‘Whakapuputia mai o mānuka’
A case study on indigenous knowledge and mitigating the threat of Myrtle Rust (*Austropuccinia psidii*)

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Toitu te marae o Tāne

Toitu te marae o Tangaroa

Toitu te iwi

If the domain of Tāne survives to give sustenance,
and the domain of Tangaroa likewise remains,
so too will the people

(Whakataukī or proverb shared by Te Ātiawa, 2018)

Abstract

This research centres on the recent myrtle rust (*Austropuccinia psidii*) incursion in New Zealand to review the literature on the disease specifically and to create a localised case study with Ngāi Tāneroa hapū of Ngāti Kahungunu ki Wairarapa. The case study focused on the importance of whakapapa, mātauranga Māori, tikanga Māori and the practices of kaitiaki to ethnobotany and the development of indigenous biosecurity measures (tools) to protect culturally important plant species within the Māori community

The proverb stated in the title of this thesis *whakapuputia mai o Mānuka, kia kore ai te whati* – (cluster the branches of the Mānuka, so they will not break off) recognizes the status of plant knowledge in te Ao Māori. It provides a foundation of understanding how Māori can participate in resource management against biological threats, which are becoming increasingly common. The science around myrtle rust and the mitigation of any incursion threats is clearly aligned to western paradigms. The information presented in this thesis outlines an extensive understanding of the intricacies of the disease as understood by the science community. But this science alone has not been able to halt the spread or risk of myrtle rust into new geographical regions. Therefore, future management of the risk of myrtle rust incursions needs to look at alternative approaches for the development of suitable management tools.

The holistic approach of traditional biodiversity management using mātauranga and tikanga Māori has much to offer to conservation of taonga resources, especially the mitigation of biological threats. The Māori worldview of the environment encompasses all elements beyond the physical attributes of an ecosystem that thrives through traditional kaitiaki inputs. The case study with Ngāi Tenaroa introduced several examples of how Māori can contribute to the mitigation of all threats on the ecosystem, not just fungal threats. Firstly, the role of whakapapa is explicit and cannot be ignored. This role consolidates the management tools across all generations at the very least. Secondly, the role of networks within Māori communities and inter-generational learning is also clear – and the risk that exists if this is lost is apparent. Lastly, examples of local knowledge such as the effect of hukahuka on plant health, companion trees and role of kaitiaki in decision-making have been identified and their importance conveyed from the hapū under study.

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Though my present be small, my loves goes with it.

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Chapter 1: General Introduction

Introduction

This thesis is manifold: it draws from western science in representing a fungal threat to a local ecosystem; it further draws from tradition in the opportunity to describe the role of traditional knowledge to mitigate such threats; and it utilises a case study focussed on a cultural space to highlight the future application of both knowledge systems. The whakatauki or proverb – *whakapuputia mai o Mānuka, kia kore ai te whati* – (cluster the branches of the Mānuka, so they will not break off) is a succinct metaphor for the emphasis of the study and has been contributed by the hapū under study, Ngāi Tāneroa of Ngāti Kahungunu ki Wairarapa, Aotearoa/New Zealand.

It has become increasingly difficult for resource managers to achieve the control of new and invasive interlopers within the natural estate. Traditional inputs from Māori managers are struggling with the contemporary pressures on an ecosystem that has become burdened with a huge amount of exotic biology. The toolbox for management therefore needs to be examined to determine the possibilities of what traditional managers can provide to support the contemporary inputs currently available.

New Zealand has a unique landscape that is constantly under pressure from external factors including new pathogens. The country is also known for the unique cultural alignment it has to its Polynesian heritage and the Māori population. Māori have had to develop environmental management techniques using traditional knowledge to utilise in both traditional and contemporary issues, especially to protect their *taonga* flora and fauna species.

> *Pathogen incursion presents an enormous threat to the biodiversity of native forests and natural ecosystems around the world. Historically, plants have been engaged in a continuous battle and co evolving with pathogens in a dynamic plant disease epidemic and management situation (He, Zhan, & Xie, 2016; Zhan, Thrall, & Burdon, 2014). Many pathogens exist and thrive in natural forest ecosystems through mutualistic, symbiotic or parasitic associations however are considered a threat when they alter ecosystem services or ecological functions (Boyd, Freer-Smith, Gilligan, & Godfray, 2013). Pathogens (as organisms or causal agents), have high species diversity with a complex genetic, biological and physical compositions that allows them to create a significant impact in plant, animal, human or ecosystem health (Kean et al., 2015; Kriticos, Phillips, & Suckling, 2005; MacDiarmid, Rodoni,*

> *Melcher, Ochoa-Corona, & Roossinck, 2013; J. Stewart et al., 2018). Ellison et al. (2005); Lovett, Canham, Arthur, Weathers, and Fitzhugh (2006) and I. D. Thompson et al. (2011) all described the results of impacts of pathogens in an ecosystem and stated;Pests and diseases can affect the ability of forests to store carbon, to reduce flood risk, to stabilise slopes against landslip and avalanche, to maintain water supplies, conserve biodiversity and to support recreation and cultural values. The loss of particular tree species from pests and diseases can have a fundamental effect on the systems' ecological function, altering the mix and value of the ecosystem services provided by forests or landscape* (Freer-Smith & Webber, 2017, p. 3169).

The Parties to the International Convention on Biological Diversity (CBD)[1] adopted and defined biodiversity as "the variability among living organisms from all sources including, inter-alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (Mace, Norris & Fitter, 2012, p. 19). Likewise, an ecosystem is observed as a "dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit" (Mace et al., 2012, p. 19). They also represent a branching network of ecological and evolutionary processes that develops ecosystem services to components and outputs from which humans directly derive goods and benefits (Mace et al., 2012). Ecosystem services therefore are what humans benefit directly or indirectly from ecosystems such as an ecological structure (e.g., wood fibre) or function (e.g., filtering function of vegetation and soils) (Barnaud & Antona, 2014; Daily, 1997; Daniel et al., 2012; Mace et al., 2012). However, both ecological structure and function will need to be able to adapt to changes in knowledge, technical, social and cultural development and meeting the demands of humans to qualify as a service (Daniel et al., 2012). This is important towards understanding pathogenic invasion.

Pathogenic invasion is important to cultural services. The Millennium Ecosystem Assessment process of the United Nations defined cultural services as "the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences" (Alcamo, 2003, p. 8).

Trees play a major role in biodiversity. They provide and support many ecosystem services. For example, providing direct products used by man (provisioning services), the indirect benefits that occur through modification of the environment (regulating services), and

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[11] CBD as an output of the Rio Earth Summit, 1992. See www.cbd.int

improving human wellbeing (cultural services) (Boyd et al., 2013). They also have a deep cultural connection and act as the foundation of many indigenous cultures around the world. For example, in New Zealand, the Māori God of the forest Tāne-nui-a-rangi is the progeny of Ranginui the Sky Father and Papatūānuku the Earth Mother (Royal, 2007b). However, they face big threats from pathogens that include bacteria, helminths, viruses, oomycetes and fungi (Bergseng et al., 2012; Boyd et al., 2013; D. Cooke, Drenth, Duncan, Wagels, & Brasier, 2000; Dwyer, Dushoff, Elkinton, & Levin, 2000; Halbert & Manjunath, 2004). Among these groups of pathogens, fungi and oomycetes are perceived as the most important threat to tree health (Boyd et al., 2013). A growing number of studies have documented the impacts of pathogenic induced diseases on trees in different forest ecosystems which has further encouraged a more serious approach in ecosystem management and biodiversity conservation today.

A diverse collection of plant diseases arising from the presence of evolutionary pathogens have developed and affected a large number of indigenous reliant ecosystems (He et al., 2016). Complex pathogens such as rust fungi are becoming a major threat today (Yamaoka, 2014). They are destructive with high chances of creating substantial impacts particularly on many culturally important vascular plants (Morin, Aveyard, Lidbetter, & Wilson, 2012; Teulon et al., 2015; Yamaoka, 2014). *Austropuccinia psidii (A. psidii),* is an important rust pathogen of the *Myrtaceae* plant family that causes the disease Myrtle rust. This disease was first identified in New Zealand in 2017 and poses a big threat to not only the country's economy and diverse flora and fauna, but also the many culturally important plant species (*taonga*) with a special connection to Māori.

Indigenous communities continue to develop effective management strategies using Traditional Ecological Knowledge (TEK) in biodiversity conservation. They continue to associate their identity with their surroundings whilst at the same time utilise traditional knowledge assisted by communal interactions which are critical to cultural services (Daniel et al., 2012). Conversely, this is different for New Zealand. Given the virulent nature of myrtle rust and that it is new to the country, this knowledge may need to be combined with modern scientific knowledge of the disease to effectively manage it (Keough & Blahna, 2006; Tamara Ticktin & Johns, 2002). Creating a collaborative framework that incorporates both TEK and modern science (Western Science) for the protection and conservation of *taonga* plant species from myrtle rust is critical in this process (Makinson & Conn, 2014; Morin, Talbot, & Glen, 2014; Pegg et al., 2014). This is a common gap in all conservation efforts to protect *taonga* or culturally important species in indigenous communities of affected places like Hawai'i, Australia and New Zealand (Loope & La Rosa, 2008; Teulon et al., 2015). Conventional methods have been used extensively to control myrtle rust in affected areas (Makinson & Conn, 2014; Summerell, 2017; Yamaoka, 2014). However, these methods have failed to incorporate indigenous practices to synergize with modern scientific techniques in protecting important plant species from the pathogen.

This thesis therefore aims to identify the role of traditional ecological knowledge (TEK) in mitigating fungal threats to local ecosystems. This research will present a case study within a tribal region and focus on the importance of cultural factors through a triadic approach: Te Ao Māori (Cosmos including whakapapa), *mātauranga* Māori (Māori corpus), and *tikanga* Māori (Praxis) (Roskruge, 2007). This will be further represented through the practice of *kaitiaki* (the act of guardianship) and understading of Māori ethnobotany and the development of indigenous biosecurity measures (tools) to protect *taonga* plant species within the Māori community.

Background

Myrtle rust is a disease caused by the fungal pathogen *Austropuccinia psidii* (formerly known as *Puccinia psidii*) (Stewart et al., 2018). The disease is native to South America and is also known as guava rust, eucalyptus rust and Ohi'a rust; all derived from the specific plant species the pathogen affects in different geographical locations around the world (Loope & La Rosa, 2008; Makinson, 2014; Makinson & Conn, 2014; Winter, 1885). Myrtle rust is a recent biosecurity introduction to New Zealand and has been identified as a major threat to important *taonga* plants and native flora species in the Myrtaceae family and Myrtaceae dominated ecosystems (Stewart et al., 2018; Teulon et al., 2015). *Taonga* plant species are plants that have a significant relationship to Māori and offer special cultural and ecological services or traits, as well as connecting the people to their *whakapapa*. *Whakapapa* in brief, is a concept that links the people's emotions, behaviour, beliefs and historical genealogy to their surroundings including *taonga* plant species (Roskruge, 2007; Teulon et al., 2015).

As at April 2019, the disease has been discovered in 988 properties across New Zealand (MPI, 2019a)[2]. The disease is relatively new in New Zealand and is projected to impact the country's established 25,000ha of small scale eucalyptus forest industry, the Feijoa (*Acca sellowiana*) industry which is worth $1.9m, the cut flowers industry that depends on nurseries and is worth $27m, and the Mānuka (*Leptospermum scoparium*) industry which is worth a staggering $315m (Dickey, 2017; Hutching, 2017; Markham, 2017; MPI, 2017a). Likewise, for Māori, all *taonga* species are at risk.

As the pathogen continues to infect new host species, and expand in geographical range, immediate prevention measures are necessary to stop the spread and intensity of the disease. Biosecurity measures and biological methods have been implemented in countries with major outbreaks of myrtle rust. For example, here in New Zealand, conventional strategies such as identifying outbreaks, spraying procedures, and removing infected plants have been developed as the focus of the management process (Lambert, Waipara, Black, Mark-Shadbolt, & Wood, 2018). However, these procedures have failed to acknowledge and incorporate sociocultural input from indigenous communities which have special connections to their flora and fauna and are facing major issues from the impact of the disease (Liu, Walshe, Long, & Cook, 2012; Loope & La Rosa, 2008; Summerell, 2017; Teulon et al., 2015).

Addressing the sociocultural consequences of this disease to Māori and integrating their responses to the incursion using Traditional Ecological Knowledge (TEK) and cultural practices is pivotal to understanding the full ramifications of this pathogen, both ecological and sociocultural (Gurr & Kvedaras, 2010; Potts et al., 2016; Teulon et al., 2015). Māori science is set in a holistic environment to conceptualize two different worldviews and understandings between the past and the present, physical and metaphysical, people and the environment (Roskruge, 2007). Furthermore, existing localised and intimate knowledge such as the use of *mātauranga* Māori, *tikanga, whakapapa* and the practice of *kaitiaki* for instance, have been developed as part of the methods of mitigating risks and threats to pest and pathogen incursions in Māori traditional history (Lambert et al., 2018; Roskruge, 2007).

[2] MPI – Ministry for Primary Industries

Research Question:

How does indigenous knowledge assist in mitigating fungal threats to local ecosystems and contribute to the management of taonga (sacred and culturally important) plant species?

Research Objectives

- To overview a fungal incursion (Myrtle Rust) in the New Zealand context.
- To understand how Māori are using *mātauranga* and *tikanga* to contribute to management of flora and taonga species.
- To compare the ways in which modern science and traditional knowledge practices influence management of native flora both in New Zealand and globally.
- To explore the threat of the impacts of myrtle rust on a local Māori community as a case study.

Case Study

A case study was undertaken as the basis of this thesis. The selection of the case study was based on terms of reference drawn from a generic interpretation of the subjective consideration applied to case study theory (Hamel, Dufour, & Fortin, 1993). They were:

- Land owners or group who identified based on *kaupapa* Māori terms
- Land/activities identified which came under the jurisdiction of the group
- Past knowledge and interests in ethnobotany are apparent
- Historical/*whakapapa* relationship to the land is apparent

Furthermore, an information gathering process focussed on indigenous (primarily Māori *taonga* plants) plant disease management was undertaken in support of the case study. Information was sourced both from primary and secondary written sources, from communities (predominantly Māori) and other informants. An awareness of the logistical, time and skill constraints is acknowledged.

The case study was undertaken in the Wairarapa region and was focussed on the ancestral reserve of Uhi-Mānuka (listed as Carters Scenic Reserve under the Department of Conservation (DOC), New Zealand).

Chapters Overview

Chapter One is the introduction and background to the research question and thesis. The research objectives are also presented in this chapter. Chapter Two covers the broad mixed-methodology being applied in the research inclusive of the Kaupapa Māori Research approach and an outline to how the Case Study has been chosen.

Chapters Three, Four and Five present an overview of Traditional Ecological Knowledge (TEK), Ethnobotany and Māori conservation, as well as fungal pathogens and Myrtle Rust respectively from exisiting literatures. These chapters ensure the fungal issue that is the basis of the research is fully understood from both a Western Science and Māori perspective. Further, they set the scene for the following discussion.

Chapter Six is a thorough overview of Māori values, especially as they might be considered and applied in the biosecurity sector. Examples of Māori participation in the biosecurity sector are also introduced.

Chapter Seven is the Case Study which focuses on a conservation area known as Uhi-Mānuka in the rohe (area) of Ngāi Tāneroa, a hapū of Ngāti Kahungunu in the Wairarapa region. This case study has a particular emphasis on the relationship of the people to the resource and what steps have, and have yet to be, taken to mitigate risks against the threat of a Myrtle Rust incursion.

Chapter Eight utilises all the information provided in the preceding chapters to discuss the role of indigenous knowledge in mitigating fungal threats to local ecosystems whereby the case study uses Myrtle Rust (*A. psidii*) as the current example. A set of conclusions are made in Chapter Nine which completes the thesis.

Chapter 2: Methodology

Introduction

This research draws from a mixed methodology, inclusive of case study and survey methods, that incorporates the holistic views of both science communities under study: Māori and Western Science. Primarily, the research utilises the "Kaupapa Māori Research (KMR)" approach that is inclusive of diverse Māori traditional ecological knowledge and practises (Roskruge, 2007). According to Roskruge (2007)and Durie (1998), Kaupapa Māori Research methodology is an approach that acknowledges the significance of Māori culture and traditional knowledge (see Table 1), thus has appropriate procedures that will allow the involvement of Māori as guardians of the land to lead and make an important contribution to the project.

Table 1: A Māori Centred Research Framework (Adapted from N Roskruge (2007, p. 14) and M Durie (1996).

Purpose of research	1. Gains for Māori 2. As Māori 3. To advance positive Māori development
Practice of research	1. Active Māori participation 2. Multiple methodologies 3. Measures relevant to Māori
The practitioner	1. Māori researchers 2. Interim solutions 3. Competencies
The politics	1. Treaty of Waitangi 2. Māori and iwi 3. Funding

The relationship between Māori and western science is acknowledged as two different subjects of understanding in this research. Māori knowledge (or *mātauranga* Māori) is based on holistic concepts that are inclusive of spiritual bonds between the people and four critical interrelated elements; physical, spiritual, intellectual and sociocultural (Roskruge, 2007). It also includes cultural practices, observations that is based on respect and seeks Māori involvement. Western science on the other hand is acknowledged in this research as a concept developed to explain various series of observations and theories with implementation of testable practices and variables (Hoover & Donovan, 2001; Roskruge, 2007). Furthermore, Roskruge (2007), and Durie (1998) both described western science methodology as mostly lacking acknowledgement of Māori involvement. In this research a common language of understanding suited to working in an indigenous environment will be developed and utilised based primarily on the Kaupapa Māori Research approach supported by accepted ethnobotany research aims to ensure parties are on the same level of understanding in gathering and disseminating information.

A conceptual approach in indigenous research was originally presented by Toledo (1992) and later refined in 2000 (Toledo, 2002). The approach was based on three components as a framework for working with indigenous peoples and knowledge. These are: Kosmos, the peoples worldview, perceptions and beliefs; Corpus, primarily 'local' or indigenous knowledge, and Praxis, the practical implementation of the corpus of knowledge (Toledo, 1992). Roskruge (2007) in his research reworked this triad to fit with Māori (and arguably Pacific) interpretations in that the indigenous element, including Māori knowledge, is incorporated into the model where kosmos is applied as Te Ao Māori, corpus as mātauranga Māori and praxis as tikanga Māori. This model applies to the project undertaken here, especially as it is drawn from a strong cultural base.

Ethics

This study emerged from discussions between my supervisor, the kaitiaki, Frances Reiri-Smith of the Ngāi Tāneroa hapū, Ngāti Kahungunu in the Wairarapa region and myself. As a first step, the research concepts were formally introduced to the Ngāi Tāneroa *hapū* through our kaitiaki, Frances Reiri-Smith (Nanny Frances) following an initial *hui* hosted by Tahuri Whenua Māori Growers Organisation[3] in the Wairarapa.

