HIGH PERFORMANCE MĀNUKA PLANTATIONS PGP PROGRAMME

FINAL REPORT

Prepared by Mānuka Research Partnership (NZ) Limited (MRPL) and Massey University

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Mānuka Farming New Zealand https://www.manukafarming.co.nz/

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Special thanks goes to Massey University for contributing to the research specifically Professor Richard Archer, Dr James Milner, Dr Jason Wargent, Professor Michael McManus, Associate Professor Alistair Robertson, Professor Chris Anderson, Dr Huub Kerckhoffs, Georgie Hamilton, Maggie Olsen, Dr Elizabeth Nickless, Rachael Sheridan, Dr Julia Bohorquez-Rodriguez, Karoline Arfmann, Dr Zuben Weeds, Ronan Leonard and Gael Gaucer.

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Recommendation & Approval - High Performance Mānuka Plantation PGP final report

Recommendation to the Programme Steering Group to Deliver the High Performance Mānuka Plantations PGP programme Final Report

All personnel involved in the recommendation of this final report are listed below:

Name	Role/Company	Signature	Date	Agreement
Richard Archer	Massey University	See email dated 8th April 2019	8th April 2019	Yes
Bronwyn Douglas	MRPL		5th April 2019	Yes
Stephen Lee	MFNZ		5th April 2019	Yes

Approval of Final Report

The person(s) who have approved the content of this Final Report:

Name and Role of Approver(s):	Role/Company	Record of the Approval:	Date
Neil Walker	On behalf of the PSG	**Refer to email dated 18th April 2019**	18 April 2018

Summary

Background

The High Performance Mānuka Plantations Primary Growth Partnership (PGP) Programme ('the Programme') started in April 2011 with the objective of developing techniques in mānuka plantation husbandry for high quality mānuka honey production. The programme ended on 30 September 2018.

The industry co-investors, through Mānuka Research Partnership (NZ) Limited (MRPL) were Comvita New Zealand Limited, Nukuhau Carbon Limited, DR & CY Tweeddale Partnership, Arborex Industries Limited, Landcorp Farming Limited and the Hawke's Bay Regional Council.

Mānuka Farming New Zealand was established in 2016 as the commercial arm of MRPL, set up to commercialise the outputs and intellectual property from the Programme through the sale of mānuka seedlings and provision of services.

Plantation mānuka for honey is in its early stages. This Programme is part of the journey of research and optimisation that is needed to generate proven results over the life-time of mānuka plantations.

Following seven years of research and associated commercialisation activities, the Programme has succeeded in developing techniques required to assess a site, then plan, implement, and manage a mānuka plantation for honey production. The research canvassed many aspects of plantation establishment, growth and operation, through observation of relatively young plantations which have not yet reached productive maturity. The aim was to test to failure a range of highly selected mānuka provenance seedlines and several clonal lines to measure their performance, learn their limitations, and develop appropriate management techniques. The challenges that the Programme uncovered can now be anticipated and managed over the lifetime of a plantation despite seasonal variation.

Key learnings from the Programme and commercialisation activity

There are several components critical to achieving high quality monofloral mānuka honey from mānuka plantations. To be successful, plantations must be large, must survive and must thrive.

1. Size of plantation. We now believe that a minimum of 100 hectares is needed to provide a large enough nectar resource for mānuka to dominate over other competing nectar sources, and to reduce the risk of boundary riding.
2. Good plantation design and plant selection.
    a. The mānuka provenance must be matched with local weather and site conditions such as soil type, altitude, and aspect.
    b. An elite mānuka variety, planted in a new location, will produce nectar as rich in dihydroxyacetone (DHA) as in its home location. This persists for years. Timing of flowering and the level of nectar production can be predicted in the new location but is influenced by season.
        i. Some of the mānuka trial cultivars have consistently over six seasons (and despite unfavourable climatic conditions over flowering in some instances) produced nectar with 1.7 to 2 times the level of dihydroxyacetone (DHA) compared with general local indigenous mānuka growing in the same district. Dihydroxyacetone is the precursor to methylglyoxal (MGO) which is itself the main agent behind the UMF® measure.

c. Plantations must flower when the weather is most likely to be conducive to bee foraging. In some circumstances, plantations may be best suited to augmenting wild mānuka stands to achieve more regular and exceptional honey harvests.

d. Most plantations will need multiple mānuka varieties, each in exactly the right niche. A mānuka selection, no matter how high the DHA in its nectar, contributes nothing unless it survives and thrives.

e. Many plantations will experience competition from local wild mānuka likely to outgrow a seedling exotic to that location.

f. Local wild mānuka populations are usually more variable than the elite mānuka seedlings that can be brought in. This variability offers a basis for eco-sourcing quality local seed. Eco-sourcing is a skill requiring testing, analysis and judgement.

3. Quality seedlings. Seedling quality should not be underestimated.

   a. Survival and growth of mānuka seedlings in the first year after planting is affected by the root collar diameter of the seedlings ex-nursery.

   b. Containerised seedlings require specific care and management during transport and planting for successful establishment.

4. Although not tested by the Programme, most plantations will likely benefit from careful mixed use with local wild mānuka and/or with timber or carbon tree species. A mix of land use provides diversity of income streams and helps to manage risk.

5. Excellent establishment and management. We have had experience of plantation failure from high browse pressure from goats and deer and pressure from brush weeds such as gorse. An increased level of management of pests and weeds, both before and after planting, is required in comparison with traditional *Pinus radiata* forestry. Plantations are unlikely to succeed close to native bush that has high pest populations or in areas of high brush weed concentration.

6. Excellent apiary practices. This is critical as is understanding the natural variability and seasonality in honey production in the area local to the plantation site. Good apiary practice can help target bees on to mānuka.

Many of the learnings above may seem obvious. But none had been proven in 2010 when the Programme was planned.

We have seen the production of high quality monofloral mānuka honey commence on the largest plantation trial site of 130 hectares five years after planting (Tutira, north of Napier). This provides indications that peak honey production in plantations will occur 5 to 10 years following the first harvest of mānuka honey.

The Programme has compiled an extensive volume of technical notes to aid in plantation mānuka design and husbandry.

A predictive model has been developed for planation mānuka for honey. This can predict/forecast the nectar production, growth rates, flowering times, and carbon sequestration rates for the elite mānuka varieties tested.

Based on a simple net present value (NPV) analysis (excluding the cost of land), a well-planned and well-established mānuka plantation can match or out-perform sheep and beef farming on most marginal land provided advantage is taken of the grant schemes currently available for planting trees, and provided the gross honey revenue share to the landowner from the beekeeper is closer to 50%.

Plantation mānuka for honey production is a developing industry so it is a challenge to predict its future growth and value with confidence. The Programme estimates that the value to New Zealand of mānuka honey from plantations could reach $100 to $150 million by 2028, 10 years post

completion of the programme. This is based on expectations that (i) some plantings will use the knowledge from the PGP programme, whilst others will not, and (ii) the One Billion Trees Programme will assist with and increase the rate of planting of mānuka for honey. It should be noted that mānuka honey from wild stands will continue to be harvested. The lack of transparent and robust data on wild mānuka stands has meant that it is not possible to estimate this portion of the industry separately.

Conclusion

Planning a successful mānuka plantation in detail, predicting its lifetime performance and managing the establishment years requires specialist knowledge and a high level of skill.

The most important conclusion reached is that the best way to ensure a good return from planting mānuka for honey is to first seek and obtain very good and detailed advice, both on mānuka establishment and apiary management.

Background

The High Performance Mānuka Plantations PGP programme (hereinafter referred to as the "programme") began in April 2011, the four industry co-investors, Arborex Industries Limited, Comvita Limited; DR and CY Tweeddale Partnership, and Nukuhau Carbon Limited forming Mānuka Research Partnership (NZ) Limited (MRPL). The original programme anticipated large mānuka plantings on steep marginal lands with information extrapolated from glasshouse experiments corroborated on central New Zealand/lower North Island trial plantations.

The original programme was expanded in 2014 to include Hawke's Bay Regional Council and Landcorp Farming Limited (also known as Pāmu Farms of New Zealand), with the goal to increase confidence in mānuka plantings by owners of marginal lands through larger applied trial numbers. It was hoped that the original honey industry target of $1b would be reached earlier and more assuredly through addressing a greater population of landowners and to explore additional mānuka applications of smaller planting pockets within lowland pastoral farms, to yield an additional $200m in industry revenue by 2028.

Te Tumu Paeroa joined MRPL in 2015. Combined the shareholders bring considerable experience in the honey industry, forestry program development, and management of hill country in NZ from small to very large scales. MRPL together with the New Zealand government (through the Primary Growth Partnership Programme) have been undertaking research to prove the business proposition for mānuka plantation as a viable alternate land use on marginal pastoral land in New Zealand.

This report covers the programme's key achievements, from the perspective of the co-investors, and captures any post-programme activities relating to the PGP Agreement. The programme ended on 30 September 2018.

MPI and Partner Contributions

A summary of the contributions from MPI and the industry co-investors is outlined in table 1.

Investment in this PGP programme "High Performance Mānuka Plantations" commenced in April 2011 and completed in September 2018. Total investment approved from industry and government was $2,983,967NZD. Actual expenditure was $2,975,759 which is $8,208 less than the original budget of $2,983,967. The reduction in industry co-investment of $8,208 was in in-kind contribution. MRPL accounted for in-kind expenditure up to the total as per the yearly budget and reported such to the Programme Steering Group. Landcorp spent more than their budget in-kind investment in 2015/2016 by $30,393.18. This was realised and formally reported to and recorded by MRPL late in the programme, too late for MRPL to report formally to the Programme Steering Group (PSG) and hence the expenditure was not recognized in the financial reports for the PGP programme.

Mānuka Research Partnership Ltd	Ministry for Primary Industries	Total
$1,575,759 (53%)	**$1,400,000 (47%)**	**$2,975,759 (100%)**

Table 1: Total actual industry and government investment in the programme

	Actual	Actual	Actual	Actual	Actual	Actual	
YEAR	1 to 4	5	6	7	8	9	
Years ending 30 June	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**TOTAL**
Research Expenditure & Outputs Account							
Income MPI	$400,000	$147,289	$349,689	$376,045	$126,977		$1,400,000
Income Partners							
Comvita Ltd	$93,750	$35,312	$42,000	$40,000	$40,989	$3,350	$255,400
Nukuhau Carbon Ltd	$37,500	$37,878	$38,000	$36,000	$38,460	$4,908	$192,746
Arborex Industries Ltd	$18,699	$3,000	$4,000	$4,000	$5,358	$462	$35,520
Hawkes Bay Regional Council		$32,688	$30,000	$28,000	$23,192	$4,178	$118,058
Landcorp		$32,688	$30,000	$28,000	$23,192	$4,178	$118,058
DR & CY Tweeddale	$79,500	$32,937	$42,000	$40,000	$33,187	$2,925	$230,549
Total investment	**629,449**	**321,792**	**535,689**	**552,045**	**291,355**	**20,000**	**2,350,330**
Total research project expense	**618,927**	**361,058**	**517,373**	**529,622**	**302,205**	**21,145**	**2,350,330**
Science Program In-kind Costs							
Project/Objective 1 - Environmental	80,454	873	0	0	0	0	81,327
Project/Objective 2 - Plantation	293,910	112,203	22,277	21,233	10,358	0	459,982
Project/Objective 3 - Genetic	0	550	5,000	5,864	0	0	11,414
Project/Objective 4 - Intensive land uses	0	43,998	13,593	7,540	0	0	65,131
Project/Objective 5 - Predictive Tools	0	429	1,731	0	5,285	0	7,445
Project/Objective 6 - PM & science audit	0	129	0	0	0	0	129
Total In-Kind Costs	**374,364**	**158,182**	**42,603**	**34,637**	**15,643**	**0**	**625,429**
Total investment from all partners to end o	**1,003,813**	**479,974**	**578,292**	**586,682**	**306,998**	**20,000**	**2,975,759**
Total PGP Programme Expenditure							**2,975,759**
							- 0
In-Kind Contributions by Partner							
Comvita Ltd	80,454	26,397	31,603	29,000	13,421	-	$180,875
Nukuhau Carbon Ltd	73,573	5,100	-	-	-	-	78,673
Arborex Industries Ltd	-	-	-	-	-	-	-
Hawkes Bay Regional Council	-	70,000	-	-	-	-	70,000
Landcorp Farming Ltd	-	42,933	11,000	5,636	2,223	-	61,792
DC & CY Tweeddale Partnership	220,337	13,752	-	-	-	-	234,089
Total In-Kind	**374,364**	**158,182**	**42,603**	**34,636**	**15,643**	**-**	**625,429**

Table 2: A summary of expenditure by project by year, cash and in-kind

	Actual	Actual	Actual	Actual	Actual	Actual	
YEAR	1 to 4	5	6	7	8	9	
	2014	2015	2016	2017	2018	2019	TOTAL
Research Expenditure & Outputs Account							
Massey Research Program Charges							
TOTAL Project/Objective 1 - Glasshouse Environmental (PhD)	**368,638**	**33,435**	**825**	**0**	**0**	**0**	**402,898**
Project/Objective 2 - Large Scale Plantations 2.1	247,059	163,017	191,533	205,000	60,391	0	867,000
Project/Objective 2 - Companion Biota (PhD) 2.2	n/a	n/a	n/a	21,000	8,000	0	29,000
Project/Objective 2 - Plantation Technical Notes 2.3	n/a	n/a	n/a	14,000	15,000	0	29,000
TOTAL Project/Objective 2 - Plantations	**247,059**	**163,017**	**191,533**	**240,000**	**83,391**	**0**	**925,000**
Project/Objective 3 - Genetic 3.1 (Water deficit)	25,485	51,831	98,166	-	2180	0	177,662
Project/Objective 3 - Genetic 3.2 (Temperature)	n/a	n/a	n/a	45,000	2180	0	47,180
Project/Objective 3 - Genetic 3.3 (Rapid screening tool)	n/a	n/a	n/a	10,000	-	0	10,000
Total Project/Objective 3 - Genetic	**25,485**	**51,831**	**98,166**	**55,000**	**4,359**	**0**	**234,841**
Project/Objective 4 - Intensive land uses	0	3,000	13,941	3,500	0	0	20,441
Total Project/Objective 4 - Intensive land uses	**0**	**3,000**	**13,941**	**3,500**	**0**	**0**	**20,441**
Project/Objective 5 - Predictive Tools 5.1 (Models)	0	40,181	101,166	126,500	109,857	0	377,704
Project/Objective 5 - Predictive Tools 5.2 (Information/Ext)	0	0	800	0	0	0	800
Total Project/Objective 5 Predictive tools	**0**	**40,181**	**101,966**	**126,500**	**109,857**		**378,504**
Admin costs - Internal to Massey University	53,125	21,873	20,739	24,117	8,748	0	128,601
Less: Student stipend costs (paid by Callaghan Innovation)	100,380	40,478	30,333	12,500	0	0	183,691
Total Massey work programme	**593,927**	**272,859**	**396,837**	**436,617**	**206,355**	**0**	**1,906,595**
Project/Objective 5 - Predictive Tools 5.1 Model Review			0	0	850	0	850
Project/Objective 5 - Predictive Tools 5.3				5,505	10,000	1,145	16,650
Project/Objective 6: - PM	0	73,829	108,036	85,000	85,000	20,000	371,865
- Science Auditor	25,000	14,370	12,500	2,500		0	54,370
Total Programme management and commercial work programme	**25,000**	**88,199**	**120,536**	**93,005**	**95,850**	**21,145**	**443,735**
Total Science Programme Cash Costs	**618,927**	**361,058**	**517,373**	**529,622**	**302,205**	**21,145**	**2,350,330**
Science Program In-kind Costs							
Project/Objective 1 - Environmental	80,454	873	0	0	0	0	81,327
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Project/Objective 5 - Predictive Tools	0	429	1,731	0	5,285	0	7,445
Project/Objective 6 - PM & science audit	0	129	0	0	0	0	129
Total In-Kind Costs	**374,364**	**158,182**	**42,603**	**34,637**	**15,643**	**0**	**625,429**
Total PGP Programme Expenditure	**993,291**	**519,240**	**559,976**	**564,259**	**317,848**	**21,145**	**2,975,759**

Programme Goal and Outcomes

The overall goal of the High Performance Mānuka Plantations PGP programme is that by 2028 (ten years post completion of the programme), through productivity gains enabled by the programme, the mānuka honey industry in New Zealand will earn $1.2 billion in annual revenue, a 16-fold increase on its value of $75 million in 2010. Overall, given the programme's findings at its completion on 30 September 2018, it is very likely that the $1.2 b target will take longer to achieve than 2028.

The primary outcome desired of this programme was to be demonstrative proof of the technical and economic feasibility of combining improved genetics with mānuka husbandry practices to achieve the following productivity gains:

1. Double the hives per hectare carrying capacity on mānuka throughout New Zealand;
2. Double the average yield of a hive;
3. Double the proportion of mānuka honey capable of sale as a medicinal product;
4. Double the land area in mānuka economically accessible to beekeepers

1. Double the number of hives per hectare carrying capacity on mānuka throughout New Zealand

This targeted outcome effectively relates to the amount of attractive-to-bees nectar on offer on a flush day of a typical mānuka block. The number of hives is the first measure of this. By using (i) seed lines and cultivars that carry more flowers, yield more nectar per flower, and have nectar that is richer in sugar so to more attractive to honeybees, (ii) companion planting to support bee nutrition and health, and (iii) skilled apiary management of the site, a given footprint of land is expected to be able to support twice the number of bees, simplistically measured as the number of hives.

The programme has made good progress toward this doubling. We now consider the potential to be more than double the amount of attractive nectar on offer on a flush day than is the case in a typical current wild-harvest site. A key caveat is that the plantations in the programme are still immature and not flowering fully nor producing nectar fully, nor yet shading out flowering pasture weeds which can provide a diluting nectar source. The plantations are flowering more heavily than the local wild mānuka and the nectar is higher quality both in terms of DHA and sugar concentration. Nectar quantity data per flower is still preliminary but is building.

A second caveat is that this doubling of hives can only be applied to plantation areas.

Concluding statement: Properly established and well managed mānuka plantations should be able to support twice the number of bees, simplistically measured as the number of hives per hectare, when compared to wild mānuka stands.

2. Double the amount of honey produced by a hive over a season/year

This targeted outcome relates to effectively lengthening the nectar flow by planting a range of proven mānuka varieties in appropriate niche environments in a single plantation. This doubling depends both on cultivar-site factors by extended flowering times, and on apiary health and apiary management – these influence harvestability of the nectar on offer. It is critical that a mānuka variety in a particular location flowers when the temperature is high enough to promote good nectar flow and high enough for bees to be active. Flowering in the rain is another cause of nectar waste, as is flowering when the local insect population is at its peak leading to nectar raiding.

Targeting extended flowering through multiple varieties remains a good strategy, particularly as the climate becomes more variable due to climate change. Planted varieties exotic to the area should be complementary in flowering time to the local indigenous varieties. It is hoped that in any one season, some of the varieties present will present nectar at a useful time even if others do not. But some of the varieties planted on some of the experimental plantations are flowering too early to be useful for honey production due to variable spring weather conditions. The flowering time expressed by an exotic variety is heavily influenced by its flowering time in its parent location, but this is modified slightly by the temperature at the plantation site. The timing of flowering can vary considerably between years, but a similar flowering order will occur, supporting the model of plantation design utilizing habitually early and habitually late flowering mānuka to augment honey harvest. There must be no gap between plantation flowering and local wild type mānuka flowering lest the bees settle on an alternate non-mānuka nectar source in the interim.

In summary we consider the strategy to be right but have not yet observed a full doubling since in only one season to date on only one of the plantations have a site been mature enough with suitable weather conditions for honey production. Because extending flowering times across a plantation relative to the flowering period of the local variety exposes the enterprise to weather events, it is likely that the gain in productivity per hive will fall short of a full doubling. In addition, none of the plantations have yet achieved full canopy cover needed for maximum production; we anticipate that plantations established at 1100 plants/ha (recommended rate), with good survival and pest control, particularly of goats, will take more than 7 years to reach this point, and perhaps 13 years in some circumstances. Under practical circumstances this doubling will be achieved only in favourable years and only in a mature plantation. But in most years a well-planned and managed plantation should achieve a significant increase in honey per hive per season.

Concluding statement: A doubling of honey yield per hive seems achievable in favourable years and in mature plantations. On average, an increase in yield per hive of up to 50 percent seems more likely from plantation mānuka, compared to wild mānuka stands due to variable site qualities and weather conditions.

3. Double the proportion of mānuka honey capable of sale as a medicinal product

This targeted outcome involves increasing the proportion of *Leptospermum scoparium* nectar offered in a given area, largely by excluding competing floral nectar sources which may act as diluents and having *Leptospermum* stands with high dihydroxyacetone (DHA) levels in their nectar. The DHA

compound converts slowly to methylglyoxal (MGO) in the honey matrix – it is the antimicrobial properties of MGO which are measured by the UMF® grading system/scale. Provided superior cultivars are selected with good plantation design, the honeybees are likely to harvest them preferentially and thus prevent floral dilution. This assumption relies on plantations of sufficient size and design so that bees from apiaries within the plantation less likely to fly long distances to reach non-mānuka nectar. And it requires beekeepers to appropriately locate and manage hives within the plantation – this can be difficult and requires safe access tracks to be maintained. It is far easier for a beekeeper to place pallets of hives at the road side rather than deeper within the property. Such roadside sites are commonly well away from the marginal, steeper land on a property where the plantations are most likely to be established, requiring the bees having to fly further for mānuka nectar than for competing nectar.

Our initial aim to double the proportion of honey capable of sale for medicinal purposes is simplistic. We now view the target as doubling the per kg value of the honey collected over what might have been achieved by natural reversion. This increase in value will be achieved partly through ensuring the mānuka honey collected meets the required legal standard for monofloral mānuka honey, and partly through achieving a high MGO level through honey maturation.

The programme to date has shown that a mānuka variety giving high nectar DHA levels in a particular location will still give high DHA levels in nectar when transplanted to other sites. Our plantations have yielded nectar of double the DHA/sugar ratio of local indigenous plants. In some parts of New Zealand, particularly Northland, significant improvement relative to the local variety is unlikely because of naturally high DHA levels and unique flowering times lessening dilution issues.

The programme indicates that establishing a near pure block of plantation mānuka will be possible in many locations and careful selection of site and companion species (e.g. a surrounding buffer zone of non-nectar bearing tree species such as pine) may result in a nectar source little diluted by other nectars. This also serves to elevate UMF® levels over what is expected from most wild harvest situations.

We still do not definitively know what the minimum threshold size of plantation is, but we do know that it is much greater than our early estimates of 20 hectares. The distance that a honeybee will fly to forage depends on the availability of desirable food sources and the competition from other colonies. Bees can fly 9 km to forage and 4 km easily. A 4 km circle encompasses 5,000 hectares so the floral population of land neighboring a plantation may have a very large impact on honey quality, especially if hive stocking rates cause increased foraging competition. Under many practical circumstances a plantation may need to be substantially larger than 100 hectares to achieve sufficiently pure mānuka nectar to double honey value.

