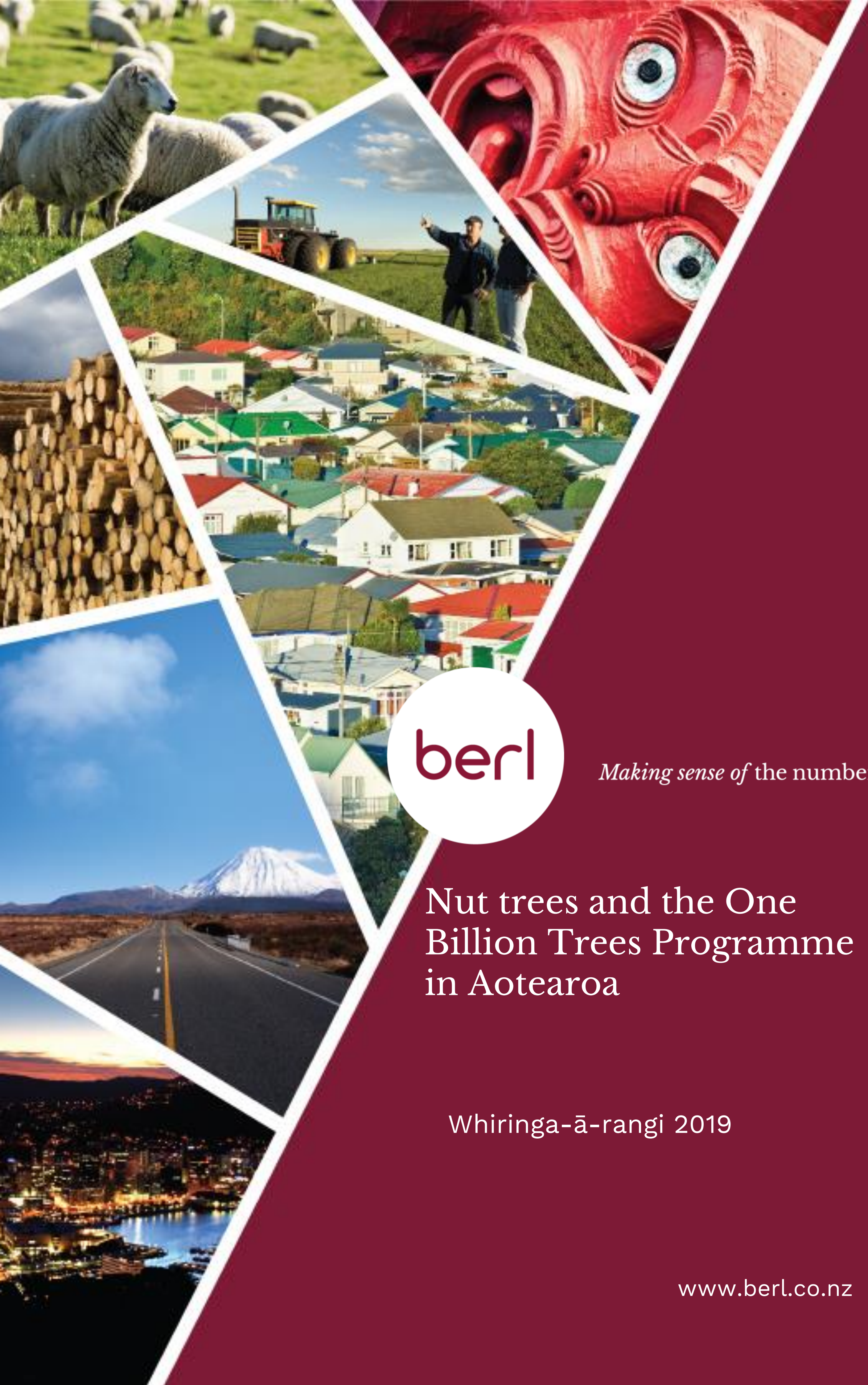

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Making sense of the numbers

Nut trees and the One Billion Trees Programme in Aotearoa

Whiringa-ā-rangi 2019

www.berl.co.nz

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Whiringa-ā-rangi 2019

Making sense of the numbers

The One Billion Trees Programme is an initiative that began in 2018 to increase the number of trees planted in New Zealand. The stated objectives of this programme are to improve wellbeing, provide jobs and income, sequester carbon, develop land, and lift productivity.

This programme explicitly excludes nut trees.

This report builds a case for including nut trees in the One Billion Trees Programme.

I assess nut trees against the stated objectives of the One Billion Trees Programme and find that nut trees are consistent with each stated objective.

This includes an assessment and quantification of how much carbon can be permanently sequestered in post-harvest nut trees. I found that this is likely between 2.8 and 9.6 tonnes per hectare though it could be as high as 20 tonnes per hectare.

I found that an estimate of the emissions from the whole supply chain of producing 100 grams of protein from farmed crustaceans is the equivalent of 18 Kilograms (KGs) of Carbon Dioxide (CO^2). While 100 grams of protein from tree nuts produces the equivalent of 0.3 KGs of CO^2.

I build an economic story of nut trees in New Zealand. I found that there are eight species of tree nuts which can be expected to succeed in New Zealand in general. Though some species (particularly macadamias) are more limited geographically than others.

Using a conservative estimate of the uptake of the One Billion Trees Programme by landowners I find that adding nut trees to the One Billion Trees Programme would result in:

- Between $1.18 and $2.42 million GDP per annum
- Between 14 and 30 additional full time equivalent jobs.

I aggregate nutritional data about tree nuts including the amino acid profile of tree nuts and found that almonds and pistachios have the highest concentrations of the nine “essential” amino acids.

I note that tree nuts are a good dietary source of magnesium and summarise research which suggests magnesium can help prevent type 2 diabetes and help regulate blood glucose.

Contents

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1 Introduction

Botanically, tree nuts are dry fruits with one seed in which the ovary wall becomes hard at maturity.

This report is intended to be a starting point to the conversation for adding nut trees to the One Billion Trees programme.

In section 2 of this report I will provide a short synopsis of the One Billion Trees Programme and its stated objectives. Following from this I will test nut trees against each stated objective to argue that nut trees do in fact meet all of the stated objectives.

Section 4 will cover carbon sequestration of plants in general, and trees in particular. In this section I also endeavour to provide a reasonable estimate of the carbon sequestered by nut trees post-harvest.

Section 5 contains a description of the historic and current tree nut market in New Zealand. In this section I also build a very conservative estimate of the likely lower and upper bound for the economic impact of adding nut trees to the One Billion Trees Programme.

In section 6 I aggregate data from various sources on the nutritional profiles of tree nuts that can be grown in New Zealand. I also explore in particular the effect of magnesium in preventing type 2 diabetes and helping regulate blood glucose.

I conclude the report in section 7 and provide a recommendation to add nut trees to the One Billion Trees Programme.

2 The One Billion Trees Programme

The “One Billion Trees Programme” (henceforth The Programme, or OBT) was developed in 2018 and is administered through the Ministry for Primary Industries (MPI).

The stated intentions of The Programme are to:

- Improve land productivity
- Tackle environmental issues like erosion
- Reduce the effects of climate change by absorbing C02
- Improve water quality
- Provide important habitats for a range of native species
- Enhance natural landscapes
- Provide another source of income from timber, honey and carbon credits
- Support wellbeing and create jobs and careers for our people.

The Programme will achieve these intentions by supporting farmers and other landowners to plant trees. Explicitly, The Programme does not include the wholesale conversion of farms to forestry.

Scope

Broadly, The Programme is aimed at landowners who are looking to create biodiversity, reduce erosion and improve water quality. Or develop Maori land.