[3] See www.tahuriwhenua.org

As required in projects like this one, Low Risk Ethical approval was sought from the Massey University Human Ethics Committee. Approval was gained prior to any information gathering or sharing was conducted (see Appendix 1).

Kaupapa Māori Research framework (KMR)

The primary consideration for this research is the Kaupapa Māori Research methodology which has evolved within New Zealand in recent decades. This approach sits alongside the mixed methodological approach and compliments the broad Polynesian cultural space which I was able to connect myself with as a Fijian and of a Melanesian background to the Māori society. There are many commonalities across Polynesian cultures not withstanding the whakapapa or genealogical links that exist thus are able to help with important cultural understanding and connections.

Kaupapa Māori according to Roskruge (2007) was developed with three crucial principles to include Māori perspectives and work into today's research methods. Enhancing local people's livelihood through integrating local innovative knowledge and practices to benefit the local community while at the same time exercising proper agreement and intellectual rights were the major components of these approach in developing a sustainable integrated methodology. Furthermore, this effort was also described as an investment to support the Māori research workforce (C Cunningham, 2000).

Kaupapa Māori has been described in many terms by several authors. There are several definitions of this concept however all are trying to elaborate on the importance of acknowledging Māori involvement and rights to access and ownership of their true traditional practices and knowledge in which many western academics and other attributes of work gain fame from. For example, the following key attributes have been derived from well-known researchers describing Kaupapa Māori Research approach;

a. *"… research which is "culturally safe", which involves the "mentorship" of kaumatua, which is culturally relevant and appropriate while satisfying the rigour of research, and which is undertaken by a Māori researcher, not a researcher which happens to be a Māori."* (Irwin, 1994 cited in C Cunningham, 1998).
b. *"research by Māori, for Māori and with Māori."* (Smith, 1995 cited in C Cunningham, 1998).
c. *"Kaupapa Māori challenges (a) universal approach … and argues that the theoretical approaches of a variety of disciplines fall well short of being able to address Māori*

> *needs or give full recognition of Māori culture and value system."* (Reid, 1998 cited in Cunningham, 1998).

These definitions of kaupapa Māori are projected to evolve over time as research develops and the understanding of different concepts and how they fit into the context of Māori research workforce becomes clearer (Cunningham, 2000).

"Māori value and have always valued knowledge".

This statement (Cunningham & Durie, 1998) is a testament to Māori as a culture that acknowledges and has the utmost respect of their existence to these unique traditional understanding that was passed down from their forefathers and has existed for generations. Similar to other indigenous communities, this important knowledge holds some of the world's unique perspectives on human existence, environment conservation, food systems and agriculture, traditional medicine, development, as well as local and international relationships (Twarog & Kapoor, 2004). These are also all expressed through related experiences and common holistic world views of indigenous people (Durie, 2004).

However, the major issues on this field of understanding is its use and the respect it's given from the western science world particularly by researchers in various academic and government associated fields (Cunningham & Durie, 1998; Roskruge, 2007). According to Durie (2004), the concept and functionality of this knowledge is somewhat impossible to be substantiated by the principles of western science or vice versa as traditional knowledge is uniquely established on what he quoted as "distinctive philosophies, methodologies and criteria" (p. 1138). Contrastingly, western science approach to research and involvement with indigenous communities have always been centred on their need of recognition in their own individualistic world (Roskruge, 2007), and financial benefit from studying indigenous cultures such as Māori for instance (Walker, 1997):

> *"I have come to the conclusion that the Pākeha attitude towards native races is on the whole saturated with the deepest hypocrisy … Even in ethnology, I doubt whether a native people is really regarded as other than a project to give the white writer a job and a chance for fame"* (Sorrenson, 1982, p. 22).

In giving his remarks, Sir Peter Buck (Te Rangihīroa) highlighted the statement above to reflect on the influence and impact of western science approaches to today's research methodologies which basically look beyond acknowledging indigenous people's involvement or more specifically the recording of their tradition and knowledge to an extent that only benefits western science community and their overall interest (Walker, 1997). In addition, colonisation played a major role not only in livelihood development but also in the exclusion of the Māori worldview for example from getting involved with mainstream scientific activities particularly in major scholarly research works (Cunningham & Durie, 1998). As a result, Māori have worked tirelessly and collectively to develop and implement an approach that will enable today's era of research methodologies to take into account the importance of mātauranga Māori, its significance to the people as part of a research project or case study, given the respect, recognition and equal benefits primarily back to the people who deserves it more than the 'non-indigenous' or foreign researcher, who at the same time should be employing the appropriate cultural practices with their methodologies (Roskruge, 2007).

Kaupapa Māori seeks to strengthen the bond between the different dimensions of past and future knowledge within the Māori community. According to Cunningham and Durie (1998), the way of life of Māori today has changed a lot when compared to the past since Maori are now more culturally and socially diverse than at any point in the past. He added that as a result, there is a big challenge on hold for the future generations. Western science methodologies for instance targets to acquire all, or mostly only the important knowledge from the Māori communities which in some scenarios could be very sensitive situation where sensible and sacred knowledge that should be highly protected and respected are shared but later be quantified, simplified or modified to fit into their research criteria's (Walker, 1997). On the other hand, kaupapa Māori provides the space for younger Māori generations to have a different perspective of understanding and supporting their contribution to the western world of study including research whilst receiving the recognition afterwards.

Walker (1997) wrote that:

> *"Māori perceive that research should benefit those who are being researched, and not the just those who are carrying out the research. Māori recognise that traditionally, Pakehas are the initiators, controllers and interpreters of research. Further, that Pakeha also control the research funds, to the extent that in order for Māori to access those funds they have to adhere to criteria determined by Pakeha"* (n.p).

This statement clarifies the concept of kaupapa Māori as an approach that is well understood and supported by the people of the land.

Ethnobotanical framework

This research has its foundation in traditional or indigenous plant-orientated knowledge; thus it has an ethno-botanical base. Previously, the discipline was refferd to as 'Applied Botany' (de Albuquerque & Hanazaki, 2010), but is now known as ethnobotany (without the hyphen) and includes ethnobotanical knowledge produced within a framework of western science based on the relationships of people and plants. Ethnobotany can be defined simply as the study of the relationship between people and plants. However, the question arises around 'who' undertakes this study; those belonging to the native (ethno) group, or those non-native researchers with different theoretical orientations and academic backgrounds (de Albuquerque & Hurrell, 2010). A broader definition refers to the term as "the study of the uses, technological manipulation, classification, agricultural systems, magico-religious concepts, conservation techniques and general economic and sociological importance of plants in primitive or pre-literate societies" (Schultes, 1994, p. 202).

Berlin (2014) stated that ethnobotanical research, by its very nature, is a collaborative research and is not undertaken in isolation. Ethnobotany and ethnobiology are seen as disciplines which combine the intuitions, skills and biases of both an anthropologist and biologist (*ibid..* p3). He further claimed that:

> *'[…] human beings everywhere are constrained in essentially the same ways – by nature's basic plan – in their conceptual recognition of the biological diversity of their natural environment. In contrast, social organisation, ritual, religious beliefs… are constructed by human society'* Berlin (2014, p. 8).

Researchers in the discipline of ethnobotany identify their role as targeting at least one of three ideals (Estrada de la Cerda, 2015; Roskruge, 2007):

1. Rescue missions – aligned to a culture near extinction. This includes the systematic recording of ethnobotanic knowledge.
2. Industry investigations – the relationship between plants and commerce, and
3. Cultural enhancement – aligning science and culture where possible.

Therefore, ethnobiology and ethnobotany must be participatory as they involve both ecology and living cultures. Their science is a combination of studies around people, plants and land: each unique in their own way. The framework that encompases both of these field of understading lays the foundation of learning knowledge and relationship of Māori to their *taonga* flora and fauna in this study.

Qualitative vs Quantitative research

Qualitative and quantitative approaches are two prominent methods applied in research. And although there are differences and similarities between them, their interpretative frameworks do not oppose each other (Landrum & Garza, 2015). This is only affected by the reference of subject in matter and methods employed in their respective fields of work (Giorgi, 2009). In this research the qualitative approach is applied to the indigenous scenario alongside Kaupapa Māori Research approach whereby the indigenous knowledge sought is accepted for its contribution rather than to be validated outside of its original context. A well-collected qualitative data will reflect research conducted through an intimate and prolonged field and life contact situation (Amaratunga, Baldry, Sarshar, & Newton, 2002). Qualitative research data reflects natural occurring events in real life with strong holistic connection and richness of explaining people's perceptions and assumptions to their social world thus is very critical to human and cultural research, specifically indigenous research work (Amaratunga et al., 2002; Kovach, 2010).

Quantitative research is the research approach that explains occurrences from the analysis of numerical data based on mathematics and statistics. The approach tests theories of social phenomenon or human problems by solving numbers that are statistically analysed to determine the nature of the theory on a phenomena of interest (Yilmaz, 2013). The process of quantitative methods are derived from testable hypothesis and theory that are concerned with "distinguishing characteristics, elemental properties and empirical boundaries and tend to measure how much or how often" Nau (1995) cited in Amaratunga et al. (2002, p. 22). Primarily this has been applied in the understanding of plants and plant disease under study and contemporary management tools being applied.

Both research approaches have their differences based on their "epistemological, theoretical and methodological underpinnings" (Yilmaz, 2013, p. 312). Table 2 summarises both approach inquiry modes. However, this thesis will be using qualitative research approach as primary method of gathering and assessing Māori TEK of management.

Table 2*: Comparison of Quantitative (Positivist) and Qualitative (Naturalist) Modes of Inquiry*
(Adapted from Glesne & Peshkin (1992); Lincoln & Guba (1985)) (Yilmaz, 2013, p. 314).

Quantitative Mode	Qualitative mode
Assumptions	*Assumptions*
• Reality is single, tangible, and fragmentable. Social facts have an objective reality.	• Realities are multiple, constructed, and holistic. Reality is socially constructed.
• Knower and known are independent, a dualism.	• Knower and known are interactive, inseparable.
• Primacy of method	• Primacy of subject matter
• Variables can be identified and relationships measured	• Variables are complex, interwoven, and difficult to measure.
• Inquiry is objective, value-free.	• Inquiry is subjective, value-bound.
Purposes	*Purposes*
• Generalisability (Time and context free generalisations through nomothetic or generalised statements)	• Contextualisation (Only time and context bound working hypotheses through idiographic statements)
• Prediction	• Interpretation
• Causal explanations	• Understanding actors' perspectives
Approach	*Approach*
• Begins with hypotheses and theories	• Ends with hypotheses or grounded theory
• Manipulation and control	• Emergence and portrayal
• Uses formal, structured instruments	• Researcher as the instrument
• Experimentation and intervention	• Naturalistic or nonintervention
• Deductive	• Inductive
• Component analysis	• Searches for patterns
• Seeks consensus, the norm	• Seeks pluralism, complexity
• Reduces data to numerical indices	• Makes minor use of numerical indices
• Abstract language in write-up	• Descriptive write-up
Researcher Role	*Researcher Role*
• Detachment and impartiality	• Personal involvement and partiality
• Objective portrayal	• Empathic understanding
• Etic (outsider's point of view)	• Emic (insider's point of view)

Indigenous Methodologies

Indigenous methodology is an important approach exercised in this thesis to acknowledge the learning of the Māori worldview and *mātauranga* Māori. This approach was defined by Kovach (2010, 2012) through her articulation of connecting herself back to her roots as "a deep pursuit of questioning one's epistemological underpinnings; of questioning what knowledge we favour in our approach to research" (p. 292).

Indigenous methodologies is set among western research paradigms to focus on upholding and respecting indigenous ways of being, knowing and learning. It has its roots based in tribal epistemologies and is also set to decolonize the qualitative approach of western researchers whose involvement has always triggered what Kovach (2010) stated as the "recollection of the miserable history of Western research and Indigenous communities" (p. 24). Within this framework the indigenous research paradigm is set in a holistic foundation that transmits knowledge and understanding in a respectful way according to the culture way of life (Wilson, 2008). Several modes of Indigenous methodologies have been studied and discussed (e.g. Kovach (2010); Lambert (2014); Wilson (2008)). The qualitative research methodology approach offers a great space for the indigenous way of researching. This includes following the appropriate cultural protocols to obtain and learn from participants.

Furthermore, non-Indigenous researchers have no affiliation to claim such a framework due to the lack of connection to tribal epistemic understanding: "Indigenous research paradigm is a guiding set of beliefs, values, and principles that parallel Indigenous ways of being, knowing, and learning" (Wilson (2008) cited in Kovach (2012, p. 44). Therefore, as an indigenous researcher, my cultural upbringing allows me to understand common, enduring beliefs about the world within a Māori worldview. According to Kovach (2010), Indigenous people are able to contextualise Indigenous epistemologies because of their tribal affiliations. I use the same approach and theory in this thesis to understand and respect the epistemic centre of Māori being and mātauranga Māori from my Fijian affiliation.

Case study methodology

For this project, the case study is applied as a form of qualitative research. The information presented is based subjectively by nature encompassing cultural bias which in itself represents the motive of how and what the case study methodology was initially set out to achieve. The case study is one of several ways of doing social science research and is dependent on three conditions: (a) the type of research question, (b) the control an investigator has over actual behavioural events, and (c) the focus on contemporary as opposed to historical phenomena (Yin, 1989).

Yin (1989) defines a case study as 'an empirical inquiry that investigates a contemporary phenomenon within its real life context especially when the boundaries between phenomenon and the context are not clearly evident' (p. 13). He added that these inquiries operate on coping with variable data points which rely on multiple sources and utilises a distinctive analysis of data in a method that will also benefit the theoretical propositions that control the ways data is collected and analysed. This is often considered more compelling and the overall study may therefore be considered more robust (*ibid.).*

The use of case study approach as a methodology has been gaining creditability in many research areas and is increasingly becoming one of the most prominent methods today including ethnobotany (Estrada de la Cerda, 2015; McGloin, 2008; Thompson, 2004; Yazan, 2015). Hamel et al. (1993) and Yin (1989) argued that case study is an approach rather than a method in that it employs various methods which includes experiments, surveys, histories, and the analysis of archival information. This process allows a case study to be applicable in many situations as a research strategy (Yin, 1989). In anthropology for instance, this allows the researcher to undertake a monographic study from which generalised conclusions can be drawn and discussed (Hamel et al., 1993).

Case Study Data collection

Yin (2014)further identified six sources of evidence usually presented in a case study; documentation, archival records, interviews, direct observations, participant observation and physical artefacts. A mix of sources has been applied to the data collection process in the case study for this thesis. Primarily, informal interviews with Māori whakapapa and knowledge experts have been undertaken to build the case study. A significant amount of the knowledge was given formally and informally at hui or traditional gatherings under the umbrella of Tahuri Whenua or related whānau/hapū interests. Where possible they are referenced as personal communications but often they have been given under the consensus of several people rather than one alone. Culturally, Māori have a strong belief in an intergenerational transmission of knowledge, acknowledging that no single process of learning will provide all the answers for each individual in our community (Pere, 1982). In reference to these traditional processes, Royal (1993) states: *'oral literature was recited continuously until it was carved into the house of the mind'* (p21).

Participatory and semi-structured methodology

This research was inclusive of a participatory research approach as a critical component of the methodology. These includes informal interaction with local *kaitiaki* (guardians of the land/ respected elder members of the tribe) during organised tribal meetings. Survey questions were developed with regards to *taonga* (sacred culturally important plant) species and associated fungal pathogen management practices. These questions served as a lead into a bigger conversation allowing the guardians to lead the conversation and own the space. This is a really important contributor to develop a strong relationship between myself as an outsider with local *kaitiaki* by enabling smooth exchange process of dialogue and visibility of mātauranga Māori (Māori knowledge)(Lambert et al., 2018; Roskruge, 2007).

Grounded theory methodology

Grounded theory is critical in indigenous qualitative research. The methods are designed to produce integrated ideas that will explain and describe cohesive theories of social phenomenon (Corbin & Strauss, 1990).

Data collection is similar to other theories in that the approach includes '*interviews and field observations, as well as documentation of historical accounts, autobiographies, biographies with analysis process based on both qualitative and quantitative techniques'* (Glaser & Strauss, 1967; Strauss & Corbin, 1994). This research grounded theory methodology follows similar approach. However, the main difference of grounded theory to other approaches lies on the emphasis on theory development particularly on the relationship between different holistic concepts and the verification of the developed objectives (Strauss & Corbin, 1994). This research considers this vital as it respects all values of Māori and mātauranga Māori and therefore all theories are not of mine alone but all participants reflected in the case study.

Creswell and Creswell (2017) expressed grounded theory as a strategy of qualitative approach in which the researcher can relate their own process undertaken in the research. This can be achieved by deriving the general theory or knowledge of the participant through multiple processes. Storytelling and narrative for instance is an important way of capturing the process particularly in an indigenous context (Kovach, 2010).

Postpositivism and social constructivism

A major component that lays out the foundation of this case study is based upon understanding Māori and learning how they as knowledge holders comprehend and utilise the different works of *mātauranga* Māori and their worldviews towards biodiversity conservation. Cunningham (2000) stated that when considering *mātauranga* Māori, one should understand and acknowledge both "past" and "future" knowledge and how they are observed from both conservative and contemporary worldviews (Table 3). He added that this is a fundamental aspect of Māori history and understandings which can be perceived as "*wholism, an iwi-based Māori social system, and an oral tradition are significant dimensions of this historical view*," (*ibid.*) (p. 63). Respect must also be given to holistic and relational nature of knowledge when choosing to utilise indigenous epistemologies (Kovach, 2010). Therefore, it is important to highlight the significant roles that epistemology paradigms play in the understanding of *mātauranga* Māori in this research since the research involves observations, gathering and analysing of *mātauranga* Māori and Māori worldviews around biodiversity conservation, traditional knowledge systems, and their views on future biological threats and indigenous biosecurity response. An additional theory, ontology, will also be highlighted in this section of the methodology as an essential part of learning Māori and the nature of *mātauranga* Māori in this research.

Table 3: *Dimensions of past and future Māori knowledge* (C Cunningham, 2000, p. 63).

Historical (past) knowledge	**Future knowledge**
Conservative Māori Worldview	***Contemporary Māori Worldview***
1. Wholism	1. Social and cultural diversity
2. Māori social system	2. Redress, protection, partnership (Treaty of Waitangi)
3. Oral tradition	3. Responsiveness (Public sector)

Epistemology is the study of the nature of knowledge. According to Williams (2006), "epistemology attempts to answer questions about what should count as knowledge, what should be rejected, and what methods are appropriate for gaining the type of knowledge that is desirable" (p. 211). In understanding the specifics of epistemology, Guba and Lincoln (1994) described three knowledge paradigms that expressed specific worldviews which determines the methods to use in social research. These paradigms includes postpositivism, constructivism, and critical theory (Guba & Lincoln, 1994; Williams, 2006). For the purpose of this paper, I choose to use all described paradigms as critical epistemologies that contributes to the understanding of the worldviews of Māori participants in the case study and how the realities and applications of *mātauranga* Māori contributes to cultural proficiency and biodiversity conservation. Additionally, ontology is also observed and is considered an important theory of learning in this research. Ontology is "the consideration of being: what is, what exists, what it means for something—or somebody—to be" (Packer & Goicoechea, 2000, p. 227). In this paper, learning the nature and being of *mātauranga* Māori is crucial thus both epistemology and ontology are considered in the process.