There is also an issue of timing – the experimental plantations are all growing more slowly than expected due to accumulation of multiple factors present in a research program, principally the need to test of the limits of the physiological niches unique to each cultivar and browse damage events occurring during mānuka husbandry trials. This means pasture weeds are being shaded out less rapidly than the ideal and will provide a diluting floral nectar source for longer. Honey quality (and hence price) may not be high in early years due to alternative nectar sources, but evidence thus far from the Tutira plantation contradicts this. Despite high amounts of pasture weeds present, a

commercial honey crop was produced in 2017/18 similar in fresh quality to honey from local mānuka, but of significantly higher quality if honey aging is considered. Looking back over the history of Tutira, this may show a certain "threshold" factor; meaning once the floral resource of a plantation has reached a tipping point, the bees tend to stick on a specific nectar source despite the availability of other nectar-producing species. Survey of wild site production does show that nectar dilution is the major quality determining factor in mānuka honey production, but the effects of relative floral attractiveness in a commercial mānuka plantation setting still requires further analysis.

Concluding statement: We consider the doubling of mānuka honey value ($ per kg) from a plantation, relative to natural reversion, to be possible. Due to the smaller size and youth of the research plantations, limited data exists at this stage to refine the parameters necessary to achieve this outcome.

4. Double the land area in mānuka economically accessible to beekeepers

This goal was flawed in logic when first set. As the price of mānuka honey increases, helicopters are being pressed into greater service and the land area of wild mānuka being reached is increasing.

More aptly stated, this goal is to attract sufficient land into mānuka plantations to reach a $1.2 billion industry. The key factors that will determine its success are:

- MRPL proving the business case for the establishment of high performance mānuka plantations on marginal pastoral land available plus cutover *Pinus radiata* forest land;
- Land retirement funding assistance such as the One Billion Trees programme, now in place;
- Other targeted assistance schemes;
- The National Environmental Standards for Plantation Forestry and associated zoning of land; and
- Increased ETS carbon returns, which is happening.

The ETS carbon returns, while likely minimal when compared to other forestry species, may appeal to people who are set on planting mānuka as a small income bonus or are looking for a passive income stream. It would not be the main income source but still may be worthwhile in a holistic scenario especially on a large scale.

Anecdotally there is much mānuka planting activity up and down the country under a range of models. This includes some beekeepers and/or honey companies buying up farm land ready for retirement, and shutting up some parts allowing for natural regrowth whilst planting other areas.

Data collected by MPI as part of its forestry nursery surveys report that 9.8 million mānuka seedlings (for approximately 6,300 ha) and 9.2 million mānuka seedlings (for approximately 5,900 ha) were estimated to have been sold for planting in 2016 and 2017 calendar years, respectively. These mānuka plantings were mostly for honey plantations but some for land remediation or mānuka oil. https://www.mpi.govt.nz/news-and-resources/open-data-and-forecasting/forestry/new-zealands-forests/

MRPL has formed Mānuka Farming New Zealand Ltd which is now operating and selling elite mānuka seedlings and offering services for successful establishment and on-going management of mānuka plantation.

The Government has set a goal to plant one billion trees over 10 years (between 2018 and 2027). The aim is to build on existing efforts and increase the rate of planting to meet this goal, requiring the combined efforts of government, landowners, commercial foresters, conservation groups, regional councils, iwi, communities, and others. This should increase land area planted in mānuka for honey purposes.

Taken in concert the current signs are that there is sufficient landowner interest to get very high planting levels. Individual plantations often take two or three years from first enquiry to plants-in-the-ground even with government funding available. Increased media coverage and incentives (e.g. the 1 Billion Trees Programme) will help to build further interest and increase a sense of security around mānuka honey production rather than a feeling of "boom-bust" that newer industries may suffer from. As planting rates build, industry technical developments and future funding schemes may further reduce planting costs and draw in more landowners. However, there are many delays in the system (building investor confidence, building nursery and planting capacity, time for a block to mature) that the $1.2 billion mark, as the value of mānuka honey from wild mānuka plus plantations if reached, will be much later than the 2028 timeline hoped for.

Concluding statement: There is increasing landowner interest in mānuka plantations, incentivised in part by land retirement schemes. New investment partnerships, supply arrangements, and potential for profit are contributing to the amount of land targeted for mānuka honey production.

Caveats

Despite the great promise currently abroad and despite our experimental plantings having been through their seventh flowering season there are large caveats:

- The three plantations in central and lower western North Island made up of the Comvita's CVT mānuka lines that flower before the wild varieties, have not yet produced an acceptable yield of honey. Establishment and growth (where weed and goat control have been effective) are good, flowering is good, and the nectar is rich in DHA. However, flowering has been too early for high nectar flows and for bees to harvest it well. This may be partly due to immaturity and partly due to the 2015/16 severe El Nino and 2016/17 La Nina activity causing poor bee flying weather. A mismatch of flowering times has become evident between northern varieties and west coast North Island spring weather conditions which suppress bee activity and wash nectar from flowers. Even the relatively benign spring of 2017 resulted in poor honey harvests from these three plantations. However, a fourth smaller 5-year old South Taranaki plantation which had been held as a validation block and observed but not routinely sampled, did indeed yield high quality plantation mānuka honey in quantity in October-November 2017.
- The Tutira plantation (north of Napier) has also established well and is growing, flowering and producing DHA-rich nectar. Tutira did, for the first time, produce good plantation mānuka honey in good quantity in 2017-18.

Although we consider, after seven years' research, plantation mānuka to have retained its potential to generate good income on marginal land, it's now clear that there are many pitfalls and little room for error in decision making. The research group now considers mānuka to be midway between traditional commercial forestry and fruit orchards in level of care required.

Additionally, the research group now consider plantation size and floral diversity of the immediate area surrounding a plantation to be a far greater determinant of honey quality than the DHA level of the nectar. The latter can swing the average DHA level in honey by a factor of up to 2-fold between good and poor varieties and has little impact on monoflorality of honey. The level of dominance of mānuka over other contemporaneously flowering plants can swing DHA level by a factor of 10 (estimated from floral loads observed in the field within apiary flying range) and has the major effect on monoflorality.

This means that plantation design factors such as boundary vegetation and plantation size and shape become very important.

Contribution of the research topics to the PGP programme's goal and outcomes – an Overview

The Programme's Goal and Outcomes section above identifies and describes the levers that influence the key variables dictating the production and financial performance of a mānuka plantation. Each of the four productivity goals are positively influenced by the research topics studied. The synergistic relationships between the various levers are summarised in Table 3 below.

The lessons learnt from the research work are of three types:

1. Well proven and robust experimental results backed up by published papers and theses;
2. Experimental findings that provide strong indications but where a longer period of plantation monitoring and observation is required to deliver proven results; and
3. Observations and logical inferences made during the research work but beyond the primary aim of the experimentation.

Table 3: Contribution of the various components of the PGP research work to outcomes for plantation mānuka

	Programme Goals and Outcome Variables	Lever									
		1	2	3	4	5	6	7	8	9	10
		Superior Cultivars	Companion Planting (to support bee nutrition)	Plantation Design (inc. combining cultivars)	Land Use Optimisation Modelling	Plantation Size	Beekeeping Skills/Apiary Management	Establishment Knowledge	Plantation Management	Govt Policy and Funding	Competing land use and honey prices
										Not within scope of PGP Programme	
1	**Double the number of hives per hectare carrying capacity on manuka throughout NZ (hives /hectare)**	✓	✓	✓			✓				
2	**Double the amount of honey produced by a hive over a season /year (Yield per hive)**		✓	✓			✓		✓		
3	**$ Value per kg Honey** (as proxy for proportion of mānuka honey capable of sale as a medicinal product)	✓		✓		✓	✓	✓	✓		
4	**Land Planted in manuka** (measured as % Share of Manuka of all tree plantings)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Note
Each tick mark shows which aspects of the PGP research study contribute to the productivity goals of the programme.

Programme Achievements

Under our thinking in 2011 we hoped, through careful research, to effect advances in four areas which together would increase the value of the New Zealand mānuka honey industry 16-fold within ten years of programme completion:

- By lengthening the flowering period by using mixed cultivars we hoped to double the average honey yield per hive
- By using cultivars with very high floral density and nectar yield we hoped to double the number of hives carried per hectare
- By using cultivars with high DHA: sugar ratio in their nectar we hoped to double the average value of extracted mānuka honey
- By succeeding in the above three domains we hoped to attract enough landowners to invest in plantations sufficient to double the production of medical grade mānuka honey.

Based on 2010 estimates of mānuka honey revenues we reckoned that a 16-fold increase would bring us to a gross revenue for New Zealand of $1.2 billion per annum.

The Programme had twin goals – (i) to provide an evidence base for the successful development of mānuka plantations for honey production and (ii) to prevent unwise investment in underperforming mānuka plantations. Both approaches were required for New Zealand to prosper. Additional intended outcomes included: increasing employment opportunities in rural New Zealand; to provide a productive use of marginal lands; and to assist in erosion control of unstable hill country.

In 2011 we expected much of the research information to be generated from the four planned broadacre trial plantations, as well as from the randomised trial plantations and radial plantations embedded within them. We planned glasshouse trials to probe specific elements of mānuka physiology such as responses of different varieties to macro and micronutrients and to water and temperature stresses. We planned to collate all data collected in a secure database and analyse data statistically. We planned to use the measured responses to build a mathematical model for predicting, for a postulated plantation, the honey yield and dollar returns over time. We planned for three PhD students, and one technician to undertake this work, all at Massey University and closely supervised by a collective of Massey staff with relevant expertise and input from the co-investors. For the last two of six years we planned to employ a research officer to build the predictive model.

By 2013 it became clear that plantations were suffering heavy losses due to pests, weeds and landslides. One plantation on dry Wairarapa gravel failed at the pre-trial stage. Later, we replaced it with another on unstable soil at Tutira. We lost most of the embedded trial plots to slips and pigs and replaced them with others protected by electric fences. In 2012 we started planting outdoor plots at Massey University and these became a further generator of detailed information.

By 2015 the concept of plantation mānuka was still looking positive despite the lack of honey from the trial plantations (due to a mix of pest browsing and wet springs curtailing bee activity during flowering, this was felt nationally). The MRPL shareholders and MPI agreed to accelerate and expand the programme. We would additionally monitor other (Comvita-established) plantations over a wider geography. We would investigate plantings on riparian margins or in shelter belts on dairy

land. MRPL would employ a part-time programme manager, and the hiring of the research officer for model-building was to be brought forward.

By late 2015 it was clear that the predictive model could not be built from masses of plantation-derived data. Rather we had to model the underlying mechanisms and rely on data collected over future years to fine-tune the parameter values that drive the model. It was also clear that MRPL needed to form a commercialisation vehicle to sell the characterised lines of mānuka and to sell the consultancy services necessary to design, establish, and maintain a new honey plantation. The research programme has delivered a partially validated predictive model, technical notes and field testing techniques to support that endeavour.

Mānuka Farming New Zealand Limited (MFNZ) was launched at the beginning of 2016 and is the commercial arm of MRPL. MFNZ has implemented a "seven steps to mānuka farming success" process available to New Zealand land owners. This process provides expertise and services to assist landowners in site specific planning and preparation and commence honey production. Through the PGP research programme MFNZ knows how to combine genetically improved cultivars that are field tested and matched to site with the best practice mānuka plantation husbandry currently developed.

Programme research achievements by PGP output

Small scale research trials and large scale plantation trials identifying environmental and site factors, and genetics that influence mānuka establishment and growth, and honey yield and quality

Large Scale Plantation Trials

- Around 400 hectares of trial mānuka plantations have been established on marginal land across 8 sites in the North Island. These trials were planted using elite mānuka varieties developed in the Comvita Limited mānuka breeding programme (CVTs). Four of the sites, plus plantings at Massey, have been closely monitored to gain knowledge on tree performance in different environments with regards to establishment, survival, growth, nectar production and quality, floral traits, and apiary performance. A full set of data from each of these sites has been used to build up a database for the predictive modelling tool and for development of technical notes on plantation establishment. Three other sites were established by Comvita in conjunction with land owners and one by Comvita on its own land. Of the three, two failed due to heavy browse and/or weed competition (Mahia – 50 hectares and Limestone Downs – 16 hectares) and the third through difficulties with the landowner (Maitaikona – 27 hectares). Comvita's Kawerau site has been monitored by Comvita (20 hectares).
- Observations and results from the plantation trials on marginal land over 7 years include:
    - Climate factors drive both sugar content and dihydroxyacetone (DHA) concentration in nectar; and shows differences in how each cultivar will perform. This highlights the importance of fitting cultivars to the appropriate sites to maximise honey yield and value.
    - We find, despite the variation, the CVT seedlings are generally yielding higher DHA concentrations than the local wild type mānuka. Results from research trials in

glasshouses generally mirrors the field results, thus cultivar testing might be able occur in nursery conditions in the future.

- Annual growth and nectar measurements have allowed the relationship between tree size and mānuka nectar on offer to be discovered. This finding is incorporated into the mānuka model and provides a basis for deciding optimum hive stocking rates and measurement of expected honey production from plantations of CVT stock.

- Some of the mānuka trial cultivars have consistently over six seasons (and despite unfavourable climatic conditions over flowering in some instances) produced nectar with 1.7 to 2 times the level of dihydroxyacetone (DHA) compared with general local indigenous mānuka growing in the same district. Dihydroxyacetone is the precursor to methylglyoxal (MGO) which is itself the main agent behind the UMF® measure.
- Genetics have been found to be the main influencer of mānuka nectar quality (i.e. the composition of nectar). Genetics also influence flowering period and flower numbers.
- All four main trial plantations were served by hives in 2017/18 and honey was harvested. Monitoring hive performance on plantation mānuka provides the "real-world" check on the success of a plantation. Understanding when and how a honey plantation becomes productive is essential to modelling plantation development:
  - Rangitatau West had hives placed late in the 2017/18 season, thus the honey harvested cannot be fully proven to be of plantation origin as the local wild population was beginning to flower only a few days after placement. The earliest honey sampled (and most likely to be from the CVT mānuka) showed a 2 to 6 times increase in DHA levels from the previous year. Later sampling showed a small decrease in quality in comparison to the previous year.
  - At the Ahu Valley plantation honey sampled at the end of CVT flowering did not show detectable amounts of DHA in the honey. Fresh honey samples taken after the wild flowering ranged from UMF® 2.3-4.5 at the plantation apiary and up to 9.9 at a neighbouring apiary. The plantation here has suffered from thorough incursion by wild mānuka as of June 2018.
  - The Ruatiti Domain plantation has not produced honey containing detectable DHA as of June 2018. The majority of the trees here are 2-3 years old, thus are not the dominant nectar source yet. No wild mānuka exists at this site for late honey samples.
  - At the Tutira mānuka plantation 8 honey samples were taken from research hives and 2 from commercial hives. 5 of the samples, representing the quality variation were tested against the MPI definition for mānuka honey which came into effect in February 2018. 4 of the 5 honey samples were confirmed as mono-floral mānuka and the last sampled was classified as multi-floral mānuka.
  - The UMF® grade for 10 honey samples taken from hives at Tutira in December 2017 at the end of plantation flowering, ranged from 4.7 to 10.6 with a storage potential of 14.2 to 27.5. Given that this honey represents the early phases of plantation growth at Tutira, the UMF® levels in future honey harvests are predicted to improve

as the plantation matures leading to increased flower density and canopy closure hence less dilution from other nectar sources.

- Mānuka honey yield from the Tutira plantation (4-6 years old) of c. 140 hectares in 2017/18 was 7.0 kg per hectare. Mānuka honey yield from a neighbouring wild mānuka stand in 2017/18 was 9.5 kg per hectare. This result shows promise that honey yields from mānuka plantations should be able to at least match, and potentially surpass that of wild stands as the plantations mature.

- Around 21 hectares of riparian mānuka plantations have been established across three sites in the North Island (two in Hawke's Bay and one in the Wairarapa) and one in the South Island (Southland). Many of the riparian sites struggled with initial losses and required multiple blankings to achieve acceptable survival rates. The goal of these planting was to explore the viability of small planting for honey production. The findings of the larger plantations suggest that these small areas do not create a nectar resource large enough for producing high-value honey. This type of planting will likely be useful for environmental or erosion control purposes.

  a) Mount Hamilton was planted in 2013 and is one of the hardest sites that could be found and so is suitable for testing extremes of survival conditions. The site was covered in snow in 2013 leading to an initial poor survival of approximately 35%. Blanking in 2014 has shown good results with roughly 73% survival.
  b) Hill View was established in 2014 with above 90% survival in two areas and 70-80% survival in the third wetter area. Two blankings have increased this survival to 80-90%. There was increased weed incursion in the 2016/17 growing season, but the mānuka is growing well. The pepper plot trial at this site failed.
  c) Tikokino was planted using two planting patterns; pepper plot and hedge rows. Overall survival was reasonably good with approximately 70-80% of seedlings surviving 10 months after planting. Survival was best on the stony soils of average fertility with these sites having 97-98% survival.
  d) Wilanda Downs was planted in 2014 with one assessment carried out in 2015 showing good growth in all plots and 80-100% survival in 3 of 4 plots, the fourth having 36% survival.

- Over 400 nectar samples and 100 honey samples were gathered from 4 regions of the North Island in the 2017-2018 season to explore mānuka honey production of wild stands and act as a proxy for mature mānuka plantations. This collection provides data for the model (in calculations of wild nectar dilution) as well as increasing understanding around the different factors driving honey production in the different regions. It should be noted that these findings may only apply to the studied sites.
- Observations from the surveyed wild sites:
  - Younger mānuka trees (vs. older trees) have been shown to have higher nectar quality.
  - The minimal size of a viable mānuka stand changes depending on the locale/region due to the presence and flowering time of competing nectar species and the overall

hive stocking pressures which manifest differently depending on access and reputation of the region as a mānuka honey producer.

- Whanganui shows a three-year cycle in honey quality production (UMF level) based on an analysis of eight years of data (from one beekeeper in the area) and anecdotal beekeeper evidence on a much longer timeframe. This coming season (2018-2019) should show an upwards spike in mānuka honey quality from the region if the pattern holds. This phenomenon has been noted anecdotally nationwide by beekeepers.
- The number of nectar competitive insects to the honeybee is usually negligible except in areas of high livestock numbers due to the inevitably higher number of large flies acting as nectar foragers.

Small scale Research Trials

Soils

- Soil type affects plant growth, flowering time and duration, flower numbers and nectar yield. Soil type does not affect nectar quality.
- These responses to soil type depends on the cultivar, therefore overall high UMF® honey yield will generally depend on the cultivar chosen and the soil in the region chosen for planting. Increased plant performance will lead to higher honey production.
- Data from the soil experiment also indicated that contrary to the previously reported studies, *Leptospermum scoparium* has better growth and produces more flowers on soils with increased nutrient content. Background nutrient content needs to be included in a consultant's assessment of a prospective plantation.

Light

- The addition of extra visible light (to mimic differences in latitude between Northland and Southland) had no significant effect on any parameters of mānuka plant growth, flowering time, or nectar quality. In predicting likely performance of a cultivar in one location relative to another, latitude is not important beyond the temperature effect of latitude.

Water availability

Water availability does affect mānuka growth and nectar quality. This highlights the need to have appropriate planting times for plantation establishment and matching of cultivar to the appropriate levels of water stress. There is also opportunity through trial work and breeding to take advantage of further leveraging this variable response to achieve higher DHA to sugar ratios.

- Statistical analyses of the Spring water-deficit trial, performed on one soil type and at two soil water contents ('well-watered' and 'droughted' treatments) showed different mānuka varieties have significantly different responses to drought conditions and as a result are more or less tolerant.
- Increasing root to shoot ratios are indicative of water deficit tolerance; one particular cultivar showed a significant increase in root to shoot ratio under limited water stress.
- One cultivar showed a significant increase of DHA:sugar ratio in well-watered soil.

- In field applications, differing physiological responses to water stress between cultivars have highlighted the importance of earlier planting times in areas of summer dry to allow for sufficient root development.

Temperature

Temperature does affect the measured qualities in mānuka. Different cultivar responses to temperature may present the opportunity to match high growth, flowering time, flower numbers, and nectar quality to new regions or sites. Further breeding and trial work can take advantage of these differences to create cultivars suitable for an increased set of site conditions.

- Controlled environment trials showed that both acute (short-term) and sustained (long-term) temperature treatment of clones have a greater effect on the quality (DHA/Total Sugar) of nectar produced rather than the quantity (yield). Nectar yield is not significantly affected by temperature changes, but there are clonal differences. Preliminary analyses indicate that some clones yield nectar with increased DHA/Total Sugar under sustained warmer temperatures.
- It is apparent in the Long-Term Temperature Experiment that there are significant differences in the clonal response to differing climate regimes.

Mycorrhizae

It is possible that inoculating seedling stock with high-quality fungal partners present at planting or in the nursery might help the establishment and performance of plantation mānuka, particularly in harsh sites where mortality is often high and growth rates poor. Notes on mycorrhizal genetics may allow further research to identify most useful and effective strains for mānuka.

- Mycorrhizal partners - the natural symbionts have been classified, their presence in nursery growing media assessed, and propriety media treatments considered. The sequences from the ITS region were predominantly classified in the phylum Ascomycota (61.7%), Basidiomycota (17.4%), Glomeromycota (5.6%) and Zygomycota (2.3%). A total of 17 fungal classes were recovered from DNA sequences. The most abundant classes were Dothideomycetes, Sordariomycetes, Agaricomycetes, Leotiomycetes, Eurotiomycetes, and Glomeromycetes in comparison to the other classes.
- Ectomycorrhizal fungi (ITS region): Due to the variability of the level of sequence in the ITS region, results were mainly evaluated at family level. Fifteen families of ectomycorrhizal fungi that have being previously listed for forming ectomycorrhizal association with L. scoparium were evaluated. *Thelephoraceae* was mainly the most abundant family in Rangitatau and Tutira. In Ruatiti, the family *Cortinariaceae* showed predominance in CVT1 and the family *Sarcosomataceae* in CVT4. The family *Russulaceae* was the most abundant in wild plants of *L. scoparium* in Ruatiti and its presence was also represented in wild plants of Rangitatau and Tutira. In cultivated plants the family *Russulaceae* was minimal, being present in CVT4 in Tutira.
- Arbuscular mycorrhizal fungi (SSU region): Eight families of arbuscular mycorrhizal fungi (*Acaulosporaceae*, *Ambisporaceae*, *Archaeosporaceae*, *Claroideoglomeraceae*,

Diversisporaceae, *Gigasporaceae*, *Glomeraceae* and *Paraglomeraceae*) were identified during the study. The predominant family was *Glomeraceae* followed by the family *Claroideoglomeraceae* in all the provenances in Rangitatau, Ruatiti and Tutira. However, wild plants of *L. scoparium* presented a similar proportion of these two families (*Claroideoglomeraceae*: 49.7%, *Glomeraceae*: 42.2%).