There are two types of fund; one is for individuals the other is for partnerships with the Crown to plant commercial forestry. To apply for funding a person must demonstrate that they have the right tree in the right place for the right purpose. This includes evidence that the tree will survive in the chosen location as well as a management plan.

With the requirements satisfied the application is completed by filling out a form provided by MPI.

The species included in the programme are indigenous, Mānuka and exotic species like *pinus radiata* and douglas fir. Species explicitly excluded are fruit trees and nut trees.

Exclusion of nut trees

Fruit trees and nut trees are explicitly excluded from the One Billion Trees Programme. To my knowledge there is no reason given within the documentation on the One Billion Trees Programme for the decision to exclude these species.

One explanation is that because MPI has a budget constraint the decision may have been made as wanting the “most bang for their buck” in terms of impact against the stated objectives. Certainly *pinus radiata,* douglas fir, and native species of tree are in general “better” at sequestering carbon (because they are mostly larger plants).

The employment opportunities in the growing of *pinus radiata* and douglas fir are also more immediately obvious than they are for nut trees. Specifically, all tree species require silviculture services as well as harvesting services. These are more labour intensive for larger forestry species than they are for smaller fruit or nut bearing species.

However, there are benefits in terms of economics, health, and wellbeing to support the inclusion of nut trees into the One Billion Trees Programme. Some of these benefits are not as obvious as they are for *pinus radiata* or douglas fir and in this report I explore them in depth.

Growing Nut trees and the stated goals of The Programme

The stated intentions of The Programme are to:

- Improve land productivity
- Tackle environmental issues like erosion
- Reduce the effects of climate change by absorbing C02
- Improve water quality
- Provide important habitats for a range of native species
- Enhance natural landscapes
- Provide another source of income from timber, honey and carbon credits
- Support wellbeing and create jobs and careers for our people.

Nut trees are consistent with these intentions in the following ways.

2.1 Improve land productivity

Trees on farms can improve land productivity in a number of ways. On sheep and cattle farms trees can be used to shelter stock from high winds or intense sun. These factors can cause the animals stress which can lead to the animals not feeding adequately and consequently producing less milk or meat.

Chestnuts can be used as shelter by stock in the same way as any other species of tree. Walnut trees in particular are sufficiently large that stock won't knock them over (once they are well established). Sheep are known to enjoy foraging on chestnuts so if a farmer's main activity is stock farming and they have little desire to harvest, chestnuts can be left on the ground for stock.

2.2 Tackle environmental issues like erosion

Preventing soil erosion relies on the roots of plants being sufficiently deep and dense to hold the earth together in areas that are prone to erosion. These areas could be steep slopes or the edges of paddocks. Most tree species are large enough and have sufficient root networks to prevent erosion, nut trees included. However, if seeking to prevent erosion on a steep bank for example planting nut trees might be less attractive than other species. Simply because harvesting the nuts could be problematic.

If one forgoes harvesting the nuts (which may be difficult on steep or unstable land) then nut trees can be used for erosion control as much as any other species of tree.

2.3 Reduce the effects of climate change by absorbing $C0^2$

This is covered in section 3

2.4 Improve water quality

Farming ruminant animals, and growing some crops causes nutrients like nitrogen and phosphates to enter waterways. These nutrients originate either in the stomachs of the animals, and are excreted, or they are applied to the land in order to fertilise crops.

If these nutrients enter waterways they can act as fertiliser for unwanted flora such as algae which can lead to a decline in water quality. In extreme cases excess algal growth can result in oxygen depletion and completely kill all organisms in the water and result in a "dead zone".

In less extreme cases the unwanted growth of algae leads to diminished water quality.

In order to mitigate the effect farming has on waterways New Zealand farmers often use strategically placed plantings of species like harakeke, cabbage tree, and sedges. These plants grow well next to waterways and help to filter the excess nutrients from the groundwater before it enters the waterway.

Nut trees generally are not well suited to this use as they do not succeed well in the boggy land next to waterways. However, growing nut trees some distance from a waterway (in areas that are not boggy) can help filter groundwater in the same way as plants established adjacent to the waterway.

An exception to this is pecan nut trees which do well as riparian plants.

2.5 Provide important habitats for a range of native species

All tree species can do this to a lesser or greater extent. Native species arguably are better suited so long as they are planted in areas where they have grown historically.

2.6 Enhance natural landscapes

With some exceptions, trees and shrubs generally are beautiful plants that enhance the beauty of natural landscapes, including farms.

In a United States study, Ellis, Lee and Kweon (2006) found that neighbourhoods with more trees and shrubs had higher neighbourhood satisfaction ratings than those with fewer trees and shrubs.[1] The effect was found to be one of moderating the effect of retail land use. Given a level of dissatisfaction associated with retail land use in neighbourhoods, installing trees and shrubs moderated the negative effect of retail land use.

Economic theory tells us that farm land prices are driven by expected yields of the commodity produced by the land as well as other income the land can produce (such as being nice to look at, or isolated).

Planting nut trees for a beautifying effect is likely to enhance the price eventually received upon sale but quantifying this is not possible.

2.7 Provide another source of income from timber, honey and carbon credits

This is covered in section 4

[1] Ellis, Christopher D., Sang-Woo Lee, and Byoung-Suk Kweon. "Retail land use, neighborhood satisfaction and the urban forest: an investigation into the moderating and mediating effects of trees and shrubs." *Landscape and Urban Planning* 74.1 (2006): 70-78.

2.8 Support wellbeing and create jobs and careers for our people

This is covered in section 4

3 Climatic factors

Anthropogenic global warming has been cited by the United Nations (UN) as an immediate threat. In response to this the New Zealand government introduced the emissions trading scheme, and the Climate Change Response (Zero Carbon) Amendment Bill.

The overall goal of these pieces of legislation is to decrease as far as possible the amount of carbon dioxide produced in New Zealand.

A key method of reducing carbon is sequestering it either in man-made materials or in plants.

In this section I review how carbon sequestering in plants works as well as provide estimates of the carbon sequestering potential of different tree species (including nut trees).

3.1 Photosynthesis and carbon sequestration

All plants use energy from the sun to bind carbon dioxide and water into sugars through photosynthesis. Plants generally have two processes involving photosynthesis to create energy from sunlight. In the first process plants use the sun's energy and water to create energy for short term use such as adenosine triphosphate (ATP), this energy powers the immediate requirements of cells.[2]

The second process by which plants create energy is used for long term energy storage, called the Calvin cycle. Under this process plants use the energy from the sun to strip hydrogen off water molecules and carbon off CO2 molecules and bind that to other compounds. Then, using ATP the plant converts these molecules into glucose.

The final result of these cycles (along with others) is that plants grow over time, either above ground or below. The net effect of a growing plant is carbon sequestration. In simple terms, plants use carbon molecules to grow and when they die these molecules of carbon are "held up" in soil organic matter. Rather than being released into the atmosphere.

3.1.1 Carbon sequestration estimates for nut trees

While we have no definitive estimate of carbon sequestration for nut trees in New Zealand, in 2018 MPI published a report titled *Carbon sequestration potential of non ETS land on farms.* This report contained an estimate of the carbon sequestration of some common cropland plants. I reproduce table D 2 from that report in Table 3.1.

It is likely that nut trees fall within the range specified in this table (2.8 to 20.5 tonnes per hectare). It is more likely that the carbon sequestration of nut trees is similar to that of pip fruit given that most species of nut tree are a similar size to pip fruit trees.

[2] This molecule is also used to power processes in animal cells.

