occur by (1) suppression of ordinary vegetative shoots, which leaves only the inflorescence, and (2) suppression of most of the flowers, which leaves sterile inflorescence bracts as the foliage. Heads (2017) argued that rather than answering the plants' 'needs', the reduction (of the vegetative shoots) and the sterilization (of the inflorescence) are outcomes of two of the main trends in seed plant evolution – reduction and sterilization. These have affected most plant parts at different times.

The idea that one growth form may be replaced or 'taken over' by another is not so surprising in evolutionary biology (e.g. juvenile features taking over the adult form through neoteny). The replacement model is consistent with the limited or determinate growth of shoots in divaricates, and the idea that the foliage of divaricates is made up of floral bracts that no longer bear flowers. If this alternation between 'normal' vegetative growth and divaricating growth is not the result of selection pressure, perhaps it is an example of recombination of genes that happened to be widespread around the southern hemisphere long before the modern clades that now host them existed. In other words, many plants groups inherited genes for divaricating growth within this region, and as a result there is a higher proportion of divaricating groups or species there now. If moas, other ratites, ungulates or any other browsers found in the same area as the divaricating plants were able to browse these plants, then they

would have. This does not mean that the browsers brought about the plants' distinctive morphology.

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Skynet: Aeroplanktonic Spiders as a Plant Defence Force

James Crofts-Bennett

It has been well established that spiders make use of aeronautical travel via ballooning to disperse themselves throughout the surrounding environment (Bell, et al., 2005). For over 300 years, spider ballooning events have been recorded by travelling naturalists, Charles Darwin having noted the aerial invasion of the HMS Beagle by thousands of tiny spiders while at sea off the coast of Argentina (Darwin, 1839) with prior references in the literature occurring as far back as the 1670s (Lister, 1992). The act of ballooning itself had acquired a degree of

mysticism regarding both how it functions and what triggers the behaviour. Modern literature has begun to emphasize the importance of electric fields in ballooning (Morley & Robert, 2018; Gorham, 2013) in contrast to the previously dominant opinion which suggests that weather and climatic (ie. wind and temperature) conditions are predominant instigators for both categories (Thomas, 1996; Yeargan, 1975; Bishop, 1990). To further distract from the point, there is evidence that a major factor in spider ballooning is human disturbance of habitat, particularly agricultural practices (Blandenier, et al., 2013).

Spider composition within the aeroplankton layer is poorly understood, but there is some evidence that spider numbers fluctuate seasonally (Weyman, et al., 1995; Bishop, 1990), potentially relating to the much higher numbers of juvenile spiders that engage in ballooning (Duffy, 1998). It would be valuable to explore this relationship further, not just as a method of agricultural pest control but also to find out how widespread this network of plant defence really is. Considering the significance to human agriculture of controlling insect plant pests, the spider-vegetation network could rival the mycorrhizal fungus-root network for ecological (and economic) importance.

There is an important factor to ballooning that is not frequently discussed; the relationship between spiders and plants. It is mentioned but not explored in Morley & Robert (2018) that electric fields which illicit ballooning characteristics in spiders are primarily found in natural environments such as plants. The biology of plants, particularly trees - rooted in the ground while biological processes such as respiration and transpiration occur - generates electrical fields in the branch and leaf tips of the plants that directly stimulate ballooning in spiders (Morley & Robert, 2018). Combined with the natural predisposition of spiders to gather in vegetation (Vasconcellos-Neto, et al., 2017), this can generate an observable effect in urban environments, where increasing vegetation not only leads to high spider abundance but also increases aerial dispersal to surrounding environments (Cusimano, et al., 2016). Bell, et al. (2005) elaborated on the strength of the relationship between spiders and plants, suggesting that ballooning behaviour coevolved alongside the

evolutionary development of deciduous trees rather than with the actual development of silk glands.