Attractiveness of bees to mānuka flowers

- The main driver of honey bee attraction to mānuka is nectar sugar content. Selecting plants with a high nectar sugar content will be important for keeping bees interested in mānuka. Clone lines showed a wide range of nectar sugar content. For instance, the content of sugar for pink provenance was 1.63 mg/flower in 2014 and 2 mg/flower in 2015. In contrast, the sugar content for yellow provenance was 0.93 mg/flower both measured years. Sugar content of nectar and the resilience of this variable in response to weather conditions, need to be key targets for any breeding or variety selection programme.

Scale insects

- Research has shown that it's unlikely that scale insects are worth controlling in a commercial plantation unless presence is excessive.

Best practice knowledge base for propagating, planting and managing mānuka plantations

- A field manual providing guidelines for sampling and monitoring of trial mānuka plantations has been developed. This manual is basis for the MFNZ Proving Service activities.
- The final Technical Notes were completed in June 2018. These technical notes are written to support Mānuka Farming New Zealand consultants and provide the basis of Mānuka Farming New Zealand's competitive advantage.
- The plantation trials have highlighted that picking the right cultivar for the right site is critical.
- The importance of eco-sourcing or development of late flowering cultivars has been highlighted by the programme, as the data shows increased harvestability risks associated with early spring flowering. Rainfall and low spring temperatures create dilution issues and lower nectar production quantities, on top of preventing bees from foraging effectively. Poor spring weather should be considered a major obstacle for nectar collection by bees with the negative effect on overall nectar flow quality.
- A Pest and Weed Management template has been developed for use by Mānuka Farming New Zealand on potential mānuka plantation sites. This information will assist landowners to understand potential complexities and budget for pest and weed control.
- The Site Information document has been updated for 30 June 2018 and presents tabular and graphical representation of the growth, nectar, and honey data available for the four main plantation sites and the Massey University Trial block. It also contains descriptions,

survival and growth information from 15 other mānuka trial sites located around the country.

- A protocol for taking nectar samples in the field has been developed and is in use by Mānuka Farming New Zealand. A training day was conducted for shareholders and interested parties on this technique. The method was applied successfully on the wild variety and yielded results consistent with samples by Massey technicians in plantation settings. The protocol is ready for use when requested by a MFNZ client.
- A protocol has been developed for the eco-sourcing of mānuka for locations without a suitable cultivar available or to meet the desires of a landowner. This protocol is held by MFNZ for use as needed.
- Mānuka Farming New Zealand website went live in February 2016 with details of the PGP programme and our services.
- A commercial consultancy is now available to land owners wishing to plant mānuka. MFNZ has commenced eco-sourcing as a service to complement the existing high performance mānuka varieties.
- TVNZ Rural Delivery episode on Saturday 2 April 2016 featuring the PGP and the Tutira plantation trial site and some of the learnings to date.
- Representatives from MFNZ, PF Olsen, and the Hawke's Bay Regional Council have been trained in the MFNZ protocol for nectar sample collection and have sampled at least three sites in the central North Island for nectar quality analysis. This will contribute to the eco-sourcing service being developed by MFNZ and enable a landowner to test nectar of local wild mānuka for DHA and sugar levels to locate appropriate seed sources if no CVT line is appropriate for that area or if the landowner decides against using mānuka lines external to the locale and/or purposefully bred varieties.
- Earlier research identified (albeit from a limited range of mānuka genetic material) that nearly 80% of the chemical compounds in leaves, which are more abundant in 'high' DHA lines, are flavonoids. Analysis of middle-positioned leaves from all four plantation sites across CVTs 1-4 indicates an even stronger correlation between both measurement techniques of leaf anthocyanins and nectar DHA, compared with the entire dataset as a whole. This suggests that further refinement of the leaf sampling techniques could provide enhanced accuracy or predictability of leaf sampling as an indicator of nectar DHA level. To develop a robust tool a significant, focused work package to address the gaps is needed and hence was unable to be completed within the time-frame and resources of the PGP programme.

A predictive model tool to identify mānuka honey yield and quality in different seasons and environments

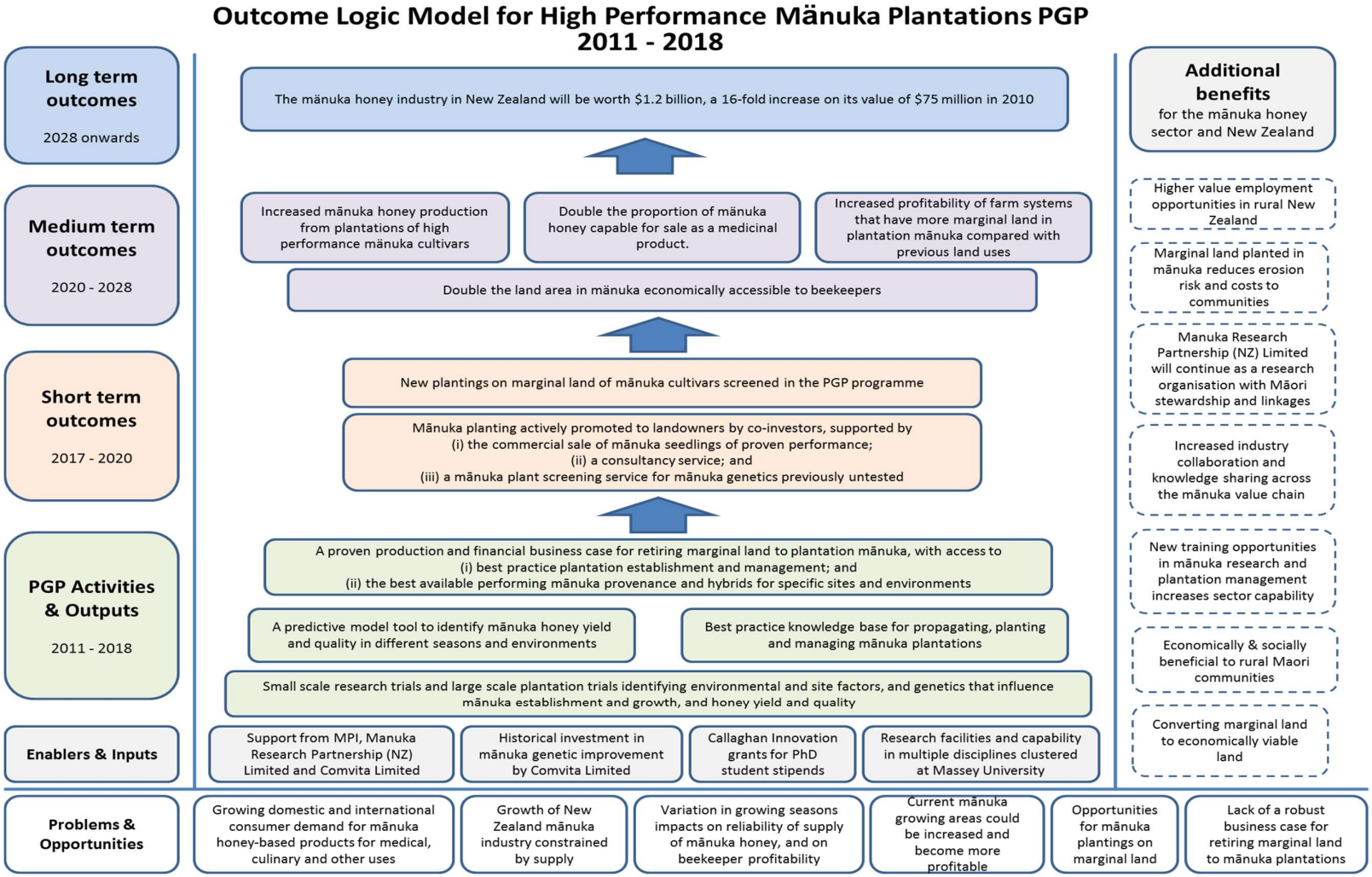
- A single secure database has been created which houses data collected from projects 1 through to 4. Early in the programme it was intended that modelling be essentially an empirical statistical exercise of mining the database.
- The commercial and technical requirements of the co-investors from the predictive tool(s) were documented.

- The basis of the predictive model was reviewed at the Programme's midpoint. Delays in achieving sufficient volumes of honey production data from the plantations had obviated the fitting of coefficients from data-base values. Instead, a more mechanistic approach has been adopted based on existing plant physiology growth models. These have, over the subsequent years, been partially parameterized for mānuka.
- A Functional Description of the predictive model was completed and included details on the measurements required to obtain parameter values. The Functional Description was suitable for coding into Excel and Visual Basic. The heart of the proposed model is the 3-PG modelling framework well established in forestry.
- A review was conducted of the full Functional Description of the predictive model for plantation mānuka by academics at Massey University independent of the PGP research, in Q2 2016/17. The reviewers supported the proposed modelling approach.
- Over the subsequent years, the necessary parameter values for mānuka have been measured for use in the 3-PG growth model.
- Parameter values have also been estimated to describe impacts on survival and growth of various pest and weed threats under different levels of management.
- Parameter values were estimated to describe all aspects of nectar harvest by honeybees and conversion to honey under competition from other insects and other nectar sources.
- An estimation of nectar production (nectar on offer) of a plantation has been incorporated into the honey harvest model to predict honey production and optimal hive stocking rates.
- NIWA weather records for 30 years across New Zealand were purchased and embedded in the model. A weather station protocol was developed to draw local weather records from the CliFlo database into the modelling calculations around bee flying times and honey harvestability.
- As of August 2018 the parameter values in the model are set from data available to date. Over time, with more observations, parameter values can be refined and more cultivars added. The model has been built with this expansion in mind.
- Historic apiary information from productive wild mānuka stands has been gathered for the Wanganui region, to act as a proxy for mature plantations and help in establishing the predictive accuracy of the tool which needs to predict nectar harvest from wild mānuka blocks adjacent to or within plantations.
- A working version of the predictive tool for mānuka plantations for honey has been transferred to MFNZ, complete with operator and administrator manuals. This includes financial outputs covering revenue, net cash flow, IRR, NPV.
- A Wild Apiary Survey Summary was conducted to identify regional drivers of differences in mānuka honey production, further clarify relationships between weather and honey quality as well as look at insect interactions and honey production. This survey also provided data to help model the relationship between nectar on offer and honey production and quality.
- Validation of the plant growth section of the model has occurred using mānuka trial plantings outside of the four main plantations.
- Usability testing and feedback was incorporated into the current model formatting as well as heightened software security around the use and sharing of the model post-PGP programme.

A proven production and financial business case for retiring marginal land to plantation mānuka, with access to (i) best practice plantation establishment and management; and (ii) the best available performing mānuka provenance and hybrids for specific sites and environments

- An indicative "first cut" financial business case (see the section on Economic Benefits) has been prepared but will require time to verify from actual data assembled from both PGP trials and the commercial field trials post PGP Programme.
- A mapping exercise of the North Island has been completed to identify potential blocks of land for mānuka plantation on LUC land classes 6, 7 and 8. Climate analysis was completed to assess for suitability for bee activity. This exercise will help MFNZ assess the potential land area for plantation mānuka and hence, the market potential of MFNZ, this information is included in the model.
- An NPV analysis has been set up by MFNZ and is being used commercially for mānuka plantation assessments (see also the section on Economic Benefits).
- MFNZ has set up a consultancy service for landowners wishing to plant mānuka for medical grade mānuka honey which includes expertise from a beekeeper, forestry and financial experts.
- The business case for retiring marginal land for plantation mānuka is unproven at this point of time with only one site producing mānuka honey in the lifetime of the PGP programme. This is mainly due to the immaturity of the plantations; further time and seasons are needed to deliver more robust technical and economic data to prove the business case.

Outcome Logic Model



Delivery of Outcomes

Short term outcomes/benefits 2017 - 2020				
Outcome	**Target for 2018**	**Progress towards target in 2018 /Actual**	**Status**	**MFNZ targets to 2020**
Mānuka plant sales and consultancy service available via MFNZ	MFNZ: 2 million seedlings sold and planted in 2018. Comvita: 1.6 million seedlings sold and planted in 2018.	Targets met. MFNZ: 700,000 seedlings + 1.8 mil seedlings via the Te Uru Rākau offer (total of 2.5 mil seedlings). MFNZ facilitated Te Uru Rākau's free mānuka seedling offer of 1.8 mil seedlings sourced from Kauri Park, Comvita, and MFNZ's stock. Comvita: 1.15 mil seedlings (c.72% of target)		2019 - 2,500,000 seedlings 2020 - 3,500,000 seedlings
	4 fee paying site visits	MFNZ has exceeded its target completing a total of 29 site visits. Of these 24 were completed for Te Uru Rākau's free mānuka seedling offer.		Up to 10 fee paying site visits per year.
	Eco-sourced mānuka plant screening service for mānuka genetics previously untested; 1 per year	Target met. 2 x mānuka plant lines have been introduced into Comvita's mānuka breeding programme. 1 additional line has undergone screening for nectar quality.		
New plantings on marginal land	MFNZ and Comvita 2018 combined target of c. 3,000 hectares.	Target met, noting contribution from Te Uru Rākau initiative. MFNZ: c. 2,273 hectares at 1,100 sph. Comvita: c. 1,000 hectares.		MFNZ 2019: 2,000 hectares MFNZ 2020: 2,700 hectares Expecting some sites to be planted at higher density than 1,100 sph.

Medium terms outcomes/benefits 2020 – 2028 [MFNZ]				
Outcome	**Target**	**Progress towards target**	**Status**	**Comments**
Increased land area in mānuka	MFNZ target of c. 9,600 hectares cumulative by 2020	Planted area of ca. 5,053 hectares for 2016, 2017 & 2018 combined based on 1,100 sph.		At 52% of 2020 target at end of 2018.
	10-15% of market share	MFNZ had c.10% and Comvita 13% of the market share of seedling sales, respectively, in 2017 based on MPI estimates of 9.2 million mānuka seedlings sold and planted in 2017.		Await MPI annual forestry nursery survey report for 2018 (due Feb 2019).
Increased mānuka honey production from plantations vs. wild stands	Increased yield of mānuka honey per hectare (kg) – derived from hives per hectare and honey yield per hive	Mānuka honey yield from the Tutira plantation (4-6 years old) of c. 140 hectares in 2017/18 was 7.0 kg per hectare. Mānuka honey yield from a neighbouring wild mānuka stand in 2017/18 was 9.5 kg per hectare. This result shows promise that honey yields from mānuka plantations should be able to at least match, and potentially surpass that of wild stands as the plantations mature.		Further data needs to be collected post-programme to demonstrate proof of concept as this was not achievable in the life of the programme.

Double the % of mānuka capable for sale as a medicinal product	Mānuka honey that meets the MPI definition for monofloral mānuka honey and > UMF® 10+	Honey samples from the mānuka plantation at Tutira taken at the end of the mānuka flowering period in 2017/18 season met the MPI standard for monofloral mānuka honey. Accredited laboratory projections predict UMF® values of UMF®14 to UMF®28 if the honey were stored. UMF® values exceeding UMF®10 are required for mānuka honey for medical use. A local wild mānuka site produced mānuka honey of a similar fresh UMF quality, but half of the DHA concentration, with a projected UMF® value of 13-14 following storage.		This finding, albeit from one season and one site only, shows promise that carefully selected and managed plantation sites with cultivars of high nectar DHA can deliver monofloral mānuka honey with high UMF values. Further data needs to be collected post-programme to demonstrate proof of concept as this was not achievable in the life of this programme.
Increased profitability of farm systems	A working version of the predictive tool for plantation mānuka, including NPV analysis for plantation mānuka and other land uses.	Partially validated working version of the predictive model delivered in June 2018. Preliminary NPV analysis completed for plantation mānuka, dairy and sheep & beef farming. Forestry NPVs not completed due to significant regional variances and a comparison not able to be done within the resources allocated.		The model's parameter settings will continue to be validated by MFNZ post-programme as more data becomes available from MFNZ client's maturing plantations.
	Feasibility of productivity gains confirmed.	Indicative data only – no proof of concept.		Further work needed post-programme.

Long Term Outcome: 2028 onwards			
Long Term Outcome	**Progress towards outcome**	**Status**	**Comments**
The mānuka honey industry in New Zealand will be worth $1.2 billion by 2028 (from a baseline of $75 million in 2010)	The original target and projections were for the New Zealand mānuka honey industry to be worth $ 1.2 billion by 2028. This included the value of honey from wild mānuka stands as well as plantation mānuka. The programme has re-estimated the potential growth and value of mānuka honey from plantations only. The Programme estimates that the value to New Zealand of mānuka honey from plantations could reach $100 to $150 million by 2028, 10 years post completion of the programme. This is based on expectations that (i) some plantings will use the knowledge from the PGP programme, whilst others will not, and (ii) the One Billion Trees Programme will assist with and increase the rate of planting of mānuka for honey.		

Benefits of the Programme

Survey of Clients of Mānuka Farming NZ limited

A survey was conducted in late 2018 to align with the end of the programme with some of MFNZ's larger clients. The objective of the survey was to understand their experience working with MFNZ and if they had seen value from the research conducted in the PGP Programme. The MRPL shareholders were excluded from the survey.

A range of 10 clients (note: none of the interviewees were MRPL or MFNZ shareholders) from beekeepers to large and small land owners were interviewed over the phone. Each call was roughly 1-hour long. Although there were 8 questions in total asked of each client the questions led onto other points of discussion regarding the mānuka honey industry and its risks and opportunities. The key messages which came through were as follows:

- 95% of clients interviewed were aware of the High Performance Mānuka Plantations PGP Programme as well as individual MRPL Shareholder activities in plantation mānuka.
- All believed that the PGP had started to contribute to the growth of the mānuka honey industry. However most believed that overall growth would be slower than the programme's original forecast.
- All believed that, environmentally, plantation mānuka was a good alternative land use to existing land uses specifically sheep and beef and radiata pine forestry, and had the opportunity to diversify income streams and spread income risk. It was also noted several times that plantation mānuka was a valuable option for carbon farming and retiring parts of the farm that were no longer in production or returning value.
- All said that seedlings supplied by MFNZ were of good/exceptional quality and one noted that where an issue occurred it was resolved quickly.
- All agreed that they were very likely to recommend MFNZ to other landowners wishing to establish a mānuka plantation.
- While most noted that communication was excellent and professional during the order taking and delivery of the seedlings, there was a general feeling that follow-up communication was lacking such as asking how good plant survival was. The feedback also included the belief that MFNZ was in a position through its relationships with Government and industry partners, to communicate relevant changes in Government policy and processes, and recent activities in the mānuka honey industry as they occurred.
- Most clients felt there was not enough face to face visits by MFNZ.
- One area of knowledge where landowners thought could be better was post planting spray releasing of plantation sites.

Overall, the feedback received covering MFNZ services was very positive.

Projected Economic Benefits from Plantation Mānuka

Background

At the start of the PGP Programme in 2011, the potential value from mānuka honey produced from plantation mānuka and existing wild mānuka stands was projected to be $1.2 billion by the year 2028.

This was broadly based upon productivity gains assumed possible through:

- Doubling of hives per hectare carrying capacity on mānuka throughout New Zealand;
- Doubling of the average yield of a hive;
- Doubling of the proportion of mānuka honey capable of sale as medical grade mānuka honey; and
- Doubling of the land area in mānuka economically accessible to beekeepers.

It is important to note that two major initiatives launched by Government during the lifetime of this PGP Programme are significantly impacting the potential growth of the New Zealand mānuka honey industry, namely (i) the definition of mānuka honey for the purpose of exports; and (ii) the One Billion Trees Programme. These initiatives are having an impact, both positive and negative, on landowner decisions around planting mānuka for honey, and it will be some time before there is clarity on the overall growth of the mānuka honey industry. Therefore, it is very difficult to forecast industry growth, and the long term outcomes and benefits of this PGP Programme.

Notwithstanding the comments above, and with new information that has come from the High Performance Mānuka Plantations PGP Programme and the passage of time, the projected value of the plantation mānuka industry[1] has been revised, with the assumptions and basis of this revision included below.

The revised estimates have been made for the potential growth and value of the New Zealand plantation mānuka honey industry only.

The programme has not attempted to re-estimate the value of mānuka honey produced from wild stands due to the inadequacy of data available.

Revised estimates of the potential value of the New Zealand plantation mānuka honey industry

The potential economic benefits from the PGP Programme are dependent largely on two factors, which themselves interact:

1. The extent to which the lessons from the PGP Programme are applied across all of the mānuka plantations developed; and
2. The area that gets planted in mānuka for honey production.

[1] The value of mānuka honey is estimated at NZ Inc. level and includes export value at fob level and domestic market value at retail level. Mānuka honey prices in these estimates are weighted at 80% volume being exported and 20% volume being sold on the domestic market, based on likely market demand.

Two scenarios (conservative and optimistic) are presented to provide an indication of the potential growth and economic value of the New Zealand plantation mānuka honey industry. It is assumed in both scenarios that all of the lessons learnt from the High Performance Mānuka Plantations PGP programme are applied.

Assumptions used in the analysis

The production and financial variables used for plantation mānuka are described in Table 4.

Table 4: Production and financial variables used for plantation mānuka

Variable		All PGP learnings are applied	Comments *[Refer to Programme Goals & Outcomes section of this report for more details]*
1	Number of hives per hectare	2.0	Based on learnings from the PGP programme, a hive density of two hives per hectare is deemed possible through the increase in nectar on offer to bees as a result of the use of elite cultivars in a mānuka plantation, coupled with smart plantation design that incorporates companion planting, and skilled apiary management.
2.1	Honey yield (kg) per hive *(refer Note 1)*	35.0-40.0	An extended mānuka flowering season (via the use of sequentially flowering mānuka lines) aligned with the time of bee foraging and combined with the absence of competing nectar sources is possible in some plantation situations. It is acknowledged that a full range of elite cultivars to extend the flowering season is not yet available but selection is underway. These estimates are averages projected over many seasons and locations within New Zealand.
2.2	Resultant honey yield (kg) per hectare	70.0-80.0	
3.1	% of honey harvested from all mānuka plantations that may be mānuka honey (*refer Note 2*)	Rough estimate 75%	In theory, the quality of mānuka honey from plantations (as measured by monoflorality and UMF®, MGO™ or equivalent industry grading systems) can be increased by using mānuka provenances and cultivars capable of producing nectar with high levels of dihydroxyacetone (DHA), in the right combinations, and plantations of sufficiently large size, with the absence of competing nectar. However, in some situations and seasons due to climatic and other factors, this may not be achieved for all mānuka plantations despite the application of best practice.
3.2	% of mānuka honey harvested from all plantations that may be capable of meeting medical grade requirements (*refer Notes 2 and 3*)	Rough estimate 75%	
4.1	$ per kg for medical grade mānuka honey at NZ Inc. level *(refer Note 4*)	$70.00	The value of mānuka honey per kg from plantations at NZ Inc. level will be greater than the price paid to beekeepers. Refer to Note 4.
5	$ per hectare for medical grade mānuka honey at NZ Inc. level *(refer Note 5)*	Approx. $3,000	The value of mānuka honey per hectare from plantations at NZ Inc. level will be greater than the price paid to beekeepers. Refer to Note 5.