Table 3.1 Carbon stock of various species of cropland plants, post harvest

	Lower	Higher
Tonnes per ha		
Kiwifruit	12	20.5
Grapes	3.8	8.7
Pip fruit	2.8	9.6
Shelter belt	18.9	18.9

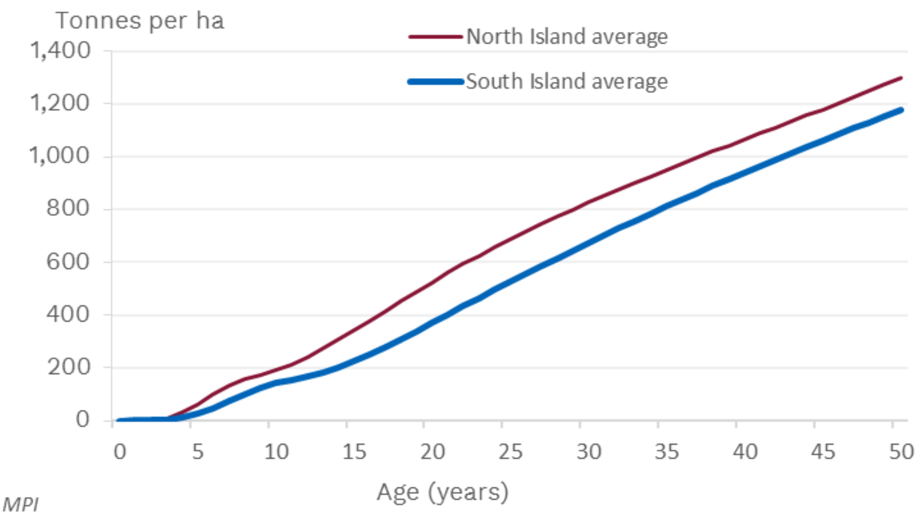
MPI

3.1.2 Carbon sequestration estimates for forest trees

In Figure 3.1 and Figure 3.2 I chart some estimates of the amount of carbon dioxide commonly grown tree species in New Zealand can sequester. Carbon sequestration rates are different in different climates so I have averaged the North Island and South Island estimates for the *pinus radiata.*

MPI data shows that as forests age more carbon is sequestered per hectare. Carbon sequestration is greater in the North Island than in the South because the North Island in general receives sunlight at a more direct angle so more energy is available for photosynthesis.

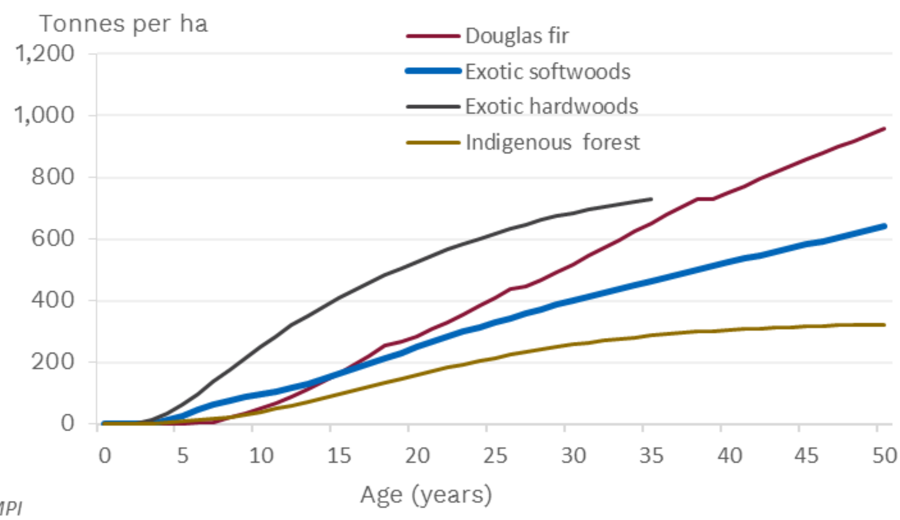
Figure 3.1 Carbon stock for *pinus radiata,* by area and age



MPI

MPI also produces estimates of carbon sequestration for various other species. The data for exotic hardwoods ends at age 35. This data shows that exotic species in general sequester more carbon than indigenous forest. This doesn't diminish the value or desirability of native forests in any way.

Figure 3.2 Carbon stock for various species, by age



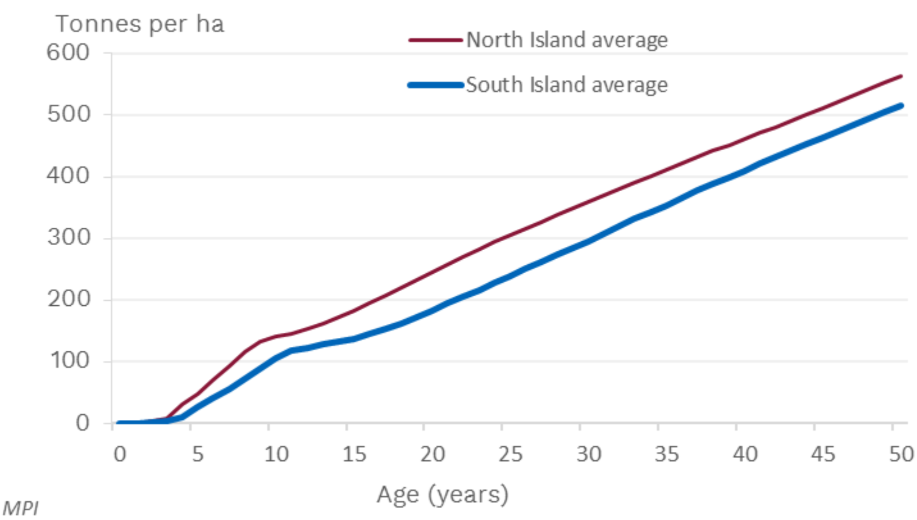
MPI

An immediate concern with estimates of carbon stock for forests is how much carbon is actually sequestered for the long term. It's no good sequestering carbon if it is all released in 30 years once the forest is harvested.

MPI has released some estimates of the carbon stock permanently sequestered in harvested forests. I chart this data in Figure 3.3 and Figure 3.4.

This data shows that the older forests sequester more carbon permanently in the residual roots and stumps after harvesting.

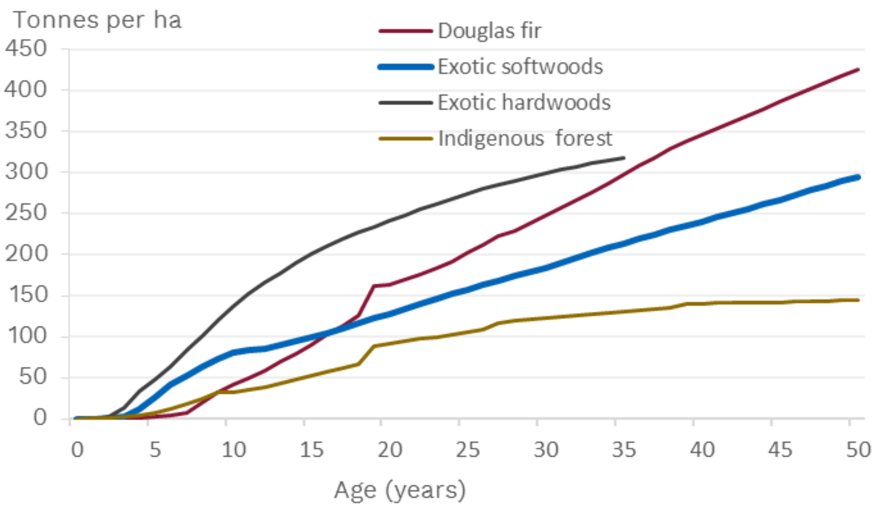
Figure 3.3 Carbon stored in residual roots and stumps of *pinus radiata,* by area and age



MPI

Finally, I found that douglas fir forests over the age of around 35 to 40 sequester the most carbon per hectare even after harvest.