A wide variety of spiders can be represented in the aeroplankton as accessed through ballooning (Greenstone, et al., 1987). Variety of spider can change alongside the seasons; Bishop (1990) found aeroplanktonic composition to be dominated by thomisids and salticids in the autumn, which then shifted to favour linyphiids and araneids in the spring. The autumn aerial assortment of spider favours actively hunting prey in vegetation (Nyffeler & Breene, 1990; Forster, 1977) while the spring collection are primarily web spinning families that use vegetation as a base scaffold to build upon (Scheidler, 1990; Herberstein, 1997). The arrival of web spinning spiders during the spring period is in sync with the emergence of the many flying insects (Wolda, 1988) including pollinators and florivores (Rafferty & Nability, 2017). There is evidence that while pollinators are inevitably taken as prey, the predatory services spider provide plants is ultimately beneficial (Knauer, et al., 2018). By comparison, the autumn season is a period a folivore pressure (Lev-Yadun, et al., 2004; Döring, et al., 2008) and recruitment of active hunters, such as salticids and thomisids, may be more beneficial to a plant. Combing the loose threads of the literature, it is established that plants passively encourage spider aerial dispersal. It is also observed that plants actively benefit from the aerial dispersal of spiders, recruiting a wide range of predatory niches that can protect the plant from the various herbivorous strategies of insects. Observations also establish that spider predatory methods, represented by abundance of specific spider families, are in sync with plant vulnerability periods. As such, plants both recruit and disperse spiders that exhibit beneficial predatory behaviours during periods of time when plants benefit the most from said behaviours.

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***Tupeia antarctica*: Distribution, Diversity & Establishment**

Zoe Lunniss

In 2018, the Otago Botanic Society awarded the Peter Bannister Field Grant to research concerning *Tupeia antarctica* (Tāpia), the “At Risk & Declining” endemic mistletoe (de Lange et al., 2017). In addition to largely fragmented populations on old host trees, *Tupeia* is dioecous, relatively host-specific regionally (*Hoheria angustifolia*, *Plagianthus regius* and *Carpodetus serratus* preferred in Otago), and heavily effected by grazing

possums and rats. My work indicates that *Tupeia* is declining at a rate greater than ever before. This grant contributed to three aspects of research currently underway. Firstly, to determine the current distribution of *T. antarctica* in Otago. Secondly, to explore invertebrate diversity associated with the species. And lastly, to establish seedlings at Orokonui, the Dunedin Botanic Gardens, and Tavora Reserve (Goodwood).

Historically, *Tupeia* has been recorded across New Zealand - predominantly easterly in distribution, with Dunedin considered a stronghold for the species (Barlow, 1983; de Lange et al., 1997). Upon surveying *Tupeia* individuals in recorded Otago locations*, it appears three key populations remain; Owaka Valley (The Catlins), Dunedin Townbelt, and Goodwood (including Goodwood Rd & Tavora Reserve). Unfortunately, the majority of individuals in these populations are old plants on aged host trees, with minimal regeneration of seedlings evident. The experimental establishment of over 170 seeds has allowed me to track long term germination and establishment on different hosts. Seed dispersal and deposition are performed in nature by frugivorous birds. However, mistletoe seeds excised from the pericarp by hand germinate just as readily and this was the selected method of seedling establishment. The establishment of mistletoes can be divided into three sequential phases: seed attachment, germination, and host penetration. Each has its own limitations which reduce the number of individuals available for the next phase. The experimentally established *Tupeia* seeds are currently transitioning between germination and host penetration phases. I expect that by midsummer I will be able to analyse establishment success across the three different sites. In addition to analyses, seedlings will help initiate the re-introduction of *Tupeia* populations at Orokonui & The Botanic Gardens, whilst integrating younger individuals amongst the Tavora Reserve population.

Globally, mistletoes are described as keystone resources (Watson, 2001); however the majority of research has focused on their influence on vertebrates rather than invertebrates. Initially, I aimed to identify *Tupeia* pollinators, yet sampling of other invertebrates I observed along the way yielded exciting discoveries. With incredible help from

James Crofts-Bennett, we have (possibly) identified two new species of spiders belonging to Theridiosomatidae and Theridiidae. The Theridiidae is defined by a row of bristles with serrated edges on the tarsus of the last pair of legs. Body length varies from 3-5 mm, exoskeleton is pearlescent white to dull cream and features a brilliant crimson vertical stripe running the dorsal length of the abdomen (J. Crofts-Bennett, personal communication, 9th August 2019). The Theridiosomatidae is not yet formally described in New Zealand. Key features include long trichobothria on the last two pairs of legs, gigantic pedipalps on males and globular abdomens (J. Crofts-Bennett, personal communication, 9th August 2019). In addition to the diversity of spider species observed, *Tupeia* appears to have a close relationship with the tentatively identified moth, *Zelleria sphenota*. *Z. sphenota* belongs to a group of moths known as ‘Mistletoe Moths’ (Patrick & Dugdale, 1995) and is currently listed as ‘At Risk & Declining’ (Hoare et al., 2015). Unfortunately, heavy grazing by pests is accelerating the rate of *Tupeia* defoliation, which impacts both the invertebrate habitat and the mistletoes survival.