Notes to Table 4

1. The 10 year New Zealand average honey yield per hive (2008-2017) for all honey types is 30.9 kg per hive. *Source:* MPI Apiculture Monitoring Report 2017.

   Honey yields from wild mānuka stands are reported to range from 15 to 52 kg per hive, with an average of 23 kg per hive. Source: The Mānuka and Kanuka Plantation Guide (April 2017), prepared by Boffa Miskell Limited. pp. 78.

2. With mānuka plantations for honey production being a developing industry, only rough estimates can be proposed for the proportion of the honey harvested from all future plantations that might meet (i) the MPI definition for mānuka honey, and (ii) the requirements for medical grade mānuka honey. These estimates are indicative only.

3. Mānuka honey exceeding UMF®10 based on the UMFHA industry grading scheme is regarded as medical grade. Conversion of dihydroxyacetone (DHA) to methylglyoxal (MGO) in mānuka honey continues during storage. Tests are usually undertaken on fresh honeys to assess their potential UMF® values following defined periods of storage.

4. $ per kg of honey at NZ Inc. level. This will be higher than prices paid to beekeepers. This is estimated at $70 per kg for UMF®10-12+ mānuka honey based on export and NZ retail value in 2018.

   A price of $60 per kg (2018 price levels) is proposed (based on information provided by the programme partners) for fully compliant UMF®10+ mānuka honey as the value of the honey at the NZ border (fob price), packed, labelled and ready to be dispatched overseas. A review of NZ retail/on-line honey prices indicates an average of $100 per kg for compliant UMF 10+ mānuka honey.

   Using a weighted approach of 0.8 (80% export) x $60 + 0.2 (20% NZ domestic market retail) x $100 = $68 per kg. Rounded up to $70 per kg for a general estimate for UMF®10+ mānuka honey reflecting export and NZ domestic market retail value for mānuka honey (NZ Inc. value).

5 The estimated revenue per hectare for medical grade mānuka honey from mānuka plantations is at NZ Inc level. This estimate does not include mānuka honey which does not meet medical grade. Rounded numbers are used.

Scenarios

For this analysis, full honey production for plantation mānuka is assumed to commence from year 7 after planting. In practice, some plantations will start producing honey for harvest from year 4 after planting. There will also be plantations where full honey production may not be reached until year 10-12 after planting. Hence Year 7 acts as a balance point to create an easy-to-understand model for honey production from plantations.

Scenario 1 (Conservative scenario) - Assumptions

- All of the lessons learnt from the PGP programme are applied and on-going learnings are also implemented.
- A full range of elite cultivars is available to suit all major microclimates in most major plantable regions of New Zealand for all relevant flowering periods. This situation does not yet apply.
- One Billion Trees Programme is in place.
- Future annual mānuka planting rate on an area basis remains stable at 2016 and 2017 levels (i.e. 6,000 hectares per annum), helped by the One Billion Trees Programme and other grant schemes for planting trees.

Scenario 2 (Optimistic scenario) - Assumptions

- All of the lessons learnt from the PGP programme are applied and on-going learnings are also implemented.
- A full range of elite cultivars is available to suit all major microclimates in most major plantable regions of New Zealand for all relevant flowering periods. This situation does not yet apply.
- One Billion Trees Programme is in place.
- Future annual mānuka planting includes the baseline of 6,000 hectares proposed in Scenario 1, plus mānuka will account for 30% of the additional tree planting in the government's targeted increase in trees planted over the 10-year period 2019 – 2028 under the One Billion Trees Programme.

Table 5: Annual planted area (hectares) in mānuka under scenarios 1 and 2 for the period 2016 to 2035

Annual Area Planted (ha)																				
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Scenario 1	6,300	5,900	4,600	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Scenario 2	6,300	5,900	4,600	7,640	11,498	15,357	15,357	15,357	15,357	15,357	15,357	15,357	15,357	6,000	6,000	6,000	6,000	6,000	6,000	6,000

Figure 1 below shows the annual planted area in mānuka under the optimistic Scenario 2, where mānuka plantings include the annual baseline of 6,000 hectares (as in Scenario 1) and also include 30% of the additional trees planted above the 2016 and 2017 base line for all tree plantings between 2019 and 2028, incentivised by the 1 Billion Trees Programme.

Figure 1: Projected annual planted area in mānuka under Scenario 2, 2016-2035.

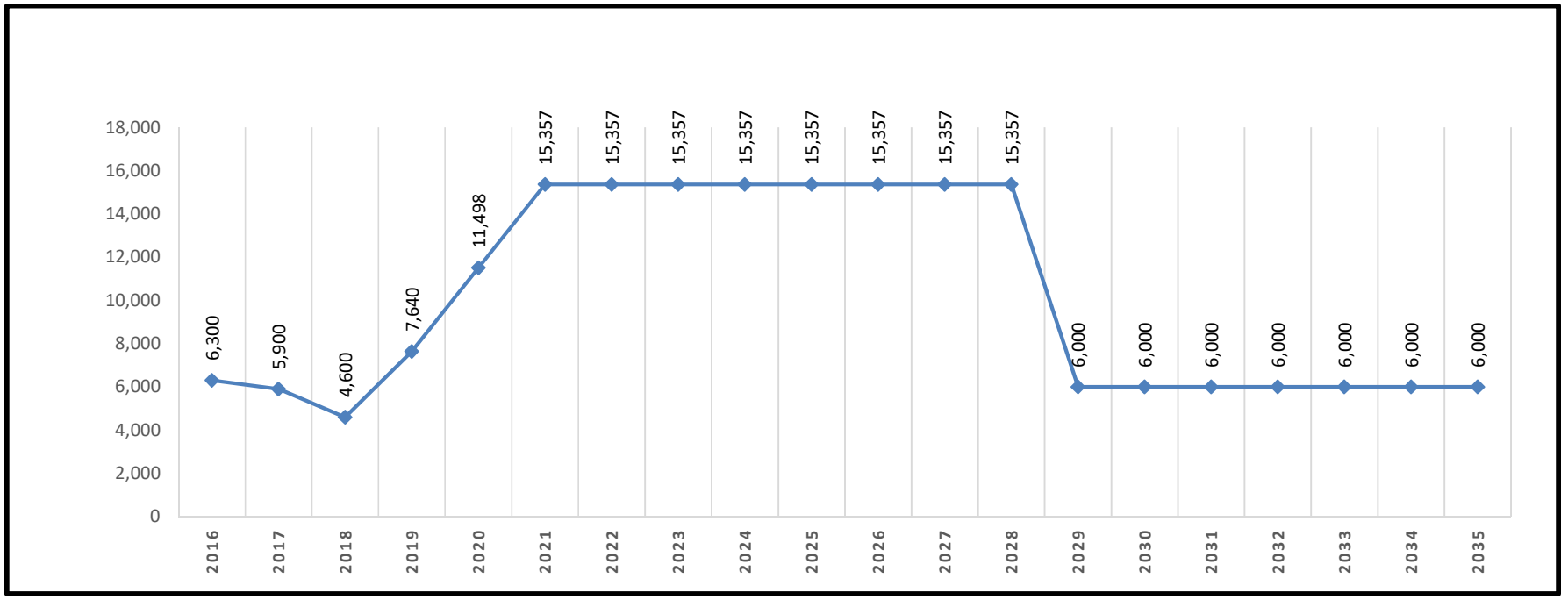

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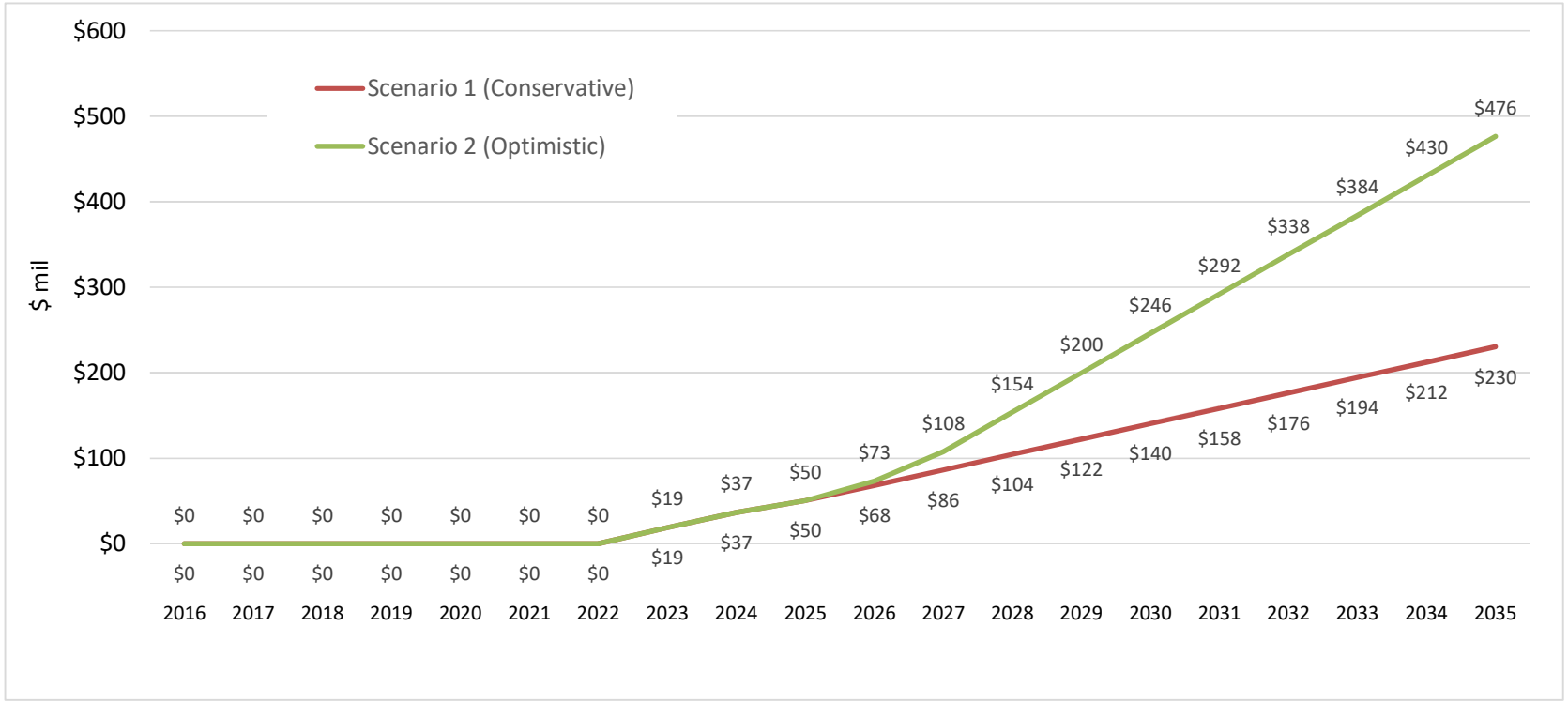
Table 6: Cumulative planted area (hectares) in mānuka under scenarios 1 and 2 for the period 2016 to 2035

Cumulative planted area (hectares)																				
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Scenario 1	6,300	12,200	16,800	22,800	28,800	34,800	40,800	46,800	52,800	58,800	64,800	70,800	76,800	82,800	88,800	94,800	100,800	106,800	112,800	118,800
Scenario 2	6,300	12,200	16,800	24,440	35,938	51,295	66,652	82,009	97,366	112,723	128,080	143,437	158,794	164,794	170,794	176,794	182,794	188,794	194,794	200,794

Figure 2: Projected cumulative value ($mil) of mānuka honey produced from mānuka plantations under scenarios 1 and 2 for the period 2016 to 2035



The programme partners anticipate that the growth and value of the mānuka plantation industry is likely to be in the range between Scenarios 1 and 2. This is based on expectations that (i) some plantings will use the knowledge from the PGP programme, whilst others will not, and (ii) the One Billion Trees Programme will assist with and increase the rate of planting of mānuka for honey.

Our projections indicate that the value of mānuka honey from plantations could reach approx. $100 to $150 million by 2028, ten years' post-completion of the programme.

It should be noted that mānuka honey from wild stands will continue to be harvested. The lack of transparent and robust data on wild mānuka stands has meant that it is not possible to estimate this portion of the industry separately, and with sufficient certainty to report on it here. The PGP programme has concentrated its efforts on plantation mānuka honey alone.

Economic Comparisons of Plantation Mānuka vs Other Land Use Options

Information generated by the programme will help landowners make choices about plantation mānuka for honey as a potential land use. The programme has generated land use comparative data for plantation mānuka, sheep and beef, and dairy. Land use comparative data against traditional forestry (mainly pine) will be developed post-programme – lack of resourcing prevented completion of this work during the programme.

Table 7: Land use scenarios assessed

1	Dairying
2	Sheep and Beef (Class 9 – All Classes – All New Zealand)
3	Plantation mānuka (4 scenarios):
3.1	Plantation mānuka (no Establishment Costs) – with 30% of harvested honey revenue to landowner
3.2	Plantation mānuka (no Establishment Costs) - with 50% of harvested honey revenue to landowner
3.3	Plantation mānuka- With Establish. Costs - with 30% of harvested honey revenue to landowner
3.4	Plantation mānuka- With Establish. Costs - with 50% of harvested honey revenue to landowner

For the plantation mānuka scenarios, it is assumed that the learnings from the PGP Programme are fully applied. The assumptions are outlined below and are similar to those used in the broader benefits estimates except that honey prices are based on prices paid to beekeepers and then split with landowners.

1. Full (100%) honey production from year 7 after planting. In practice, some plantations will start producing honey for harvest from year 4 after planting. There will also be plantations where full honey production may not be reached until year 10-12 after planting. This assumption allows for simplified and easy-to-understand analysis of the projections.
2. The planted area is heavily dominated by the planted varieties with limited overgrowth or incursion by local wild type mānuka.
3. Hives per hectare = 2 hives per hectare.
4. Average yield per hive of 35 to 40 kg per hive = 37.5 kg per hive.
5. Percentage of the total honey produced that is mānuka honey = rough estimate of 75%.
6. Percentage of mānuka honey produced that is capable of meeting requirements of medical grade mānuka honey = rough estimate of 75%.
7. Price paid to beekeepers for medical grade mānuka honey = $40.00 per kg[2]
8. Price paid to beekeepers for non-medical grade mānuka honey and non-mānuka honeys = $10.00 (as a general average)[3]

[2] Price paid to beekeepers for fully compliant UMF®10+ mānuka honey. Price estimate information provided by programme partners mid-2018.
[3] Price estimate information provided by programme partners mid-2018.

9. No returns from carbon credits for mānuka have been included in the analysis.
10. Calculations based on a 20-year period and a discount rate of 8%.
11. The cost of land is excluded from the NPV analysis.
12. Provision for expenditure on pest and weed control has been made at $50 per hectare from Years 1-5 as the plantation is established, and $5 per hectare for every year thereafter.
13. Fixed overheads have been assumed to average $ 7,950 per year for a 100-hectare plantation site. These overheads include apportionment for rates; accountancy, legal fees, and other specialist services; mānuka plantation insurance; and fees for regular professional monitoring/management of the plantation by a forestry company.

Table 8: Further details of the mānuka plantation scenarios

Plantation mānuka (no Establishment Costs) - 30% revenue share to landowner	This is where the (assumed) establishment costs of $2,500 per hectare is not included in the cash flow projections, and where the landowner gets a 30% share of the gross revenue (yield x wholesale price) received by the beekeeper. The establishment costs have been excluded for 2 reasons: (1) these have not been included for dairy and sheep and beef farming scenarios and (2) to account for the situation where the establishment costs are covered by external funding (e.g. Central or Regional Government).
Plantation mānuka (no Establishment Costs) - 50% revenue share to landowner	This is where the (assumed) establishment costs of $2,500 per hectare is not included in the cash flow projections, and where the landowner gets a 50% share of the gross revenue received by the beekeeper. The establishment costs have been excluded for 2 reasons: (1) these have not been included for dairy and sheep and beef farming scenarios and (2) to account for the situation where the establishment costs are covered by external funding (e.g. Central or Regional Government).
Plantation mānuka With Establishment Costs (30% revenue share)	This is where the (assumed) establishment costs of $2,500 per hectare has been included in the cash flow projections, and where the landowner gets a 30% share of the gross revenue (yield x wholesale price) received by the beekeeper.
Plantation mānuka With Establishment Costs (50% revenue share)	This is where the (assumed) establishment costs of $2,500 per hectare has been included in the cash flow projections, and where the landowner gets a 50% share of the gross revenue (yield x wholesale price) received by the beekeeper.

Table 9: Metrics used to compare the different land uses

	Metric	Explanation
1	First Year of net positive cash flow (Annual)	The first year in which revenue exceeds expenditure
2	First Year of net positive cash flow (Cumulative). This is the same as the first year of break-even.	The first year in which all accumulated revenue since the year of establishment exceeds all accumulated expenditure since the year of establishment
3	Cumulative Nominal Cash Flows over a 20 year period for a 100 hectare unit	The unadjusted cash flow accumulated over a 20 year period for a 100 hectare unit
4	Cumulative Nominal Cash Flows over a 20 year period per hectare	The unadjusted cash flow accumulated over a 20 year period and then averaged on a per hectare basis for that 20 year period
5	Avg (Average) nominal return per ha per year over 20 years	The unadjusted cash flow accumulated over a 20 year period and then averaged on a per hectare and averaged for each year.
6	Net Present Value (NPV) of the nominal cash flows over a 20 year period for a 100 hectare unit	The unadjusted cash flow accumulated over a 20 year period for a 100 hectare unit
7	Net Present Value (NPV) of the nominal cash flows over a 20 year period per hectare	The unadjusted cash flow accumulated over a 20 year period and then averaged on a per hectare basis for that 20 year period

Table 10 below shows the cash flows and NPV figures comparing dairy, sheep and beef with several potential plantation mānuka arrangements.

Table 10: An assessment of plantation mānuka against other land uses. All the plantation mānuka options assume that the learnings from the PGP programme are fully implemented.

Land Use Option	Key Metrics							Ranking of NPV
	❶		❷		❸	❹		
	First Year of Positive Returns	First Year of Break-even	Cumulative Nominal Cash Flows over 20 yr Period		Avg per ha / yr over 20 yr period	Net Present Value (NPV) Over 20 yrs (8%)		
			100 ha	Per ha		100 ha	per ha	
Dairy	Yr 1	Yr 1	2,321,771	$23,218	$1,161	$1,139,774	$11,398	1
Manuka (no Establishment Costs) - 50% to landowner	Yr 7	Yr 7 - 8	1,018,563	$10,186	$509	$346,489	$3,465	2
Sheep and Beef	Yr 1	Yr 1	415,963	$4,160	$208	$204,199	$2,042	3
Manuka (no Establishment Costs) - 30% to landowner	Yr 7	Yr 7 - 8	532,938	$5,329	$266	$166,278	$1,663	4
Mānuka - With Establish. Costs (50% share)	Yr 7	Yr 10 -11	768,563	$7,686	$384	$96,489	$965	5
Mānuka - With Establish. Costs (30% share)	Yr 7	Yr 13 - 14	282,938	$2,829	$141	-$83,722	-$837	6

Notes

1. Source: Dairy New Zealand Economic Survey 2015-16 at https://www.dairynz.co.nz/publications/dairy-industry/dairynz-economic-survey-2015-16/

2. Source: Beef & Lamb's Sheep and Beef Farm Survey at http://www.beeflambnz.com/data-tools/sheep-beef-farm-survey Figures used for based on average 5 year period from 2013 – 2018

3. The analysis of the mānuka options was done by Mānuka Farming NZ Limited with input from Massey University and MPI.

In terms of NPV analysis, dairy provides the best returns overall and on a per hectare basis.

Plantation mānuka for honey is able to out-perform sheep and beef farming (average over all farm classes) where all of the estimated establishment costs of $2,500 per hectare are covered via a grant or suchlike, and the gross honey revenue share to the landowner from the beekeeper is 50%. A drop in the gross honey revenue share in this instance to 30% showed that plantation mānuka might only match sheep and beef farming on poorer performing land.

It should be noted also that the first year of positive cash flow and the first year for break-even to occur takes longer for all mānuka land use scenarios than for the other land uses analysed.

The land use comparison above is merely that – a simple comparison for information. Although outside of the scope of the PGP programme, it is envisaged that for effective and profitable land use, you are more likely to prosper by having an optimal **mix** of elite plantation mānuka along with wild mānuka stands, and timber/carbon forestry. There are land-use synergies on offer which should mean that such a mix of land use provides a better return than either one or the other, primarily by providing a diversity of income streams and better managing risk.

Additional and spillover benefits

- At least two qualified PhD scientists working in New Zealand research.
- Employment opportunities in rural New Zealand for planters, nurseries and beekeepers. The nurseries used by MFNZ have increased staff on their seeding and packing lines. There was a significant shortage of planters for 2018 planting year. The industry is going to need more people willing and able to plant trees.
- MRPL intends to continue research through its commercial arm MFNZ.
- MFNZ has employed 4 people each based in different areas throughout the North Island with skills covering project management, plantation design, plantation establishment and management, apiary health, bee nutrition and management.
- MFNZ is growing its linkages and stewardship with Maori having developed a Maori business and engagement strategy working with TPK, MPI and Regional and District Councils.
- Continued sharing and collaboration of knowledge across the mānuka value chain.
- MFNZ will speak at the 2019 Apiculture Conference in collaboration with Massey University.

Conclusions / Recommendations

After seven years of research and associated commercialisation activity, we know a great deal more about mānuka functioning in a plantation environment for the purposes of honey production.

- An elite mānuka variety, planted in a new location, will produce nectar as rich in dihydroxyacetone (DHA) as in its home location.
- Most important for high UMF® honey is the dominance of mānuka over other nectar sources throughout the bee foraging area. Plantations must be large, must survive and must thrive.
- Despite its role in the wild as a pioneering species, mānuka thrives best on moist, fertile soils.
- Plantations must flower when the weather is most likely to be conducive to bees flying. In some circumstances, plantations may best be suited to augmenting wild mānuka populations to achieve more regular and exceptional harvests.
- Nearly every plantation needs multiple mānuka varieties, each in exactly the right niche, to support the right plantation design for that site to produce high quality mānuka honey.
- Nearly every plantation will benefit from careful mixed use with local wild mānuka and/or with timber or carbon tree species – the synergies can be strong and will maximize plantation value.
- An increased level of management of pests and weeds, both before and after planting, is required for plantation mānuka compared to traditional *Pinus radiata* forestry.
- Many influences can reduce the economic viability of a plantation including pests, weeds, drought, floods, wind, mistimed flowering, presence of other dominant nectar sources, wasps or competition from neighbouring beekeepers. With skill and knowledge, these can be anticipated and managed over the lifetime of a plantation despite seasonal variations and challenges.