Figure 3.4 Carbon stored in residual roots and stumps of various species, by age



MPI

When comparing carbon sequestration of cropland plants (like nut trees) to forest plants it can be easy to dismiss the relatively small effect of the cropland plants in sequestering carbon. However, this relatively small impact is an added bonus to the other benefits of planting nut trees.

3.1.3 Carbon emissions of different food sources

The primary use of nut trees is protein production. In general we can consume nuts for protein, or animal protein sources, or some mix of the two. In section 5.1 I describe the proteins found in tree nuts more completely.

I reproduce a selection of data points from Figure 1 of Poore and Nemecek (2019).[3] This study is a meta-analysis of 1530 studies from all over the world. For our purposes I focus on the CO^2 equivalent greenhouse gas emissions. This is a measure of all the greenhouse gases emitted in the production of each commodity aggregated and normalised to CO^2. It is worth emphasising that this is an international study of the entire supply chain for these products and thus represents a global average. The specific numbers for New Zealand are not yet known.

Table 3.2 shows that to produce 100 grams of protein with nuts results in emissions of 0.3 kilograms (KGs) of carbon dioxide (CO^2) equivalent. While producing the same amount of protein using farmed crustaceans, for example, produces 18 KGs.

This implies that increased substitution of current protein sources in our diets to tree nuts would mean less greenhouse gas emissions. I would argue against a forced substitution of nuts for every protein source as human protein needs are complex and no single source provides the entire range of amino acids we need.

The above notwithstanding, consumers are the right people to ask. And providing options for consumers is a critical role of the entrepreneur. Entrepreneurs can be assisted in this task by supporting landowners choice to plant nut trees through the One Billion Trees programme.

[3] Poore, J., and T. Nemecek. "Reducing food's environmental impacts through producers and consumers (vol 363, eaaw9908, 2019)." *Science* 363.6430 (2019): 939-939.

Table 3.2 CO^2 emissions of different protein sources - selection of Poore and Nemecek (2019)

100g Protein	
Food type	**KG CO2 equivalent**
Beef (beef herd)	50
Lamb & Mutton	20
Beef (dairy herd)	17
Crustaceans (farmed)	18
Cheese	11
Pig Meat	7.6
Fish (farmed)	6
Poultry meat	5.7
Eggs	4.2
Tofu	2
Groundnuts	1.2
Other Pulses	0.8
Peas	0.4
Nuts	0.3
Grains	2.7

4 The economics of nut trees

4.1 What species of nut trees will be successful in New Zealand

New Zealand contains a multitude of different climates and soil types. Different areas of the country will be more or less successful with each species of nut tree.

In general, the following eight nut tree species have been successfully grown in New Zealand:

1) Chestnuts
2) Walnuts
3) Pecans
4) Hazelnuts
5) Macadamias – in warmer areas that do not get frost, such as Auckland and Northland
6) Pine nuts
7) Almonds – succeed wherever peaches succeed such as the Hawke's Bay, Nelson and Wairarapa
8) Pistachio – in the South Island pistachios can be grown and succeed.

4.2 Market structure

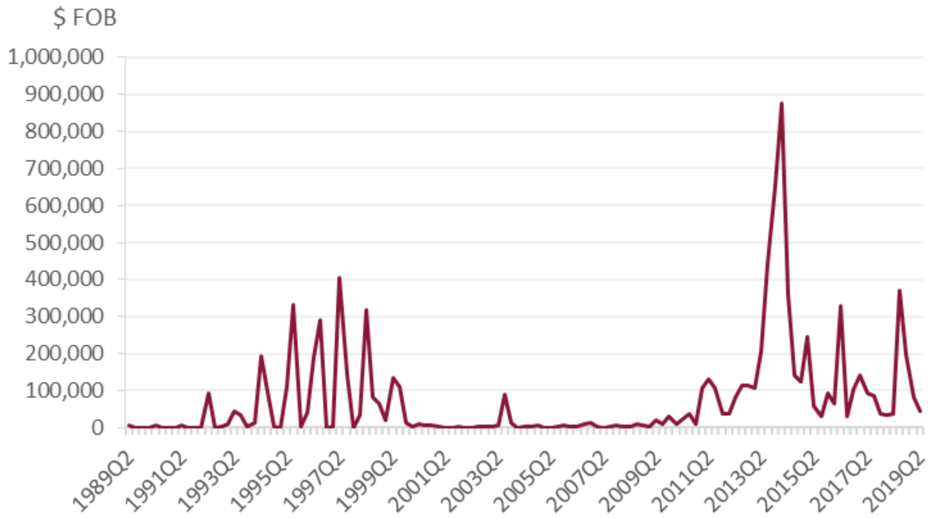
Marketing nuts

The tree nut industry overall in New Zealand is not yet well developed. Growers in New Zealand can sell their unprocessed nuts to one of the main processors or they can make arrangements to share processing facilities with other growers.

After processing, tree nuts in New Zealand are generally sold at local markets, or at the farm gate. Discussions with industry stakeholders confirmed that some growers do export tree nuts in small shipments to specialty shops and restaurants overseas.

I summarise the export data available from Statistics New Zealand in Figure 4.1. The data summarised in the chart is all exports of nuts from New Zealand, dried, shelled and in-shell. This chart shows that apart from the first quarter of 2014 tree nut exports from New Zealand have totalled below $200,000. And in some years, no tree nuts have been recorded as exported from New Zealand.

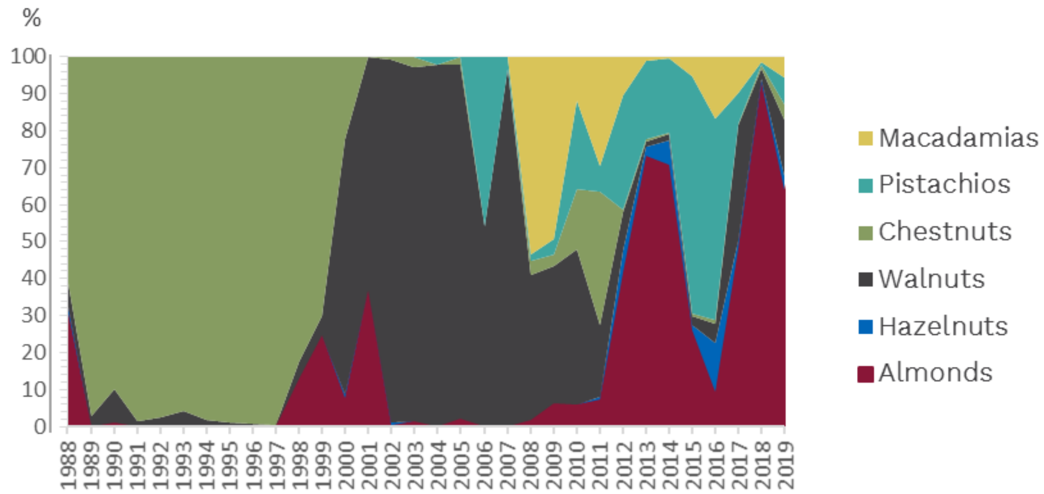
Figure 4.1 Nut exports, total



Statistics NZ

In Figure 4.2 I break down the annual nut exports from New Zealand by species. I do so because an interesting picture emerges. Before 1999, though small, the export market for tree nuts was dominated by chestnuts. After that, walnuts overtook all others as the highest export until 2008 when macadamias became a large export earner for a short time. In more recent years the export market has been dominated by almonds.