The majority of data for this study will be collected up until December, thus definitive conclusions are hard to draw. I hope by the end of this study period to gain a better understanding of *Tupeia antarctica* in general and provide plans for the future conservation management of this species.

*I am extremely eager to talk to anyone who knows of any other *Tupeia* around the Otago Region, or is just keen to chat about the species! Please contact me via email – lunzo991@student.otago.ac.nz.

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Tupeia antarctica on *Hoheria angustifolia*, Goodwood.



Establishing *Tupeia* seeds on *Plagianthus regius* for a farmer in Owaka Valley.

Meeting and Trip Reports

Fungal Foray to Knights Bush, Tuapeka West, Saturday 25th May 2019

Sharon Jones

Located on the banks of the Clutha River near Tuapeka West, Knights Bush covers a 228ha section of land that is host to a diverse ecosystem containing a large variety of plant communities, including many different fungi - which of course was the focus of our attention. The forest is comprised of remnants of indigenous native forest at various stages of regeneration. An area within the forest has been fenced, creating a biodiversity reserve to aid in forest regeneration.

We were greeted by clear skies as everyone gathered in the Botany Department car park, chatting excitedly amongst ourselves, making our introductions in the crisp morning air. Once everyone was assembled, Allison Knight passed around some items of mycological interest as a roster of those present was taken. We ended up with a hearty turnout of 22 individuals, making for an impressive group of keen mycologists. After a brief introduction by our group leader Andy Nilsen, we headed toward Tuapeka West.

Having never visited Knights Bush I was unsure what to expect. As we neared the site 4WD was required to cover farmland in order to reach the forest track. Upon reaching our destination the group set off, dwarfed, despite our numbers, by a large stand of pine that hugs the outer slopes that surround Knights Bush. As we began our descent, the ground appeared to be very dry, not ideal conditions when hunting for fungi! However, my worries quickly dissipated as we journeyed further down the slopes toward the Clutha. Having a curious nature, I quickly became separated from the main group as I lost myself amongst the leaf litter in search of interesting fungi. As the morning progressed, I bumped into several other slow moving groups of curious souls foraging along the edges of the path and coming up with many fascinating finds!

At one point during the morning I almost managed to catch up with the main group; hearing voices near at hand, I hurried to join them. By this time the forest floor had transitioned from dry leaf litter scattered across bare ground to lush ferns, with soft beds of moss lining the edges of the path and carpeting fallen logs. As I came to a small clearing I felt compelled to take a momentary pause. Casting my eyes around, everywhere I looked countless tiny dewdrops glistened like jewels, reflecting the dappled light filtering down from a break in the canopy above. I cast my eyes downward and noticed several dark brown, almost black, cup shapes growing up from rotting twigs embedded in the mossy litter; *Urnula campylospora* aka Brown Forest Cup. Moving through the clearing, I paused here and there to admire the diverse array of tiny slimy caps balanced atop delicately thin stipes protruding from the undergrowth. By this point I was beginning to fall behind again; time to pick up the pace.



Urnula campylospora, Brown Forest Cup (Photo: Sharon Jones).

A short while later the lunch spot came into view. Everyone was gathered outside a charming little log cabin, sharing their finds of the day whilst enjoying some lunch in the afternoon sunshine. After adding my fungal collection to those already on display, I decided to have a look around to see what others had found, before sitting down for a quick bite to eat. The mornings' exploits had delivered a bountiful array of fungi in many different colours, shapes, sizes and textures. Many of the fungi on display had been identified by the group with the aid of Andy's expertise. This included a specimen of *Hericium coralloides* commonly known as the Icicle Fungus,

found by Ian Geary, which is prized for its edibility - and indeed it smelled and tasted delicious! As people finished their lunch they headed off in groups to continue down the track toward the river. Arriving late to the lunch spot meant I was again behind the bulk of the group. Not deterred in the slightest, I continued on alone to see how far I could get. In the end, I am unsure how close I came to the Clutha before encountering others already on their return journey. The forest grew damper the closer I got, and it didn't take long for my pace to slow as I encountered brightly coloured fungi protruding from rotting logs and moss covered soil.