Based on a simple NPV analysis (excluding the cost of land), and assuming the learnings from the Programme are fully implemented, plantation mānuka for honey is able to out-perform sheep and beef farming (average over all farm classes) where all of the estimated establishment costs of $2,500 per hectare are covered via a grant or suchlike, and the gross honey revenue share to the landowner from the beekeeper is 50%. A drop in the gross honey revenue share in this instance to 30% showed that plantation mānuka might only match sheep and beef farming on poorer performing land. Note that plantation forestry (typically *Pinus radiata*) was not included in this NPV analysis.

In hindsight many of these findings seem obvious. But none had been proven in 2010. The Programme has compiled an extensive volume of technical notes to aid in plantation mānuka husbandry. The most important conclusion reached is that the best way to ensure a good return from planting mānuka for honey is to first procure very good and detailed advice. Good plantation establishment requires the right choices for site preparation and selection of cultivar. Advice should be sought on ongoing pest, weed, and plantation management. Excellent apiary management is critical to success as well as understanding the natural variability and seasonality in honey production. Beekeeper expertise and local knowledge is also critical to plantation success. The PGP programme has delivered the platform for continued development of the tools and information necessary to create a successful mānuka plantation industry in New Zealand.

PGP Outputs

All MRPL shareholders and co-investors in the PGP programme will have access via a Dropbox folder of each of the deliverables including final copies of key reports, industry guides, technical guides, academic papers, promotional material, media publicity, pamphlets and all other documentation relevant to the High Performance Mānuka Plantations PGP Programme from the 1st of September 2018 until 20th of January 2019. Shareholders will be given notice when completed deliverables are available and when the Dropbox folder will be closed.

The mānuka plantation predictive model, user manual and administration manual, and the database will be held by MRPL and not sent to the co-investors. Co-investors will be able to access use of these tools for their own properties for free through MFNZ. Comvita Limited will receive a copy.

The Programme has generated a lot of knowledge about mānuka planting, growth and nectar production. But significant knowledge gaps exist in bee foraging behaviour. For the predictive model to work to the best of its ability, it must be fed good information on insect competition and competing floral sources over a 20-year period into the future. This is an area where further research is necessary to realize the value of the predictive model.

The following are a list of the key deliverables from the programme.

1. Nectar sampling protocol (for researchers)
2. Nectar sampling kit and field manual (for landowners & others)
3. Guidance on nectar analysis and interpretation
4. Technical Notes for Plantation Mānuka
5. Trial site information report
6. Research Field Manual
7. PGP Mānuka Trial Site register
8. Gorse control – agrichemical applications
9. Weed and Pest management Plan template for Plantation Mānuka
10. Database / Data warehouse
11. Weather station download protocol
12. Filter Paper Wick Method for sampling nectar from mānuka
13. Predictive model for plantation mānuka – Version as of 30th June 2018 (access through MFNZ)
14. Functional Description of the predictive model for plantation mānuka - Version 2
15. Database for all data collected for the life of the programme
16. Commercial findings to date from PGP
17. Mānuka leaf sampling as an indicator of mānuka nectar quality potential
18. Dualex leaf sampling protocol
19. Sampling Protocol for Eco-sourced Mānuka
20. HPLC Method for Analysing DHA in nectar
21. Quarterly Progress Reports from Massey and Programme Manager
22. Quarterly Financial Reports
23. Quarterly Public Progress Summary
24. Pest and weed plans for 4 main trial sites
25. Mānuka Variety Library report
26. Thesis - Influential Factors in Nectar Quality and Yield in *Leptospermum scoparium*
27. Thesis – Companion biota associated with *Leptospermum scoparium* (mānuka; *Myrtaceae*)

28. Published research paper: Nickless, E.M., Holroyd, S.E., Stephens, J.M., Gordon, K.C. and HPLC Method for Analysing DHA in nectar *L. scoparium* and generate predictive models for screening for dihydroxyacetone levels in floral nectar. Journal of Raman Spectroscopy 45 (10): 890-894.
29. Published Research Paper - Harrington, K. C., Nurhayati, R. H., & Millner, J. P. (2015). Field assessment of herbicides to aid establishment of manuka (Leptospermum scoparium). New Zealand Plant Protection, 68, 132-138.
30. Published Research Paper - Hamilton, G.; Millner, J.; Robertson, A.; et al. 2013. Assessment of manuka provenances for production of high 'unique manuka factor' honey. Agronomy New Zealand, 43, 139-144
31. An oral poster presentation at the combined NZIAHS & NZIAPB 'Plants for the Future' Conference (1-3 July 2015 at Massey University, Palmerston North) "Genetic Constraints of High Performance Mānuka".
32. A poster titled Are Arbuscular mycorrhizal fungi drivers of Mānuka Honey was designed to present in the Fungal Genetics Conference the 3 April 2016 in Paris by the PGP PhD student.
33. Four presentations were given by Massey students and staff and two by Comvita employees at the "Mānuka the Plant" conference workshop held in July 2017 at Massey University.
34. Paper – Analytical FT-Raman spectroscopy to chemotype *Leptospermum scoparium* and generate predictive models for screening for dihydroxyacetone levels in floral nectar
35. Paper - Soil influences on plant growth, floral density and nectar yield in three cultivars of Mānuka
36. Paper entitled "High UMF® honey production from mānuka plantations" was presented at the Hill Country Symposium held in April 2016.
37. Paper- High UMF® honey production from mānuka plantations.
38. Paper (draft)- Honey bee visitation study
39. Paper (draft) - Mycorrhizal fungal study
40. Paper - Scale insect survey study
41. Land use comparison model
42. Report - Evaluation of mānuka for companion riparian and irrigation shelter plantings
43. Report – Industry size and Land Use Comparison
44. Report – Testing of the mānuka model
45. Report – Review of the mānuka model
46. Report - Projected benefits
47. PGP Communications plan
48. In-kind reporting protocol and process
49. Final Programme Report

Intellectual Property

MRPL is continuing to commercialise the IP by making it available to NZ Inc. through its commercial arm, Mānuka Farming NZ Limited. Mānuka Farming NZ Ltd now provides a complete end-to-end service for the establishment and management of mānuka plantations for high quality mānuka honey in New Zealand. This will maximise the benefit of the PGP programme to New Zealand through commercialisation and distribution of the IP through MFNZ services.

The below Intellectual Property register includes all IP brought into and developed within the Programme. A review of the IP register was conducted by Comvita's IP specialist and it was found that nothing could be protected as a trade secret or patented method due to the publication of most of the materials and methods.

A paper entitled "PGP IP including the rights, obligations and restrictions of each shareholder in regard to the IP" that was tabled at both MRPL Board meeting and the PSG meeting held in May 2018 is attached in Appendix 5

INTELLECTUAL PROPERTY REGISTER												
IP Title	**Short Description of IP**	**IP Type/Format e.g. Data; know-how; standard operating procedure (SOP); IT; new plant material; technology/equipment, etc.**	**Date IP Developed**	**Date Introduced**	**Creator/ Authorship**	**Owner of the IP**	**Source? e.g. which PGP project was this developed from**	**How is the IP protected/controlled/ managed by the co-investors?**	**Is the IP being made available?**	**How is the IP being made available?**	**COMMENTS**	**Distribution so far**
Background IP												
Mānuka seed provenances	CVT 1, 2, 3, 4 and 6	New plant material - Selections of *Leptospermum scoparium*	2005-2011 (pre-PGP)		Comvita Limited	Comvita Limited	Pre-PGP	No PVRs. Licence and supply agreement between MRPL and Comvita Limited for mānuka seedlings and cultivars.	Yes	Sale of plants by MFNZ and Comvita Limited		MFNZ, Massey, and clients who have signed a purchase agreement

Mānuka cultivars	Ten cultivars of *Leptospermum scoparium*	New plant material - Clones of *Leptospermum scoparium*	2005-2011 (pre PGP)		Comvita Limited	Comvita Limited	Pre-PGP	Some PVRs. Licence and supply agreement between MRPL and Comvita Limited for mānuka seedlings and cultivars.	The clones have not been released as individual cultivars but have been integrated into Comvita's mānuka seed orchards	N/A		
Apiary information	Historical data on honey production and associated site and weather information	Data	2015-2017	May-17	Don and Conchita Tweeddale	Tweeddale Apiaries	N/A		No	As inputs to the predictive tool for plantation mānuka		Massey
Apiary information	Historical data on honey production and associated site and weather information	Data	2015-2017	May-17	Johann Ander	Yobees Bees	N/A		No	As inputs to the predictive tool for plantation mānuka		Massey
Apiary information	Historical data on honey production and associated site and weather information	Data	2016	May-17	Dan Riddiford	Dan Riddiford	N/A		No	As inputs to the predictive tool for plantation mānuka		Massey
Foreground IP												
Nectar sampling protocol (for researchers)	A technical protocol (SOP) for undertaking and handling nectar samples from a stand of mānuka for the purposes of measuring DHA content of the nectar. This protocol is separate to the protocols for DHA analysis and interpretation.	know-how; standard operating procedure (SOP)	Jan-12	Jun-16	Georgie Hamilton	MRPL	Project 2	Consultancy Agreement between MFNZ and client	Yes	Consultation service through MFNZ Will be made available on MFNZ website, our guideline for nectar sampling Published		MRPL Shareholders, MFNZ, Comvita, Massey, PSG members Published in:

												Wooton, S. (2018). *Planting Manuka in the South Island of New Zealand to develop the economic value of manuka honey and impact on the apiculture sector*. Kellog Rural Leadership Program: Course 38.
Nectar sampling kit and field manual (for landowners & others)	A field protocol (SOP) and list of equipment for non-researchers for undertaking and handling nectar samples from a stand of mānuka for the purposes of measuring DHA and sugar content of the nectar. This protocol is separate to the protocols for DHA analysis and interpretation.	know-how; standard operating procedure (SOP)	Apr-16	Jun-16	Georgie Hamilton, Maggie Olsen	MRPL	Project 2	Consultancy Agreement between MFNZ and client	Yes	Available to NZ Inc. via MFNZ consultancy services Will be made available on MFNZ website, our guideline for nectar sampling		MRPL Shareholders, MFNZ, Comvita, Massey, PSG members
Guidance on nectar analysis and interpretation	A short guidance document, with examples, explaining how laboratory analysis and results of DHA and sugar content of nectar samples should be interpreted.	know-how;			Georgie Hamilton	MRPL	Project 2	Consultancy Agreement between MFNZ and client	Yes	Available to NZ Inc. via MFNZ consultancy services Made available via a paper written		MRPL Shareholders, MFNZ, Comvita, Massey, PSG members
Technical Notes for Plantation Mānuka	A collation of technical information and guidance for plant selection, site preparation, planting, plantation management and apiary aspects of high-performance mānuka plantations.	Data; know-how;	Jan-15	Jun-16	Georgie Hamilton, Liz Nicklaus, Rachael Sheridan, Julia Bohorquez-Rodriguez, Maggie Olsen	MRPL	Projects 1, 2, 3, 4 and 5	Consultancy Agreement between MFNZ and client Confidential. Not for distribution	Yes	Available to NZ Inc. via MFNZ consultancy services	Last updated in June 2018, all previous versions are not for distribution Comvita and MRPL can develop this for commercial purposes. Other MRPL shareholders may use this on their own property(ies)	MRPL Shareholders, MFNZ, Comvita, Massey, PSG members, PF Olsen's

Weed and Pest management Plan for Plantation Mānuka	A template document which enables landowners to capture information and management practices for weeds and pests for their site	know-how;	Mar-16	Jun-16	Bronwyn Douglas, Georgie Hamilton, Maggie Olsen	MRPL	Project 2	Consultancy Agreement between MFNZ and client	Yes	Available to NZ Inc. via MFNZ consultancy services	Internal document used on sites where MFNZ is doing complete management Comvita and MRPL can develop this for commercial purposes. Other MRPL shareholders may use this on their own property(ies)	MRPL Shareholders, MFNZ, Comvita, Massey, PSG members, MFNZ Clients
Database / Data warehouse	All data, trial results and information developed from Project 1, 2, 3 and 4 is contained in a database	Database (in MS Access) of research results	Apr-15	Jun-15	Karoline, Arfmann, Zuben Weeds Richard Archer	MRPL	Projects 1, 2, 3 and 4	Secure database held by MRPL at Programme completion. Not for distribution to shareholders other than Comvita, nor to NZ Public.	Yes -	via the Predictive model for plantation mānuka	Not for distribution	Massey, MRPL, PSG members
Predictive model for plantation mānuka - Version 1	A multivariate model. This modelling approach requires large volumes of data which the PGP programme was unable to deliver in the timescale available. This model still exists and could be developed in the future provided enough data was provided.	Decision support tool	Dec-15	Mar-16	Zuben Weeds, Richard Archer	MRPL	Project 5		No		Not available to public because this version of the predictive model is not fit for purpose at this stage. Comvita and MRPL can develop this model further for commercial purposes. Other MRPL shareholders may use this on their own property(ies)	Massey, MRPL, PSG members

Predictive model for plantation mānuka - Version 2	Mechanistic model based on the 3PG model. This is a decision support tool for plantation mānuka, based on what-if; it is not an optimiser model.	Decision support tool	Dec-16	Jun-18	Karoline Arfmann, Maggie Olsen, Richard Archer	MRPL	Project 5	Contracts will be in place with any 3rd parties that use the model through MRPL and Comvita	Yes	Available to NZ Inc. via MFNZ consultancy services.	A Master licence will need to be granted to MFNZ by MRPL. The model may be sub-licensed to selected companies and others with permission sought from MRPL. Comvita and MRPL can develop this model further for commercial purposes. Other MRPL shareholders may use this on their own property(ies) through MFNZ.	Massey, MRPL, Comvita, PSG members
Functional Description of the predictive model for plantation mānuka - Version 2	A document which describes the functionality and parameters of the predictive tool for plantation mānuka - Version 2	Decision support tool	Oct-16	Dec-16	Zuben Weeds Richard Archer	MRPL	Project 5		Yes	via the Predictive model for plantation mānuka	This document will not be distributed	Massey, MRPL, Comvita, PSG members
User guide (Admin and User) for Predictive Model for Plantation Mānuka Version 2	Two guides which describe maintenance and use of the Predictive Model Version 2	Decision support tool			Karoline Arfmann	MRPL	Project 5	Available through MFNZ for shareholders. Comvita holds copies.	Yes	Available to NZ Inc. via MFNZ 7 step consultancy services	Not for distribution	Massey, MRPL, Comvita
Commercial findings to date from PGP	A register of all commercially-relevant findings from the PGP programme and other sources, including experimental findings and general observations and interpretations.	Data; know-how	Dec-16	Dec-16	Richard Archer, James Millner, Karoline, Arfmann, Maggie Olsen	MRPL	Projects 1, 2, 3, 4, 5 and other sources	To be held as a commercially sensitive register by MRPL, licenced to MFNZ	Yes - via means listed above	Available to NZ Inc. via MFNZ 7 step consultancy services	Not for distribution	Massey, MRPL, Comvita, PSG members

Mānuka leaf sampling as an indicator of mānuka nectar quality potential	The discovery of a potential correlation between flavonoids in mānuka leaf tissue and DHA potential in the nectar of mānuka plants. A technical protocol (SOP) for undertaking and handling leaf samples from a stand of mānuka for the purposes of (i) measuring leaf metabolites in situ using a Dualex device, and (ii) measuring leaf metabolites in the laboratory via spectrometry.	know-how; standard operating procedure (SOP)	Dec-16	Dec-16	Maggie Olsen	MRPL	Projects 1 and 3	To be held as commercially sensitive information by MRPL, MFNZ and shareholders	No	Confidential to MRPL	This discovery and know-how will not be commercially developed nor made public at this stage as the leaf assay has not proven to be a reliable predictor of mānuka nectar quality. Position to be re-assessed by 30 September 2021 under the terms of the PGP IP management plan. Further R&D is required.	Massey, MRPL, Comvita, PSG members

High Performance Mānuka Plantation Data Report	Report covering data obtained from the multiple field trials and broad-acre plantations planted using elite mānuka varieties developed in Comvita's mānuka breeding programme. Report includes monitored data to gain knowledge on how these plants perform in different environments with regard to establishment, growth, nectar production and quality, floral traits and apiary performance. A full set of data from each of these sites was used to build up a comprehensive database for the predictive modelling tool and for technical notes on plantation establishment.	Know how	Jul-15	Jul-15	Georgina Hamilton, Julia Bohorquez, Maggie Olsen	MRPL	Project 2 and 4	To be held as commercially sensitive information by MRPL, MFNZ and shareholders	Yes through MFNZ consulting services	Available to NZ Inc. via MFNZ 7 step consultancy services		
Sampling Protocol for Eco-sourced Mānuka	A technical protocol (SOP) for undertaking eco sourced seed collection from a site in NZ, including nectar samples from a stand of mānuka for the purposes of measuring DHA content of the nectar, number of samples required from within site	know-how; standard operating procedure (SOP)	Dec-17	Dec-17	James Millner, Maggie Olsen	MRPL	Project 2	To be held as commercially sensitive information by MRPL, MFNZ and shareholders	Yes - via means listed above	Available to NZ Inc. via MFNZ 7 step consultancy services		Massey, MRPL, Comvita, PSG members

Thesis- Influential factors in nectar quality and yield Leptospermum scoparium	In-depth research on the influence of genetic and environmental factors on the composition and yield of nectar in L. scoparium. The research in this thesis establishes the effect of various parameters on overall DHA yield from Mānuka and the beginnings of modelling influencing environmental factors. The commercial value is the ability to assess cultivars from breeding programs for the best potential to increase overall UMF honey yield. Predictive modelling of yields is invaluable to the developing honey industry to allow assessment of environmental influences that may affect overall yield along with seasonal influences on nectar production in Mānuka	Know how	Jul-15	Jul-15	Elizabeth Nickless			Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author	Yes	Thesis was embargoed for 2 years, this time has now passed		

Thesis - Influential factors in nectar quality and yield in leptospermum scoparium		Know how	Jul-18	Jul-18	Julia Bohorquez - Rodriguez,			Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author	Yes	Thesis embargoed for 2 years (2020)		
Thesis - Rachael title tbc as thesis not yet submitted								Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author				
Paper – Analytical method development using FTIR-ATR and FT-Raman spectroscopy to assay fructose, sucrose, glucose and dihydroxyacetone, in Leptospermum scoparium nectar		Paper-Analytical Method	Sep-16	Oct-16	Liz Nickless, Georgie Hamilton, Jason Wargent		Project 1	Public domain	Yes	Paper published Vibrational Spectroscopy journal		

Paper - Soil influences on plant growth, floral density and nectar yield in three cultivars of mānuka	This paper investigated whether phenological patterns of flowering, plant growth, nectar composition and nectar yield were influenced by soil composition. When assessing L. scoparium as a nectar source for honey in marginal land areas, the possible effect of soil on nectar chemistry and yield should be considered. We		Oct-16	Nov-16	Liz Nickless		Project 1	Public domain	Yes	Paper published in New Zealand journal of Botany		NZ Public
Paper- High UMF® honey production from mānuka plantations.	establishing mānuka plantations using seedlings grown from seed sourced from areas producing high quality honey is a potential solution. This study compared establishment, growth and nectar dihydroxyacetone content of four mānuka provenances and indigenous mānuka at Maxwell and Tutira.	Paper presented at Grasslands conference	Jul-16	Jul-16	James Millner, Georgie Hamilton and Jonathan Stephens		Project 2	Public domain	Yes	Paper presented at 2016 Grasslands conference		NZ Public https://www.grassland.org.nz/publications/nzgrassland_publication_2772.pdf

Phenotypic description of Mānuka wild varieties	This report identifies and describe several wild varieties of Leptospermum Scoparium found across the North and South islands of New Zealand. Mānuka's phenotype is known to be highly variable having adapted to its wide species range. This description will help in recording where these variations occur, and enable better understanding about potential agricultural applications in establishing honey plantations.	Know how	Dec-17	Dec-17	Gael Gaucer	MRPL	Project 2	Public domain	Yes through MFNZ consulting services	Available to NZ Inc. via MFNZ 7 step consultancy services and eco sourcing service		
Paper - Honey bee visitation study	To come								Yes			Massey, MRPL, Comvita, PSG members
Paper - Mycorrhizal fungal study	To come											
Paper - Mycorrhiza	To come											
Paper - Scale insect survey study	To come											
Final Programme Report	To come										A public version of the final report for this programme will be made available via the MPI website	

Post-programme reporting:

An annual programme outcome report covering progress towards achieving short term outcomes and medium term outcomes of the programme will be prepared by MRPL and submitted to MPI within one month of the periods ending 31 March 2019, 31 March 2020, 31 March 2021, 31 March 2022 and 31 March 2023. There is no funding provided by MPI to MRPL to cover this reporting. Any further reporting beyond this time or reporting on the state of the wider mānuka industry will be subject to negotiation and potentially a separate agreement with MRPL.

It is proposed that MRPL will provide MPI with a brief annual report in writing (MS Word and/or MS Excel) on the following;

- Key achievements and highlights for MRPL (including those achieved via relevant subsidiary or delivery companies), including progress with commercialisation of IP developed in the programme.
- Outcomes via MRPL (and via relevant subsidiary or delivery companies)
    1. Number of mānuka seedlings sold by MRPL for planting on a calendar year basis.
    2. Number of desk top assessments completed for landowners by MRPL per calendar year.
    3. Number of mānuka seedlings sold and area planted in NZ on a calendar year basis – subject to data being available from MPI
    4. Number of hectares (Ha) planted in mānuka by MRPL on a calendar year basis.
    5. Percent (%) market share.
    6. Consultancy services and site visits completed for landowners, including eco-sourcing assessments.
    7. Harvested honey data (quantity and quality) from mānuka plantation sites that MRPL has access to, to provide information on productivity gains on plantation mānuka.
    8. Track NZ mānuka honey industry export volume and value (based on data available from Statistics NZ)

The Ministry for Primary Industries (MPI) will commission an independent evaluation of the High Performance Mānuka Plantations PGP Programme. This report will be shared with the Shareholders of MRPL.

Before the final report is signed off, MPI and MRPL will agree (via a letter) the reporting format and templates to be used for reporting over a 5-year period. The templates will include some baseline data as a reference (i.e. 30 June 2018).