Figure 4.2 nut exports, breakdown by species



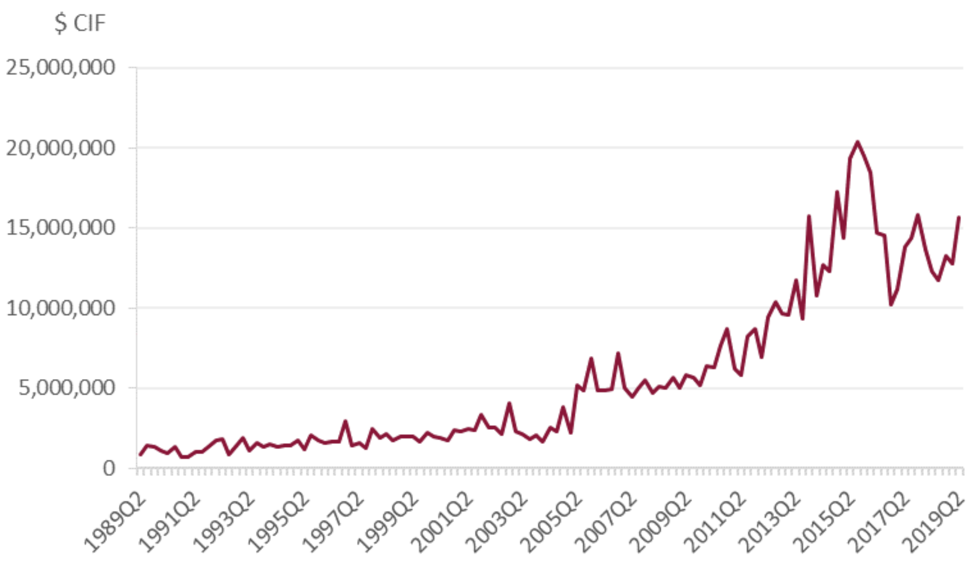
Statistics NZ

Nut imports

To get some idea of market demand in New Zealand for tree nuts generally we can use the imports of tree nuts as a proxy.

Compared to the export data I summarized earlier, imports of tree nuts (in Figure 4.3) looks very large. The trend has been a steady rate of growth up until 2010 when tree nut imports took off to a peak in 2016. Since then tree nut imports have whipsawed between 10 and 15 million dollars in value.

Figure 4.3 Imports of nuts since 1989

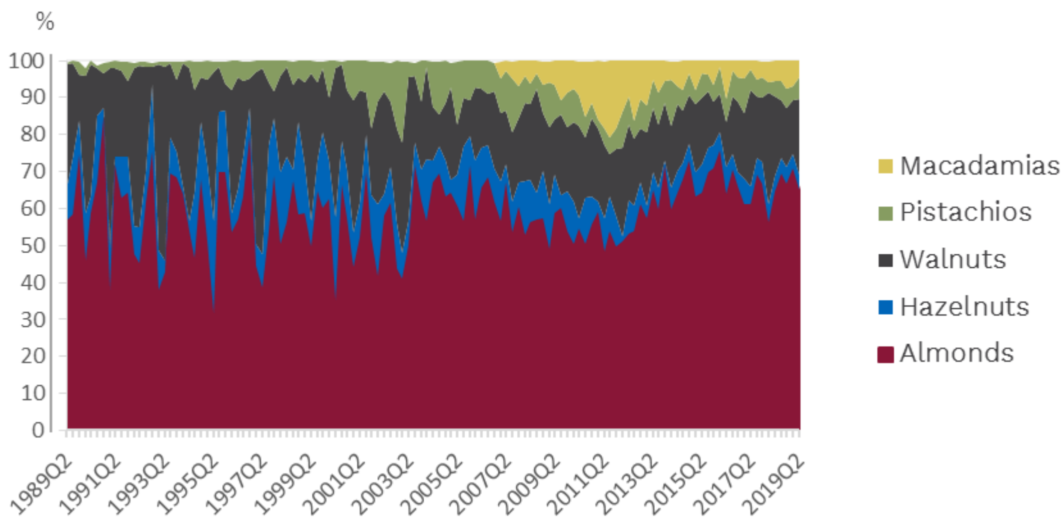


Statistics NZ

I also summarise a breakdown of tree nut imports by species in Figure 4.4. I have omitted chestnuts from this chart as the numbers are vanishingly small.

This data reveals that the most common type of imported tree nut has been the almond for the last 31 years. Followed by walnuts. Since 2007 macadamias have grown as a share of tree nut imports.

Figure 4.4 Tree nut imports by species



Statistics NZ

This data, combined with the export data, makes it pretty clear that there is more demand in New Zealand for tree nuts than what can be supplied locally at present.

Adding nut trees to the One Billion Trees Programme would boost the supply of nuts mostly at the local regional levels.

4.3 Current employment and Gross Domestic Product

The current nut tree growing industry in New Zealand is very small; it represents around 2.5 percent of the total horticulture industry.

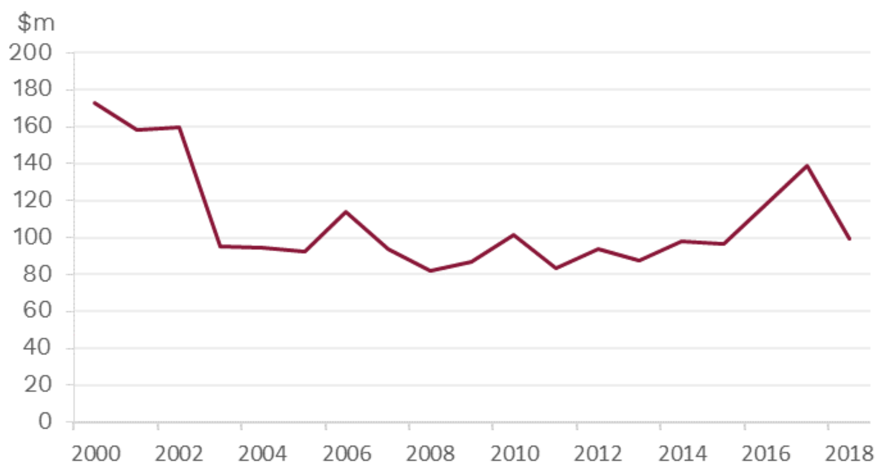
Table 4.1 Current economic contribution of nut trees in New Zealand

Other Fruit and Tree Nut Growing	2008	2017	2018	Change 2017 - 2018	%	Change 2008 - 2018
Employment (FTEs)	922	1,241	843	-398	-32.1	-0.9
GDP ($mn)	82	139	99	-39	-28.2	1.9
Business units	1,608	1,317	1,248	-69	-5.2	-2.5

BERL regional database, Statistics NZ

The GDP contribution of nut trees in New Zealand has been relatively stable over the past decade after a precipitous drop in 2009, as shown in Figure 4.5. Conversations with industry stakeholders included discussion on how the Global Financial Crisis of 2008 and subsequent Great Recession affected nut growers in New Zealand. Our data confirms the theme of these discussions.

Figure 4.5 GDP of nut tree growing in New Zealand



Statistics NZ, BERL database

4.4 A hypothetical scenario

The data I have summarised confirms the story gathered from industry stakeholders, that the tree nut industry in New Zealand is not well developed yet.

An immediate question is: what happens if adding nut trees to the One Billion Trees Programme results in a reasonably substantial uptick in nuts produced and sold locally, what is the economic impact in terms of GDP and employment?

To get a handle on a likely economic impact I assume that a very conservative number of landowners choose to plant nut trees and apply for assistance through the One Billion Trees Programme. My assumption is that the take-up of the offer is sufficient to make local production equal to five percent of the average imports over the years for which we have data.

My conservativism is justified by the fact that the One Billion Trees Programme explicitly excludes wholesale conversion of farms to forestry. This exclusion would likely also apply to nut trees if nut trees were included. Therefore, my scenarios implicitly exclude the creation of new orchards and nut tree farms. Rather, the intention of the One Billion Trees Programme is to support small-scale plantings.