Hericium coralloides, *Coral Tooth Fungus/Icicle Fungus* (Photo: Sharon Jones).

By the end of the day, over 80 species of fungi were recorded, adding 40 more taxa of non-lichenised fungi to the Knights Bush checklist. This included several species of *Cortinarius* which Andy collected for his research. Many thanks to Andy Nilsen for a wonderful day out. Although I didn't manage to make it all the way down to the Clutha River, I had a fantastic time and look forward to visiting the site again in future.



Cortinarius rotundisporus (Photo: Laura van Galen).

Field trip participants: Allison Knight, Ben Knight, John Knight, Duncan Nicol, Pamela Olmedo-Rojas, Alf Webb, Gabrielle, Bella, Dhana Pillai, Mark Hesson, Sharon Jones, John Steel, Andy Nilsen, Jessica Paull, Zola Yun, Nicole Bezemer, Laura van Galen, Sinead Spedding, Hadley O'Sullivan, Karen Tustin, Ian Geary, Suus Claessen.



Podoserpula pusio: *Pagoda Fungus* (Photo: Allison Knight).

Field trip to Okia Reserve, 8th June 2019

Duncan Nicol

A cold huddle around the Okia entrance initiated the day with a welcome and plan-of-attack explained by our guide for the day, John Barkla. We were joined by some members involved in the conservation and history of the reserve, enriching the environmental context. The day was joyously windy and the plant trunks certainly provided helpful holdfasts as we trod up Little Pyramid. A bunch of *Korthalsella* were copying us by hanging onto shrubs, including the *Corokia*(?) and *Coprosma* and *Helichrysum*(?). Although abundant on these little shrubs, word-of-mouth has it, the *Korthalsella* were only present in this area on Little Pyramid. *Melicytus alpinus* tucked itself into the little rock crevices and most rock around the pyramid was covered in carpets of lichenised-fungi. The top of the pyramid opened us up to the elements as hail screamed passed us near-

horizontal. For sure, we didn't remain there long, but it was enough to get a wider view of the reserve and terrain, including the undulating dunes toward the sea, reminiscent of the *Myrsine* and *Pittosporum* leaves we had just passed.



Korthasella (Photo: Duncan Nicol)

Using Little Pyramid as cover, we found the beginnings of the bogs that scattered themselves throughout the dunes wherever there were depressions. A stranger to some of us was *Azolla rubra*, a mat-forming aquatic fern within the Salvinaceae that has been batted around in a game of systematic pinball over the last few decades and is also the only documented *Azolla* in the South Island. The surrounding plants included Pikau's sister *Ficinia nodosa* with a solitary and lateral inflorescence head; *Lepidosperma australe* with a dense spicate head; *Lemna disperma*, *Ranunculus glabrifolius*, and *Hydrocotyle sulcata* covering the mud as micro-leaved mats; *Sagina procumbens* formed some micro-colonies with individuals scattered about and few with pin-head sized flowers; *Geoglossum* spp. was found pointing its tongue to the sky among some *Carex* seedlings; another few intriguing finds included a *Myosotis* sp., *Myriophyllum propinquum*, and *Lobelia perpusilla*.



Geoglossum (Hounds tongue fungus) (Photo: Duncan Nicol)

After lunch, as numbers started dwindling for the cold and other Saturday commitments, the remaining gang headed toward the beach for a loop back round to the entrance. The undulating dunes were more defined as we approached the beach. *Veronica elliptica*, *Myoporum laetum*, *Olearia avicenniifolia*, *Lupinus arboreus*, *Senecio elegans*, and others covered the last strip and bank of vegetation before the full brunt of the ocean. Walking into the wind felt like a scene out of the sci-fi novel *Dune* as sand soared across the surface as suspended streams, whipping around our feet and casting strays into our eyes; even the oyster-catchers were huddling behind kelp cover to escape the chill and shards.