Chapter 3: TEK, Ethnobotany and Māori conservation

TEK and Ethnobotany conservation

Traditional ecological knowledge (TEK) provides an important role in the lives of indigenous people who depend heavily on their physical environment for survival. These people possess intimate knowledge that connects their existence in a particular location where they have lived for generations and harvest its resources to their understanding of their surroundings. According to Stevenson (1996), this knowledge includes the understanding of the "distribution of resources, the functioning of ecosystems, and the relationship between the environment and their culture," (p. 278). As a concept of TEK, these understading also allows these groups of people to intimately appreciate the relationship and connection with their environment, sanctioning them to value biodiversity conservation by "fostering adaptation and resilience strategies to environmental, biological and climate change" (Berkes, Colding, & Folke, 2000; Gadgil, Berkes, & Folke, 1993; McMillen, Ticktin, & Springer, 2017; T Ticktin & Spoon, 2010).

TEK encompasses a wide range of information which overlaps significantly in different dimensions as to the type of knowledge, the identity of knowledge holders, and the process of knowledge acquisition regarding its variety of practices and extensive nomenclature interpretation (Houde, 2007). Primarily, TEK has mostly been expressed by its definition (Davis & Ruddle, 2010). This in return, have raised major concerns in the understanding of its roles and association to people, the environment and how they protect important resources (Davis & Ruddle, 2010). Berkes (1993) argued that there is no universally accepted definition of TEK in literature today that defines or includes all localised worldviews. However, to arrive at an essential point of the concept, it is critical to acknowledge the work employed by various scholars on this subject and on indigenous community of interest who have helped build into what is now widely defined as *traditional ecological knowledge* (TEK).

According to Berkes (1993):

> *"TEK is a cumulative body of knowledge and belief, handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment. Further, TEK is an attribute of societies with historical continuity in resource use practices, by and large, these are non-industrial or less technologically advanced societies, many of them indigenous or tribal"* (p.3).

TEK exists all over the world in native societies independent of ethnicity. In the Pacific for instance, indigenous communities, have "*over centuries, acquired extensive biological knowledge (as a form of TEK) about their biodiversity*" (Keppel, Naikatini, Rounds, Pressey, & Thomas, 2015, p. b; Thaman, 1994). These knowledge is holistically observed and adaptive by nature, gathered and passed over generations orally and observations by indigenous people whose lives depend on its practices (Gadgil et al., 1993).

Furthermore, the value of TEK holds significant purposes in biodiversity conservation and applies to many cultural community that have lived in an area for an extensive period of time (T Ticktin & Spoon, 2010). Conceptualizing these values requires critical understanding of the different aspects of TEK. Nonetheless, TEK with its core understanding can also be observed as a unique cultural wisdom of the past that holds our future as expressed through this Hawaiian proverb:

I ka wa ma mua, i ka wa ma hope.

This Hawaiian proverb translates to *''in the time in front, in the time in back,''* meaning the future is behind us, because wisdom from the past is before us*"* (McMillen et al., 2017, p. 579).

Understanding TEK and its link to Conservation

The ambiguity of the concept or term TEK requires proper insight to define "What really is TEK?" According to Berkes (1993), many scholars today find it difficult to associate with the term *traditional* simply because of the equivocation of its definition hence they avoid it completely. Likewise, there are great misperceptions between the understanding, and inquisitiveness in the validity and reliability of the terms TEK, *Indigenous Ecological Knowledge (IEK)* and *Local Ecological Knowledge (LEK)*; (note that IEK and LEK are both new terms and are being observed as two different concepts of knowledge in this paper, however applicable to the whole TEK phenomenon). Some prefer to use the term IEK or LEK due to the intimate relationship people have to its "localness, embeddedness, contextual bound or commitment to local context" (Antweiler, 2004; Warren & Rajasekaran, 1995), or due to its "uniqueness to a particular community or ethnic group" (Houde, 2007, p. 158; Warren & Pinkston, 1998). For some researchers there are also difficulties on how the term *ecological knowledge* directly translates to local nomenclatural systems of certain indigenous communities (Berkes, 1993; Ticktin & Spoon, 2010). For example, the native people of the Canadian North refer to it as *knowledge of the land* rather than *ecological knowledge* (Berkes, 1993; Leopold, Sewell, & Brower, 1949). These situations require critical understandings of environmental systems for effective biodiversity management practices.

It is important to note that TEK in whatever forms, connects in varied dimensions and levels and is not just restricted to an indigenous group of people but to generations of a living cultural existence in a particular place (Houde, 2007; Ticktin & Spoon, 2010). Likewise, when linking TEK to biodiversity conservation, it is critical to comprehend the complexities in the relationship between TEK and conservation, understanding the dynamics of these different dimensions, and the factors that influence the heterogeneity of TEK in different indigenous communities (Ticktin & Spoon, 2010).

The following two scenario highlights how these concepts will determine what term of knowledge (TEK vs IEK vs LEK) will be referred to in this thesis according to how it is understood from the Pacific and specifically Māori community point of view and its relationship to biodiversity conservation.

Scenario 1:

The first scenario summarises the different levels of TEK conceptualised in 4 dimensions through the work of Berkes et al. (2000). He conceptualises four overlapping levels of TEK (Figure 1) as summarised by (Ticktin & Spoon, 2010). These levels are interrelated and provide a framework to understand TEK from a perspective that draws from the works of scholars and including Berkes (1993);

Figure 1: *Levels of analysis in traditional knowledge and management systems* (Berkes et al., 2000, p. 1257).

The conceptualised dimensions were broken down into firstly being observed as based in local knowledge of the environment, second on the practices based on the local knowledge, third from the influence of social institutions and lastly worldviews (Ticktin & Spoon, 2010). The levels adapted from Berkes et al. (2000) were then simplified to three broad themes by Turner (2000). They represent practices and strategies for resource use and sustainability; philosophy and worldview; and communication of knowledge and information (Ticktin & Spoon, 2010).

Scenario 2:

The second scenario is from the work of Houde (2007) with the First Nations people of Canada. He synthesized TEK into six faces (Figure 2) inclduing factual observations, management systems, past and current land uses, ethics and values, culture and identity, and cosmology. He also expressed the different challenges and opportunities that each face poses towards biodiversity conservation. Houde (2007) used TEK to refer to “all types of knowledge about the environment derived from experience and traditions of a particular group of people and emphasizes the connection of traditional knowledge to ecological processes, as well as to highlight its importance in the context of environmental co-management” (p.4).

Figure 2: *The six faces of traditional ecological knowledge* (Houde, 2007, p. 34).

Within the six faces of TEK developed by Houde (2007), cosmology is identified as the foundation and an inseparable face of TEK that holds the other faces together. The pentagon structure of the model also articulates the strong bond between the six faces that signifies the flow of values between the different faces (a very similar interpretation and understating of flow to that of the *Te Whare Tapa Wha*). Theoretically, this would represent how knowledge is transmitted generationally; an important aspect of how TEK is transmitted.

Therefore, as a critical aspect of managing biodiversity and conserving important native species, this thesis argues in support of the conceptualised views of TEK linked to models defined by Berkes et al. (2000); Houde (2007) and Mason Durie (1994). The concepts are pervasively applicable to Māori and the wider Pacific communities in the sense that all dimensions are interconnected and are core strengths of indigenous social structure and of TEK.

The context depth of the faces and values of TEK defined by Houde (2007)can be related to concepts of Māori traditional knowledge (*Mātauranga Māori*) embedded in Māori cosmology and its association to resource management. In the Pacific indigenous communities including Māori, cultural cosmology is deemed highly sacred because it shows much of the ancient roots and is the foundation of what connects TEK to values, beliefs knowledge, skills and practices (Nainoca, 2011; Roberts, Norman, Minhinnick, Wihongi, & Kirkwood, 1995). For example, Mason Durie (1994) developed a holistic health model that represents the four cornerstones of Māori well-being (Figure 3). The four dimensions (*Te Taha wairua* (spiritual health), *Te taha hinengaro* (mental health), *Te taha tinana* (physical health) and *Te taha whānau* (family health)), represent the four corners of the *wharenui* (meeting house) or *tapawha* which symbolises the connections that need to be all present to strengthen functionality of Māori as a community and as a foundation of success (Mason Durie, 1994; Rochford, 2004).

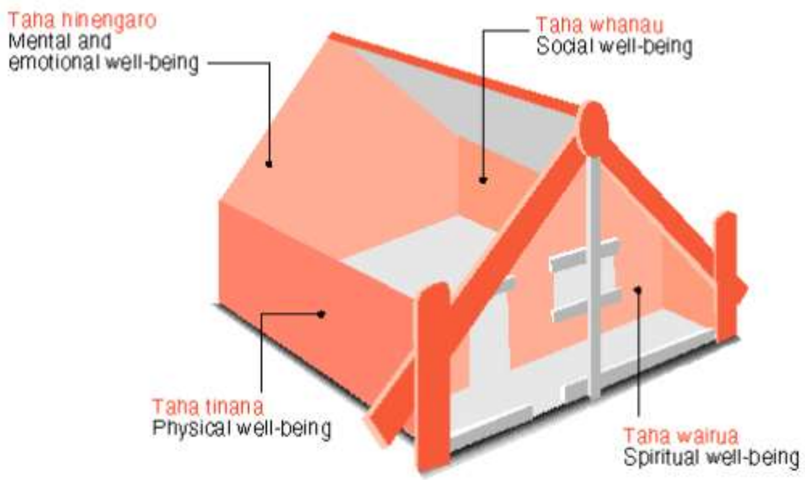

Figure 3: Te Whare Tapa Whā (Hauora, 2019).

This same understanding aligns Māori to how they treat their natural resource viewing it as part of the people whom they belong together with and not that they have authority in owning it (Durie, 1987).

TEK and Western Science

TEK and western science should be observed as two complementing paradigms of knowledge although overlap exists. From an ecological point of view, TEK sets to supplement WS and offer a unique understanding into ecological process (Latulippe, 2015). In resource management, TEK provides the dimension of the cultural connection of people and their knowledge to the fundamental process of their land and resources.

Berkes et al. (2000) stated that:

> *'…conservation biologists, ecological anthropologists, ethnobiologists, other scholars, and the pharmaceutical industry all share an interest in traditional knowledge for scientific, social, or economic reasons'* (p. 1251).

On the same note, Lertzman (2010) acknowledged this aspect of the relationship as critical to ecosystem based management and key to understanding the different worldviews that both paradigms present towards ecosystem management. Several works have been done (e.g. Lertzman (2010), Latulippe (2015), Tsuji and Ho (2002), McGregor (2008)) to studying the different perspectives of both TEK and WS and presenting their common grounds as adaptive combined tools for management. Table 4 elucidates the effectiveness of TEK as a tool of resource management at the same time providing the opportunity to complement and enhance understanding with WS.

Table 4: *Applying the typology to two research questions adapted from Fish-WIS* (2015) (Latulippe, 2015, p. 126).

Orientation	**What is the relationship between WS and TEK?**	**How can Indigenous knowledge or TK improve resource management?**
Ecological	Indigenous knowledge complements post-positivist science	Through adaptive or ecosystem-based management frameworks
Critical	Epistemic colonization renders Indigenous knowledge unintelligible	Through structural change and decolonization
Relational	Distinct knowledge systems can be shared for mutual benefit	shared for mutual benefit Through Indigenous governance models, including treaties
Collaborative	There is potential for knowledge co- production	Through empowered, collaborative processes at multiple scales

The role of TEK within Ethnobotany

Ethnobotany is widely described as the *study of the interactions and relationships between plants and people over time and space* (Prance, 2007). Paramount within this study is the use of TEK and practices. In every indigenous society, there are people who possess considerable knowledge on the properties of plants, an indication that traditional botanical knowledge is extensive and that earliest humans were early ethnobotanists (Schultes, 1994). According to Schultes and Von Reis (1995), ethnobotany is based upon two primary goals in its process to provide the understanding of plant use and plant management systems. These goals includes: *(1) the aim to document facts about plant use and plant management, and (2) to elucidate the ethnobotanical text by defining, describing, and investigating ethnobotanical roles and processes (p. 25).* In conservation, the ethnobotanical knowledge of indigenous people play an important role in differentiating species that supports biodiversity. This covers observation of both wild and domesticated plant species. Such knowledge evolves over time and is constantly changing (Schultes, 1994).

The Māori worldview

"Kotahi ana te tupuna o te tangata Māori,
Ko Papatūānuku e takoto nei.
Ko Ranginui e tu iho nei. "
There is but one ancestor of the Māori people
Papatūānuku lying here
Ranginui standing above.
(A whakataukī or proverbial saying of Te Rangikaheke of Te Arawa) (Roberts et al., 1995, p. 7).

Indigenous people have a deep feel of respect and admiration to their resources (flora and fauna). A holistic worldview drives indigenous people to have a personified connection that relate there resources as cognizant and communicative subjects rather than as an inert or insignificant objects to them (Snodgrass & Tiedje, 2008). Timoti, Lyver, Matamua, Jones, and Tahi (2017) cited and define worldview in series as:

> *"… a coherent collections of value orientations and cognitive maps that allow people to orient and make sense of their world (cited in Aerts et al. (1994); Van Egmond and De Vries (2011); Van Opstal and Hugé (2013); Vidal (2008) … a worldview (or cosmovision) is the way a certain population perceives the world (or cosmos). It includes assumed relationships between the human world, the natural world and the spiritual world. It describes the perceived role of supernatural powers, the relationship between humans and nature, and the way natural processes take place (cited in Haverkort and Reijntjes (2006)) … worldviews represent the ethical basis, principles, and assumptions around which people and populations organize themselves to interact with nature"* (Allport, 1935; Haverkort & Reijntjes, 2006).

Indigenous worldviews are predominantly centred on the quality of the human–environment relationship. All cultures have their own way of seeing the world articulated as their worldview which informs and guide their behaviour to their environment (Roskruge, 2007; Van Opstal & Hugé, 2013). On the other hand, worldviews of modern societies are set in a different perspective where often observation is in a materialistic and dualistic views with the assumption that humans are superior (Van Opstal & Hugé, 2013).

The worldviews of indigenous peoples and local communities are important for biodiversity conservation and management globally. Timoti et al. (2017) claimed that two-thirds of the world's land area is managed by the customary tenure systems of indigenous people. Together, the revere of indigenous people to their environment leads them to develop conscious conservation thought and practices towards ecosystem biodiversity (Snodgrass & Tiedje, 2008). Māori for example provide appropriate cultural responses to environmental issues through the practices of *kaitiaki* and *kaitiakitanga* centred within the Māori holistic worldview (Roberts et al., 1995).

Figure 4*: 'Tāne Mahuta's triumph' by Jane Crisp, 2007. This painting is inspired by the scale of Māori legends and mythology. For Crisp, it evokes the saying 'I te whai ao, ki te ao marama' ('Into the world of light') (Tribunal, 2011, p. 64).*

The Māori holistic worldview is ultimately derived from an indigenous belief system that seeks to elucidate the origin of the universe (Roberts et al., 1995). This belief system acknowledges Māori TEK including customs and values to all derived from the existence of cosmogony, cosmology, mythology, religion, and anthropology (Harmsworth & Awatere, 2013).

Roskruge (2007) elucidated that the traditional Māori worldview is based and understood through whakapapa (genealogy) which he stated, explains how Māori understand the origin of the world. Similar sentiments were reiterated by Roberts et al. (1995) where they summarised Māori holistic worldview from two important accounts. Firstly, that Māori worldview emerged from the three cosmological realms of *Te Kore* - the realm of potential being; *Te Po* – the realm of becoming; *Te Ao Marama* - the realm of being through the creation process and path of Tāne mahuta (god of the standing forest) (Figure 4). And secondly, through whakapapa that is linked to the emergence of the universe through Ranginui and Papatūānuku *(who after separation, became known as Ranginui-e-tu-iho-nei, the male principle, or "sky father", and Papatūānuku, the female principle or "earth mother")* (p. 9).

An important point derived from these two accounts is the expression of whakapapa through the intimate connection between Māori, the environment, and their gods (an example is given as Figure 5).

Figure 5: *The environment as family – whakapapa of the offspring of Ranginui and Papatūānuku modified after Yoon (1986) (Roberts et al., 1995, p. 11).*

Māori view themselves as an important component of the ecosystem through their diverse set of cultural values and worldviews. These sets of values are derived from the traditional belief systems that is based on mātauranga Māori (Harmsworth & Awatere, 2013). Traditionally for Māori, these values are further interwoven into the concepts of whakapapa, mana and kaitiakitanga, and possession of the spiritual qualities of tapu, mauri, and wairua.[4] Harmsworth and Awatere (2013) articulated that to understand how Māori perceive the ecosystem, one requires respect and an appreciation of the Māori worldview, values and the concepts related to Māori ecosystem conservation. The term 'Te Ao Marama' is used within Māori society to define the current 'world of light' i.e. the present time as against the mythical period when the world was evolving into what we now know it as (N Roskruge, 2007). Each living thing has a mauri, a life-force, that relates to, and interacts with, the earth's forces (Harmsworth & Awatere, 2013; Pere, 1982).

[4] See glossary for the full definition of these terms

Māori and whenua (land)

Ko Papatūānuku to tātou whaea
Ko ia te matua atawhai
He oranga ma tātou
I roto i te moengaroa
Ka hoki tātou ki te kōpū a te whenua
The land is our mother
She is the loving parent
She nourishes and sustains us
When we die she enfolds us in her arms (Roberts et al., 1995, p. 10).

Māori consider the ecosystem with the same significance or respect held for land or whenua. The land is recognised metaphorically as the placenta that surrounds the embryo in the womb – the Māori word 'whenua' is the term used for both the land and the placenta. Whenua refers to land in all its forms for Māori. To Māori, whenua is considered the '*mother*' and is treasured for its spiritual significance (Roberts et al., 1995). The importance of this connection often leads to the understanding of the term whenua in certain places of Aotearoa as the placenta of the womb (e.g. Taranaki (Roskruge, 2007)) (Roberts et al., 1995). There are several classes of land identified by Māori, all contributing to tribal well-being (fiscally, physically and spiritually), and the identity and security of future generations. These include *take tūpuna* (ancestral), *take tuku* (gifted), *take raupatu* (conquered or through conquest) and *take whenua kite* (discovery) (Durie, 1998; Forbes, 1996; Roskruge, 2007).

Māori and Taonga species

Māori have a unique connection to their *taonga* resources including *taonga* plant species. *Taonga* are any species or element of nature that is culturally and sacredly significant to Māori. According to the *Te Roroa* Report (Paterson, 1999), *taonga* is described as:

> *Taonga is an umbrella term, inclusive of a wide range of things upon which Māori in general…place great value and regard as treasures. Among them are intangibles like spiritual values as well as tangible objects. They include the land, sea fronts, forests, lakes and rivers; also places and things associated with life and death. Although the degree of tapu (sacredness) varies, all these taonga touch the "heart," the manawa pā (desires) and ngakau pā (ends) of the people"* (Paterson, 1999, p. 113).