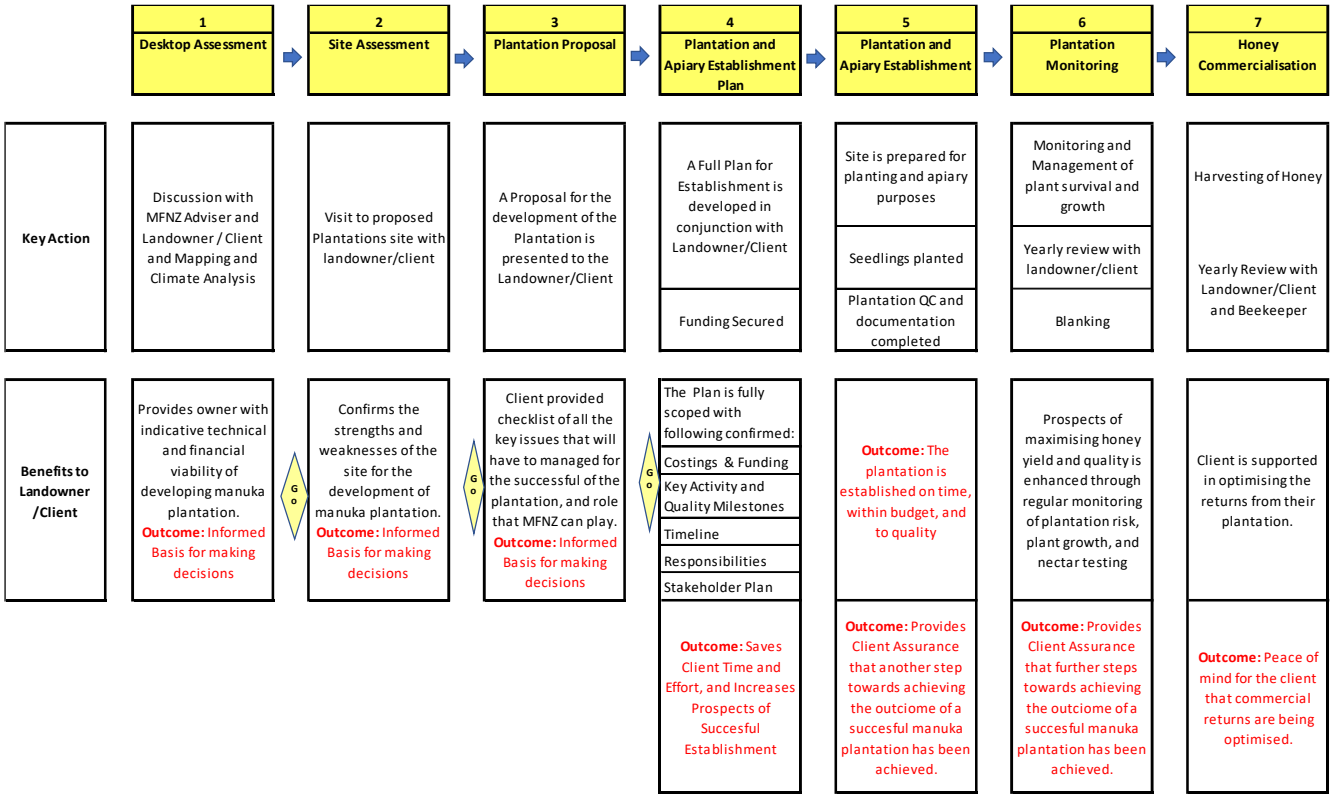
Post-Programme

Post-Programme Plan to set out how initiatives will continue or transition once the programme has finished;

1. MFNZ's strategy includes a combination of providing some of the findings from the PGP research freely to the public /industry and providing some on a fee-paying basis:

    - Some of the research/technical papers will be made available via the MFNZ website.

    - Findings from all the PGP outputs will, wherever relevant, feed into one or more of MFNZ's Seven Step Process for engaging with landowners on Mānuka Plantation establishment.



2. Within each step, relevant findings from the PGP research will be used for the development of mainly (1) Evaluative Tools (2) Templates. It is anticipated that these will be expanded and improved as opportunities for improvement are identified as they are applied in a practice over time.

3. MFNZ where able will continue to collect plant survival, growth, nectar, and honey samples to continue to grow its knowledge of mānuka plantation development.

4. MFNZ will also continue to obtain data to further develop the predictive model that has come out of the PGP programme by expanding the number and locations of plantation sites from which monitoring will be used as inputs to developing the model further. It is anticipated that these sites will come from some of MFNZ's existing clients as well as from Comvita. It is possible that other industry parties will contribute data or site access.

5. MFNZ has sought to fully utilise the outputs of the PGP programme by employing the personnel who have been extensively involved in the programme – namely the PGP Programme Manager (Bronwyn Douglas), and Research Technician (Maggie Olsen). In August 2018, an experienced forestry consultant was also employed. With this appointment, MFNZ now has the complete team it requires to provide landowners with the complete service for establishing and managing mānuka plantations for honey.

6. It is planned that the team will formulate the list of possible commercially relevant research initiatives that will be pursued by MFNZ over the next 3-5 years, many of whose origins will likely be from the PGP Programme. MZNZ is developing a research strategy for approval by the MRPL Board early in 2019. Research gaps are identified in Appendix 3.

Communications Plan

Mānuka Farming New Zealand has completed a communications plan. The full version is in Appendix 3.

PGP specific output communications are in the below table;

	Story	Type	Description	When	Who	Placement
1.	New Staff	Media release	An introduction of Plantation and Apiary Performance Manager finishing at Massey and commencing with MFNZ.	August 2018	MRPL/ MFNZ	Regional Media/National Media
2.	New staff	Media release	An introduction of Plantation Establishment role commencing with MFNZ	September 2018	MFNZ	Regional Media/National Media
3.	CVT6 new release story	Media release	Describing introduction of CVT6 into cultivar range	October 2018	MFNZ/ Comvita	Regional Media/National Media
4.	Re-forecast of industry benefits	Media release	A statement covering the revised industry growth by 2028	March 2019	MRPL/ MFNZ/ MPI	Regional Media/National Media
5.	End of PGP programme	Media release	A statement of High Level findings and benefits to industry	April 2019	MRPL/ MFNZ/ MPI/Massey	Regional Media/National Media
6.	Opinion pieces in local papers on merits of Mānuka	Article	Use the expertise within the programme partners and MFNZ to write content on specific subject areas. This would be a series of articles	May 2019 through to December 2019	Shareholders/ MPI/ MFNZ	Rural Media, regional media, Farmers weekly, stakeholder publications e.g. HB Regional Council newsletter
7.	End of programme evaluation	Press release	Public findings from the programme evaluation	May 2019	MPI/MRPL/MFNZ	Regional Media/National Media

8.	Land comparison model	Case study	Use shareholder (Te Tumu Paeroa or Nukuhau Carbon) land scenarios and run through land comparison model. This could also cover decision process shareholder went through before they planted	July 2019		Rural Media, regional media, Farmers weekly, stakeholder publications e.g. HB Regional Council newsletter
9.	Launch of model	Media release	Economic benefits Farmer Benefits Environment benefits	July 2019	MRPL/MFNZ	National Media – Big launch to attract attention, Press
10.	Learnings for HPM PGP	Presenter	Speaker at Apiculture Conference 2019	July 2019	MRPL/MFNZ	Apiculture Conference
11.	Trial Site Successes	Article	Article on 2018/19 results of the trial plantations, positive learnings	September 2019	MFNZ	Farmers weekly article

Appendix 1 - Milestone Achievements

Objective	Objective 1
Objective Title	A glasshouse-based study to examine the effects of soil and light on mānuka plant growth and flowering.
Objective Description	Determine the effects of soil and light on mānuka plant growth, flowering, nectar yield and nectar quality (sugar and DHA levels) through controlled greenhouse trials

Milestone 1.1	Soil as an environmental factor	
Achievement measures	Description: Determine the effects of parent soil type and latitude on mānuka plant growth, flowering, nectar yield and nectar quality.	
	By 01 December 2011 a PhD student has been registered.	Achieved
	By 30 June 2013 and 2014, results are reported to the Programme Steering Group from a glasshouse trial of one clone of *L. scoparium* var. incanum and ten soil types.	Achieved
	By 30 June 2013 and 2014, results are reported to the Programme Steering Group from a glasshouse trial of ten clones of *L. scoparium* var. incanum and one soil type.	Achieved
	By 31 December 2014, the data from the glasshouse soil trials will have been collated for subsequent entry into a single secure database (by 30 June 2015) and for subsequent use in developing the predictive modelling tool under Objective 5, and the final results presented to the Programme Steering Group.	Achieved

Milestone 1.2	Light as an environmental factor	
Achievement measures	Description: Determine the effects of light (light intensity, light type and day length) on mānuka plant growth, flowering, nectar yield and nectar quality.	
	By 30 June 2013 and 2014, results from a glasshouse trial of (at least) two clones of *L. scoparium* var. incanum, grown to simulate two different latitudes are reported to the Programme Steering Group.	Achieved
	By 31 December 2014, the data from the glasshouse trials on light will have been collated for subsequent entry into a single secure database (by 30 June 2015) and for subsequent use in developing the predictive modelling tool under Objective 5, and the final results presented to the Programme Steering Group.	Achieved

Milestone 1.3	Implementation	
Achievement Measures	Description: Implementation of knowledge gained on key environmental factors. By 31 December 2014, FINAL results from glasshouse trials will have been collated for subsequent entry into a single secure database (by 30 June 2015) and for subsequent use in developing the predictive modelling tool under Objective 5. By 31 December 2014, draft technical notes will have been prepared on mānuka plantation management to maximise high quality honey (based on glasshouse trials). These notes will provide the basis for commercialisation of the programme's results, including husbandry notes to be supplied with individual elite mānuka cultivars at the time of sale. By 31 December 2014, (at least) one peer-reviewed journal publication will have been accepted for publication, and a PhD thesis written in accordance with the IP management plan.	Achieved late Achieved Both achieved

Objective Number	Objective 2	
Objective Title	Field plantation evaluation of quality	
Objective Description	Determine the key plantation management parameters to influence mānuka growth, flowering, nectar yield and nectar quality (sugar and DHA levels), and honey yield and quality through field trials	

Milestone 2.1	Site, microsite and stocking rate plantation management	
Achievement Measures	Description: Determine the effects of site, microsite and stocking rate on mānuka growth, flowering, nectar yield and nectar quality. By 01 November 2011, a research technician has been appointed for a 15-month term. By 31 October 2012, plantings at three North Island sites have been established. By 31 October 2013, planting at a fourth North Island site has been established. By 31 October 2013, replicated microsites (varieties and clones) have been established at four North Island sites. By 01 July 2014, a research officer will have been appointed for a 3.75-year term (to end March 2018).	Achieved Achieved Achieved Achieved Achieved

	By 31 October 2014, four further existing plantation sites across New Zealand will have been incorporated into the sampling and monitoring programme. By 31 October 2014, two further new plantation sites will have been established across New Zealand and incorporated into the sampling and monitoring programme. By 31 October 2015, planting and replicated microsites (varieties and clones), as appropriate, will have been established at all selected further sites of relevance to the programme. By 30 June of each year from 2012 to 2018, an assessment of (i) mānuka seedling survival, (ii) plant growth rates, (iii) nectar yield, (iv) nectar quality, (v) apiary activity including hive management, bee activity, honey production and honey quality (as per appropriate mānuka honey labelling guidelines) plus (vi) site identification and climate data (where possible) for each site in the programme, will have been completed, and data collated into a secure database, analysed and reported to the Programme Steering Group. By 30 March 2018 historic (where possible) and 2017/18 season apiary and honey data will be collected from wild type plantations for use in the harvest component of the predictive tool.	Achieved but with a late start Achieved for 2017/18 season

Milestone 2.2	Influence of companion biota on mānuka honey yield and quality	
Achievement Measures	Description: Determine the effects of selected companion biota on mānuka growth, flowering, nectar yield nectar quality and potential honey production By 01 July 2014, a PhD student has been registered. By 31 December 2015, 2016, 2017 and by 30 June 2018: I. the relative attractiveness of cultivars, CVTs and wild mānuka to honeybees and other insects will be analysed and reported to the Programme Steering Group; II. the effects of scale insect infestation on growth, flowering, nectar yield and nectar quality will be analysed and reported to the Programme Steering Group; III. the effects of mycorrhizal associations on growth, flowering, nectar yield and nectar quality will be analysed and reported to the Programme Steering Group; and IV. data from the companion biota work will be trials will have been collated into a single secure database for subsequent use in developing the predictive modelling tool under Objective 5.	Achieved Achieved Achieved Achieved Achieved

Milestone 2.3	Implementation	
Achievement Measures	Description: Implementation of knowledge gained on key mānuka plantation management factors and influence of companion biota By 31 December each year from 2014 to 2017, draft and updated technical notes on mānuka plantation management to maximise high quality honey, will have been prepared and presented to the Programme Steering Group. By 30 June 2018, FINAL data from mānuka plantation trials will have been collated into a single secure database for subsequent use in developing the predictive modelling tool under Objective 5. By 30 June 2018, FINAL technical notes on mānuka plantation management to maximise high quality honey (based on plantation trials), will have been presented to the Programme Steering Group. The notes submitted will provide the basis for commercialisation of the programme's results including husbandry notes to be supplied with individual elite mānuka cultivars at the time of sale. By 30 June 2018, (at least) one peer-reviewed journal publication will have been accepted for publication and a PhD thesis written in accordance with the IP management plan.	Achieved Achieved Achieved Thesis written and examined; publication in progress.

Objective Number	Objective 3	
Objective Title	A controlled environment study to examine the influence of temperature, water stress and salinity on mānuka plant growth and flowering.	

Milestone 3.1	Water deficit and salinity as environmental factors	
Achievement measures	Description: Determine the effects of salinity and/or a water deficit on plant growth, flowering, nectar yield and nectar quality. By 01 April 2014, a PhD student has been registered. By 31 October 2017, final results have been reported to the Programme Steering Group from a glasshouse trial on (at least) two clones of *L. scoparium* var. incanum, grown under three different soil and/or foliar salinity treatments and/or two different soil water contents.	Achieved Achieved for water deficit – salinity not attempted.

	31 October 2017, the final results from the water deficit and/or salt stress glasshouse trials have been collated in to a single secure database for subsequent use in developing the predictive modelling tool under Objective 5.	Achieved for water deficit – salinity not attempted.

Milestone 3.2	Temperature as an environmental factor	
Achievement Measures	Description: Determine the effects of acute changes in temperature (simulating short term high diurnal temperature range) on nectar yield and nectar quality and of chronic temperature (simulating zones in New Zealand) on plant growth, flowering, nectar yield and quality. By 30 June 2016, results have been reported to the Programme Steering Group from a growth chamber trial of (at least) two clones of L. scoparium var. incanum grown in soil at different night/day temperature regimes. By 31 October 2017, results have been reported to the Programme Steering Group from a glasshouse trial of (at least) two clones of *L. scoparium* var. incanum grown in soil at two different temperatures simulating the annual mean temperature range across New Zealand. By 31 October 2017, the final results from the controlled environment temperature trials have been collated into a single secure database for subsequent use in developing the predictive modelling tool under Objective 5, and the final results presented to the Programme Steering Group.	Achieved Achieved

Milestone 3.3	Secondary leaf metabolites in mānuka as indicators and predictors of nectar quality	
Achievement Measures	Description: Determine (i) the feasibility of using laboratory- or field-based methods to correlate the occurrence of specific leaf metabolites with nectar DHA level and (ii) evaluate laboratory or field-based methodology to measure specific key metabolites as indicators of nectar DHA content. By 30 June 2016, identification of a class (or classes) of secondary leaf metabolite compounds that may be indicative of high DHA content in nectar will have been completed, and at least one laboratory- or field-based method identified to measure indications of these compounds in leaf extracts or whole plants. The results with recommendations for next steps will be presented to the Programme Steering Group. By 30 September 2016, a draft technical protocol will be developed for the facile laboratory- and/or field-based measurement of a least one class of secondary metabolites as an indicator of high DHA content.	Achieved

	By 31 March 2017, using laboratory or field-based methodology devised by 30 June 2016, the assessment of the influence of plant development and environment and cultivar/clone on the reliability of the use of specific metabolite classes as indicators of DHA content will be completed. By 30 June 2017, a technical protocol and supporting information will be provided for the mānuka cultivar testing service to be developed under Milestone 5.2 ***This is a stop go point for milestone 3.3*** If all indications are positive by 30 June 2017, further assessment of the influence of plant development and environment and cultivar/clone on the reliability of the use of specific metabolite classes as indicators of DHA content will be completed by 31 May 2018.	Decision made by the PSG in May 2017 not to progress with further work

Milestone 3.4	Implementation	
Achievement measures	Description: Implementation of knowledge gained on key environmental factors By 31 October 2017, FINAL data from glasshouse and controlled environment trials on temperature, water deficit and salinity will have been collated into a single secure database for subsequent use in developing the predictive modelling tool under Objective 5. By 1 December 2017, FINAL technical notes on plantation management to maximise high quality honey will have been presented to the Programme Steering Group. The draft notes will provide the basis for commercialisation including notes to be supplied with elite mānuka cultivars. By 1 December 2017, (at least) one peer-reviewed journal publication will have been submitted for publication, and a PhD thesis written in accordance with the IP management plan.	Achieved but no work done on salinity to keep student focused Achieved Both still in progress at 30 September 2018, Student hopeful that this will be achieved

Intermediate outcome objective

Objective Number	Objective 4	
Objective Title	Evaluation of mānuka for companion riparian and irrigation shelter plantings	
Objective Description	Determine the key plantation management parameters, viability and economic feasibility of mānuka in riparian strip plantations and for shelter in irrigated pastures	
Objective Leader	Comvita Limited and MRPL.	
Objective achievement measures	By 30 June 2018, the key plantation management parameters and practices which influence viability and economic feasibility of mānuka for companion riparian plantings and as shelter under centre-pivot irrigators have been established, to enable a judgement to be made on the suitability or otherwise of mānuka for deliberate planting in these settings. By 30 June 2018, data from riparian and companion irrigation plantings will have been incorporated into a single secure database for subsequent use in developing the predictive modelling tool under Objective 5. By 30 June 2018, draft technical notes on plantation management of mānuka for riparian and companion irrigation plantings to maximise high quality honey will have been presented to the Programme Steering Group. The notes submitted will provide the basis for commercialisation including husbandry notes to be supplied with individual elite cultivars at the time of sale. By 30 June 2018, (at least) one peer-reviewed journal publication will have been accepted for publication and written in accordance with the IP management plan.	[Note: this Objective was commenced strongly but struck major setbacks within 12 months. Work under objective 4 was scaled back by the PSG in June 2016 with money diverted to Objectives 2 and 5]

Milestone 4.1	Mānuka for riparian plantings	
Achievement Measures	Description: Determine the environmental influences on water ways of mānuka used in riparian plantings and the plantation management parameters, feasibility and economic viability of mānuka plantations in riparian strip plantations. By 01 November 2014, (at least) two trial format riparian plantings of selected mānuka cultivars/clones (as appropriate) will be completed on one North Island site.	Achieved

	By 01 November 2014, riparian plantings of selected mānuka cultivars/clones (as appropriate) will be completed on two North Island sites.	Achieved
	By 31 January 2017 an initial aerenchyma trial assessment of survival at 3 sites to be reported to the Programme Steering Group.	Achieved
	By 30 June 2017, an assessment report on aerenchyma trial including survival and growth rates of seedlings planted. All data will be recorded and reported to the Programme Steering Group	Achieved
	By 30 June 2017, an assessment report on the seedling survival and growth rates of seedlings planted in the five riparian plantings, reporting on specific areas that have performed better than others as well as any differences seen between the hedge and pepper plot plantings. All data will be recorded and reported to the Programme Steering Group.	Achieved
	By 30 June 2018, a final report on the aerenchyma trial including survival and growth rates of seedlings planted. All data will be recorded and reported to the Programme Steering Group	Achieved Included in Q3 2017
	By 30 June 2018, a final report on the seedling survival and growth rates of seedlings planted in the five riparian plantings, reporting on specific areas that have performed better than others as well as any differences seen between the hedge and pepper plot plantings. All data will be recorded and reported to the Programme Steering Group.	Achieved

Milestone 4.2	Mānuka for planting under centre pivot irrigators	
Achievement Measures	Description: Determine the feasibility and economic viability of mānuka planted as low shelter under centre pivot irrigators and otherwise associated with irrigated pastures.	
	By 01 November 2014, at least one trial format planting of selected mānuka cultivars/clones (as appropriate) will be completed on at least one South Island farm.	Achieved
	By 15 June 2017, an assessment report of seedling survival and plant growth rates at these sites will be completed and data recorded and reported to the Programme Steering Group.	Achieved
	By 15 June 2018, a final report of comparative shelter effectiveness between the double and staggered row plantings, seedling survival, growth rates, from these sites will be completed and data recorded and reported to the Programme Steering Group.	Not achieved [only a very limited trial was permitted]

Milestone 4.3	Implementation	

Achievement Measures	Description: Implementation of knowledge gained from the assessment of the viability and economic feasibility of mānuka as a companion species in riparian plantations and in irrigated pastures.	
	By 30 June each year from 2015 to 2018, data from milestones 4.1 and 4.2 will have been collated into a single secure database for subsequent use in developing the predictive modelling tool under Objective 5.	Achieved [within limitations of available data]
	By 30 June 2018, FINAL draft technical notes on mānuka plantation in riparian planting and irrigated land settings to maximise high quality honey will have been presented to the Programme Steering Group. The notes submitted will provide the basis for commercialisation of the programme's results including husbandry notes to be supplied with individual elite mānuka cultivars at the time of sale.	Achieved
	By 30 June 2018, (at least) one peer-reviewed journal publication has been accepted for publication in accordance with the IP management plan.	Not achieved

Intermediate outcome objective

Objective Number	Objective 5	
Objective Title	Predictive tools	
Objective Description	To develop predictive tools for mānuka plantation management.	