Azolla rubra (Photo: Duncan Nicol)

One the way back toward Little Pyramid and the start of the track we passed some creeping herbs including *Gaultheria macrostigma* and *Helichrysum filicaule*, some *Olearia linearis* and the segmented *Apodasmia similis*. We couldn't leave before Lydia added some more data to her *Urtica ferox* stinging research by rubbing the spines against her hands and measuring the resultant subjective duration of "pain" or "tingling."



Urtica ferox (Photo: Duncan Nicol)

Thanks for everyone coming well prepared for the conditions with adequate clothing and cheerful attitudes!



Little pyramid (Photo: Duncan Nicol)

Revegetation of Wangaloa Coal Mine Reserve, a talk by Dr Cathy Rufaut and Professor David Craw, 12th June 2019

Alex Wearing

Cathy Rufaut and David Craw gave a very interesting talk on native revegetation at the former opencast Wangaloa Coal Mine, near Kaitangata, South-East Otago. The talk generated a lot of comments and questions, a testament to the intrinsic interest of the subject and the efficacy of the presenters.

Wangaloa geology comprises Late Cretaceous Taratu Formation, which includes quartz conglomerates, siltstones and multiple coal seams. The Wangaloa landscape has a thin layer of loess, about 1 m thick, deposited during the Pleistocene about 20,000 years ago. The loess has a crucial influence on vegetation establishment, as the Wangaloa soils developed on loess. The pre-human vegetation was lowland coastal forest with a variety of forest types determined by topography. Kamahi (*Weinmannia racemosa*), totara (*Podocarpus totara*), and southern rata (*Metrosideros umbellata*) occurred on drier slopes, spurs, and ridges. Podocarp/broadleaf forest with rimu (*Dacrydium cupressinum*) and kahikatea (*Dacrycarpus daccryioides*) occurred on wetter slopes and in poorly drained areas. Natural fires around coal outcrops before human settlement influenced vegetation patterns.

The Wangaloa opencast mine operated between 1946 and 1989. The mining practice was to remove the topsoil and loess layers first. These formed the bottom layers of quartz-rich waste rock overburden heaps. Current mining practices stockpile the soil separately for later site rehabilitation.

The geology of the Wangaloa site drives indigenous plant rehabilitation. Mining completely transformed and simplified the surface topography, creating site conditions often inimical to native plant establishment and growth. The last load of waste rock overburden governed the nature of the substrate for rehabilitation. Natural or spontaneous recolonization is facilitated by the presence of fine-grained sediments. Most of the potential plant colonization sites comprised barren surfaces of coarser materials, consisting predominantly of poorly consolidated mixtures of quartz pebbles, quartz sands, coal, and siltstones. A small area of coal waste had very high concentrations of pyrites. There was substantial fine-scale variation in site properties. 2002 was Ground Zero, and the start of site and vegetation rehabilitation. (In 2002 the mine was owned by Solid Energy. It is now owned by City Forests). Wangaloa Mine is a prototype for mine site rehabilitation, and is currently the most studied ex-mine site in New Zealand.

In 2002, the vegetated areas of Wangaloa Mine were dominated by gorse (*Ulex europaeus*), *Pinus radiata*, manuka (*Leptospermum scoparium*) and kanuka (*Kunzea ericoides*). Unfortunately, the pre-rehabilitation area of manuka and kanuka was reduced by bulldozers. The gorse was cut and put into windrows, and *P. radiata* was removed. Tree fuchsia (*Fuchsia excorticata*), wineberry (*Aristotelia serrata*) and mahoe (*Melicytus ramiflorus*) established in the gorse windrows.

More than 100,000 native plants were planted. Plants were spaced 1.0 to 1.5 m apart. Each plant was given a slow-release fertilizer pill. Top-soil was added in some areas. The goal was to fast-track the development of a native plant cover. Species planted include: manuka, kohuhu (*Pittosporum tenuifolium*), lemonwood/tarata (*Pittosporum eugenioides*), koromiko (*Veronica/Hebe salicifolia*), broadleaf (*Griselinia littoralis*), wineberry, and toetoe (*Cortaderia richardii*). Plants were sourced from

nurseries south of Christchurch. The plants were chosen by a landscape architect from Christchurch. There was no local botanical input in species selection. Some of the putative successional end-point species (e.g. totara and kamahi) were not included in the initial plantings.