The flora and fauna of the forest ecosystem for example, are observed as *taonga* species and their relationship with Māori is one of *kaitiakitanga* (guardianship, discussed below). This includes important indigenous and non-indigenous species such as kūmara (*Ipomoea* *batatas*), taro (*Colocasia esculenta*), kiore (Pacific rats), or native plant species such as harakeke (*Phormium tenax*), tī kouka (*Cordyline australis*), pōhutukawa (*Metrosideros excelsa*), kawakawa (*Piper excelsum*) and mānuka (*Leptospermum scoparium*) (Teulon et al., 2015).

Taonga also includes tangible things such as land, water and intangible things such as language, identity and knowledge of the culture (Waitangi Tribunal, 2011). The relationship between *taonga* and Māori can define a lot about the ethnobotanical practices they provide for the people. These practices also preserve Māori worldviews and knowledge. Many *taonga* species were regarded as guardians (*kaitiaki*) in Māori (e.g. tuatara and pōhutukawa), they also hold whakapapa connection to Māori (e.g. komiko and Ngāti Koata), medicinal purposes (e.g. kawakawa), weaving (e.g. harakeke), and other building materials (Waitangi Tribunal, 2011).

Māori have a long history of occupying Aotearoa following their migration across the Pacific. By the time of Captain Cook's arrival in 1769, there was evidence of extensive utilisation and modification of land by Māori (Waitangi Tribunal, 2011). For example, there was evidence of clearing of forest areas to make space for agricultural purposes by the people and also what was observed (Davidson, 1987) as evidence of fire and impacts from the Pacific rat (kiore), introduced by Māori on the natural ecosystem.

Māori mostly lived in transient occupation according to the seasons in order to survive on different resources (N. Roskruge, personal communication, 6 May, 2019). Horticulture was a big part of their daily lives where traditional practices were used. However, special adaptation had to be made for tropical crops to survive the climatic condition of the new environment. New and important agricultural practices were developed and used by Māori and include management practices that provided for their sustenance and continued survival (Roskruge, Puketapu, & McFarlane, 2010).

The more recent Māori impact on the environment could be related to typical changes that colonisation brings. Māori like most indigenous culture, were hunters and gatherers, and the environment including the ocean was their '*most precious life-support system'* (Park, 1995). The impacts to the environment post-colonisation have hugely modified this country, it is to be noted that until their first contact with Europeans through Cook and others in the 18th century, Māori had developed a very close-knit relationship with the flora and fauna of their new motherland – Aotearoa – which was maintained through the process of whakapapa.

Māori TEK - environment and conservation

Kei raro i ngā tarutaru,
ko ngā tuhinga o ngā tūpuna.
Beneath the herbs and plants,
are writings of the ancestors (Waitangi Tribunal, 2011).

The Māori relationship with the environment is expressed through whakapapa. This articulates the importance of understanding the origin of essential elements of the environment and belief systems for Māori. Kaitiakitanga is observed as what drives the attitude towards environmental conservation and expression of practices for Māori. The Māori understanding and relationship with their environment has allowed them to develop an intimate connection and customary practices to sustainably manage their resources. The adoption of Māori conservation knowledge has been widely elaborated on in many scholarly reports. However, the majority of these reports have documented predominantly on harvesting of wild food sources from the conservation estate (Lambert et al., 2018). For example, the harvesting of *kererū* (New Zealand Wood Pigeon, *Hemiphaga novaeseelandiae*) and *tītī* (Sooty Shearwater, *Pufnus griseus*) (Lyver, Jones, & Doherty, 2009; Lyver, Taputu, Kutia, & Tahi, 2008; Moller et al., 2009) and the harvest of flax (*harakeke* in Māori, *Phormium tenax*) and seaweed, *karengo* (*Bangiaceae* spp.) (McCallum & Carr, 2012; O'Connell-Milne & Hepburn, 2015). On the contrary, it is to be noted that Māori were able to sustainably preserve most of their resources through important traditonal practices.

Whakapapa

All indigenous cultures have varied ways of identifying themselves to their surroundings and functions of the knowledge they possess according to their own worldviews. For Māori, these understandings lies deep within the roots of their families and the connections they have to their land (*whenua*) (Roberts et al., 2004). Māori have always viewed their surroundings as the source of their cultural, spiritual, emotional and physical well-being which traditionally relates to their *whakapapa* (Kerckhoffs & Smith, 2010).

Expressed in English as "*genealogy*", Roskruge (2007) described *Whakapapa* as the understanding of the links between Māori culture's history, people and nature supported by *tatai,* the ability to layer the information for future understanding. Additionally, Roberts et al. (2004) further elucidated whakapapa in a scenario they called "*to place in layers*" the records of Māori histories connected through generations. Whakapapa serves to display the origin of an individual's knowledge and their right to use it, as well as their right to their understanding in a community (Marsden, 1988). It traces not only the descent of their blood, but also the descent of their skills and the mana (power) which provides their identity (Roberts et al., 1995). For Māori, identity is closely linked to their land and by extension, to their crops or trees, or other resources through the understanding of their roles (*tikanga*) as guardians (*kaitiaki*) from their primal parents *Ranginui* (sky father) and *Papatūānuku* (earth mother) (Roskruge, 2007).

Mātauranga Māori

Mātauranga Māori is the *"the knowledge, comprehension or understanding of everything visible or invisible that exists across the universe'; this includes all Māori knowledge systems or ways of knowing and doing,"* (Maori Marsden, 1988). *Mātauranga* Māori provides the foundation of Māori worldview and encompasses all aspects of knowledge that includes *philosophy, beliefs, language, methods, technology and practice* (Harmsworth & Awatere, 2013, p. 275). Likewise, the association also lies with the physical (*tinana*), spiritual (*wairua*), intellectual (*hinengaro*) and social or cultural (*whānaungatanga*) components (Roskruge, 2007).

Sadler (2007) determined the whakapapa of *mātauranga* Māori to ancient Polynesia. According to Sadler, *mātauranga* Māori went through periods of changes as Māori navigated their way from their [mythical] homeland of Hawaiiki to present Aotearoa. Harmsworth and Awatere (2013) stated that the transition of *mātauranga* Māori from its traditional state into many contemporary forms is a result of historical, local and regional interventions which attempt to complement western scientific knowledge. On the same note, Sadler (2007) attributes the changes to *mātauranga* Māori primarily to colonisation and its effect in reconstructing worldviews. Importantly however, Māori have managed to protect their knowledge through developing *tikanga* or cultural best practices to give order and purpose to the utilisation, sharing and protection of *mātauranga* Māori.

Tikanga

Tikanga is described as the collective traditional customary practices developed overtime and used in undertaking any activity including different management systems. *Tikanga* has its roots in the word '*tika'* meaning correct, true or just, and in this manner *tikanga* is seen as the correct or just way of doing something (Mead, 2016). Roskruge (2007) elaborated on the conceptual approach of *tikanga* Māori resource management for future generations to the cultural approach of *kaitiakitanga* (discussed below) involving health, spiritual input and communal contribution of the people in achieving sustainability of the land.

Tikanga Māori therefore can be perceived as a normative way of dealing with the norms of Māori society. *Tikanga* Māori is also embedded in *mātauranga* Māori because the practices stands to exercise Māori knowledge in its correct and rightful manner (Mead, 2016). Māori horticulture for instance practice *tikanga* by dictating all activities and exercising Māori knowledge for a successful cropping season (Hutchins, 2013). *Tikanga* arise from *kaupapa* Māori (everything Māori), is embedded in *mātauranga* Māori, and is passed down to generations through cultural means of narratives and traditions that lead people in the correct course of action.

Kaitiaki and Kaitiakitanga

Kaitiaki stems from the verb '*tiaki'* which means to guard; to protect; to keep; to watch for; to wait for (Maori Marsden, 1988). The word '*kai*' denotes the doer of the action which collectively would define the term *kaitiaki* as a guardian. The role of *kaitiaki* is determined primarily through whakapapa in the Māori context and relates to the concept of being the protector of all things which originate from the primal orgins of the natural world including the resources of which the forest is formed. Māori do not consider the resources of the earth to belong to them but they belong to the earth (Roskruge, 2007). Critically, the term *kaitiaki* encompasses sacred Māori concepts that connects them to the land such as *tapu* (restricted, sacred), *mana* (authority, power), whakapapa and *tika* (correct, upright). Thus to use the word *kaitiaki* or perform the role, that person must be Māori because of the sacred values and cultural responsibilities they are associated with.

Kaitiakitanga is the act of guardianship (Maori Marsden, 1988). The term has been broadly defined and interpreted differently between different Māori kin groups and organisations as well as its application. However, the general understanding of *kaitiakitangi* has its roots in the management of resources and upholding of customary values and identity that are fixed through whakapapa (Kawharu, 2002).

> *"It incorporates a nexus of beliefs that permeates the spiritual, environmental and human spheres: raNgāti ratanga, mana whenua 'customary authority over, and of, land', tapu, rahui, hihiri and mauri 'life principle' (Māori Marsden & Henare, 1992). Kaitiakitanga also embraces social protocols associated with hospitality, reciprocity and obligation (manaaki, tuku and utu). These beliefs are moulded with, and by, each generation for they have an important role in maintaining the social fabric of the kin group. Moreover, kaitiakitanga is a fundamental means by which survival is ensured-survival in spiritual, economic and political terms. Since Māori society is a tribal society with respect to relationships with environmental resources, their actual management is itself a constituent element in the tribal kinship system"* (ibid.) (p. 351).

Kaitiakitanga is also about managing the relationship between time and space. In the context of biodiversity conservation and environmental management, *kaitiakitanga* involves managing the relationship between people in the past, present and the future considering the relevance of ancestral association with the land and resources whom Māori belong to (Kawharu, 2002; Roberts et al., 1995).

Mana

The role of *Kaitiaki* through *kaitiakitanga* is recognised as having the *mana* to perform and guide the process of *kaitiakitanga*. Mana implies a direct spiritual benevolence to any process or activity; i.e. the traditional atua or gods bestow mana. The *mana* in the context of TEK and conservation can be defined in several ways but is observed here in dual dimensions. Firstly, it is observed through its integrity and strength which needs to come from a person of hierarchy and respect (prestige power and authority), and secondly, *mana* is observed in terms of the fruitfulness of the reward or success achieved when all proper knowledge (*mātauranga* Māori) and *tikanga* are followed and aligned to the proper *whakapapa* (S. Ratahi, personal communication, 18 July, 2019). All that is achieved in conservation management is supported through the mana acquired by everything or everyone involved.

Chapter 4: Fungi pathogens

Fungi

The fungal kingdom consists of a wide range of species with diverse physiological and morphological characteristics (McLaughlin, Hibbett, Lutzoni, Spatafora, & Vilgalys, 2009). Evolutionary origin based on molecular analysis of the kingdom initially described fungi as a distinctive group of unicellular eukaryotes in the Precambrian, and estimated their existence from 760 million to 1.06 billion years ago (Watkinson, Boddy, & Money, 2015). All fungi are eukaryotic meaning they have nucleus and membrane organelles (Adl et al., 2005; Galagan, Henn, Ma, Cuomo, & Birren, 2005; Margulis, 1990; Van de Peer, Ali, & Meyer, 2000). The relationship between fungi and other eukaryotes is illuminated in the timeline composed by (Watkinson et al., 2015) (Figure 6) where it is also understood that the development of new fungal kingdom organisms took place around about the same time. This is further explained with evidence of fossil records elucidating the original symbiotic relationships of oribatal mites and fungi, and the presence of fungi with bryophytes as the only existing land plants for instance during this time (Bernini, Carnevale, Bagnoli, & Stouge, 2002; Redecker, Kodner, & Graham, 2000; Siniscalco et al., 2013). Additionally, the Lower Devonian Rhynie chert described the oldest unambiguous fossils of fungi that included unique chytrid sporangia and zoospores, zygomycete sporangia and ascomycete fruiting bodies to be 400 million years old (Walker & White, 2017). These findings however, are suggested to be incomplete with reference to actual ages of fungi which are believed to be much greater than initial estimations (McLaughlin et al., 2009; Taylor & Berbee, 2006; Taylor et al., 2004). Nonetheless, understanding the relationship within the fungal kingdom is also critical in linking to the historical lineage of the diverse species of fungi present today to future fungal prospects assisting in the overall concepts of their roles to our natural ecosystems as described in Figure 6 (McLaughlin et al., 2009; Watkinson et al., 2015).

Figure 6: Timeline of the evolutionary relationship between fungi, animals choanoflagellates and plants (Watkinson et al., 2015, p. 2).

Roles of Fungi

Fungi are important components of biodiversity in many natural ecosystems. They provide comprehensive advantage and disadvantage roles with multifaceted ways of interacting with the environment and other ecosystem components that often is uniquely aided by the fungal physiology (Carnegie et al., 2010; Lutzoni et al., 2004; Stewart, Kim, & Klopfenstein, 2018; Walker & White, 2017). According to McLaughlin et al. (2009), the antiquity of the role of fungi lies extensively in the unique ways of interactions they have with plants, animals, bacteria and other organisms. Fungi are important mutualistic symbionts and play a major role in decomposition and nutrient cycling process (Stewart et al., 2018; Taylor et al., 2004). Saprotrophic fungi, which are often categorized into either litter, or wood decay fungi for example, play pivotal role in forest ecosystems as key components in decomposition and nutrient cycling (Cooke & Rayner, 1984; Hobbie, Weber, & Trappe, 2001; Lutzoni et al., 2004). These ways of symbiotic interactions enable fungi to enhance forest health and disease resistance in endophytes and epiphytes (Stewart et al., 2018).

However, fungi are also the major foundation of different diseases of both plants and animals (McLaughlin et al., 2009; Stewart et al., 2018). Their heterotrophic, absorptive nutrition and unicellular vegetative form allows fungi to be a well-known parasites that significantly impact human and ecosystem wellbeing (McLaughlin et al., 2009; J. Stewart et al., 2018; Stewart et al., 2018). A significant history of a fungal disease can be related to the famous Irish potato famine in the 1800s caused by the fungi *Phytophthora infestans*, which was also the first formally described species in this genus (Drenth et al., 2006; Erwin & Ribeiro, 1996). In addition to this, fungus and fungus-like diseases are today responsible for the significant losses in costs, quantity and quality of many important agriculture and horticulture crops, importantly rice, wheat, maize, potatoes and soybeans (Boddy, 2016). Globally, fungi causes about 27% of crop losses related to disease problems (Boddy, 2016). Furthermore, the making of various types and number of spores by fungi during the reproduction stage provides opportunities for long distance travelling and tolerance that does contribute to their dominance in ecological environments (Money, 2016; Taylor et al., 2004). These attributes of fungi are often accredited to the strengthening of their invasion prospecting in native forest flora and has been experienced in the introduction of many forest diseases that have negatively affected these ecosystems (Potts et al., 2016; Stewart et al., 2018). These diverse roles of fungi and ways of interaction are the major causal factor of change in diversity of many natural ecosystems today.

Understanding Necrotroph & Biotroph Phytopathogens

Globally, the health of forest and natural ecosystems has been unceasingly hindered by the predominance of phytopathogens. Phytopathogens are fungus or fungus-like pathogens that are specifically responsible for many of the new emerging and continuously growing plant diseases (Boddy, 2016). The fungal pathogen *Puccinia graminis f.sp tritici.* race Ug99 that causes stem (black) rust is a recently emerged phytopathogen and disease that affects ninety percent of wheat varieties worldwide as its host plants (Boddy, 2016). In addition, a new fungus-like pathogen *Phytophthora agathidicida*, was recently detected and found to be the major causal factor of Kauri (*Agathis australis*) tree dieback and threatens their potential extinction in New Zealand (Lambert et al., 2018). In such natural ecosystems, significant pervasive phytopathogen incursions such as these are presenting enormous effects primarily from the impact on ecosystem health that has resulted in higher costs incurred from social, economic, ecological loss and breach in biosecurity (Pimentel, 2014; JStewart et al., 2018).

Phytopathogens are categorized and described in two categories. Biotroph pathogens require living cell tissues to obtain nutrients without killing the host yet they affect the plant's fitness and productivity in the process. Necrotroph pathogens on the other hand rapidly kill their host in order to feed and attain the required nutrients from the dead cell tissues (Boddy, 2016; Glazebrook, 2005). Apart from the different ways they interact with host plants, the groupings of these pathogens into these categories are also dependent on the extent of nutrients they acquire from their hosts (Boddy, 2016; Glazebrook, 2005). There is also an additional category although not usually addressed (and will be left aside in this paper), but the necrotrophic pathogens are sometimes considered hemi-biotrophs due to the ways they interact with their hosts and period of their life cycle. In this process, the pathogen changes from being biotrophic in the initial stages of the infection where the host plant cell death does not occur to necrotrophs in the later stages where nutrients are obtained from the then dead cell tissues (Boddy, 2016; Glazebrook, 2005). Moreover, with their host-parasite relationship, biotrophic pathogens are limited to a narrow host plant range therefore unable to function further away from their source describing them as obligate pathogens such as most rust fungi (Helfer, 2014; McKenzie, 1998; Viljanen-Rollinson & Cromey, 2002). In contrast, necrotrophic pathogens are facultative saprophytes and have very broad host plant range that also enables them to grow saprophytically (Boddy, 2016; Glazebrook, 2005). A well- described necrotroph is the destructive fungal pathogen Botrytis cinerea, which destroys cell tissues of more than 200 dicotyledonous host plants after killing them in the early stages of the infections (Boddy, 2016; Colmenares, Aleu, Duran-Patron, Collado, & Hernandez-Galan, 2002; Glazebrook, 2005; Williamson, Tudzynski, Tudzynski, & van Kan, 2007).

Plant-pathogen and diseases

Plants have historically been engaged in a continuous battle with pathogens and seek to find a balance. A diverse collection of plant diseases arising from the presence of evolutionary pathogens have developed and have affected a large number of ecosystems (He et al., 2016). Complex pathogens such as rust fungi have presented a wide range of diseases that cause serious damage to many agricultural crops (Yamaoka, 2014). In plants, these losses will always persist because of globalisation, agricultural intensifications and the complexity of the pathogens and diseases' life cycle (Brunner & Eizaguirre, 2016; He et al., 2016; Zhan et al., 2014). Additionally, for fungi, the broad array of pathogens in the fungal phyla presents a significant threat of diseases to plants with the majority of biotrophic pathogens in the Basidiomycota fungi division such as Uredinales (smuts) and Ustilaginales (rusts) having an intricate life cycle (Boddy, 2016). However, the significance of the different variables influencing host-parasite interactions does not always allow a successful invasion of the pathogen with plants forming physical and chemical defence mechanisms and also with environmental changes that affects both the pathogen and the host directly (Boddy, 2016; Brunner & Eizaguirre, 2016). As well, the establishment and exploitation of these pathogens are often directly related to their lifecycle (Figure 7) (Boddy, 2016).