In order to account for the large upswing in nut imports over the last decade and to get a higher and lower bound of this conservative estimate I construct two scenarios:

- In the first (Scenario 1) I assume that five percent of the average imports of nuts over the last 30 years is the total value of local production
    - For reference the average imports over the last 30 years was $21,068,911
- In the second (Scenario 2) I assume that five percent of the average imports of nuts over the last 10 years is the total value of local production
    - Over the last ten years the average value of imports was $43,098,211.

Scenario 1

In this scenario I assume that the total value of tree nuts produced as a result of inclusion in the One Billion Trees Programme is equal to five percent of the average value of imported tree nuts over the last 30 years.

The average imports over the last 30 years was $21,068,911

I summarize my results in Table 4.2. I found that under this very conservative estimate total production is around $1 million. Once we account for the roundaboutness of economic activity the total effects sum to 1.18 million GDP which is sufficient to support employment of 14 Full Time Equivalents (FTEs).

I consider this a good lower bound of the impact of including nut trees in the One Billion Trees Programme.

Table 4.2 Results for Scenario 1

Scenario 1: 30 year average imports			
5% of imports substituted for local production			
	Direct	Indrect	Total
Output ($m)	1.05	2.05	2.60
GDP ($m)	0.47	0.91	1.18
FTEs	7	12	14

Scenario 2

In this scenario I assume that the total value of tree nuts produced as a result of inclusion in the One Billion Trees Programme is equal to 5 percent of the average value of imported tree nuts over the last 10 years.

This shorter time period accounts for the marked difference in the last decade of import data as shown in Figure 4.3.

Over the last ten years the average value of imports was $43,098,211.

I summarise my results for Scenario 2 in Table 4.3. I found that total production under this scenario equals around $2.15 million. Once we account for the roundaboutness of economic activity the total effects sum to 2.42 million GDP which is sufficient to support employment of 30 Full Time Equivalents (FTEs).

This estimate is likely to be the upper bound of a conservative view of the effect of the One Billion Trees Programme.

Table 4.3 Results for scenario 2

Scenario 2: 10 year average imports			
5% of imports substituted for local production			
	Direct	Indrect	Total
Output	2.15	4.20	5.32
GDP	0.96	1.86	2.42
FTEs	15	24	30

Sensitivity

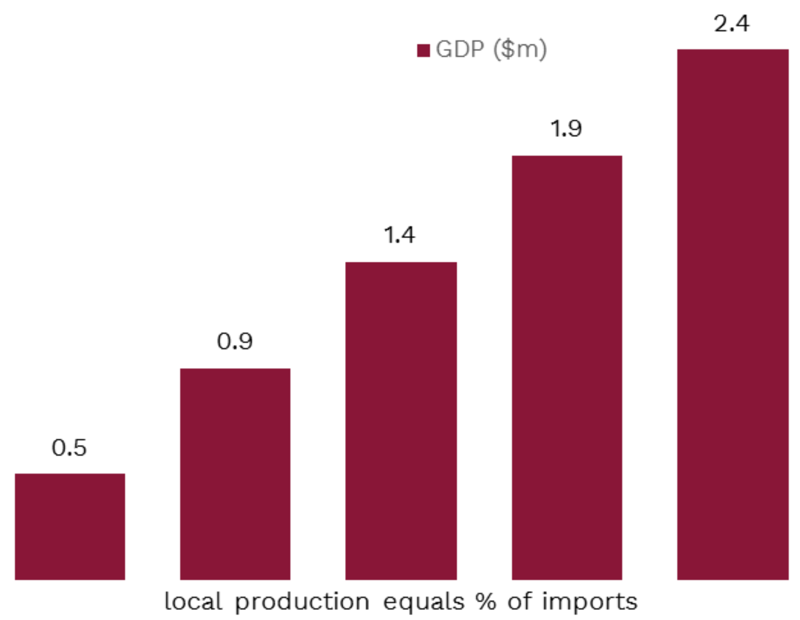
I wanted to find out what happens if I make a less conservative assumption about how many landowners take up the opportunity to get support to plant nut trees and produce nuts. To do so I vary the assumed production of tree nuts by assuming that production could be equal to two, four, six, eight, or 10 percent of imports in the last 30 or 10 years.

In Figure 4.6 and Figure 4.7 I chart the total GDP and FTE estimates for different assumed production.

Scenario 1 was where local production is equal to a proportion of the last 30 years imports. In this scenario we might expect that at the most ambitious the effect would be 2.4 million extra GDP generated and 29 FTEs employed.

Scenario 2 (Figure 4.7) was where local production is equal to a proportion of the last 10 years imports. In this much more ambitious scenario and assuming further that local production is equal to 10 percent of imports over the last 10 years we could expect the effect to be $4.8 million GDP and 59 FTEs.

Figure 4.6 Scenario 1 sensitivity



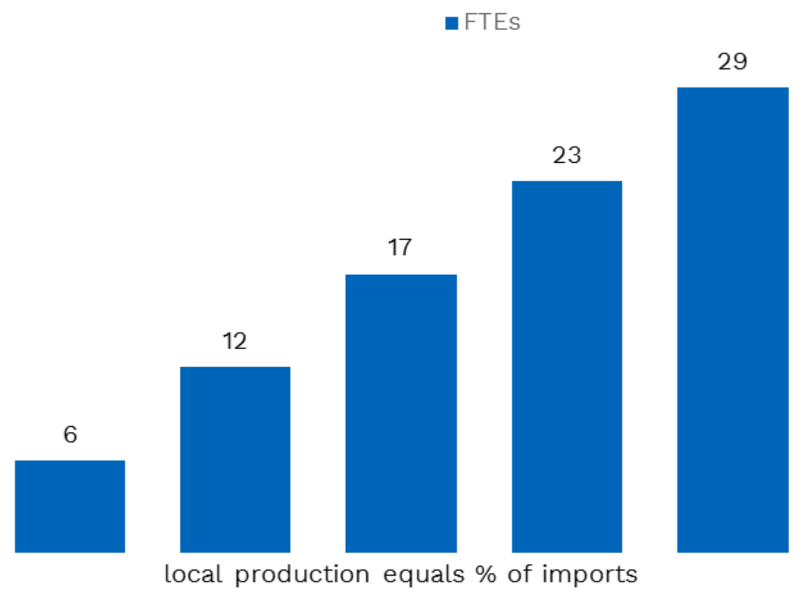
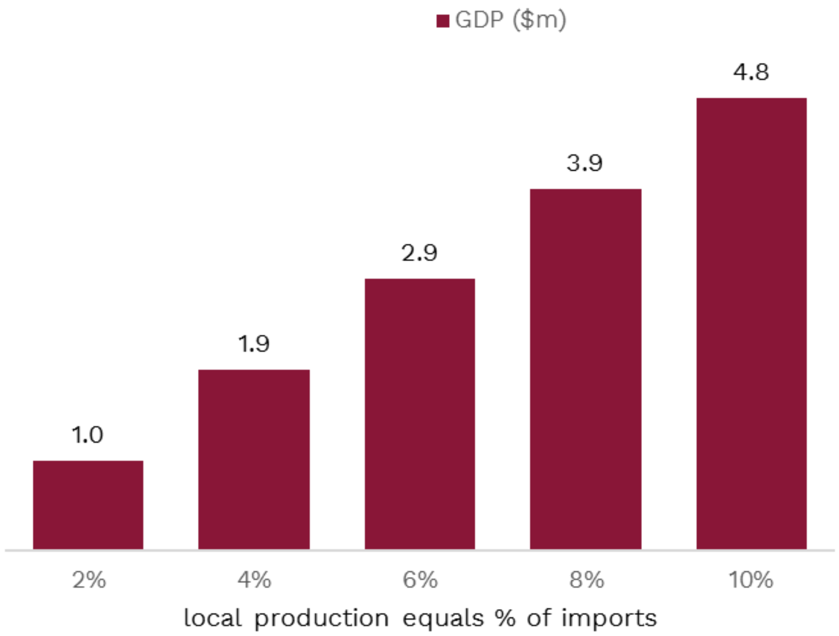
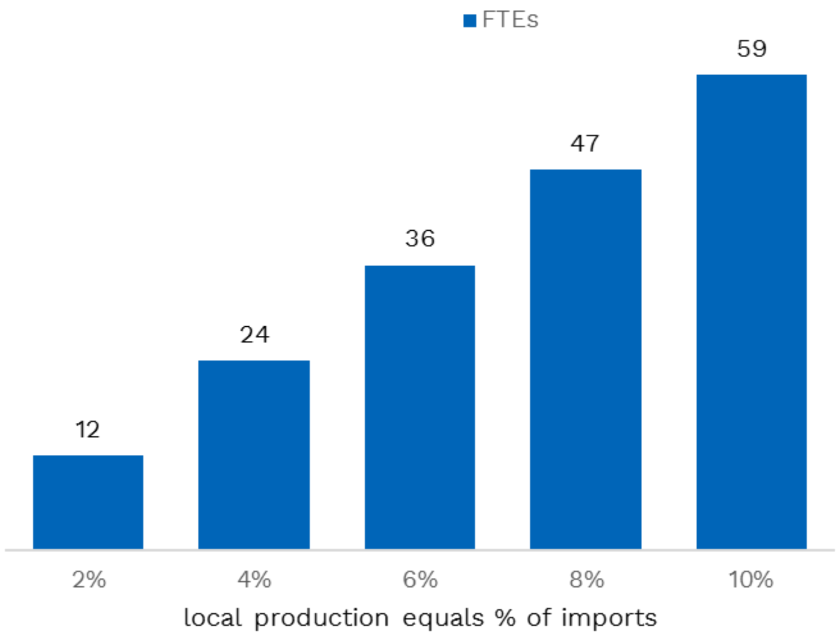