In general, plantings have been successful. For example, 15 year old *Pittosporum spp.* is up to 5-6 m tall. Growth rates and survival were highest on overburden with high silt content in the topsoil layer. Gaps between plants were often filled in by naturally established manuka and kanuka.

Planting survival rates were lower on untreated waste rock substrates. For example, koromiko survived but did not thrive, and experienced early senescence. Waste rock with high coal content retained none of the original plantings. These sites had high levels of boron. Plants take up boron at different rates (e.g. broadleaf (fast), manuka (medium), and toetoe (slow)). The effects of boron toxicity are different depending on plant species, but can cause leaf damage, stunted growth, and lower productivity. In waste rock with high coal content, pH values of 3.5 were recorded. At pH values <4 leaves wilt, turn yellow, and drop off. Plants deteriorate and die. The most problematic site for revegetation was a 1 ha area of coal-rich overburden with surface pyrites, and pH values of <3. Initially, all plants died. In 2010, manuka slash was placed on the surface. There was successful seedling germination from the slash within three years. There were also manuka seedlings growing in erosion rills where the water content was higher. When plant roots reach loess the pyrite zone will be isolated.

The coal-rich overburden has been rapidly colonized by manuka and kanuka. Manuka has engulfed planted toetoe. Individuals of manuka and kanuka preferentially establish at sites where fine materials have accumulated. Seedlings established within three years on the edges of existing stands. Species such as mosses are not establishing first as site pioneers. They are entering the sites at the same time as mid- and end-point successional species. Manuka and kanuka are growing side- by-side at Wangaloa. This challenges thinking about their behaviour in seral vegetation in other parts of New Zealand. The establishment of manuka and kanuka facilitates self-

colonization of other plant - and animal - species. For example, 80 beetle species have been found in manuka-kanuka patches. This represents a typical southern coastal Otago forest assemblage.

A second generation of seedlings is now establishing. Monitoring will determine if the progeny does better than their parents. Regeneration under some of the plantings is difficult because of low light- levels and thick leaf-litter. Bird-dispersed species (e.g. Fivefinger/orihou (*Pseudopanax colensoi*) have been found at the site.

Introduced species with weedy propensities have also established (e.g. Spanish heath (*Erica lusitanica*) was initially controlled, but is now establishing in new sites). Currently, there is no control of animal pests. Hare damage has been noted, and there are possums and pigs in the area.

Revegetation by plantings and natural recolonization have achieved the mine-site rehabilitation goals of improved soil and water quality (in 2019, substrates remain largely acidic, but less so than at the start of site rehabilitation), and the recovery of native vegetation, and landscape-aesthetic values.

The talk by Cathy Rafaut and David Craw was an apt demonstration of the importance of the geology-plant interface, an excellent account of the revegetation of difficult terrain, and insightful with respect to the complex dynamics of plant establishment and succession pathways.

The importance of ectomycorrhizal fungi for Beech forest restoration, a talk by Laura van Galen, 10th July 2019

Matthew Larcombe

It was an inauspicious start. Unresolvable IT problems... Could she do her talk without slides? "Wait, no, there is another room"... last minute venue change... through the dark rambling corridors of the Zoology building.... It would have been understandable if Department of Botany PhD student Laura van Galen was rattled. If she was, it didn't show.

Laura gave an outstanding talk about her fascinating and incredibly ambitious PhD research, investigating beech forest restoration in New Zealand. Despite only arriving in the country in October 2018, Laura appears to have done an incredible amount of work. The project has two components; an island wide study of symbiotic fungal communities associated with beech forest and a large scale experiment looking a range of factors that contribute to beech establishment in a restoration setting.

Laura explained that a complicating factor in understanding distribution of beech forest is the symbiotic relationships that beech species form with ectomycorrhizal (ECM) fungi. These “root-fungus” associations provide nutrients and water to the tree as well as carbohydrates to the fungus. Importantly, the relationship is obligate, meaning that beech cannot establish and grow without ECM fungi. Globally, little is known about the specificity and distribution of ECM in regard to their host species. Laura points out that in New Zealand we know that ECM fungi are diverse, with over 200 species (mostly endemics) found with beech, but no targeted regional surveys have been conducted. Subsequently, almost nothing is known about ECM fungi host specificity, site level diversity, species ranges, regional distributions or community structure.