Figure 7: Events in the development of a disease cycle (Boddy, 2016, p. 257).

Rust fungi

Rust fungi (order Uredinales or Pucciniales) are in the phylum Basidiomycota and are among the most destructive plant pathogens yet important components of ecosystem functions and services (Helfer, 2014; Viljanen-Rollinson & Cromey, 2002). There are over 8000 described species of rust fungi today and that number continues to grow (formerly 7800 (Helfer, 2014; Yamaoka, 2014), and 7000 (Aime, McTaggart, Mondo, & Duplessis, 2017; Kolmer, Ordonez, & Groth, 2009; McKenzie, 1998; Viljanen-Rollinson & Cromey, 2002). As obligate biotrophic pathogens, rust fungi are exclusive parasites of many vascular plants including ferns, angiosperms, gymnosperms, and pteridophytes (Helfer, 2014; McKenzie, 1998; Yamaoka, 2014). The spores are easily spread by wind and are typically distributed through this process. Additionally, rust fungi are also introduced to new areas by animals, accident or deliberate human related activities and distribution of planting materials (Viljanen-Rollinson & Cromey, 2002). Rust fungi, usually circular or elongate, derive their name from the orange or yellow rust coloured lesions normally observed on leaf surface (Kolmer et al., 2009; McKenzie, 1998). Economically, rust fungi are responsible for significant losses in many agriculture and forest crops such as wheat, soyabean, pine and eucalyptus (Helfer, 2014; Yamaoka, 2014). The wheat stem rust caused by the fungus *Puccinia graminis f. sp. tritici* is one of the common fungal disease by rust causing 10% reduction in total yield worldwide while the exclusion of the coffee industry by coffee rust in Ceylon (Sri Lanka) is another notable impact of rust pathogens (McKenzie, 1998).

The biology and phytopathology of rust fungi has been well studied in many countries and is documented in the works of Gäumann (1959); Arthur (1934); M. Wilson and Henderson (1966) (Yamaoka, 2014). Since the first discovery and descriptions of various events and theory of existence of rusts (e.g cereal rusts by Aritotle 384-322 BC and Theophrastus 371-287 BC), new species encounters have continuously emerged (Aime et al., 2017; Kolmer et al., 2009). G. H. Cunningham produced a supplementary growth record of new species discovery in New Zealand (Figure 8), and recorded 146 species from the year 1855 to 1997. As of 1998, this figure had grown to 234 species (McKenzie, 1998).

Figure 8: Cumulative record of all rusts discovered by New Zealand's first resident mycologist G. H. Cunningham from 1855 to 1997 (McKenzie, 1998, p. 235).

Rust fungi life cycle

Rust fungi have a unique and variable life cycle. According toPetersen (1974), the life cycle of rusts is perhaps the most plastic and complex, yet, considering their economic importance, one of the better-understood life cycles of any fungal pathogen. In his paper "The Rust Fungus Life Cycle", Petersen (1974) presented an intensive and complete insight into the extraordinary interaction and functionality of the different spore states and life cycle of rust fungi. Rust fungi have up to five different spore stages; spermatia, aeciospores, urediniospores, teliospores, and basidiospores (Aime et al., 2017; McKenzie, 1998; Yamaoka, 2014). Urediniospores together with teliospores and basidiospores are of economic significance and sometimes known as primary hosts with uredinial able to produce the same spore state repeatedly on the same host (McKenzie, 1998; Yamaoka, 2014). The variation between the spores produced and their state on the life cycle is however a complicated yet interesting component of understanding rust fungi (Figure 9).

Figure 9: Full life cycle of rust fungi. Puccinia spp. All life cycles are presented with spore states also identified where they are present. Note that uredinia having a repeat of spore production in the mitosis process (Aime et al., 2017, p. 269; Tranzschel, 1904).

An autoecious rust fungus is one that completes its life cycle on a single host whilst those that require two different and unrelated host plants are termed heteroecious species (Aime et al., 2017; Helfer, 2014; McKenzie, 1998; Yamaoka, 2014). The variation is described in the state of spores of a rust fungi life cycle where different species would be lacking a single or two of the spore stages (McKenzie, 1998). Macrocyclic species produce all five spore states in their life cycle, while microcyclic species lack the aecial and uredenial stages; demicyclic species lack the uredinal stages; hemicyclic species lack the spermogonial and aecial stages; and endocyclic having an interesting variation similarity in the teliospores of certain microcyclic species to aeciospores of parental macrocyclic or demicyclic species (Aime et al., 2017; Yamaoka, 2014). Furthermore, a breakdown of the process of the different spore production and states in the rust life cycle is thoroughly described in the work of Kolmer et al. (2009).

Understanding the life cycle and different spore stages of rust fungi is ecologically and biologically important for developing control methods (Helfer, 2014; Yamaoka, 2014). A common feature of most economically important rust fungi is their macrocyclic heteroecious life cycle but understanding the variations of the various spore stages and susceptibilites of spores at production stages is essential to influence their establishment (Kolmer et al., 2009). Certain scenarios could be related to susceptibility to long distance travelling, fragility, and the availability of vigorous alternate hosts such as that experienced with the exclusion of the fungal disease *Gymnosporangium clavariiforme* from New Zealand in 1960 (Kolmer et al., 2009; McKenzie, 1998).

Chapter 5: Myrtle Rust (*Austropuccinia psidii*)

Myrtle rust, a disease caused by the fungal pathogen *Austropuccinia psidii* (formerly known *as Puccinia psidii)*, has caused significant population decline in many plant species of the *Myrtaceae* family and has been labelled "*the greatest threat to ecosystem*" by Australian scientists (Makinson & Conn, 2014; Roux et al., 2016; Stewart et al., 2018; Teulon et al., 2015; Winter, 1885; Yamaoka, 2014). New accounts of the disease have emerged from other places around the world triggering its risk potential as it continues to expand its geographical and plant host range (Makinson & Conn, 2014; Roux et al., 2016; Winter, 1885).

Understanding the risks of the pathogen is critical especially having a complex life cycle, particularly its biology including the different biotypes, spore types, host range (species and geographically), conditions for germination and infection and its process, epidemiology, means of dispersal, spore survival and scale of impacts (Makinson & Conn, 2014; Morin et al., 2014; Stewart et al., 2018). This chapter reviews the fungal pathogen *Astropuccinia psidii* and the disease myrtle rust for the benefit of understanding control options.

History of the disease

Myrtle rust is a mycological disease caused by the autoecious biotrophic fungus *Austopuccinia psidii* (*A. psidii* formerly known as *Puccinia psidii)* (Beenken, 2017; Stewart et al., 2018). The fungus originated from the neotropics particularly in Brazil where it was first described on guava (*Psidium guajava*) in 1884 and later on non-native eucalypts in 1944 (*Corymbia citriodora*) (Joffily & Bragantia, 1944; Loope, 2010; Pegg et al., 2014; Stewart et al., 2018; Winter, 1885; Yamaoka, 2014). Myrtle rust is also commonly known as guava, eucalyptus or Ohi'a rust; all names derived from the specific plant species the rust pathogen significantly affected across other locations (Loope & La Rosa, 2008; Makinson & Conn, 2014). Unlike other rust fungi with a narrow host range, *A. psidii* currently infects 460 species in 73 genera of the *Myrtaceae* family only (McTaggart et al., 2018b). Since its discovery, the pathogen has continued to expand its geographical host range (Figure 10) to other places for example in neighbouring Uruguay (1889), in the Caribbean (Dominica in 1945-1948 and Jamaica in 1933), Florida (USA, 1977), Hawai'i (2005), Japan (2007), Australia (2010), China (2011), New Caledonia and South Africa (2013), and now recently in New

Zealand (2017) (Baker & Dale, 1948; CABI, 2019; Giblin, 2013; Koch de Brotos, Boasso, Riccio de Machado, & Gandolfo Antunez, 1981; MacLachlan, 1938; Makinson & Conn, 2014; Morin et al., 2012; MPI, 2017b; Roux et al., 2016; Stewart et al., 2018).

According to Makinson and Conn (2014), the lightweight and flexibility of the urediniospores of *A. psidii* allows long distance dispersal with high incidence of infection from its strong viability characteristics. *A. psidii* also proves to have the ability to adapt easily into these new areas and host plants by generating variable a genetic sequence with transposable elements found in their DNA sequence that was determined from recent genomic studies (Stewart et al., 2018).

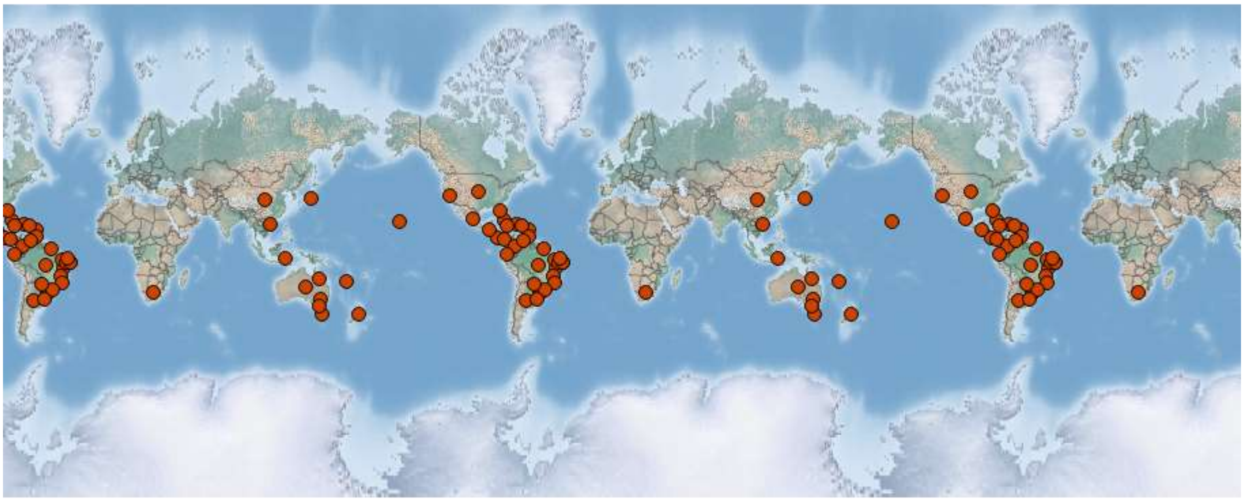

Figure 10: *Distribution map of Austropuccinia psidii worldwide* (CABI, 2019).

Economic and environmental impacts of myrtle rust

The impacts of *A. psidii* varies in different geographical locations and native flora host species (Teulon et al., 2015). Historical evidence of the disease shows fewer impacts around the native range (neotropic Americas) of the pathogen (Glen, Alfenas, Zauza, Wingfield, & Mohammed, 2007; Potts et al., 2016). Most occurrence has been recorded from neighbouring places of South and Central America and the Caribbean indicating the hostility of the pathogen's invasiveness, conditions suited to disease development and susceptibility of its host species (CABI, 2019; Simpson, Thomas, & Grgurinovic, 2006). However, significant impact of *A. psidii* was recorded in *Eucalyptus* plantations in Brazil (CABI, 2019; Ferreira, 1983).

Myrtle rust has greatly affected many forest and agricultural industries around the world. In Australia alone, it is expected to cause direct mortality to 10% of native forest plant species including the exotic eucalypts currently grown in 20 million hectares worldwide (Makinson & Conn, 2014). Other major events of economic significance of *A. psidii* have resulted in the fall of the spice (*Pimenta dioica*) industry in Jamaica from an arrival of a new strain of the pathogen (Carnegie et al., 2016; MacLachlan, 1938; Makinson & Conn, 2014), the guava industry (*Psidium guajava*) in Brazil from fruit production infection, the *Melaleuca* industry in Australia (Makinson & Conn, 2014; Stewart et al., 2018). In Hawai'i, *A, psidii* threatens 10% of horticultural nurseries growing 'ohi'a and majority of the plants native ecosystem (*Metrosideros polymorpha*) (Burnett, D'Evelyn, Loope, & Wada, 2012; Teulon et al., 2015).

Moreover, many susceptible native host species dominant in natural ecosystems and island biodiversity of the Oceania, Australia, Southeast Asia, South and Central America and Southern Africa regions are endangered and listed in the IUCN Red List of Threatened Species which has 338 species from the Myrtaceae (CABI, 2019; Potts et al., 2016; J. Stewart et al., 2018). *A. psidii* poses a big threat to at least 80% of the culturally important endemic plants of Hawai'i, and New Zealand such as O'hia (*Metrosideros polymorpha*) and Pōhutukawa (*Metrosideros excelsa*) (Lambert et al., 2018; R. Makinson & Conn, 2014; Teulon et al., 2015; Uchida, 2008), and native bushland plant species in Australia such as *Rhodamnia rubescens* (scrub turpentine) and *Rhodomyrtus psidioides* (native guava) (CABI, 2019; Pegg et al., 2014). The loss of these important native forest and bushland plant species through myrtle rust will significantly affect ecosystem services including nutrient cycling, watershed impacts, and also threatens the survival of many animals and other biology that depend on these ecosystems by affecting food reserves (Loope & La Rosa, 2008).

Life cycle

Controversy lies in defining the life cycle of *A. psidii* despite the work done by Glen et al. (2007) and Morin et al. (2014). Beenken (2017) described the life cycle of *A. psidii* as "not definitively clarified". He also attributed this statement to the lack of work done in investigating the cycles with alternate hosts of tropical rust which includes *A. psidii*. However, this has been updated by McTaggart et al. (2018a) with their recent study now identifying three known life cycle stages of *A. psidii* including asexually by uredeniospores (see Fig. 11) that are produced abundantly under natural conditions and mainly outside their native range (Beenken, 2017; Glen et al., 2007; Machado, Glen, Pereira, Silva, & Alfenas, 2015). The conditions for germination and infection is crucial for the establishment of the disease. Urediniospore germination for example are highly affected by temperature, leaf wetness, light intensity and photoperiod (Glen et al., 2007; Ruiz, Alfenas, Ferreira, & FXR, 1989).

Figure 11: *A. psidii. (a) Uredinia on abaxial surface (scale bar = 500 lm), (b) uredinia and telia (arrowed; scale bar = 500 lm), (c) erumpent uredinium (scale bar = 125 lm), (d) erumpent uredinium (scale bar = 20 lm), (e) single urediniospore with tonsure (scale bar = 5 lm), (f) teliospores (scale bar = 10 lm)* (Pegg et al., 2014, p. 1017).

Signs and symptoms

On individual trees and shrubs, tree mortality have been observed from the severe effect of the disease initiated on the young shoots and foliage to gradual crown loss of matured plants (Carnegie et al., 2016; Pegg et al., 2014). *Austropucciniia psidii* mostly infects actively growing young shoots, leaves, fruits and flowers of host plants (Stewart et al., 2018). Uchida (2008) developed a myrtle rust disease identification index on Ohi'a (*M. polymorpha)* trees in Hawai'i and is an example of the several illustrative indexes documented as guidelines to accurately identify the disease. Initially, rust colonies develop concentric circles of urediniospore pustules (Figure 12c (single cell)) on the underside of younger growing leaves (Figure 12, a-b, e-f) (Glen et al., 2007; Uchida, 2008). These masses of urediniospores are usually bright yellow or orange-yellow in colour (Figure 13) and marks the stage where the spores are ready to be dispersed (Glen et al., 2007; Makinson & Conn, 2014).

Figure *12: Typical symptoms of A. psidii infection on Myrtaceae. (a) Leaf spots with yellow masses of uredinia and rust brown telia on Eugenia erythrophyllum, (b) telia on E. erythrophyllum, (c) teliospore and urediniospores on a Myrtus communis leaf, (d) dying leaves and shoot of E. erythrophyllum covered with masses of yellow uredinia, (e) infected flower buds of Backhousia citriodora, (f) young, infected shoots of E. umtamvunensis with uredinia* (Roux et al., 2016, p. 649).

Figure 13: Masses of *A. psidii* uredinospores on *Lophomyrtus bullata* (Ramarama), Massey University, 2019.

The teliospores (Figure 12c (double cell)), often less common, are usually concentrated light-to mid-brown colour pustules in the telia (Glen et al., 2007; Makinson & Conn, 2014).

In addition, merging of multiple pustules will occur overtime where secondary infection is then initiated on young tissue, shoots, buds and growing foliage (Figure 14) (CABI, 2019; Glen et al., 2007; Uchida, 2008).

Figure 14: *(a, b) Branch dieback and infection of shoots on a mature Rhodomyrtus psidioides tree, (c, d) infection and dieback of regenerating seedlings under adult trees* (Pegg et al., 2014, p. 1018).

Figure 15: *Photographic sequence showing the impact of A. psidii over time on Rhodamnia angustifolia, a rare and endangered Queensland species. (a) Initial detection of rust on new shoots and expanding foliage, March 2011; (b) high level of A. psidii infection on new shoots and expanding leaves, December 2011; (c) severe defoliation following repeated infection by A. psidii, January 2012; (d) foliage and branch dieback 15 months after initial infection was detected, June 2012* (Pegg et al., 2014, p. 1017).

The symptoms (Figures 13, 14 & 15) vary according to the susceptibility level of host species and time period. Continuous impact of the infection will result in leaf spots and severe foliage deformation, infections on flowers & fruits and, shoot and stem dieback (Glen et al., 2007; Pegg et al., 2014).

Movement and dispersal

The biological characteristics of *A. psidii* make it a pathogen that can easily move to new environments. Tests on external surface of shipping containers verified positive results for presence of *A. psidii* urediniospores proving the viability of the pathogens spores in long-term dispersal and high risk potentials through cargo, people, food and packaging movement (Grgurinovic, Walsh, & Macbeth, 2006). Loope and La Rosa (2008) and Grgurinovic et al. (2006) summarised the different pathways of entry of the disease. According to Grgurinovic et al. (2006), other pathways of *A. psidii* to new places include;

1. *Movement of host plants, germ plasm and plant products;*
2. *Unregulated movement of plant material;*
3. *Movement of people; and*
4. *Long distance dispersal in air currents* (p. 487).

A. psidii uredeniospores have also been observed to be dispersed by honeybees which increases the risk of its movement (CABI, 2019; Carnegie et al., 2010; Chapman, 1964).

While records of the spread of the disease are becoming more readily available, information about the impacts and extant effect of the disease into areas free of the pathogen is less known. This is due, in part, to uncertainties in taxonomic identification of the disease, and knowledge about its epidemiology (Makinson & Conn, 2014). However, given the diversity of species in the *Myrtaceae* family that *A. psidii* has already successfully attacked, the impacts of this disease are predicted to be severe.

Myrtle Rust status in New Zealand

Myrtle rust (*Austropuccinia psidii*) was first identified in New Zealand in 2017 and constitutes a major threat to important native flora species in the Myrtaceae ecosystems (Lambert et al., 2018; Teulon et al., 2015). *A. psidii* was first reported on Raoul Island and is believed to have arrived in New Zealand by strong westerly winds from Australia (MPI, 2017b).