Milestone 5.1	Development of predictive tools	
Achievement Measures	Description: To use information gained from the PGP programme to develop and validate a predictive tool for use by the co-investors.	
	By 30 September 2014, a paper will have been presented to the Programme Steering Group outlining the architecture for a modelling tool (base algorithm and data fields accessed by the algorithm) to predict lifetime yield and quality of mānuka honey from a particular potential plantation.	Achieved
	By 01 November 2014, a suitable Research Officer has been appointed.	Achieved, appointment was delayed

	By 30 June 2015, a single secure database will have been created as (a) a safe repository for data generated in Objectives 1 through 4 and (b) to be the basis of modelling.	Achieved with a late start
	By 30 June 2015, actual historic apiary performance data from co-investors and meteorological data from public sources have been acquired and incorporated into the database to support modelling.	Achieved with a late start
	By 31 December 2015, a first cut quantitative (yield and quality over plantation lifetime) and economic returns model is available for use by co-investors for central and lower western North Island plantations.	Achieved with a late start
	By 30 September 2016, a functional description of the model for plantation mānuka will have been completed and submitted to the Programme Steering Group. The Programme Steering Group will decide whether an expert review of the functional description by external parties is required in order to give the co-investors confidence in the modelling approach, and information on the level of investment required in the future. A target of 30 November 2016 is set for completion of the review.	Achieved
	By 30 September 2016, the Programme Manager will have lead a check and assessment of what models Scion, Landcare Research, AgResearch and others have regarding mānuka for honey production, understand these and report on their value to MRPL, and make recommendations to the Programme Steering Group.	Achieved
	By 31 October 2016, the Programme Steering Group will decide whether to seek collaboration with existing model owners.	
	By 31 July 2017, a working version of the predictive tool for mānuka plantations for honey will be available to MRPL to test on behalf of the co-investors.	Achieved with a late start
	Between 1 August 2017 and 31 March 2018, user testing covering the interface and parameterisation of the model will follow a learning loop with modifications, continuous improvements, modification and client feedback included into the predictive tool.	Achieved
	By 31 August 2017, a draft glossary of terms used within the predictive tool is to be developed.	Achieved
	By 30 September 2017, a draft document including details on systems requirements, assumptions, and data backup process for the predictive tool to be presented to the Programme Steering Group.	Achieved
	By 1 December 2017, a draft end user manual and administration manual, including a change log will be presented to the Programme Steering Group.	Achieved

	By 31 March 2018, a final end user manual and administration manual, including a change log and a glossary of terms will be presented to the Programme Steering Group.	Achieved
	By 30 June 2018, the final, partially validated predictive tool, annotated and made sufficiently robust for use by the co-investors is made available to the co-investors.	Achieved

Milestone 5.2	Influencing the volume and quality of New Zealand mānuka honey	
Achievement Measures	Description: To use the information gained from the PGP programme to support the development of a mānuka plantation industry, including an assessment of the potential returns of mānuka at a plantation level vis-à-vis alternate land uses.	
	By 31 December 2017, DRAFT technical notes on mānuka plantation management in a range of land uses (marginal and intensive) to maximise high quality honey will have been presented to the Programme Steering Group. The notes submitted will provide the basis for commercialisation of the programme's results including husbandry notes to be supplied with individual elite mānuka cultivars at the time of sale.	Achieved
	By 30 June 2018, FINAL technical notes on mānuka plantation management in a range of land uses (marginal and intensive) to maximise high quality honey will have been presented to the Programme Steering Group. The notes submitted will provide the basis for commercialisation of the programme's results including husbandry notes to be supplied with individual elite mānuka cultivars at the time of sale.	Achieved
	By 30 June 2018, mānuka plantation husbandry techniques will be made readily available within the wider New Zealand industry including but not limited to the following means: • A commercial consultancy available to land owners wishing to plant mānuka on a prospective plantation site or extending mānuka cultivated areas.	Achieved
	• Information on the technical and economic feasibility of best practice mānuka plantation, against alternate land uses, is made available to the wider New Zealand honey industry. This might be in the form of scenario reports using outputs from the predictive tool developed under milestone 5.1 and outputs from milestone 5.3, as well as external information.	Achieved in part

	• Technical notes are provided with elite cultivars sold in return for a small levy. • A commercial consultancy for the purpose of assessing, identifying and propagating eco-sourced material as could be requested by landowners within New Zealand. • A testing service whereby newly developed cultivars can be tested rapidly and optimal husbandry techniques identified. • Scenario reports, conference presentations, published theses, journal papers, reports and popular articles, in accordance with the IP management plan.	Achieved Achieved Not achieved; resourcing redirected towards eco-sourcing Achieved in part [two further publications and one thesis outstanding at 30 September 2018]

Milestone 5.3	Feasibility of productivity gains	
Achievement measures	Description: Demonstrate the technical and economic feasibility of productivity gains from plantation mānuka Description: Quantify potential costs and returns of plantation mānuka on a national basis across New Zealand over time by identifying the multiple potential constraints and modelling their cumulative effect over a range of scenarios. Transfer this assessment tool to MFNZ custody and curation. By 30 September 2017, a framework for (i) assessing the technical and economic feasibility of the productivity gains; (ii) quantifying the potential economic value of plantation mānuka at a national level; and (iii) estimating the benefits and contribution of the PGP programme to NZ Inc., including assumptions will be completed and presented to the Programme Steering Group. By 30 September 2017, (i) a first draft of the productivity gains report;(ii) an analysis of the potential net economic value of plantation mānuka at a national level; (iii) an estimate of the benefits and contribution of the PGP programme to NZ Inc.; and (iv) an update to the OLM's indicators, targets and measures, including details of the assumptions will be completed and presented to the Programme Steering Group.	Achieved in part with a late start Achieved in part with a late start

	By 30 June 2018, a final draft of (i) the productivity gains report; (ii) an analysis of the potential net economic value of plantation mānuka at a national level; (iii) an estimate of the benefits and contribution of the PGP programme to NZ Inc.; and (iv) an update to the OLM's indicators, targets and measures, will have been completed. These analyses will have been updated since 30 September 2017 with additional insights and information gained from the work of MFNZ in the marketplace and further information from use of the predictive tool/model; with a presentation made to the Programme Steering Group by MFNZ.	Delayed until final report & mostly achieved

Objective Number	Objective 6	
Objective Title	Programme Management and Science Auditor	
Objective Description	To professionally manage the High Performance Mānuka Plantations PGP Programme by providing high quality management, to ensure: • timely and within budget delivery to a high standard of outcomes from the Programme and contractual requirements; • reliable cost accounting and financial reporting; • effective management of all contracted suppliers and services; • responsiveness to unknown variables; and • appropriate and effective communication with all stakeholders and with MPI.	

Objective achievement measures	1. Ensure that the milestones for Objectives 1 to 5 are met.	All achieved except milestones 3.4 and 5.3 with thesis and papers still underway
	2. All co-investors, MPI and research and service providers are satisfied with the level of communication and engagement throughout the term of the PGP programme.	Achieved
	3. MRPL GOVERNANCE: In consultation with the co-investors, review and implement changes as necessary to maintain good governance practices.	Achieved

	4. PROGRAMME STEERING GROUP (PSG) REPORTING AND MANAGEMENT: In consultation with the co-investors, implement more streamlined and dynamic programme monitoring and reporting processes to the PSG, to assist the PSG in its governance role.	Achieved
	5. PROGRAMME MANAGEMENT SYSTEMS: Systems, templates, and standard operating procedures for recording and forecasting delivery, financial management and subcontracting are reviewed and developed where needed, and communicated to programme participants updated as needed	Achieved
	6. PGP WORK PROGRAMME: Effective management and co-ordination of services contracted to Massey University and other providers, and work to be undertaken by the co-investors. In particular (i) the co-ordination of plantation and apiary data collection along with associated database management, and (ii) the development of a verifiable method and process by which the PSG can assess data generated in the trials as being of acceptable quality for use in the prediction tools.	Achieved
	7. IN-KIND CONTRIBUTIONS: Processes to pre-approve, record and track in-kind contributions from industry parties are updated as needed.	Achieved
	8. ANNUAL PLANS: Annual plan and associated budget prepared and approved by PSG by 31 July each year, starting from 31 July 2014.	Achieved
	9. ANNUAL REVIEW OF BUSINESS PLAN: Annual review of the Business Plan in discussion with co-investors and recommend changes (if any) to objectives and budgets to the PSG.	Achieved
	10. CONTRACT VARIATIONS: Variations in relation to annual plan approved and incorporated into Schedule 7 of the PGP Agreement by 30 September each year, starting from 30 September 2014.	Achieved
	11. REPORTING: Quarterly progress and financial reports for the Programme are prepared and circulated in good time ahead of PSG meetings and approved by the PSG for submission to MPI within 6 weeks of the end of each quarter. Timely reporting to MRPL Board and PSG as required.	Achieved

	12. CASHFLOW FORECAST: Updated year end and programme forecast approved by the PSG quarterly as part of the quarterly financial reporting. 13. MEETINGS: PSG meetings are held quarterly with adequate secretarial support. 14. OUTCOME LOGIC MODEL AND INDICATORS: Outcome Logic Model and indicators reviewed/updated annually as part of the annual plan update process. 15. REVIEWS: Assist with reviews undertaken as per Clause 9 of the PGP Agreement.	Achieved Achieved Achieved

Appendix 2 – Establishment Risk Register

Pre-planting Preparation	Description of Risk	Risk Elimination/ Reduction/Mitigation Action
Weed	The site is overgrown with uncontrolled weeds before seedling plantation/not controlled during seedling establishment and growth	▯ Weed control around planting spots is required before planting; exact treatment will depend on weed type, degree of evasiveness, maturity and weather ▯ Ex-forestry blocks should be left for at least a year & then be treated with autumn pre-plant spray with Metsulfuron to eliminate pine seedlings. ▯ Herbicide trials have shown that pre-plant herbicide treatment provided better weed control overall and was more cost effective than post-plant control; by avoiding the need to apply herbicide after planting the time involved with herbicide spraying was reduced, as spraying with a shield was time consuming, and trying to locate the small mānuka plants for post-planting applications was difficult (and therefore time consuming). ▯ It is recommended to have a 5-year plan that is reviewed each year.
Pest	Animals such as goats, pigs, deer, and hares live on the site and proliferate uncontrolled, mānuka beetles will affect seedlings and roots. Leaf roller caterpillars will chew the foliage of mānuka.	▯ Pest control should be carried out/either by ongoing shooting until the seedlings are fully established (up to 4 years) and be controlled through stockproof fencing, poison pellets and/or bait stations for possums and wallabies; ongoing pest control is necessary, helicopter cull at high and remote sites, monthly shots and control by man on the ground needs to be considered. ▯ Manuka beetle can be controlled by heavy stocking of the pasture area during winter to crush larvae (cannot be done on young plantations!). ▯ Leaf roller caterpillars do not generally destroy plants but if serious damage appears to be occurring, the plants may need to be sprayed with an insecticide. ▯ It is recommended to have a 5-year plan that is reviewed each year.

Cultivar Selection	To maximise the chances of survival and attain optimal growth, the choice of Mānuka cultivar must be carefully selected to suit the altitude, climate and soil conditions of the proposed planting site	□ Information provided by MFNZ on the various mānuka cultivars should be used as a basis for cultivar selection as a minimum. □ Ideally cultivar selection would be based as part of a wider Site Assessment by MFNZ.
Planting	**Description of Risk**	**Risk Elimination/ Reduction/Mitigation Action**
Timing	Young mānuka seedlings are sensitive to drought and frost so timing of planting is important. It is recommended that seedlings are planted in July-September period.	□ Planting should occur at a time that the plant is least likely to be impacted by frost, snow or drought
Delivery	The longer the delay between seedlings leaving the nursery and being planted, the lower the chance of survival	□ Coordinate delivery of plant arrival as close as possible to the plantation site where planting crew should be on hand to plant seedlings immediately. □ Seedlings should be checked against the agreed specifications prior to planting. □ If storing is required prior to planting, seedlings should be stored in a cool place out of direct sunlight; or in a cool store. If the seedlings heat up, the seedlings inside can die if the soil dries out and fungal disease can start to occur.
Planting	Wrong planting methods increase the risk of failure in plant establishment	□ Planters should be given the instructions on proper planting method and instructions for the specific site; be provided with a Planting Map and a systematic Quality Control process in place AS planting occurs
Post Planting Follow Through	**Description of Risk**	**Risk Elimination/ Reduction/Mitigation Action**
Weed	Weeds will continue to grow after the mānuka is planted. In many cases weed growth, if not controlled, will impede mānuka survivability and or growth	□ Follow up weed control 6-8 weeks after planting with release spray. Exact treatment will depend on weed type, degree of evasiveness, maturity and weather at that time. □ It is recommended to have a 5-year plan that is reviewed each year.
Pest	Pest control of hares, goats, deer and pigs as well as ensuring no access by stock will help substantially with seedling survival.	□ On-going pest control will help substantially with seedling establishment. It is recommended to have a 5-year plan that is reviewed each year. Follow up pre-plant control measures by maintaining a focus on pests such as deer, goats, hares/rabbits, and pigs. Also ensure livestock do not have access to the mānuka seedlings during establishment.

Appendix 3 – Research Gaps Still Existing in The Plantation Mānuka Industry

1. Effects of canopy closure
    a. On weeds/pests, growth, honey production
    b. Acceptable hive stocking rate of plantation upon reaching closure and maintaining productivity
    c. Lifetime of mānuka plantation
        i. End of production plan?
2. Variability of honey production from plantations
    a. Annual variation in honey quality and quantity
    b. Effects of hive numbers and apiary locations
    c. Full plantation (conversion) vs. plantation+wild (augmentation)
3. Environmental/climatic limitations of current genetic lines
    a. Frost, heat, drought, flood tolerances for seedlings and adults
    b. Effect of climate/latitude on flowering start and duration
    c. Growth and survival trials of new seedlines
    d. More mycorrhizal trials
        i. Fungal species which speed root development/plant establishment
        ii. Importance of mycorrhizal species diversity on mānuka establishment, growth, and nectar quality
4. Testing of carbon sequestration at plantation stocking rates and height potential (target of 5m at maturity in order to qualify under the definition of a forest for ETS)
5. Plan for areas of increased mortality
    a. Feasibility of blanking versus higher initial planting density
    b. Bee feed options and their effects (how much, where to plant)
6. Weed control options
    a. Selective versus residual herbicides
    b. New herbicide and or pesticide recipes
    c. Woody species control
    d. Good vs. average vs. poor management effects
7. Pest control

a. Good vs. average vs. poor management effects

8. Seed processing/cleaning protocol
9. Direct seeding opportunities
    a. with or without seed coatings
    b. with or without animal hoof disturbance after broadcasting
10. Prediction of where wild mānuka will establish naturally to avoid wild type incursion (e.g. management to address Ahu Ahu plantation)
11. Germination trials for current seedlines
    a. Amount of seed to collect
    b. Can improvement be made through seed applications?
        i. Artificial smoke?
    c. Temperature, light schedule, soil, mycorrhizal inoculation
    d. Options for improvement of nursery practices
12. South Island
13. Future tree consistency
    a. Will future generations of eco-sourced trees hold nectar characteristics?
    b. Consistency through years for current seedline nectar and floral qualities?
14. Myrtle rust
    a. Resistant genotypes and susceptible pheno- or genotypes
    b. Establish record of incidents/monitor planted areas
    c. Effects on honey production
    d. Effects on bee health
15. Testing of densely planted mānuka low on pines slopes as slash barrier/silt fence.
    a. Financial analysis of this with several future scenarios of harvest restrictions.

Bees

1. Carrying capacity on plantation
    a. At what point is intra-specific competition becoming a problem?
    b. Effect of distance from hive on harvesting capability
2. Interspecific insect competition

    a. Possibly becoming a factor depending on proximity to bush, dung, or something else?

3. Apiary design for increased production
    a. Size, location, physical features
4. Hive health
    a. How to quantify?
    b. Pollen and feed variety effects
    c. Hive pest measurements and records
5. Sugar content as an attractant
    a. High sugar mānuka seedline
    b. Effect of changed nectar sugar ratios
    c. Early season nectar may have higher DHA:sugar ratio
6. Flower characteristics as an attractant
    a. Relative floral attractiveness of mānuka
    b. What else is attracting bees to mānuka flowers?
    c. Other planted species as an attractant to draw bees to the area
    d. Hive applications (supplements) to increase honey production
    e. Quantify mānuka attractiveness vs other species
        i. Control of competing nectar species vs. distinct flowering times
7. New hives
    a. Can hive health or production be increased with new hive logistics?
    b. New hive materials
8. Monitoring options
    a. Can monitoring lower the in-person assessment investment?
    b. Or would more beekeepers allow for better production?
9. Bee breeding
    a. Mānuka nectar preference possible?
10. Fly/harvest zone

a. What is the actual size of honeybee harvest area?

The Model

1. GIS model integration
    a. Initial site location and assessment
    b. Vegetation calculations for modelling
2. Data
    a. More plantation honey quality results matched with nectar quality are needed
    b. Further develop pest and weed management predictions
    c. Continue both growth, mortality and honey quality validation
    d. Validate honey yield predictions (other factors than just weather?)
    e. Better weather data for remote areas

Appendix 4 – MFNZ Communications Plan (August 2018)

Purpose

Mānuka Research Partnership (NZ) Limited (MRPL) is a company with a wide range of primary industry shareholders and interests including Landcorp (Pāmu Farms of New Zealand), Te Tumu Paeroa (The New Māori Trustee), the Hawke's Bay Regional Council, DC and CY Tweeddale Partnership, Nukuhau Carbon Limited, Arborex Industries Limited, and Comvita NZ Limited. MRPL was set up to co-invest with Government through the Ministry for Primary Industries to complete the High Performance Mānuka Plantations Primary Growth Partnership.

This programme of work ends in September 2018.

Through findings of the High Performance Mānuka Plantations PGP programme, Mānuka Farming New Zealand (MFNZ) has been set up to commercialise the learnings and tools developed within the programme for the mānuka industry.

The purpose of this communications plan is to direct and plan MFNZ communications at three levels – for:

- Marketing purposes
- Industry engagement and
- Sharing of technical information

as the High Performance Mānuka Plantations PGP programme comes to an end, and commercial activities continue this includes

Background

In 2011 the goal of the High Performance Mānuka Plantations PGP programme was that by 2028 (ten years post completion of the programme), through productivity gains enabled by the programme, the mānuka honey industry in New Zealand will be worth $1.2 billion per annum, a 16-fold increase in its value of $75 million in 2010.

The primary outcome of the PGP Programme is demonstrative proof of the technical and economic feasibility of combining improved genetics with mānuka husbandry practices to achieve the following productivity gains:

1. Double the hives carrying capacity per hectare on mānuka throughout New Zealand;
2. Double the average yield of a hive;
3. Double the proportion of mānuka honey capable of sale as a medicinal product;
4. Double the land area in mānuka that is economically accessible to beekeepers

The programme started in June 2011. The existing PGP work programme was expanded in April 2014. This included extension into new work areas, with the addition of new co-

investors. The expansion increased the total value of the PGP Programme from $1.7 million to $2.9 million.

MFNZ was created in December 2016 as the commercial arm of MRPL. This gave the Research Partnership a public face to apply the tools and technologies created through the High Performance Mānuka Plantations PGP programme. MFNZ has since developed a strong presence in the market place, with a coordinated communication approach covering its seven step process to mānuka plantation success.

Communication objectives

1. Continue to build strong functional relationships with industry, Iwi, landowners, bee keepers, farm managers, research partners, and potential investors by engaging with target audiences to foster good relationships and using key project milestones to keep these target audiences engaged during the timeframe of the PGP programme and beyond.

2. Establish effective communication protocols and processes for the end of the programme that will:
    a. Communicate and promote MFNZ function and role in the industry, its capabilities and technologies with clients, Focus on clear, concise, and consistent messaging.
    b. Differentiate the role of official spokespeople from that of shareholder partners
    c. Enable MFNZ and partner teams to communicate effectively and securely with each other
    d. Ensure a no-surprises approach for communications (i.e. partners inform each other in advance of any external event participation and/or other announcements, allowing opportunity for comments from partners.)

3. Maximise exposure through a range of channels, e.g., New Zealand news media, trade media, events, website, and appropriate social media.

4. To **protect** our IP and our credibility in all communications.

Our unique selling proposition

Our Vision "To be a world leader maximizing "Value" from Mānuka Plantations for our client." (where "Value" is defined primarily as being the commercial and environmental returns realisable from a plantation)

Our Mission "To deliver an end-to-end integrated service maximising the value from mānuka plantation for our clients"

Our Focus To work with landowners in New Zealand who are able to make a material difference to the **wellbeing (hauora)** of our **people (tangata)** and our **land (whenua)** through an economically, environmentally, and socially sustainable mānuka-based industry in New Zealand.

We have 5 key unique competitive advantages:

1. We are the only company in New Zealand that is dedicated solely to the

establishment and management of mānuka plantations for high grade mānuka honey.

2. We are the only company that provides a complete end to end service for the establishment and management of mānuka plantations for high grade mānuka honey; and honey harvest thereof.

3. We are the only company whose mānuka expertise is based on science (through the Primary Growth Partnership Programme on High Performance Plantation Mānuka) and practical mānuka plantation experiences.

4. We are the only company in New Zealand with access to all major sources of mānuka seedlings and the only one in New Zealand with exclusive access to the hybrid mānuka seedlings bred especially for high grade mānuka honey production.

5. Lastly, we take a holistic, long term, and collaborative approach to working with our clients incorporating the 4 “E’s” being:

- Environment
- Education
- Economic Development
- Employment

Target audiences

An initial stakeholder analysis was completed in 2015 and then updated in 2018, noting stakeholder power, influence, and interest in MFNZ. Further analysis and details have been completed by the Client Relationship Manager and General Manager to develop a continued understanding of the most important stakeholders to engage, and work out how to win their support.

Stakeholder Matrix

HIGH

THE **INFLUENCE ON MFNZ**

LOW

Important Influencers *These groups assist or reduce likelihood of the MFNZ delivering its strategy*	**Key Players** **This group is critical to the survival and prosperity of MFNZ**
• Central Government (Policy & Incentives) • Regional Councils (Regulations & incentives, and endorsement of MFNZ) • Influential journalists/publications • Previous and Existing clients • Industry bodies or cooperatives – Apiary NZ, UMF Association, Fed Farmers, Fonterra **Overall Communication Strategy** **Main Focus: Inform** **Nature of communication:** • On an "As Required" basis but planned • Proactive and Reactive • Customised information to each stakeholder/stakeholder group	• Existing MFNZ Shareholders • Existing Customers • Promising Prospects • Suppliers of products and services to MFNZ (e.g. Comvita, Kauri Park) • Internal Staff **Overall Communication Strategy** **Main Focus: Collaborate** **Nature of communication:** • Regular, frequent, timely • Proactive and Reactive • Customised information to each stakeholder/stakeholder group
Keep Informed *These people are not directly involved, but their support is an advantage*	**Key Influences** *These people assist or reduce likelihood of MFNZ benefits being realised*
• General Public • Other political parties and local MPs and Mayors where MFNZ operates • Research Institutions (SCION, Landcare) **Overall Communication Strategy** **Main Focus: Inform** **Nature of communication:** • Regular and timely • Customised information to each stakeholder/stakeholder group	**Key Prospect Groups** (in as far as decisions regarding mānuka planting is concerned) • Large (100 ha) Landowners • Iwi (and TPK) • Professional Investors • Carbon Farming companies • Honey companies • Bee Keepers **Potential allies** in related services: • Agricultural consultants (inc Trees for Bees) • Rural real estate agents • Suppliers of products and services to the honey or beekeeping industry • **Previous and Existing clients** • **Influential journalists/publications** • **Specific individuals or business units within central and local government** **Overall Communication Strategy** **Main Focus: Inform** **Nature of communication:** • Regular and timely • Proactive and Reactive • Customised information to each stakeholder/stakeholder group

The **Impact of MFNZ** on them — **HIGH**

Internal

- MRPL/MFNZ Board
- PGP Programme Steering Group (until 30th September 2018)

External

The key prospective market is:

a) the medium to large-sized enterprises that make up the dairy, sheep and beef, forestry and deer farming sector (land with available area to plant 100 ha or greater)
b) Māori agribusinesses that own farms, processing, service and supply firms (Māori land and forest owners)
c) Bee keepers buying or who own land.
d) NZ Carbon traders who own land.
e) Investors

This key target market is supported and influenced by:

f) Agribusiness industry
g) the firms that process and export products from those farms' outputs
h) the firms that supply and service those farms and processors
i) the industry organisations that represent farms, processors and exporters
j) the local, regional and government sector organisations (MPI, MBIE, Regional councils)
k) Beekeeping communities

Secondary audiences are:

- Public
- Research and development networks and collaborators.
- Relevant government agencies
- Media
- Environmental commentators and groups
- Ministers

Communication risks

The success of this plan may be influenced by the following risks:

Risks	***Mitigation***
(Some) PGP Partners unwilling to invest	Have a plan to look for other investment partners

further after the PGP finishes	Be financially secure so no further investment from Partners is needed
Partners use conflicting/inconsistent messages to stakeholders	Make sure Partners understand MFNZ services. Maintain consistency of collective communications. Each of the Co-investors have specialty areas and need to receive recognition for the work they do. This requires a collaborative communications approach and shared ownership to ensure the success of MFNZ. Presentation to be done and distributed to Shareholders employees
Brand clutter	Adhere to branding protocols and key messaging.
Multiple audiences	Clear communication systems and process for each level of audience participation.
Unavailability of key spokespeople	Assign back up spokesperson and content approvers
That co-investors and collaborators don't understand the scope of MRPL and MFNZ function and roles	Clear roles and functions. Clarity and consistency of messaging across existing and new collaborators.
Competition for market share	Clear messaging around the uniqueness of MFNZ partnership, services, and our unique approach to independent science and research that provides access to expertise and technologies.
Engaging and maintaining media interest	Ensure regular media releases around new technologies using communications protocols and media (print, web, social), with engagement from appropriate Board members.
Communication outputs are not delivered on time, owing to resource constraints	Ensure capacity within MFNZ, use in-kind facility of co-investor in-house communication teams or engage a contractor.
Caution is required with all communications referencing Comvita to ensure their obligations as an NZX-listed company are not compromised.	Any such communications need to be reviewed by Comvita prior to release.