Figure 4.7 Scenario 2 sensitivity





One of the stated goals of the One Billion Trees Programme is to "Support wellbeing and create jobs and careers for our people". In this section I have shown, under very conservative assumptions, an upper and lower bound for the impact on employment I would expect from the inclusion of nut trees in the One Billion Trees Programme.

It should be emphasised that any landowner with enough space for a small planting could grow a sufficient quantity of nuts in a season to supplement their income by selling those nuts from home. This provides opportunities for rural New Zealanders on lifestyle blocks, and/or rural New Zealanders who own portions of land not big enough for large scale farming.

The opportunities could be taken up by rural Iwi looking to supplement either their income or nutrition by better utilising small pockets of land on and around the marae.

Including nut trees in the One Billion Trees Programme could help support these small rural landholders.

5 Other benefits of nuts

5.1 Nutraceuticals

Tree nuts are a nutrient dense food rich in calories from protein and fat. On top of these macronutrients tree nuts are a source of many micronutrients.

I reproduce the following table from the U.S. Department of Agriculture, Agricultural Research Service, 2010. The table contains a summary of the macronutrient and micronutrient quantities in eight commonly consumed tree nuts. As described in section 4.1 all species on this table apart from Brazil nuts and Cashew nuts will grow in New Zealand.

This information is useful for those entrepreneurs considering making small batches of artisanal nut butters. This is a potential new income source for landowners that can be helped along by the addition of nut trees into the One Billion Trees Programme.

Table 5.1 Tree nut nutrients per ounce as reported by the USDA[4]

	Almond	Brazil	Cashew	Hazelnut	Macadamia	Pecan	Pistachio	Walnut
Calories	163	186	157	178	204	196	159	185
Protein (g)	6.0	4.1	5.2	4.2	2.2	2.6	5.8	4.3
Total Fat (g)	14.0	18.8	12.4	17.2	21.5	20.4	12.9	18.5
Saturated Fat (g)	1.1	4.3	2.2	1.3	3.4	1.8	1.6	1.7
Polyunsaturated Fat (g)	3.4	5.8	2.2	2.2	0.4	6.1	3.9	13.4
Monounsaturated Fat (g)	8.8	7.0	6.7	12.9	16.7	11.6	6.8	2.5
Carbohydrates (g)	6.1	3.5	8.6	4.7	3.9	3.9	7.8	3.9
Dietary Fiber (g)	3.5	2.1	0.9	2.7	2.4	2.7	2.9	1.9
Potassium (mg)	200	187	187	193	104	116	291	125
Magnesium (mg)	76	107	83	46	37	34	34	45
Zinc (mg)	0.9	1.2	1.6	0.7	0.4	1.3	0.6	0.9
Copper (mg)	0.3	0.5	0.6	0.5	0.2	0.3	0.4	0.5
Vitamin B6 (mg)	0	0	0.1	0.2	0.1	0.1	0.5	0.2
Folate (mgc)	14	6	7	32	3	6	14	28
Riboflavin (mg)	0.3	0	0	0	0	0	0	0
Niacin (mg)	1.0	0.1	0.3	0.5	0.7	0.3	0.4	0.3
alpha-tocopherol (mg)	7.4	1.6	0.3	4.3	0.2	0.4	0.7	0.2
Calcium (mg)	75	45	10	32	24	20	30	28
Iron (mg)	1.1	0.7	1.9	1.3	1.1	0.7	1.1	0.8

[4] Source: U.S. Department of Agriculture, Agricultural Research Service. 2010. USDA National Nutrient Database for Standard Reference, Release 23. Nutrient Data Laboratory Home Page, http://www.ars.usda.gov/ba/bhnrc/ndl.

Diabetes

According to Ministry of Health data as at June 2018 there are just over 240,000 people in New Zealand living with diabetes mellitus – most of whom suffer from type 2 of the disorder. The Ministry of Health notes that there may be a further 100,000 people with the disorder who have not been diagnosed.[5]

Tree nuts have many beneficial nutrients as shown in Table 5.1. In particular tree nuts contain magnesium. As shown in Table 5.1 a one ounce (28.3 grams) serving of almonds contains 76 mg of magnesium. According to National Health and Medical Research Council (Australia) adult men should consume 420 mg and adult women should consume 320 mg of magnesium per day.

Since the early 2000s a large body of evidence has been built in the journals relating to nutritional science on the possible link between magnesium intake and risk of type 2 diabetes mellitus.

Some notable additions to the literature are: Jiang eta l (2002), Hruby eta al (2017), Dong et al (2011), Hruby et al (2014) and Fang et al (2016).

These studies are longitudinal using surveys, follow up studies, and medical records of people and their dietary intake of magnesium.

As illustrated in this body of research dietary intake of magnesium is associated with a lower risk of developing type 2 diabetes and is also associated with greater ability to control blood glucose.

Protein

There are 20 amino acids utilised by the human body. Of these nine are considered “essential”. In this context essential means that these amino acids cannot be produced inside your body and must be obtained through your diet.

The only source of amino acids in the human diet is protein.

I provide in Table 5.2 an estimate of the amino acid profile for the nine essential amino acids found in tree nuts. This is calculated for a 200 calorie serving of each tree nut type.

Overall this data indicates that, per 200 calorie serving, almonds and pistachios have the highest concentrations of the nine essential amino acids followed closely by walnuts and hazelnuts. The lowest concentrations are found in chestnuts.

These amino acids are essential to wellbeing and tree nuts are a convenient source of them.