To plug this knowledge gap, Laura has begun a truly massive study across the South Island. She has designed special fungal baits (hyphal in-growth bags) which she has buried in 82 beech forest patches across the South Island and at each site she has buried 50 baits; that’s 4100 total! These will be collected in autumn and she plans to use DNA methods to quantify and map the diversity of fungi associated with different beech species. This will allow the identification of relationships between certain species or groups of species and beech distributions.

As if this wasn’t enough, Laura has also established a second massive experiment in Central Otago. This aspect of her work aims to come up with better restoration approaches for establishing beech forest. There has been work done looking at the importance of things like shelter, weed control, ground disturbance and fertiliser, however no one has ever looked at these aspects together. Laura’s study is

established at a large private reserve outside of Wanaka called Mahu Whenua. She has established 20 large plots, each testing every combination of her treatments shelter, weed control, fertiliser and mycorrhizae. Laura also explained how, in order to run this experiment, she needed to collect millions of seeds from the remnant beech patches on Mahu Whenua and was lucky that her project coincided with a ‘mega-mast’ year for beech flowering.

The talk was very well presented, and raised many questions from the audience. It will be fascinating to see how this timely research pans out.

Beech Forests and their Fungi, a talk by Dr David Orlovich, 28th August 2019

David Lyttle

The life and existence of *Nothofagus* beech forests is intimately connected with the ectomycorrhizal fungi that are associated with them. In the first part of the talk, David explored aspects of the ecology of beech forests in New Zealand and the genetic techniques he and his co-workers have used to explain the origin of the distribution patterns we observe today.

There are five *Nothofagus* beech species found in New Zealand. These may be placed in two genera; *Lophozonia* and *Fuscospora*. Silver beech (*Lophozonia menziesii*) is the sole member of its genus in New Zealand. The closest relatives to silver beech are the Australian species *Nothofagus* (*Lophozonia*) *cunninghamii* and *Nothofagus* (*Lophozonia*) *moreii*, rather than the New Zealand *Fuscospora* species. Red beech (*Fuscospora fusca*), hard beech (*Fuscospora truncata*), black beech (*Fuscospora solandri*) and mountain beech (*Fuscospora cliffortioides*) are more distantly related and have been separated into their own genus. Beech forests are found throughout New Zealand but each species tends to have its own habitat and climatic preferences. Red, silver and mountain are found from the Coromandel Peninsula southward, black beech is found from Little Barrier Island and near East Cape southwards to mid Canterbury and hard beech is found from Northland to the northern part of the South Island with a tiny, disjunct population occurring in South Westland. Beech forest is absent

from large areas of New Zealand, notably Stewart Island, the central South Island, Manawatu and Taranaki. The gaps are thought to be due to the lack of recolonising of these areas by beech following the Last Glacial Maximum (LGM 34-19 ka) when forest in New Zealand was very much reduced in extent and was thought to exist predominantly in the northern part of the North Island.

A set of chloroplast DNA markers covering 2.4 kb of variable DNA was sequenced to understand the history of *Nothofagus* populations in New Zealand against a background of glacial-interglacial cycles over the last million years. Two haplotypes were found across all *Fuscospora* beech species. Chloroplast DNA is readily transferred between the closely related *Fuscospora* species by hybridisation which occurs frequently. One haplotype occurred in all the North Island and northern South Island *Fuscospora* species and the second haplotype was found only in populations in the southern South Island south of the central South Island beech gap including the isolated *Fuscospora truncata* population in South Westland.

Silver beech (*Lophozonia menziesii*) chloroplast DNA was much more variable. Six haplotypes were found in the northern South Island. One haplotype was found south of the southern beech gap. Two haplotypes were found in the North Island, separated by the Manawatu beech gap. The northern most and southern most haplotypes were not present in the northern South Island. This suggests the northern South Island populations were the most stable throughout the long term climatic fluctuations of the Pleistocene era, and the northern and southern populations were re-established from local refugia following the last glacial maximum (LGM). Further genetic analysis looking at a large number of single nucleotide polymorphisms (SNPs) from 93 individual trees collected from across the South Island at 32 locations enabled the populations to be mapped in finer detail. Results showing the northern South Island population was distinct and the south west (Fiordland) and south east (Otago/Southland) were more closely related are consistent with this explanation.