Communications approach

This communication plan aims to achieve the communication goals and address barriers using an integrated approach where the function, roles and activities of each co-investor are clearly aligned. It will be important to establish clear and targeted lines of communications with future research partners and co-investors.

Three levels of communications will be required for:

i. marketing purposes,

ii. industry engagement, and

iii. PGP progress and technical information.

A website was built in early 2016 that gave Mānuka Farming NZ and the PGP programme a presence and a point of contact/reference as more and more people become interested and engaged. It is proposed to have only public information stored on the website, with no

separate login access. The website contains the following

- Why Mānuka?
- Our services
- Research and PGP updates
- About us/Contact us
- Published theses, journal papers and reports

It is planned for the website to be reviewed in late 2018 and upgraded in early 2019.

Mānuka plantation husbandry techniques have been made available through MFNZ's commercial consultancy services to landowners wishing to plant Mānuka. This is known as the MFNZ seven steps to Mānuka Plantation Success.

Key messaging that appeals to and is understood by different audience groups needs to be crafted and supported with a range of marketing and technical information and data. The benefits and uniqueness of MFNZ need to be articulated, such as the breadth of the partnership and the breadth of independent science knowledge gained through the PGP by MFNZ.

Key messages

Key messages will be developed for specific audiences, based on the following high-level messages:

- Mānuka Research Partnership (NZ) Limited (MRPL) was formed in 2011 by a wide range of primary industry shareholders and interests including Landcorp (Pāmu Farms of New Zealand), Te Tumu Paeroa(The New Māori Trustee), the Hawke's Bay Regional Council, DC and CY Tweeddale Partnership, Nukuhau Carbon Limited, Arborex Industries Limited, and Comvita NZ Limited to understand how High Performance Mānuka Plantations could increase the value of the NZ mānuka honey industry

- MRPL has co-investing with Government through the Ministry for Primary Industries in the High Performance Mānuka Plantations Primary Growth Partnership and has commercialised its findings through Mānuka Farming New Zealand (MFNZ).

- MFNZ has designed and intimately understands best practice Mānuka Plantation establishment and management practices.

- MFNZ is a growing leader in the New Zealand agricultural industry providing independently sourced science based solutions to landowners and apiarists to partner together to increase both on-farm and honey productivity.

- Through the PGP research MFNZ has developed new technologies that allows for predictability in honey yield and activity in given environmental conditions. Implementation is through MFNZ consultancy six step process.

- MFNZ in association with MRPL and Comvita have developed a range of seedlines that are suitable for plantation development. These seedlines have been shown to be field-hardy in a number of environments throughout New Zealand and have been selected for floral density, flowering times, and nectar quality. Implementation is through MFNZ consultancy six step process.

- MFNZ will, where appropriate, encourage the retirement of marginal pastoral farmland and planting in Mānuka to reduce the effects of hill country erosion and

costs to communities through improving water quality, biodiversity and animal welfare.

- MFNZ is offering a non-traditional but legitimate forestry alternative for land owners to convert marginal land and land that needs to be retired into economically viable land. MFNZ will provide a full solution (total package) to land owners.

- MFNZ can work with the landowner to provide specialists for land environmental planning who use and develop tools that allow land owners to evaluate best land use for each individual site and reducing on-farm environmental impacts.

- MFNZ will assist the landowner with applications for National and Regional funding assistance through its specialist staff and networks and access to MPI and Regional Council funding schemes.

- MFNZ will offer advice on site evaluation, plantation establishment, and maintenance utilising its research-led experience through its specialist staff.

- MFNZ will make available the best of its field tested Mānuka seedling provenances and cultivars (sourced either from its own breeding programme, or from its partner, Comvita) matched to individual planting sites.

- MFNZ will link the landowner to specialist, preferred service providers for apiary services

- Each co-investor is actively engaged in deriving high performing Mānuka plantations and a greater value from marginal and riparian land; MFNZ bring together specialised capability and knowledge across these organisations.

Implementation

Communication protocols

To ensure communications are controlled, consistent, and accurate over the life of the research programme and as we progress into full commercialisation of MFNZ, communication protocols have been developed and are provided as part of this plan.

The protocols cover branding, collateral, events, media / spokesperson, website, internal communications, and reports.

It is expected that all Co-investors, contractors, and staff shall observe these protocols, which are intended to helpfully guide tracking and approvals for communication activities.

The key protocol concerns spokespersons:

General and high-level messages (Governance)
The MFNZ Chair (or approved delegate) will be the spokesperson on matters concerning MRPL and MFNZ itself, such as purpose/role, structure, funding, and priorities.

General and high-level messages (Operational)
The MFNZ Chief Executive Officer will be the spokesperson for comment on MFNZ activities.

All spokespersons will adhere to a ‘no-surprises’ principle by informing the Chief Executive Officer whenever public statements have been made.

Until 30th of September 2018 the Programme Steering Group will be responsible for approving the release through MFNZ of significant public communications relating to the PGP programme, such as media releases and feature articles.

After the 30th of September 2018 the Chief Executive Officer will be responsible for approving the release through MFNZ of significant public communications relating to the PGP programme, such as media releases and feature articles.

Coordination of communications activity will be managed by the Programme Manager and supported by the communications resource.

A communications register has been established to record communications activities across MFNZ. The Programme Manager will be responsible for updating the register.

All public responses to competitor commentary such as media releases, announcements, and claims will follow the same governance and operational protocol outlined above. MFNZ may choose to ignore competitor commentary or to selectively respond where considered appropriate. At all times the primary focus will be to promote the positive attributes and key messages of MFNZ.

Look and feel

A marketing and communications style guide and visual brand standard will be developed in early 2019 to ensure consistency of branding, messaging and style across all partners in MFNZ.

A logo and brand profile has been developed for MFNZ. These visual elements must be used consistently when used jointly or separately by research Co-investors, including correct logo placement and positioning.

The default assumption is that all public communications relating to the PGP are co-branded with MPI and released through MFNZ.

Communication activities

Industry engagement via:

- Hosted events (conference, regional symposiums/workshops; open and closed)
- Attended events (as presenters, delegates, exhibits)
- Sponsorship (selected for impact)
- Website
- Audio/visual products (presentations, videos, webinars)
- Advertorial articles (key rural publications)

Technical and research information sharing and resourcing

- Website (secure)
- Programme of meeting and reporting (via Programme Manager)

Marketing via:

- News media (media strategy, creating opportunities)
- Written materials (articles for trade and professional magazines, newsletter, web content, information/fact sheets)
- Branded marketing collateral (display materials including banners, hand-outs)
- Social media (LinkedIn, Facebook, etc.)
- Direct marketing to identified targets (market intelligence needed)
- Advertising (if needed for controlled reach to target audiences, subject to budget)

Communication priorities and media strategy

Year One (July 2018 to June 2019) *This plan covers communication activities for the next year*

Marketing activities

- MFNZ Branding and technical content website redevelopment
- Development of video material for website, YouTube, and presentations
- Information on MFNZ "Seven-steps to Mānuka Plantation s=Success" process documented
- Regional road show
- Apiculture conference booth and presentation
- Advertising in the Farmers Weekly publication

PGP specific output communications are in the below table;

	Story	Type	Description	When	Who	Placement
1.	New Staff	Media release	An introduction of Plantation and Apiary Performance Manager finishing at Massey and commencing with MFNZ.	August 2018	MRPL/ MFNZ	Regional Media/National Media
2.	New staff	Media release	An introduction of Plantation Establishment role commencing with MFNZ	September 2018	MFNZ	Regional Media/National Media
3.	CVT6 new release story	Media release	Describing introduction of CVT6 into cultivar range	October 2018	MFNZ/ Comvita	Regional Media/National Media
4.	Re-forecast of industry benefits	Media release	A statement covering the revised industry growth by 2028	March 2019	MRPL/ MFNZ/ MPI	Regional Media/National Media
5.	End of PGP programme	Media release	A statement of High Level findings and benefits to industry	April 2019	MRPL/ MFNZ/ MPI/Massey	Regional Media/National Media

6.	Opinion pieces in local papers on merits of Mānuka	Article	Use the expertise within the programme partners and MFNZ to write content on specific subject areas. This would be a series of articles	May 2019 through to December 2019	Shareholders/ MPI/ MFNZ	Rural Media, regional media, Farmers weekly, stakeholder publications e.g. HB Regional Council newsletter
7.	End of programme evaluation	Press release	Public findings from the programme evaluation	June 2019	MPI/MRPL/MFNZ	Regional Media/National Media
8.	Land comparison model	Case study	Use shareholder (Te Tumu Paeroa or Nukuhou Carbon) land scenarios and run through land comparison model. This could also cover decision process shareholder went through before they planted	August 2019		Rural Media, regional media, Farmers weekly, stakeholder publications e.g. HB Regional Council newsletter
9.	Launch of model	Media release	Economic benefits Farmer Benefits Environment benefits	July 2019	MRPL/MFNZ	National Media – Big launch to attract attention, Press
10	Learnings for HPM PGP	Presenter	Speaker at Apiculture Conference 2019	July 2019	MRPL/MFNZ	Apiculture Conference
11	Trial Site Successes	Article	Article on 2018/19 results of the trial plantations, positive learnings	September 2019	MFNZ	Farmers weekly article

*** Proposed Video Topics**

	Topics
1	**About MFNZ**
	Who we are
	What we do
	Benefits of working with MFNZ
2	**Case Study** - How we have worked with clients (and regional councils), and what they say about us
3	**Case Study - Mānuka Plantation at Lake Tutira**
4.1	**Overview of MFNZ Six Step Process**
4.2	Detail of each step
4.2.1	Step 1 - Desktop Assessment
4.2.2	Step 2 - Site Assessment (covering the use of the Model)
4.2.3	Step 3 - Securing of Finance (including JV arrangements, and local and central government funding)
4.2.4	Step 4 - Plantation Establishment
4.2.5	Step 5 - Plantation Monitoring
4.2.6	Step 6 - Honey Harvest options

Resources

MFNZ will use contractors such as AttN! Marketing to resource media watch, communications and marketing capabilities. The budget needs to be approved by the MFNZ Board.

The Programme Manager will be used as a conduit between the Chief Executive and the communication and marketing contractor(s).

MFNZ has purchased a CRM system to manage its clients and potential clients. This has 4 main classifications;

1.	Prospect	Someone that we want to target as a client, they may not necessarily have contacted us.
2.	Lead	Basically an Enquirer – someone who has asked for information
3.	Opportunity	an Enquirer, Lead, or Prospect who has asked for further info or expressed further interest since receiving info from us (e.g. a person/company regarded as likely to succeed or as a potential client)
4.	Customer/Client	Anyone who has paid us for a service/product

Measurement

- Protocols adhered to by co-investors
- Key messages well utilised in review of co-investors communication outputs
- Number of enquiries from potential clients, contractors, end-users
- Number of new contracts for seedlings
- Unique visitors to MFNZ website
- Feedback from existing and new customers, endorsements, testimonials
- Attendances at workshops and conferences

- Media pick up
- Volume of printed collateral generated on demand.

Key people

MRPL Chair	**Office**	**Mobile**
Neil Walker (Nukuhau Carbon Limited)		027 278 2667
Chief Executive		
Stephen Lee (MFNZ)		020 4122 2858
Client Relationship Manager		
Bronwyn Douglas (MFNZ)		027 6666 863
Plantation and Apiary Performance Manager		
Maggie Olsen		022 422 7280
Plantation Establishment Manager		
Rob Tiopira		027 6458 579
MFNZ Board		
Andrew Slipper (Landcorp)	04 382 1860	027 404 6941
Chris Rich (Te Tumu Paeroa, The New Māori Trustee)	04 474 4669	027 431 4432
Campbell Leckie (Hawke's Bay Regional Council)	06 833 8099	027 214 7436
Don and Conchita Tweeddale (DC and CY Tweeddale Partnership)	06 388 1217	
Tony Wright (Comvita NZ Limited)		021 386 710
Dan Riddiford (Arborex Industries Limited)	06 306 9849	04 475 8705
Other key persons		
Barry Poole (Comvita NZ Limited)		027 476 1381
Jonathan Stephens (Comvita NZ Limited)		021 386 923
Gordon Williams (Landcorp)		027 473 3763
Sera Price (Te Tumu Paeroa, The New Māori Trustee)	04 474 4669	027 431 4432
Maria Boyle (DC and CY Tweeddale Partnership)	06 388 1217	
Simon Walker (Nukuhau Carbon Limited)		
Ben Douglas (HBRC)		027 706 7455
Richard Archer (Massey University)	06 951 7557	021 246 3084
Steve Penno (MPI)		027 275 7736
Annette Carey (MPI)	06 974 8817	029 974 8817
Communications Managers	**Office**	**Mobile**
Brad Young (MPI)	04 894 0884	021 868 734

Julie Chadwick (Comvita)	07 533 1708	021 510 693
Heidi Norman (Landcorp)	04 381 4050	
Drew Broadley (Hawke's Bay Regional Council)	06 835 9200	
Sarah Ropata (Te Tumu Paeroa, The New Māori Trustee)	04 474 4688	021 633 800

Appendix 1: Communications action plan

Elements

Written	Digital	Events	Media	Educational
Brochures (marketing)	Excel spreadsheet of stakeholders and potential clients	Workshops, symposiums	Media strategy	Website content (public level)
Website content	Presentations Video	Presentations at conferences, symposiums	Co-investor and partner profiles on website	Website content (public level)
Display banners (marketing)		Conference attendance	Achievement and news items on website	
Marketing and branding style guide	Promotional videos (marketing)			
Science reports and papers (engagement)	Scenarios	Possible conference and site visit to plantation e.g. Tutira)		Published data/information in journal databases, sometimes on google scholar.

Proposed future actions (subject to resourcing)

Timing	*Focus*	*Audience*	*Activities*
	Build on foundation	Current and potential partners, research partners and clients	• Continue to refine messages and marketing material as new cultivars/new IP become available • Market research, surveys • Further mapping to identify key suitable sites • Update website
	Maintaining interest	Clients	• Update website • Conference calendars – hosting, attending, speakers • Build on CMS database
	Proof of concept	Clients	• Publication of papers • Reporting • Updating website with success stories and case studies

Appendix 5 - PGP IP rights, obligations and restrictions of each shareholder

Purpose

The purpose of this paper is to outline each Mānuka Research Partnership (NZ) Limited (MRPL) shareholders entitlement to the IP that comes out of the PGP Programme including the associated rights and restrictions. The views expressed here have been formed following a review of the relevant shareholder and other relevant agreements.

Unlike tangible property or concrete things, such as a car or land, intellectual property (IP) is an intangible thing of value, or potential value, such as information or data which can exist in the abstract and can easily be transferred or multiplied. For example, IP will include:

- operational research reports;
- formulas or processes whether electronic or chemical;
- more generally, any information that can be easily copied or transferred whether manually, orally, or electronically.

The shareholders of MRPL understand and accept MPI's guiding principle that commercialisation and distribution of the IP needs to be done in such a way that maximises the benefit of the PGP programme to New Zealand. This guiding principle is outlined in more detail in Schedule 2 of the PGP Agreement (Intellectual Property (IP) Management Plan) under Clause 5. Clause 5 lists several principles that the co-investors have agreed to adhere to regarding the management and use of IP held by MRPL during the course of the Programme, and for a period of 5 years from the date of termination or expiry of this Agreement (i.e. 30 September 2023).

Schedule 2 of the PGP Agreement (and its variations) (Intellectual Property (IP) Management Plan), states that "the IP generated and developed during the term of this Agreement (referred to as "Research Project IP") shall be transferred to MRPL". In other words, MRPL is the entity that will hold the IP and not the individual shareholders. Clause 16.2 of the MRPL Shareholders Agreement supports this position, with the statement that all IP arising out of the research project conducted by Massey University pursuant to the research agreement between MRPL and Massey University, excluding any background IP, shall be owned by MRPL.

It was agreed by the MRPL Board that MFNZ would be set up as the commercial arm of MRPL to commercialise the IP from the programme, enabling the shareholders to see a return from their investment from the PGP programme and so that IP was being made available to NZ Inc. through its service offerings.

MRPL is continuing to commercialise the IP by making it available to NZ Inc. through its commercial arm, Mānuka Farming NZ Limited. Mānuka Farming NZ Ltd. now provides a complete end to end service for the establishment and management of mānuka plantations for high grade mānuka honey in New Zealand.

Clause 16.2 of the MRPL Shareholders Agreement (confirmed in Clause 4 of Schedule 2 of the PGP Agreement (and its variations), outlines how MRPL and Comvita (Comvita Limited and Comvita New

Zealand Limited) can use the IP from the programme. Clause 16.2 states that MRPL and Comvita are each entitled to use such research project intellectual property on a non-exclusive, non-transferable, royalty free basis for the purpose of developing and commercialising such Research Project IP in New Zealand. MRPL and Comvita may sub-licence the right to use such Research Project IP to any wholly owned subsidiary of Comvita Limited without the need for approval. Any other sub-licence requires the approval of MRPL (such approval not to be unreasonably withheld). Any IP arising out of MRPL's use and development of such research project IP shall be owned by MRPL. Any intellectual property arising out of Comvita's use and development of such Research Project IP shall be owned by Comvita.

All other Shareholders may use the IP developed from within the programme for their own means and on their own land. Shareholders (other than Comvita) may not sub-licence, share and disclose the IP developed within this programme. Any intellectual property arising out of MRPL's use and development of such research project intellectual property shall be owned by the Company. Any intellectual property arising out of Comvita's use and development of such research intellectual property shall be owned by Comvita.

All Comvita Background IP owned by Comvita or any of its related companies is the property of Comvita or the relevant related company (as applicable).
All intellectual property arising out of Comvita's Breeding Programme (as defined in Schedule 4) is the property of Comvita.
MRPL shall be entitled to use CVT's Background IP for the purpose of the research project contemplated by the PGP Agreement and to commercialise the same in accordance with the terms of the Licence and Supply Agreement – Mānuka Seedlings

MPI does not wish to own the IP from this programme.

The High Performance Mānuka Plantations PGP programme has several potential spill-over benefits or public good aspects, in particular potential environmental benefits. Where the research project IP can deliver such benefits (which is in the majority of circumstances with this PGP programme), MRPL undertakes to commercialise the IP and make it available to any party within New Zealand under normal commercial terms and within 3 years of the date of expiry or termination of the PGP Agreement (i.e. by 30 September 2021 at the latest). Where IP from the programme has not been commercialised by MRPL by 30 September 2021 (and in particular where it could contribute environmental and other benefits), MRPL will make this IP publically available via the MFNZ website, or to MPI for open-access release should MFNZ cease to exist by this date.

All pre-existing IP (noted as background IP in the IP register below) provided by a Party for use in the Programme will remain the property of the Party contributing the IP or its third party licensors;

Where a research method is developed within the programme Massey University retain the right to use this method for other work.

Most IP will end up in the model, the protocols developed, student theses and publications. The theses will be embargoed for 1 to 2 years. And electronic copies of the theses and publications will be distributed to each shareholder to use for its own purposes.

An IP register has been developed (below) and contains all IP developed within the High Performance Mānuka Programme. The register lists all IP and how it will be commercialised.

All shareholders will have access via a Dropbox folder of each of the deliverables from 1st of July until 30th of November 2018 including. Shareholders will be given notice when completed deliverables are available and when the dropbox folder will be closed by the 30th of November 2018

50. The Technical notes
51. Nectar sampling protocol (for researchers)
52. Nectar sampling kit and field manual (for landowners & others)
53. Guidance on nectar analysis and interpretation
54. Technical Notes for Plantation Mānuka
55. Weed and Pest management Plan for Plantation Mānuka
56. Database / Data warehouse
57. Predictive model for plantation mānuka – Version as of 30th June 2018
58. Functional Description of the predictive model for plantation mānuka - Version 2
59. Commercial findings to date from PGP
60. Mānuka leaf sampling as an indicator of mānuka nectar quality potential
61. Sampling Protocol for Eco-sourced Mānuka
62. Seed germination and viability protocol
63. Quarterly Progress Reports from Massey and Programme Manager
64. Quarterly Financial Reports
65. Pest and weed plans for 4 main trial sites
66. Thesis - Influential Factors in Nectar Quality and Yield in *Leptospermum scoparium*
67. Thesis – Companion biota associated with *Leptospermum scoparium* (mānuka; *Myrtaceae*)
68. Thesis- Rachael title coming
69. Paper – Analytical FT-Raman spectroscopy to chemotype *Leptospermum scoparium* and generate predictive models for screening for dihydroxyacetone levels in floral nectar
70. Paper - Soil influences on plant growth, floral density and nectar yield in three cultivars of mānuka
71. Paper- High UMF® honey production from mānuka plantations.
72. Paper - Honey bee visitation study
73. Paper - Mycorrhizal fungal study
74. Paper - Mycorrhiza
75. Paper - Scale insect survey study
76. Final Programme Report

Note: As per Clause 16.2 of the MRPL Shareholders Agreement and Schedule 2 of the PGP Agreement - All Shareholders (other than Comvita) may use the IP developed above that comes from within the programme for their own means and on their own land only.