Biowastes to convert former pine forests into cash-producing native ecosystems

By Brett Robinson

Some 1.8 million hectares of NZ soil is under pine plantations. This figure is rapidly decreasing as there is little economic incentive to replant timber crops that are worth less than one-fifth of their 1995 value (inflation-adjusted). Historically, pine forestry was an effective means of providing an economic return from low-fertility soils. This is no longer the case.

The growth of pine trees followed by logging often results in degraded soils, with depleted organic matter and low concentrations of plant nutrients. Conversion of former pine forests into productive farmland requires the continual application of mineral fertilisers at high rates. High rates of nutrient loss from such farmland can further degrade lakes, rivers, and groundwater.

We propose that such low-fertility degraded soils would be better restored to vegetation that provides an economic return off the land, while not requiring high nutrient inputs. Vegetation dominated by mānuka *(Leptospermum scoparium)* could produce honey that would add to NZ's burgeoning ($120M) mānuka honey industry. In areas such as Canterbury, that are less suited to mānuka growth, vegetation dominated by kānuka *(Kunzea ericoides)* could be established to produce essential oils. Depending on the region, mānuka and kānuka may develop spontaneously in the decades following the clearing of a pine forest. However, the time taken for such vegetation to produce an economic return may be prohibitively long.

Minakshi Mishra (left) and Saloomeh Seyedalikhani (right) are investigating environmental and economic benefits of mānuka and kānuka production on soils amended with biowastes.

Potentially, degraded soils that were formally under pine forest could be rebuilt using biowastes, which would increase the soil's water and nutrient holding capacity and provide essential elements to accelerate plant growth. Biowastes could include dairy shed effluent, municipal wastewater or biosolids. Dharini Paramashivam, a CIBR PhD student at Lincoln University, has shown that pine waste and some charcoals created from pine waste can significantly reduce the leaching of nitrates from biosolids, while significantly improving soil fertility. Dharini's research will allow high rates of biosolids to be used to rebuild degraded soils without endangering the quality of groundwater, lakes and rivers.

Preliminary experiments at Lincoln University and ESR have demonstrated that biowastes augment the growth of mānuka on most, but not all, degraded soils. Biowastes, such as biosolids, also change the quality of essential oils produced by these plants. The nature of these changes is the subject of PhD research undertaken by Saloomeh Seyedalikhani (pictured right). In her initial studies, Saloomeh aims to identify key factors in biowastes that can improve the production and quality of essential oils derived from mānuka, kānuka and other species. Biowastes may also change the amount and quality of mānuka honey produced on degraded soils, thus potentially augmenting NZ's burgeoning honey industry.

Interestingly, mānuka and kānuka can significantly affect the quality of soil amended with biowastes. Both species produce antiseptic chemicals, such as monoterpenes and polyphenols that may enter the soil environment. Jennifer Prosser and Roshean Fitzgerald demonstrated that these species increase die-off of pathogens in biosolids-amended soils. Their pioneering research has resulted in a PhD programme that will be undertaken by Minakshi Mishra (pictured left). Minakshi will elucidate the effect of mānuka on survival times of various pathogens that are associated with faecal-containing biowastes such as municipal effluent, biosolids and dairy shed effluent. Her research may enable the reuse of biowastes that are currently unacceptable for land application due to their high pathogen loadings. Her research may also mitigate some of the "yuk" factor often associated with the land application of biosolids.

The antiseptic properties of mānuka may affect soil microbes involved in nutrient cycling. Rachel Downward demonstrated *in vitro* that mānuka extracts significantly reduced *nitrification*, the conversion of ammonium into highly-leachable nitrate. This effect could reduce the amount of nitrate entering groundwater. Hannah Franklin and Roshean Fitzgerald demonstrated that kānuka suppresses the production of nitrous oxide from soil amended with dairy shed effluent. Nitrous oxide is greenhouse gas, some 300 times more potent that carbon dioxide. Lessening New Zealand's nitrous oxide emissions could reduce expenses incurred by climate change agreements. The environmental benefits of mānuka and kānuka are being investigated by Obed Lense as part of his PhD programme. Obed is working closely with Dr Juergen Esperschuetz.

Ultimately, our research seeks to return NZ's landscapes to native vegetation that generates cash on degraded soils. Further economic returns would be realised by reusing nutrient-rich wastes that would otherwise go to (expensive) landfills or be inappropriately disposed of. Unlike timber production or dairy farming, mānuka and kānuka production cannot easily be adopted by overseas competitors. Native vegetation may be a key player in NZ's economic future.

Publications

Hahner JL, Robinson BH, Zhong HT, Dickinson NM (2014). The phytoremediation potential of native plants on New Zealand dairy farms. *International Journal of Phytoremediation* 16(7-8), 719-734.