[5] https://www.health.govt.nz/your-health/conditions-and-treatments/diseases-and-illnesses/diabetes

Table 5.2 Essential amino acids in a 200 calorie serving of tree nuts

	Pecan	Almonds	Hazelnuts	Walnuts	Chestnuts	Pistachios	Macadamia
Weight (g)	29	35	32	31	102	36	28
Phenylalanine(mg)	123	391	211	217	70	390	185
(% RDI)	14%	45%	24%	25%	8%	45%	21%
Valine(mg)	119	295	223	230	93	446	101
(% RDI)	7%	16%	12%	13%	5%	25%	6%
Threonine(mg)	89	208	158	182	59	244	103
(% RDI)	8%	20%	15%	17%	6%	23%	10%
Tryptophan(mg)	27	73	61	52	18	90	19
(% RDI)	10%	26%	22%	19%	7%	32%	7%
Methionine(mg)	53	54	70	72	39	129	6
(% RDI)	7%	7%	10%	10%	5%	18%	1%
Leucine(mg)	173	509	339	358	98	573	168
(% RDI)	6%	19%	12%	13%	4%	21%	6%
Isoleucine(mg)	97	259	174	191	65	327	87
(% RDI)	7%	19%	12%	14%	5%	23%	6%
Lysine(mg)	83	196	134	130	98	406	5
(% RDI)	4%	9%	6%	6%	5%	19%	0%
Histidine(mg)	76	186	138	120	46	183	54
(% RDI)	11%	27%	20%	17%	7%	26%	8%

5.2 Nut milks

One way to consume tree nuts is to make tree nut milks.

To do so is a simple process of soaking the nuts overnight. Draining them. Then combining them with twice their volume in water and pulverising the nuts and water in a blender. Often sweeteners are added such as sugar or honey.

Any variety of tree nut can be processed like this into milk.

Presently the most common variety of nut milk available commercially is made with almonds. This is likely because almonds are available in sufficient quantities and at a price point where the almond milk can compete with dairy milk. Whereas other nuts are not available at such quantities or price points.

Commercially available almond milks contain anywhere from 2.5 percent up to seven percent almonds by volume.

Including nut trees in the One Billion Trees Programme has the potential to begin a process to move the market to a stage where other nuts (particularly hazelnuts) could be grown in sufficient quantity and at a price point to compete with dairy milk. This would add more choices for consumers in the market, enhancing wellbeing.

Environmental consideration

Though it has in the past received some media attention there is little merit to the debate around whether dairy or alternative milks use more or less water. Comparing food production processes based on whether they consume less or more water is an odd metric to look at considering that water used in production cycles back as rainfall eventually, it is not permanently used up. It is doubly odd in a country which was historically temperate rainforest with very few arid areas.

The best people to decide are the consumers. Those consumers who prefer cow’s milk will buy cow’s milk, and likewise for tree nut (or other alternative) milk buyers. What is helpful is if producers of these goods publicly release calculations of water use. Then those consumers who value water use as a metric will make more informed decisions, and so too will those consumers who do not value this metric. This can be part of a marketing strategy used to inform consumers.

Further, if there was allowed to exist a market for water with well-defined and transferable property rights there’d be no need for any debate. The use of water would be priced into the price of various milks produced in areas with different water availability.

6 Conclusions and recommendations

The One Billion Trees Programme has a number of stated objectives around improving wellbeing of people in New Zealand, improving land and water quality and sequestering carbon dioxide.

The One Billion Trees programme explicitly excludes fruit trees and nut trees, with no reason given as to their exclusion. I have shown in this report the economic, health and environmental wellbeing benefits of including nut trees in the One Billion Trees Programme.

I have shown that generally all tree species offer the services required to meet these stated objectives – including nut trees.

I have aggregated data from multiple sources on the carbon sequestered by different tree species. This includes those planted for timber such as douglas fir and pinus radiata as well as those planted for fruit such as kiwifruit and pip fruit trees. This data shows that all tree species sequester carbon to a greater or lesser extent so the One Billion Trees programme, if it is intended to be consistent with its stated objectives, should include all tree species, including nut trees.

An important consideration in this regard is the amount of greenhouse gas emissions produced in the production of various food sources (estimated over the entire supply chain). I found that producing 100 grams of protein from tree nuts resulted in greenhouse gas emissions equivalent to 0.3 KGs of CO^2 while producing 100 grams of protein from farmed crustaceans produces 18 KGs of co^2 equivalent.

Producing protein using nut trees is an opportunity to move New Zealand to a lower carbon economy.

I have analysed the tree nut market in New Zealand from the perspective of what species might be expected to succeed here as well as what species have historically been imported and exported. I found that tree nut exports have historically been low and confirmed with industry stakeholders that this is because tree nut exports are usually specific small shipments to boutique shops.

I have analysed the import data available for nuts and found that the species that accounts for the most imports is almonds.

Using this import data as a starting point I have created a number of scenarios to describe what could be the effect of adding nut trees to the One Billion Trees Programme in terms of GDP and employment. Though I was very conservative in my assumptions, I found this effect to be modest but positive.

In general the lower bound of my estimate is that adding nut trees to the One Billion Trees Programme will add $1.18 million to the GDP of New Zealand and 14 more jobs. While the upper bound is likely to be somewhere around $2.42 million GDP and 30 additional jobs.

Finally, I have aggregated some nutritional data of tree nuts to describe how the addition of tree nuts to our diets can improve wellbeing.

Based on the data I have managed to find and the stated objectives of the One Billion Trees Programme I recommend adding nut trees to the One Billion Trees Programme.

Appendix A References

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Appendix B Complete amino acid profile of tree nuts

	Pecan	Almonds	Hazelnuts	Walnuts	Chestnuts	Pistachios	Macadamia
Weight (g)	29	35	32	31	102	36	28
Tryptophan(mg)	27	73	61	52	18	90	19
(% RDI)	10%	26%	22%	19%	7%	32%	7%
Threonine(mg)	89	208	158	182	59	244	103
(% RDI)	8%	20%	15%	17%	6%	23%	10%
Isoleucine(mg)	97	259	174	191	65	327	87
(% RDI)	7%	19%	12%	14%	5%	23%	6%
Leucine(mg)	173	509	339	358	98	573	168
(% RDI)	6%	19%	12%	13%	4%	21%	6%
Lysine(mg)	83	196	134	130	98	406	5
(% RDI)	4%	9%	6%	6%	5%	19%	0%
Methionine(mg)	53	54	70	72	39	129	6
(% RDI)	7%	7%	10%	10%	5%	18%	1%
Cystine(mg)	44	74	88	64	53	104	2
(% RDI)	15%	26%	31%	22%	18%	36%	1%

	Pecan	Almonds	Hazelnuts	Walnuts	Chestnuts	Pistachios	Macadamia
Weight (g)	29	35	32	31	102	36	28
Phenylalanine(mg)	123	391	211	217	70	390	185
(% RDI)	14%	45%	24%	25%	8%	45%	21%
Tyrosine(mg)	62	155	115	124	46	182	142
(% RDI)	7%	18%	13%	14%	5%	21%	16%
Valine(mg)	119	295	223	230	93	446	101
(% RDI)	7%	16%	12%	13%	5%	25%	6%
Histidine(mg)	76	186	138	120	46	183	54
(% RDI)	11%	27%	20%	17%	7%	26%	8%
Arginine(mg)	341	851	704	697	118	762	391
Alanine(mg)	115	345	232	213	111	347	108
Aspartic acid(mg)	269	912	535	559	287	673	306
Betaine(mg)	0	0	0	0	~	~	~
Glutamic acid(mg)	529	2144	1182	861	214	1536	631
Glycine(mg)	131	494	231	250	86	360	126
Proline(mg)	105	335	179	216	88	335	130
Serine(mg)	137	315	234	286	83	458	117