To date, *A. psidii* has been identified across much of New Zealand with varying level of impact (MPI, 2019b) (Figure 16). The disease is relatively new in New Zealand and the exact threat (economic, environmental or otherwise) are currently being quantitfied.

Furthermore, myrtle rust has been identified to have a potential cultural impact on important taonga plants (Lambert et al., 2018; Teulon et al., 2015). Taonga species are sacred plants that have a significant relationship to Māori with special connections to their cultural and ecological services (Roskruge, 2007; Teulon et al., 2015). These plant species include mānuka (*Leptospermum scoparium*), pōhutukawa (*Metrosideros excels*), kānuka (*Kunzea* spp.) and rata (*Metrosideros* spp.) and are all utilised and provide medicinal use, construction materials and food (Lambert et al., 2018) for Māori. This may significantly affect species such as mānuka and kānuka, which depend on early development stages for succession of plant communities and honey production may also be affected in productivity and quality. Another example is the quality of medicinal plants (traditional rongoa/taonga and modern) which may be compromised (Hood, 2016; Teulon et al., 2015; Vennell, 2014).

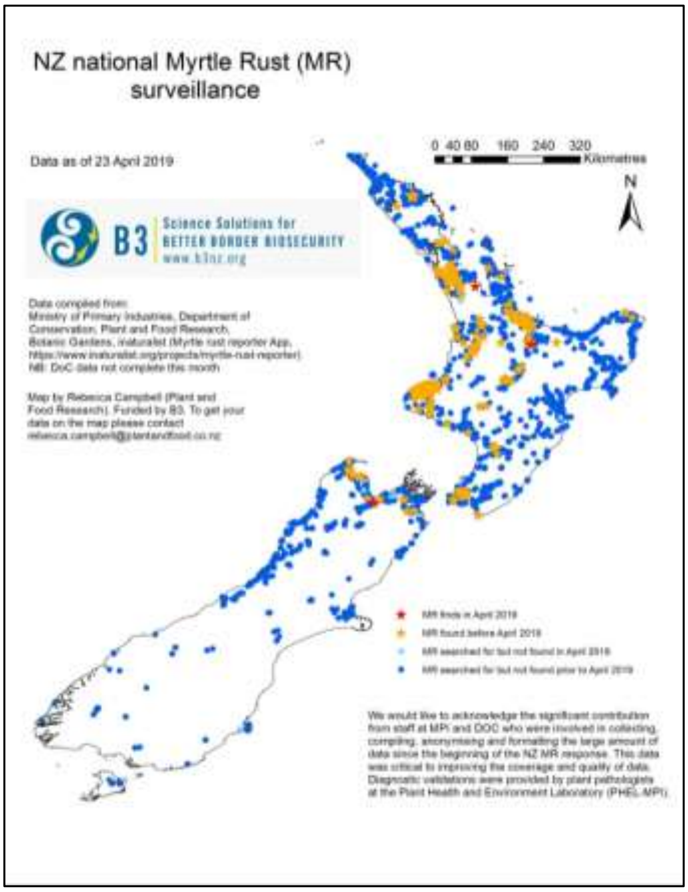

Figure 16: Distribution map of NZ national myrtle rust surveillance (MPI, 2019b).

Response action

A recent report of myrtle rust impact on New Zealand ecosystems has encouraged the government to now focus on managing the disease through identifying outbreaks, spraying infected hosts and removing severe infected plants from their surroundings

(Lambert et al., 2018; MPI, 2018). New Zealand has tightened its border control inspections of imported materials developing a comprehensive pathogen risk analysis for nursery stock (MPI, 2018). Since an Australian outbreak of Myrtle rust, all imports on cuttings and Myrtaceae plants have been ceased. Import species such as Acca, Agnonis, Eucaplyptus and Euginia are quarantined longer as the fungus' uredeniospores survive longer and it takes time to notice symptoms of infections (Pegg et al., 2014; Glen et al., 2007). Since 2010, there has been an increase in information and expert sharing between New Zealand and Australian experts to learn more about the fungus ensuring quick actions. MPI has maintained an emergency hotline for immediate reporting of incursions of suspected pests and diseases (Hood, 2016). Government investment in research to gain a better understanding of myrtle rust and the sustainable management of Myrtaceae plants in a New Zealand situation for future generations has been initiated (MPI, 2018). Most would consider this is just the beginning of the response needed.

Biosecurity is an important part of plant protection in New Zealand. The country relies heavily on this agency within MPI to protect the biodiversity of its native ecosystems and the productivity of its primary industries by preventing invasions of destructive pests and pathogens such as *A. psidii* (Bewsell, Bigsby, & Cullen, 2012; Jay, Morad, & Bell, 2003; Meyerson & Reaser, 2002). Invasive phytophagous pests pose a large risk to New Zealand's thriving $8.8 billion horticulture industry with an estimated $1.15 billion output loss cost per year, and a control cost of $921 million being projected by the end of 2017 (BiosecurityNZ, 2011; Horticulture, 2017; Kriticos et al., 2005). Mortality due to myrtle rust has already caused significant population declines in many of the host species and has initiated research into the topic on how to prevent the spread of the pathogen (Teulon et al., 2015). Comprehensive approaches have been adapted to maintain and improve biosecurity systems in New Zealand. However, while the country maintains one of the most successful biosecurity programs in the world, some pests and diseases still manage to pass through the system (incursion), and are among the biggest threats to plant health (Bewsell et al., 2012; Kriticos et al., 2005; Meyerson & Reaser, 2002; Teulon et al., 2015).

In its native environment, the neotropic Americas, *A. psidii* has not caused significant impact to Myrtaceous plants; however, it has caused devastating effect on commercial plantations, native plants and nurseries. Many importing countries have placed A. psidii as an export risk leading to quarantine restrictions by importing countries. The following three scenario of risks that myrtle rust presents to New Zealand.

Economic

Myrtle rust presents a big threat to the New Zealand horticulture industry through economically important myrtaceae species. Since the disease is relatively new in New Zealand the exact threat it poses at has not yet been precisely identified, myrtle rust is projected to impact the country's 25,000 ha small scale of eucalyptus forestry already established, the Feijoa industry which is worth $1.9m, the cut flower industry that depends on nurseries and worth $27m, and the growing mānuka industry which is worth a staggering $315m (Dickey, 2017; Hood, 2016; Hutching, 2017; Markham, 2017; MPI, 2018). The majority of the areas where these commercial plant stands are identified as high-risk areas are located in the North Island with suitable climatic conditions that support *A. psidii* (Refer to Figure 16). However, *A. psidii* has now been identified in the South Island causing more interest into its impacts on various predominant myrtaceous plants (MPI, 2018). As a result, quarantine measures are in place banning the transfer of planting materials and closing of nurseries in some parts of the country. This of course causes significant loss to the commercial nurseries affected (Hood, 2016).

Environment

New Zealand still has considerable area in native forests, scrublands and native vegetation. The impacts of *A. psidii* varies in different geographical locations and native flora host species (Teulon et al., 2015). On individual trees and shrubs, tree mortality has been observed from the severe effect of the disease initiated on the young shoots and foliage to gradual crown loss on matured plants (Carnegie et al., 2016; Pegg et al., 2014). Historical evidence of the disease shows fewer impacts around the native range (neotropic- Americas) of the pathogen (Glen et al., 2007). However, the existence of *A. psidii* has been extensively described in other species of myrtaceae plants outside the fungus' usual native range. This indicates the hostility of the pathogen's invasiveness and susceptibility of its host species such as currently experienced in New Zealand (Carnegie et al., 2016; Glen et al., 2007; Makinson & Conn, 2014; Potts et al., 2016; Roux et al., 2016).

A. psidii poses a big threat to the 29 national critical individual myrtaceae of which 27 are important endemic plants of New Zealand such as pōhutukawa (*Metrosideros excelsa*), rata (*Metrosideros diffusa*), Mānuka (*Leptospermum scoparium*), kānuka (*Kunzea* spp.), swamp maire (*Syzygium maire*) and ramarama (*Lophomyrtus bullata*) (Lambert et al., 2018; Teulon et al., 2015).

Socio-cultural

The potential impact of myrtle rust is of high risk on culturally important taonga plant species (Lambert et al., 2018; Teulon et al., 2015). Taonga species have a significant relationship to Māori with special connection to their cultural and ecological services, which also aligns to their whakapapa that defines their ancestry lineage and identity to their surrounding environment (Roskruge, 2007; Teulon et al., 2015). These plant species include the previously introduced mānuka, pōhutukawa, and rata tree species which are well utilised and provide Māori with medicine, construction materials, food and protection (Lambert et al., 2018). A further example of the cultural value of the myrtaceae species can be found in the story of the pōhutukawa at Te Rerenga Wairua, Cape Reinga, Northland, which is the guardian of the entrance to the cave through which spirits pass on their way to Hawaiki.

> *As the souls approach the land's end they think of their old homes in this world of light and of the dear ones they have left behind them; and they halt on the rocky ridge of Haumu and gaze backward over the painful way by which they have come. They weep in high, thin, wailing voices like the whistling wind, and they lacerate themselves with sharp splinters of obsidian (mata-tuhua), as people did at funeral gatherings or tangihanga, and those volcanic-glassy flakes and knives are there on the trail to-day. They pluck green leaves of shrubs, which they weave into kopare, or death chaplets, for their heads. The streams that here and there in this long peninsula ripple down from the hills cease their low music as the ghosts pass by. The path goes along the broken knife-back ridge until the ultimate cape is reached, the Reinga, or leaping-place, sacred to the countless army of the dead. Here there grew a great and venerable pōhutukawa tree; the blossoms were called in legend Te Pua o te Reinga—The Flowers of Spirits' Flight. The branches (now broken off) bent over the dark, unrestful ocean; some of the roots went searching like wizardly fingers for the water. By these boughs and roots the spirits descended, the one after the other they dropped into the tideway, where seaweed swirled like ocean monsters' hair, and as they vanished into the depths the mihi-tangata was heard, the wailing of the innumerable dead greeting their coming to the Tatau-o-te-Po, the Gateway of the Hereafter. So, with the seafowl screaming their requiem, the winds of Land's End*

whistling about the cape, the ocean murmuring in a thousand voices, the Wairua Māori departed from this land of Aotearoa (Cowan, 1930 :p48).

Additionally, within the Mānuka, kānuka and rewarewa there are many species of economic importance to Māori and the whole of New Zealand particularly in the thriving honey industry (Teulon et al., 2015).

Climatic models have already predicted major impacts on these plant species in the North Island and rata species predominantly in the South Island with future outward growth of the disease projected in the coming years on favourable environment and climatic condition (Stewart et al., 2018; Teulon et al., 2015). There is currently minimum impact on long-lived trees such as pōhutukawa in the short term however, in the long term it is likely to be significant as it affects seeding and seed mortality from infestations. This may significantly affect species such as mānuka, which depends on early development stages that eventually will affect honey production (Teulon et al., 2015). The quality of medicinal plants (traditional/taonga and modern) may also be compromised (Hood, 2016; Teulon et al., 2015; Vennell, 2014). Overall, identity and connection through whakapapa from any loss of these culturally important plants or associated biology will be very much affected.

Current situation

As at 2019, the disease has been discovered in 988 properties across New Zealand (MPI, 2019). *A. psidii* has also established in the Tasman region in top of the South Island during this time and has confirmed the presence of the disease across the whole country (MPI, 2018). The increase in notification has been attributed to increase in public awareness and news media with the Ministry of Primary Industry (MPI) and Department of Conservation (DOC) primarily spearheading the campaign. Further assistance guidelines were enhanced by the introduction of a myrtle rust identification application developed by a group of Te Tira Whakamātaki (TTW) researchers, a Māori Biosecurity Network who oversee the Māori response to significant biosecurity issues and participation in policymaking (Lambert et al., 2018). Furthermore, most initial sightings have been confirmed from ramarama (*Lophomyrtus bullata*) thus has been primarily used as an indicator in early identification process (Lambert et al., 2018). The main clusters of findings however have been recorded from private properties after it was first originally introduced from cutting materials off a nursery in Kerikeri, North Auckland (MPI, 2018). The 2018 breakdown is given in Table 5.

Table 5: Surveillance findings of Myrtle rust in New Zealand (MPI, 2019a).

Host	Total Surveyed	Confirmed
Ramarama: *Lophomyrtus* spp.	11,944	653
Pōhutukawa, Northern rata, Southern rata: *Metrosideros* spp.	40,163	409
Monkey apple: *Syzygium* spp.	9,561	158
Bottle brush: *Callistemon* spp.	9,979	21
Willow myrtle: *Agonis flexuosa*	447	7
Feijoa: *Acca* spp.	16,410	5
Mānuka: *Leptospermum scoparium*	17,511	3
Chilean Guava: *Ugni molinae*	1,164	2
Gum: *Eucalyptus* spp.	6,321	1
Australian Tea Tree: *Thryptomene* spp.	73	1
Australian Water Gum: *Tristaniopsis* spp.	303	1
Other	15,289	0
Total:	**129,165**	**1,260**

Current Policy Response

New approaches are being applied to manage myrtle rust in New Zealand. The two leading agencies MPI and DOC are working in collaboration with the government, science, industry and the people – including Māori interests - to determine the scale of the situation, and develop the best policy to manage the disease (MPI, 2018). Unfortunately, initial eradication efforts were unsuccessful due to the complexity of the pathogen and lack of appropriate tools. As a result, MPI and DOC are now indicating a commitment towards a long-term management approach (MPI, 2018, Lambert et al., 2018). Within this wide network of collaborators, MPI and DOC have now put legislation and regulations in place after drawing preliminary assessments from impacted areas.

The implementation of the Biosecurity 2025 Direction Statement is set to incorporate the efforts that is going to be centred towards management of certain incursions such as myrtle rust (BNZ, 2018). This statement provides the direction for New Zealand's biosecurity system to follow in order to make it more resilient and future-focused (BiosecurityNZ, 2011). The statement includes the strategic mission and principles of biosecurity that are guided by five strategic directions (Figure 17) that is led by a steering group and implemented by a working group within MPI (Biosecurity New Zealand, 2018). The implementation of these directions is intended to ensure better management of future incursions and strengthening of the country's biosecurity system beyond 2025.

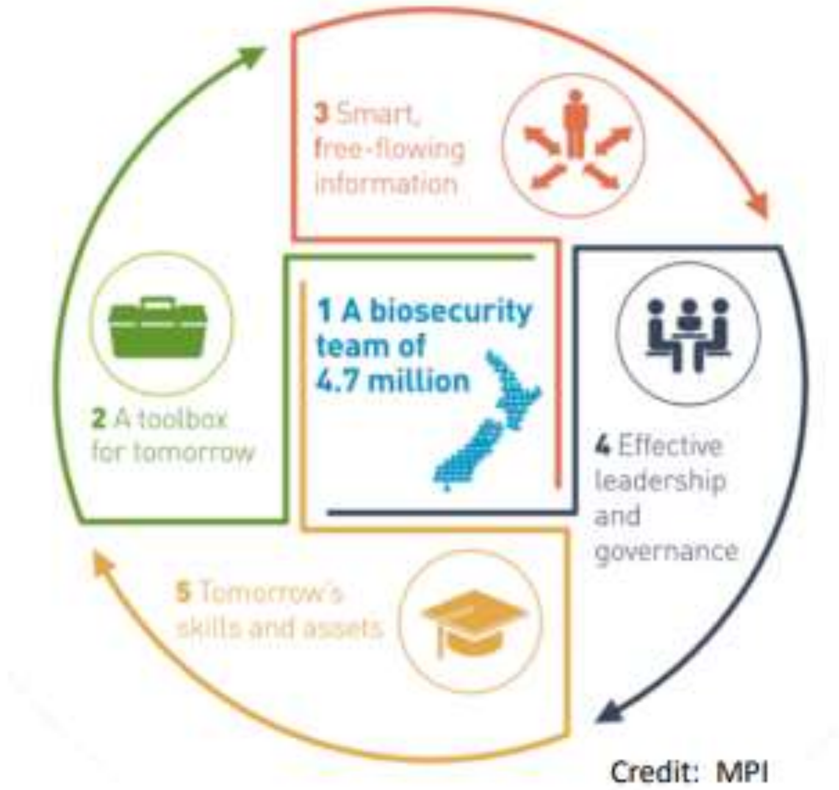

Figure 17: Biosecurity 2025 Direction Statement Five strategic directions (MPI, 2017b).

Better Border Biosecurity (B3) is fully engaged in the Biosecurity 2025 Direction Statement. As a multi partner, cooperative science collaboration, B3 is primarily focussed on the breach in point of entry of New Zealand's biosecurity system and successful establishment of pathogens such as *A. psidii* (National Science Challenge, 2018; Teulon, 2017). They also offer strategic support towards the five strategic directions and development of research programmes for long-term management. From this network, development of new consolidated advice and regulations have been formed. The new guidelines for large scale planting and restoration programmes of myrtle rust susceptible plant species has been developed by MPI and DOC as a policy component of the Biosecurity 2025 (MPI, 2018). A complete ban of importation of cut flower materials from the myrtaceae species in New South Wales, Queensland and Victoria have been imposed for the whole of New Zealand as strict regulations (DOC, 2018).

In the short term, MPI and DOC are focussing their effort on developing new tools, to build an understanding of myrtle rust resistance and susceptibility and explore possible treatment and management options (MPI, 2018). Raoul Island has specifically been designated as the primary site for science programme designed to aid in this process (DOC, 2018). MPI is also engaging and is currently enforcing Crown Research Projects. In enhancing policies around the understanding and better management of the disease, these projects are focussed on building engagement and social license, the inclusion of Te Ao Māori which is also fully supported by the B3 and DOC, evaluation of impacts and responses and the more scientific understanding of the pathogen. This includes understanding the pathogen, hosts, and environmental influences, genome sequencing of the pathogen *A. psidiii*, and improving management tools and approaches (MPI, 2018). It is expected that findings from all this research will assist in the focus of the two agencies (MPI and DOC) in surveillance efforts in the long term and updating of regulations and policies that are currently in place for the country's effort towards myrtle rust management.

Disease management for A. psidii

Disease management is critical for any pathogen invasion. Although eradication has been suggested it is highly unlikely to be successful due to the abundance and invasiveness of A. psidii urediniospores (Lambert et al., 2018; Roux et al., 2013). Managing *A. psidii* is thought to be the ultimate option of dealing with the disease thus several means have been proposed including both contemporary and cultural methods. For short-term management practices, integrated pest and disease management (IPMD) is employed with the aim of preventing build-up of the disease inoculum through host removal, physical treatments, chemical treatments, biological controls and host resistance.

Host removal

Host removal is critical in early stages of detection. Accurate identification of the different signs and symptoms of the disease is also important in this process to avoid further dispersal of spores (Glen et al., 2007). However, removal is recommended for highly susceptible plants such and that depends on locality and host species (Glen et al., 2007).