The genetic data shows the silver beech forests north and south of the SI beech gap have existed isolated

from each other since the LGM. Analysis at finer resolution suggests that scattered pockets of silver beech forest have gradually re-colonised the areas they now occupy.

The remainder of the talk dealt with the mycorrhizal fungi of the *Nothofagus* beech forests. David talked about the New Zealand Fungal Foray and the opportunities it presents to collect and study the fungi from different localities throughout New Zealand. One notable finding gained over several years of collecting and research is that the seeming ubiquitous purple pouch fungus *Cortinarius porphyroideus* is a group of unrelated fungi. This has been established by sequencing the DNA from extensive collections of these purple sequestrate fungi. More surprises have emerged. The red-truffle-like fungus *Cortinarius beeverorum* first described by David and his co-workers is not related to a morphologically similar orange pouch fungus *Cortinarius perauranticus* as once thought, but to a conventional mushroom *Cortinarius dulciolens*. It appears that truffle-like fungi have evolved from mushroom ancestors not once, but many times. Many are highly coloured. The superficial resemblance of these sequestrate, truffle like fungi to fallen fruit has led to speculation that this form has evolved in New Zealand to promote dispersal by grazing birds. There is evidence that truffle-like fungi are dispersed in Australia by small marsupials. Since the establishment of beech forest is dependent on the availability of suitable mycorrhizal fungi, it is possible that birds dispersing truffles helped beech to spread post-LGM.

Despite the intimate association between mycorrhizal fungi and their *Nothofagus* hosts, not a lot is known about the distribution patterns and fungal diversity in the different beech forest communities. Mushrooms and truffles are the sexual reproductive structures of the fungus but it is difficult to compile good distribution information because these fruiting bodies are ephemeral and sporadic in their occurrence. A second method being used by David and PhD student Laura van Galen is to collect fungal samples for DNA analysis by the use of hyphal ingrowth bags. These bags contain sterile sand and are buried in the forest under the trees. Mycorrhizal fungal hyphae grow into these bags, which can then be retrieved for DNA extraction and analysis. It is anticipated that

this approach will help to determine the diversity of ectomycorrhizal fungi across the South Island, their relationships to the different beech forest communities and shed some light on beech forest biogeographic history.

David ended his talk by presenting a sequencing project aimed at comparing the genome of his favourite truffle-like fungus *Cortinarius beeverorum* with that of its nearest relative *Cortinarius dulciolens*. The latter is not a truffle but a normal mushroom with normal cap and stipe morphology. The aim of the project was to sequence, assemble and produce a draft annotation of both genomes and identify potential genetic changes associated with species differences between the fungi. Both total DNA and transcriptome cDNA were sequenced. The problem with genomic DNA sequencing, especially with organisms where the knowledge of their genetics is rudimentary to non-existent, is that the ability to acquire sequence data far exceeds the capacity to analyse it in a meaningful way. Differential gene expression in the stipe and hymenium (cap) tissue of both species was examined by extracting the protein encoding messenger RNA from the targeted tissue, reverse transcribing it into the corresponding DNA, and then sequencing it to identify the genes expressed in the source tissue. In summary, truffle-like *Cortinarius beeverorum* was found to have a smaller genome but otherwise the genomes were fairly similar in predicted gene model numbers. Overall, fewer genes were differentially expressed in the truffle-like *Cortinarius beeverorum*. Expanded and reduced gene families in each species are candidates for further analysis, especially those that show differential gene expression.

There was a lot of information to unpack from this talk. Modern genetic techniques provide a powerful tool to account for the biogeographic *Nothofagus* species distribution patterns we observe today. Genetic techniques are useful to sort out the systematics of closely related and cryptic unrelated fungal taxa. Genetic techniques can be used to examine diversity and distribution of beech forest, mycorrhizal fungi. Genomic sequencing is a powerful tool to explore the development and evolutionary biology of closely related but morphologically very different fungal species. I look forward to the next episode of this continuing saga.

Field trip to Chrystalls beach, 31st August 2019

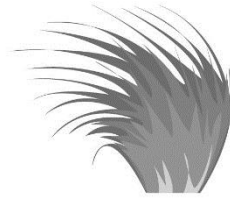
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