Chemical treatments

There is a range of established fungicides that have been tested and described as best to use for preventative and/or curative measures. Spraying regimes have been developed from recent studies (Alfenas, Zauza, Mafia, & De Assis, 2004). Non- systematic fungicides were tested on guava from Brazil. Although these tests did not result in total eradication, the successful control of the pathogen means a better management of its invasiveness in natural ecosystems.

Biological treatments

Biological control is an important tool for minimising disease incidence. 24 isolates of Bacillus subtilis were treated to A. psidii urediniospores to examined germination. Result shows an effective reduction of in vitro germination of A. psidii urediniospores from 34% to 0-4% (Glen et al., 2007). Other biological control agent that have been usefully observed include Fusarium decemcellulare, Pseudomonas aeruginosa (Amorim, Pio-Ribeiro, Menezes, & Coelho, 1993; Glen et al., 2007).

Host resistance

Several studies have found the existence of R-genes in Eucalyptus (Roux et al., 2016; Tobias, Guest, Külheim, Hsieh, & Park, 2016). The occurrence of R-genes for example in Eucalpytus in Brazil suggest significant advantage in screening breeding programmes in commercial industries (Roux et al., 2016). Also, the presence of resistance genes and poor host-parasite interactions have resulted in the unsuccessful establishment of *A. psidii* in Indonesia (Hardiyanto & Tridasa, 2000; Makinson & Conn, 2014). This could be critical for preservation of native species in natural ecosystems with future climate complexities.

Chapter 6: Māori Values and Biosecurity

The wellbeing of Māori is inextricably linked to the wellbeing of Te Taiao (our natural resources) and the protection of Māori cultural lineage (Nga Kaiawhina o Wai262, 2019)[5]. Indigenous biosecurity provides an important link to forest conservation and biosecurity management. With reference to Lambert, Waipara, Black, Mark-Shadbolt, and Wood (2018), the concept of indigenous biosecurity presents an important opportunity for indigenous responses to be recognised as a major component of biosecurity in general. To support this, Lambert et al. (2018) highlighted that participation of local communities in New Zealand using Māori-sourced traditional ecological knowledge (TEK) or mātauranga played a critical role in the development of biosecurity strategies and programs that have factored majorly in the protection of the taonga giant conifer, *Agathis australis* (New Zealand Kauri) from the disease Kauri Dieback (*Phytophthora agathidicida*) (S. Lambert et al., 2018). From this case study, the relationship between the Māori and existing TEK indigenous responses was observed through efforts undertaken by indigenous people to respond to the issue.

Impact on Māori

In New Zealand, work has only recently begun to understand how to manage this disease, and more specifically how to involve Māori communities in the long-term efforts (Teulon et al 2015; TTW, 2017). The development and implementation of guidelines and regulations by MPI and DOC is slowly being experienced with the lifting of local ban on distribution of cutting materials from nurseries (MPI, 2018) however in the long-term, these regulations, as part of preliminary policies will vastly enhance capacity growth in both the business and indigenous communities. Since the leading agencies are concentrating more today on long-term management with ongoing intensive research work, impacts of these policies or regulations including guidelines implementation can be theorised with reference to impact analyses recorded from affected places around the world. This could also be highly related to Australia where the majority of research work on myrtle rust including policies are currently being conducted (CABI, 2018). Nonetheless, the application of a strict importation ban on cut flower materials from Australia will significantly influence the nursery and cut

[5] Unpublished report prepared by Nga Kaiawhina o Wai262 (representative group) to the Hon. Nanaia Mahuta, Minister of Māori Affairs, June 2019, on the response to the WAI262 report.

flower industry in New Zealand, including any Māori involved in these production sectors. Other policy implementation such as the mentioned new consolidated guidelines for large scale planting and restoration programmes of myrtle rust susceptible plant species is critical in the supporting the sustainability and safety of the eucalyptus and mānuka [honey] industry. Mānuka particularly is steadily becoming a prominent industry in New Zealand and these avenues will be critical to this industry (Lambert et al., 2018).

Moreover, a small focus group conducted with Māori interests from different backgrounds showed that Māori communities prioritize early engagement and response with regards to myrtle rust as was also indicated in the battle against kauri dieback (Lambert et al., 2018; Teulon et al 2015). The Māori Biosecurity Network Te Tira Whakamātaki believes that Māori are best placed to identify the first signs of the incursion and report to local authorities in a timely manner. Māori can do this by practicing their role as kaitiaki or guardians of the land and be “eyes on the ground” since the government officials cannot monitor all areas (Lambert et al., 2018; Te Tira Whakamātaki, 2017). The use of ramarama as an indicator of susceptible species for instance is based on observations by Māori (Lambert et al., 2018). However, the question is how much knowledge can the local communities relate to concerning responding to new diseases like myrtle rust? Both leading agencies have included in their propaganda an extensive inclusion of Te Ao Māori and increase in educational awareness into the Māori communities (MPI, 2018; DOC, 2018). There are also publications that include identifying responses from local iwi, hapū and individuals who are well aware of the different signs and symptoms of the disease (MPI, 2018; DOC, 2018). Development of seed banking projects is also in the propaganda of MPI and DOC and will be included in the awareness programs that will greatly assist the long-term process. This increase in the level of awareness and engaging the community can only better enhance understanding by Māori about the disease and its control.

The Māori Biosecurity Network: Te Tira Whakamātaki (TTW)[6]

The Māori Biosecurity Network, Te Tira Whakamātaki (TTW) was formalised in 2017 and is extensively involved in the response to myrtle rust, and with respect to addressing the Māori dimension of the policy response. The network group is predominantly of Māori

[6] See https://ttw.co.nz/ and http://www.biologicalheritage.nz/resources/highlights-2017/impact-3-detect-and-eradicate/mātauranga-Māori/Māori-biosecurity-network for more information.

researchers who have had important hui (meetings) with different iwi, hapū and individual kaitiaki, and was formed after the experience with the Kauri dieback disease to voice Māori participation in biosecurity policy making (Lambert et al., 2018). The recent myrtle rust incursion has become a major challenge to the work TTW does as an overseer of Māori response to identification of the disease, its threats to the indigenous community and overall management of the disease (Lambert et al., 2018; Te Tira Whakamātaki, 2017). The network are pushing boundaries to evaluate the policy response in terms of how it provides specifically for Māori interests. Together with MPI and DOC, TTW has been encouraging Māori to continue their practices of kaitiakitanga of their natural resources while at the same time offering support to the two leading agencies in their management approach (Lambert et al., 2018; Te Tira Whakamātaki, 2017). This has resulted in the inclusion and consideration of important mātauranga Māori into MPI and DOC's current work of interest (MPI, 2018; DOC, 2018). However, TTW is in the process of having mātauranga Māori not only in the projects of the two leading agencies but also the implementation of this knowledge into the whole biosecurity policy decision making. TTW believes such a collaborative approach will enable efficiencies in national and local biosecurity strategies that will fulfil indigenous communities of economic, environment and cultural wellbeing. They are a good example of a lobby group who actively challenge and contribute to policy development and implementation

Traditional Māori Horticultural Networks – Tahuri Whenua example

Tahuri Whenua Inc. the National Māori Horticultural Collective developed a first response called *He Tatai Hono* in a recent project aligned to Traditional Māori Horticultural Networks (Roskruge & Estrada, 2019). This response drew on the cultural expertise and existing networks aligned to the collective to present a clear 'picture' of the Māori relationship to plants and plant distribution as it might be understood for the potential spread of unwanted organisms such as pests, diseases or weeds. The whakataukī aligned to the title of this particular project – ***He Tātai Hono*** – explicitly identifies the continuous relationship Māori have to each other, the natural world and all elements which contribute to our existence across the generations from the spiritual realm to the physical world we know today. These relationships are also the basis for this project and Tahuri Whenua.

Four (4) pou or mainstays were determined that illustrate the traditional response to biological issues by Māori generally:

1. **Poutahi (1):** the first and arguably the most important phase is to contextualise the issue and response to clearly articulate the cultural element which is going to be the overriding factor and key driver to all outputs.
2. **Pourua (2):** In this phase the emphasis is on acknowledgement of the whakapapa or relationship of the Māori community to the flora or fauna under threat, especially those plants accessed for food. This also aligns to the mātauranga or traditional knowledge.
3. **Poutoru (3):** an overview of the relationship between Māori communities and the biosecurity challenges. This phase will clearly draw upon an interface between traditional and western science knowledge systems and provide an opportunity to build the understanding of all parties on the role Māori have in the biosecurity space. In particular this phase will focus on the building of capacity and capability for Māori to participate.
4. **Pouwhā (4):** this is effectively the knowledge consolidation processes and to gather information from a range of sources to determine the best response. The data gathered is categorised both geographically and culturally.

TEK and mātauranga Māori

Māori use the term *mātauranga* for their knowledge and *tikanga* for their customary lore concerning resource management rules. Together, these terms have guided natural resource use and conservation of native biodiversity for centuries in Aotearoa (Kawharu, 2002; Roberts et al., 1995).

Through *whakapapa*, Māori are connected to their land and natural resources. According to Roskruge (2007), the land along with the oceans, bush and forest resources, have sustained the survival of the people through their ability to provide food, shelter, spiritual linkages and strength (p. 1). These services (acknowledged in this thesis as ecosystem services e.g. provisional, regulating, cultural and supporting) allows Māori to acknowledge their connection to the land by identifying its significance in a holistic way which they will never detach themselves from.

Similar to Māori horticulture, *mātauranga* Māori or Māori TEK through their connection to plants, link one's identity through the intimate contact it provides to the understanding and utilisation of the ecosystem services provided by native flora and fauna, weather, climate, as well as the associated biotic and abiotic factors. This study acknowledges that due to this connection Māori are able to understand biological threats and thus develop traditional management tools and techniques as *tikanga* to manage native ecosystem biodiversity and conserve their *taonga* species through the practices of *kaitiaki* and *kaitiakitanga*.

The adoption of *mātauranga* Māori in this study is predominantly aligned to identify the traditional tools for the management and conservation of threatened *taonga* plant species from fungal diseases. Fungal diseases are collectively termed *Nga kōpurawhetu* (Roskruge et al., 2010).

Whakapapa

The Māori view of the land, its flora and fauna is best observed through their whakapapa. Whakapapa is more than just genealogy (Hutchins, 2013). The Māori concept of whakapapa is ideal in capturing and explaining the inter-relatedness and interconnectedness of people, places and things across space as it is also a tool that arranges and governs relations within and between them. Therefore, whakapapa is more of a receptacle of knowledge of tribal histories and Māori intellectual basis that is observed in place in layers of cultural and holistic interconnection which ultimately contributes to the integrity of biodiversity conservation (Roskruge, 2007). This is particularly relevant to the management of native *taonga* species.

Figure18: Māori creation theory from the beginning – Te Tīmatanga (Harmsworth & Awatere, 2013, p. 275).

In the concept of whakapapa we are concerned with the genealogical layers and how Māori through these interconnections are placed in an ethnobotanical and biodiversity conservation context. This includes the connection, lineage, or genealogy between humans and ecosystems and all other flora and fauna and natural resources as part of a hierarchical genetic assemblage with identifiable and established bonds to their primal gods (Figure 18).

Whakapapa is considered to be the genealogical record of Māori history. Roskruge (2007) stated that *whakapapa is but one of the modes of transmitting history in the Māori society* (p. 30). Inherent in this relationship is the preservation of narratives, songs (*waiata*), and proverbs (*whakatauaki*); or names given to special *taonga* plant species such as the origin of the 'rata' and 'pōhutukawa' trees (Simpson, 2005) both of the myrtaceae family.

The following is a version of one of Tawhaki's (semi-supernatural being associated with lightning and thunder) many ordeal that led to the unique gleaming red colour of both the rata and pōhutukawa flowers as described by Best (2005) cited in Conly and Conly (1988):

> *"Tawhaki persisted and, in the uppermost heaven, he found the band dogs of Tama. But Tama was a being possessed of great powers and he caused Tawhaki to fall from the uppermost heaven and so perish at the far off place where the sky hangs down. When people of this world awoke the next morning they saw that the blossoms of the rata and pōhutukawa were of strange new colour produced by the blood of Tawhaki when he fell from the heavens, and that gleaming red colour they have retained from that time down to our own, the folk who now wander athwart the body of Papa, the Earth Mother"* (p. 9).

In the essence of understanding the whakapapa of trees in the forest, Māori creation traditions align to Tāne (also known as Tāne-mahuta) as the God and Fertiliser of the forest. Apart from being accredited the respect of separating the sky and the earth and shining light and life to the *whenua* (land), Tāne in many occasions partook in rituals that resulted in the existence of many iconic native trees and plants species.

> *Thus when Tāne took Mumuhanga to mate she produced the totara (Podocarpus totara) tree; he took Te Puwhakahara who brought forth maire (Nestegis cunninghamii) and puriri (Vitex lucens), while Tukapua became the mother of the tawai or beech (Fuscospora solandri), Tauwharekiokio of all tree ferns, Rerenoa of climbing and epiphytic plants, Apunga of many small plants, Tutoro-whenua of the bracken, Hinewaoriki of the kahika (Dacryocarpus dacrydioides) and matai (Prumnopitys taxifolia) trees…Huna of the harakeke or so called flax (Phormium tenax) plant…and Pani-tinaku of the sweet potato* (Best, 2005) p. 271).

This representation of Tāne's great work is also observed as the whakapapa of the essence of growth that arises within a man similar to when a tree rises from the ground (Royal, 2007b).

The whakapapa of a *taonga* plant species also defines its ethnobotanical purpose to Māori. For example, in the origin of the '*tī kouka*' or cabbage tree (*Cordyline australis*) and its ethnobotanical relationship to Māori (Figure 19). This composite whakapapa shows the origin of the tī kouka tree from three of the seventy children of Ranginui and Papatūānuku. Uru-te-ngangana (responsible for growth, ecology and reproduction), Rakataura (responsible for features of the leaves), and the offspring of Haumia after several incarnation (responsible for the unique fibrous wood of the *tī*, the food that it contains (*kauru*), the vegetable tip (*kouka*) and the medicinal purposes) are all responsible for the origin of the cabbage tree (P. Simpson, 2000).

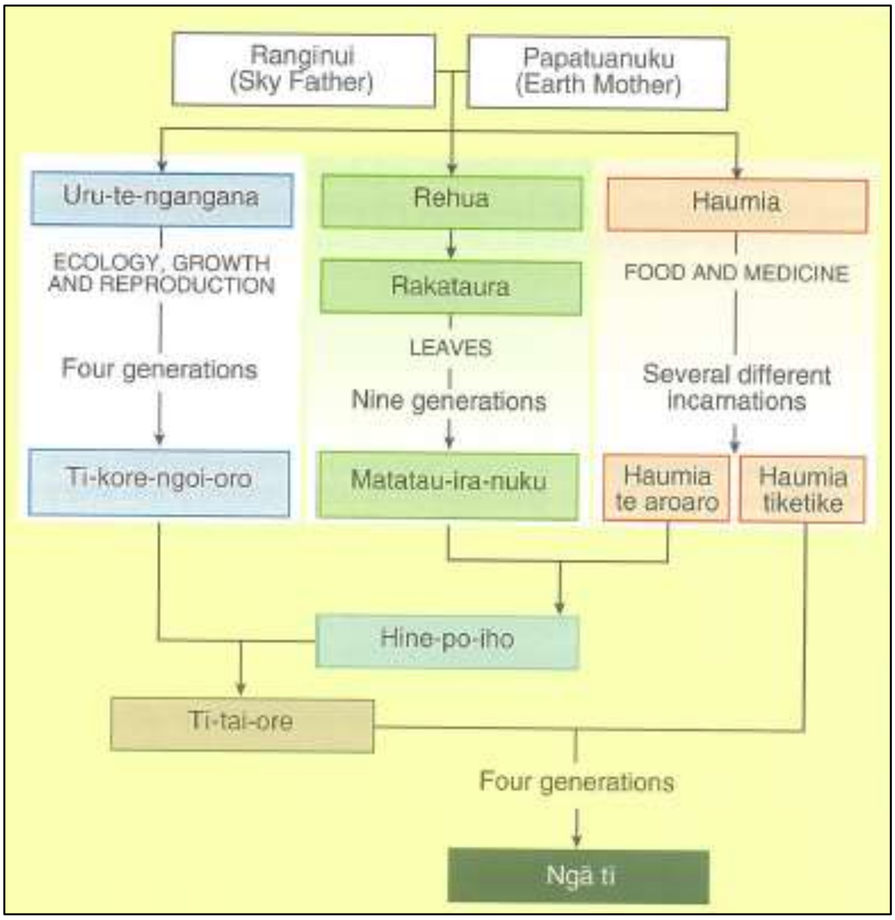

Figure 19: Ti Kouka (tree) as derived from about fifteen generations from Ranginui (sky father) and Papatūānuku (earth mother) (P. Simpson, 2000).

As a key environmental concept, whakapapa also projects local views and conceptual models of ecosystems that helps in the elucidation of ecosystem services to Māori, including the threats to *taonga* species, and the role of TEK in conservation. Hua Parakore, an indigenous verification and validation system for *mahinga kai* (food and product production) associated whakapapa to the safeguard handling of seeds. In reference to Hutchings et al. (2012), and upon their conversation with a survey participant from the NgāPuhi tribe she stated:

> *I think (whakapapa) is all a part of Hua Parakore. Knowing about where the seed comes from so that it has some integrity in ensuring that they are safe seeds and that they're easily dependable and you know that the seeds are going to grow again … it's about integrity and dependability in terms of sustainability* (p. 136).

Through this principle of whakapapa, Hua Parakore was able to identify the threats of mishandling of seeds and what it means to their work. As a result, this ultimately led them to develop cultural process of maintaining the integrity of seeds by introducing diverse cultural practices (*tikanga*).

Similarly, a priority area of focus when dealing with diseases threatening *taonga* plant species would be the understanding of the origin of the causal agent of the disease. For myrtle rust, understanding the origin of the fungal pathogen *A. psidii* is where management begins. Elthea Vercoe (Ngāi Tuhoe) talked about the importance of whakapapa in understanding the threats of fungus to plants and to *rongoa* (traditional herbal medicine) practices. She stated:

> *"So just in a general discussion sense, wouldn't it be the genetic of how it's made up? …maybe that one gene would say more of the fungus…so it's come from somewhere but what is it? Why is it called that name? If it's a fungus, so what is the whakapapa of that fungus? That's where you got to look into to understand its foundation of how it came here and what happened in the beginning because that fungus could have been healthy and a good fungus but something along the trail must have been added to it and now it's reacting in a negative way…but even though the fungus might be a negative one, how can we make it a positive one if we can't get rid of it or not knowing how to manage it? It's all down to the whakapapa"* (E. Vercoe, personal communication, June 14, 2019).

Therefore, whakapapa is observed in this study as what places Māori to identify, connect, utilise and pass on to the next generation traditional *mātauranga* Māori, and practices of *kaitiaki* and *kaitiakitanga* to protect *taonga* species from the disease myrtle rust and other future fungal or biological pressures.

Karakia

Karakia is essentially the process which invokes respect from the realm of the traditional gods towards the presen and future actions. In modern language it is often translated as ‘prayers’ however it is much more than that. Where whakapapa identifies the relationship between all things, karakia recognises that component which we cannot see or change; the elements that were the origin of the world as we now know it. So in a modern context karakia is an acknowledgement that we do not, and can not, have control over absolutely everything and we therefore prepare ourselves for the ‘unknown’ contribution that may occur. In a traditional context we recognise the spiritual world as representing the unknown and as being the vehicle for change (N. Roskruge, Personal Communication, 10 June 2019).

Mātauranga Māori

He aha te kai o te rangātira? He Kōrero, he kōrero, he kōrero.[7]

(What is the food of the leader. It is knowledge. It is communication.)

Mātauranga Māori is a major tool for traditional ecosystem management approach. This includes the understanding of *taonga* plant species and their protection from biosecurity risks and threats. Evidence of Māori understanding of fungi can be found in various context(s), for example the naming of different fungi in Te Reo Māori (Māori language) and their uses (see Table 6) or the language applied by Māori horticulturists through their collective activities[8] (Roskruge, et al., 2010).

Table 6: Language terms in Te Reo for native fungi in Aotearoa/New Zealand (Moorfield, 2003-2019).

Fungi description	Te Reo
General term for mushroom and fungus and for *Pholiota adiposa* mushroom	harore
General term for a short lived fungus	harore-rangitahi
Several collection of basket fungi, *Ileodictyon cibarium*	matakupenga, kōpurawhetu, tikowhatiri, kokirikiriwhetu, paruwhatitiri, tutae whatitiri
Fungus icicles, *Hericium clathroides*	pekepeke-kiore
Ear fungus, *Auricularia polytricha*	hokeke, keka, tarawhata, hekaheka
Flower fungus, *Aseroe rubra*	puapua-a-Autahi
The esoteric naming of transient fungus	Tutaekehua for some puffballs
Septate-spored polypore, *Polyporus septosporus*	popoia hakeke (native fungi)
Puffball, *Lycoperdon perlatum*	tutae atua

[7] Whakataukī or proverb as given by Ngāi Tāneroa hapū (case study group) to support this thesis

[8] See *Ngā Porearea me ngā matemate o ngā māra taewa* – a publication of the pest and disease issues for Māori potato crops – which has a focus on fungal issues, *nga kōpurawhetu*.

Names of these fungi also have connection to Māori either as related to a place, event (which might define its physical outlook or form of existence) or plants (host), for instance the puffball, *Lycoperdon perlatum* known colloquially as tutae atua which means, faeces of a god. Also included is the name for parasite which in Te Reo Māori is translated *Pirinoa* and is also a name of a place in the Wairarapa where the Kohunui Marae is located. This is an indication of connection among name, places and causal agent.

It is to be noted that during pre-European times, Māori had less knowledge of understanding fungi as a biological pathogen but were considered as either food or medicine e.g. wood fungi (*Polyporus septosporus* – popoia hakeke) (N. Roskruge, personal communication, July 18, 2019). These understandings would have changed and developed post-European society.

Prehistoric Oceania including the settlement of Māori in Aotearoa indicated that inhabitants of the Pacific Islands used resources but sometimes lacked the great interest of developing a strict conservation ethic to preserve their pristine resources (Clarke, 1990). A critical example is related to the extensive hunting of moa birds (*Dinornithiformes*) which led to their extinction (Clarke, 1990), and the clearing of plants and forest cover through deforestation or constant slash and burn practices for agriculture purposes (Cumberland, 1961, 1962, 1963). This resulted in the alteration of many *taonga* fauna and flora existence. But not until the settlement of the *pakeha* (non-Māori, predominantly of European origin) and increase in climate change effects did more environmental issues ascend including biological risks that proved hazardous for native ecosystems (Clarke, 1990; Taiepa et al., 1997).

Mātauranga Māori however in the form of ecosystem management and conservation still enabled Māori to continue to use their resources and manage their environment accordingly. A significant example of this can be observed in its application to traditional crop management in Māori horticulture systems. Māori tradition supports the notion that many plants including cultivated crops were ethnobotanically important to them therefore knowledge was developed and based around cultivation, pest and disease monitoring, harvesting and storage practices of important crops (Estrada de la Cerda, 2015).

Māori were traditional horticulturalists and were able to successfully cultivate tropical crops such as kūmara (*Ipomoea batatas*) and taro (*Colocasia esculenta*) in a temperate climatic region like Aotearoa whilst reserving seeds or plant materials for next season's planting (Roskruge et al., 2010).

> *Māori lived in a permanent settlements and their cultivation were distributed around a district claimed by residents. They had no beasts of burden…very few crop pest and disease issues…practiced a form of rotational land use, generally used only wood ash as fertilizer and cropped for no more than three annual seasons on a piece of land. Food storage was important…without knowledge of storage they were likely to be without good nutrition during winter month…"* (N Roskruge et al., 2010) (p. 8-9).

Māori *rongoa* practitioners play a big role for Māori health wellbeing. *Rongoa* refers to a broad range of traditional Māori healing practices that encompasses a wide use of *mātauranga* Māori and Māori ethnobotany (Durie, Potaka, Ratima, & Ratima, 1993). There are several methods of *rongoa* practices including physical remedy that is derived from the use of trees, leaves, berries, fruits, barks and moss materials (Ahuriri-Driscoll et al., 2008). The application of these plant materials to the practice of *rongoa* involves the use of specific Māori knowledge that help support the understanding of the anatomy and physiological principles, recognition of the healing properties of various plants, methods and clear separation between mind body and spirit (Mason Durie, 1994; Mark & Lyons, 2014). Old time Māori *rongoa* practitioners believed that illnesses had a spiritual cause and that the use of herbal plants was only an addition to the *karakia* (prayer) directed to the Gods to heal the illness or the affected area of the body (Mark & Lyons, 2014).

Also applicable is the knowledge of protecting *taonga rongoa* plants. Protecting and sustaining the source of materials for *rongoa* practices is priority for practitioners and *mātauranga* Māori plays an important role in this process. Rita Tupe (Ngāti Haka, Patuheuheu) a traditional expert healer and *rongoa* practitioner elucidated the use of soil or mud from the river to cover open scars and of herbal plants to protect them from diseases (wakahuiatvnz, 2019). This has been part of her practice together with healing in assuring the conservation of the source of her *rongoa* plant materials as well as the protection of traditional knowledge passed down to her by her ancestors.

Mātauranga Māori also connects the application of *tikanga* of *rongoa* to fungal issues management. This can be observed through the understanding of the cultural relationship between two *taonga* species and their conservation. Whale *kaitiaki* Hori Parata (Ngāti wai) considers the kauri (*Agathis australis*) and whales (*tohora*) as siblings and uses the same connection to identify the possible link between the disease kauri dieback, caused by the fungal pathogen *Phytophthora agathidicida* and the increase in whale stranding (Roy, 2019). Similar knowledge allows *rongoa* practitioners to use *mātauranga* Māori and *tikanga* to identify what possibly could protect kauri from the disease. Recent findings by Māori medicinal expert Tohe Ashby (Ngāti Tu) and Bonita Bigham (Ngāti Tu) indicates the development of a treatment from whale bones and fat oil (Coster, 2019).

Māori depend on the *maramataka* (Māori lunar calendar) in their desire to, not only have a successful cropping season, but also for the sustainable use and protection of their *taonga* plants. It gave orderliness and assisted Māori in decision making and management process (Roskruge, 2007). *Matariki* is based on Māori traditional knowledge of astronomy, cosmology and the seasons which were all developed from periods of observation of the environment by Māori ancestors. According to Matamua (2017), knowledge of Māori astronomy was studied and taught by experts or *tohunga kokorangi* to only a few selected individuals from their '*observations of the sky from sunset to sunrise, noting the appearance of the stars, and deducing meanings from their position, colour, movement and brightness*' (Matamua, 2017 p. 1).

Matariki (commonly known as Pleiades or Messier45 (M45)), the star of the year is critical in Māori *taonga* conservation. Māori knowledge expressed connection of the traditional role of *matariki* as a significant indicator or *tohu* (signs/omen) of change in seasons and behaviours of the environment, animals and crops (Matamua, 2017). For example, the indication of flowering of plants or moulting of birds and other local knowledge (Best, 1922). Furthermore, phases of the new moon known in Māori as *whiro* mainly influence the behaviour of all the world's inhabitants. *Whiro* relates to *matariki* as the god of darkness, illness and diseases. *Matariki* as an indicator star and through this relationship enable Māori to observe threats and read signs before the new moon. This period beforehand is observed to be the most productive and fertile time of the month for all activities on land (Matamua, 2017). So therefore the knowledge of understanding is both unique and sacred.

There is much in Māori knowledge or *Mātauranga* that is applied across Oceania through variations of Polynesian TEK. The following example is expressed in the Fijian context.

The iTaukei (Fijian) traditional knowledge (*kila ka vaka iTaukei*) is connected to our daily lives. It is what that connects us to our land and culture. It is the main component of what sustains our agroforestry and our livelihood. Fijian TEK is passed down through generations in two defined ways: (i) *Ai Vola Tamata* and, (ii) *Ai Vola Gauna*. A few examples of importance of Fijian TEK in plant disease management was explained by Suli Vunibola (Naduru, Macuata, Vanua Levu, Fiji). He stated:

E levu sara nai vakaraitaki ni kena bibi na kilaka vaka iTaukei kei na kedra bibi kina taqomaki ni noda I yau bula wili kina na noda veikau kei na I teitei. Na kila oqo e yaga vakalevutalega ena kena kilai e dua na leqa ena dua nai tei ni gauna e vakatakilai taki mai kina e dua na kena I vakaraitaki. Na kila oqo e qai dau vurea na kena bucini se cava me caka mei wali ni leqa oqo se na kena taqomaki nai tei me kua ni dewava mai na mate. E vica na kena I vakaraitaki bibi kau vulica mai vei na noqu qase sai koya:

i. Na moli ni sa tekivu me karokaro mai sai vakaraitaki ni tiko na manumanu ni mate ena vuni moli, ka sa qai dau caka me wali kina leqa oqo sai koya na kena kuvui na vuni moli ena kena vakamai na qa ni bulu ni niu,

ii. dau waraki me vula levu qai dau caka na ta kau se bitu me tara kina na vale. Oqo ena kena vakabauti ni oqo na gauna era dau vunitaki ira kina na veimamnumanu se mate eso main a kau kara dau vakayagatki me tara kina vale. Ke ra na musu ena bogi buto se cila veimama tuga na vula, oqo ena vakavuna na nodra kana na manumanu kei na mate ena kau ni vale oqo,

iii. dau toni na I doko ena soso ni oti main a tei se cavu dalo. Oqo me kua kina ni vadewa na manumanu ni mate na I doko kina dua tale na qele vou ni teitei.

There are many ways Fijian TEK is important to the conservation of natural resources including our forests and farms. TEK also assist people to observe signs of issues with the plants. When this happens it enables them to develop mitigation methods or ways of protecting crops or plants from diseases. There a few examples of these that I learnt from my grandfather and they are:

i. When the skin of lime (Citrus limon) starts to show signs of scabs this indicates that there is presence of disease (lime skin scab is mainly caused by a fungus), so we light fire under the tree and smoke the whole tree by using coconut fibres and shells to clean the tree and its fruits,

ii. When harvesting timber for building a house, we should only harvest during full moon, this is because during this time of the month there are no insects or pathogens present in the wood that will infect the timber that is going to be used for building, if harvesting is done during dark nights or half-moon, insects and pathogens are present and will feed on the wood thus affecting the durability of the timber,

iii. After harvesting or planting taro (Colocasia esculenta), the "i doko" (traditional cultivating tool made of special wood) is to be immersed in the mud to eliminate all pathogens and purify the i doko before it is used again on new soil (S. Vunibola, personal communication, April 12, 2019).

It is important that Traditional knowledge be passed on and taught to new generations. A knowledge not passed on is a dead knowledge. Evidence of the significance of knowledge can be explained in many forms from different indigenous communities of the Pacific. *Mātauranga* Māori serves as one aspect of this and is highlighted in this thesis as an important tool in understanding threats of biological pressures such as fungal diseases.

Tikanga

Tikanga is a unique cultural approach to management and biodiversity conservation. Māori like all indigenous cultures, operate management systems differently according to how they are related to the activity. In putting traditional knowledge to practice, the primary focus of the approach is to benefit both the people and the resources. This is achieved through the holistic relationship Māori have with their land and the sustenance which they live off it (Roskruge, 2007).

A number of important rituals are applied to the use and protection of resources and were mostly targeted to the gods who would look after the flora and fauna of the people. It should be noted that the majority of the disease pathogens seen today were not present pre-European Mori society and hence no specific traditional management approach exist for the many current plant health issues surrounding native floras including myrtle rust. However, incorporating ages of observations and put into concepts of practices, *tikanga* Māori is able to relate most rituals and understanding to a general application context of management that is culturally applicable across the management systems in place. *Tikanga* includes the conceptual management approach of *kaitiakitanga* (guardianship) of resources and protecting the interest of future Māori generation (Roskruge, 2007).

Karakia (charms, incantations, invocations) are observed to be an important introduction to any activity. It aligns the spiritual connection and *tikanga* approach of management to Māori, the gods, the environment and the activity at hand. Certain rituals are pertained to agriculture for instance, where ceremonies were done to celebrate first fruit or first caught birds of the seasons. Owing to the beliefs of Māori to their gods and life principles of plants, these rituals increases the fertility and safeguarding of the forest and birds (Best, 2005). The raising of a *tuapa* (a post) to set up a birth of a child and represent the soul of a deceased person is another rite performed in reference to the Ruatāhuna (Ngāi Tuhoe) people who also do this to prevent bad spirits from injuring plants including crops or other food products. This rite also included the generating of fire and raising of wind as once practiced by the Tama-Kaimoana clan of Tuhoe and Urewera to aid in the protection of plants from diseases inhibited by spirits of the dead (Best, 2005).

The use of fire is also sacredly important in Māori environmental management. Fire is used in many rituals including plant protection. Fire rituals are also associated to *tapu* (restricted, sacred) where several specific names of *ahi tapu* (sacred fires) are derived from their respective roles (Best, 2005). Certain *tikanga* associated with the use of *ahi tapu* include:

- *Ahi purakau; ahi tumuwhenua: these were sacred fires kindled in the forest to placate the god Tāne when a taonga tree is about to be felled for traditional use,*
- *Ahi amoamohanga: rite connected with offerings of first fruits to the gods…in order to remove all harmful influences (including diseases),*
- *Ahi torongu: a fire rite performed to destroy the torongu, a species of caterpillar that infested the kumara (sweet potato) (Best, 2005).*

Ritenga is inclusive of all concepts that are associated with customs, protocols and laws that regulate actions and governs the behaviour of people particularly towards management. These concepts include *tapu* and *rahui* (Harmsworth & Awatere, 2013).

Tapu (sacred or holy) according to Best (2005) *is the origin of mana, and the gods are the source of tapu, so that, if relief comes from a mention of tapu places, that relief emanates from the gods* (p. 371). *Tapu* as *tikanga* in protecting *taonga* species can be emphasised through the use of *rahui*.

Rahui is basically an act of a temporary protection. In Māori, the practice of *rahui* is referred to the use of an object (such as a pole) to signify restriction of access to an area and the prohibition of any form of human activity from happening in it (Benton, 2004; McCormack, 2011; Wheen & Ruru, 2011). Different types of *rahui* are established for different purposes and gives further coherence as an important cultural tradition. Conservation *rahui* conceptualises a holistic system of *tikanga* that combines practical and spiritual fundamentals in respecting and protecting resources including *taonga* plant species (Wheen & Ruru, 2011).

The application of ***mauri*** in addition, brings about good health to plants, the people and the environment. *Mauri* is the energy and vibrations for conserving *taonga* species and is seen as a principle essence for Māori ecosystem management approach including managing plant diseases on *taonga* species;

> *Mauri is an internal energy or life force derived from whakapapa, an essential essence or element sustaining all forms of life. Mauri provides life and energy to all living things, and is the binding force that links the physical to the spiritual worlds (e.g. wairua). It denotes a health and spirit, which permeates through all living and non-living things. All plants, animals, water and soil possess mauri. Damage or contamination to the environment is therefore damage to or loss of mauri (Harmsworth & Awatere, 2013) (p. 21).*

Mauri is also observed as a major factor of increasing biodiversity. Mauri could be represented by the use of tangible and non-tangible *taonga* resources like a stone or rock, a totem animal or tree, or the forest ecosystem as a whole to represent a physical being of a spiritual essence of guardianship. A shift in the energy components (*mauri*) of any part of the ecosystem will result in the whole system being affected and the management approach broken. Therefore, the protection of the *mauri* is critical for the health of the various *taonga* plants species and ensuring the quality and integrity of their health to enhance the wider ecosystem services they provide.

Kaitiaki/Kaitiakitanga

The practice of *kaitiaki /kaitiakitanga* supports the remarkable awareness of Māori towards the protection of *taonga* resources and biodiversity conservation. In Māori horticulture for instance, the philosophy of *kaitiakitanga* allows Māori as *kaitiaki* with all the rightful *mana* to care for the land and support sustainable cropping practices (Hutchins, 2013). The concept of *kaitiaki/kaitiakitanga* are closely linked to *tikanga* with the obligation to care for the environment including *taonga* plant species. *Kaitiaki/kaitiakitanga* therefore should be inclusive of the understanding of a much more Māori centred resource management approach (Kawharu, 2000).

Māori tradition of *kaitiaki* aligns whakapapa to the relationship of the offspring of Ranginui (sky father) and Papatūānuku (earth mother). As guardians of the different aspects of Māoridom, sacred tribal *tikanga* was attached to their existence to keep a holistic order to the land and the people (Roberts et al., 1995). *Kaitiaki* therefore can only be carried out with the right *mana* by a *tangata whenua* because of the holistic *whakapapa* connection it has to their primal gods and their cultural responsibility to protect the *mauri* of their resources (Matunga, 1995).

The primary obligation to carry out *kaitiakitanga* lies with Iwi, its members and appointed *kaumatua, kuia* or *tohunga* as *kaitiaki* of their *taonga* resources including important plant species. This approach to managing and protecting *taonga* plant species is also holistic (Matunga, 1995). Spiritual *kaitiaki* appear in the form of mythical beings, such as *taniwha* (spirit which can be guardians and also have malignant influences) or tribal gods. Best (2005) represents *kaitiaki* through the appointment of different *poutiriao* (spiritual guardians) to be the guardian of several realms. In the context of environmental protection, Tāne was the primary *poutiriao* assigned to this department. There were several roles under his assignment which includes being:

- *The guardian sanctified for the purpose of preserving peace and unity among themselves (meaning all chosen poutiriao)…,*
- *The guardian consecrated in order to preserve the welfare of all matters pertaining to … lest trees, herbage, vegetation, lose its vitality, its fruitfulness, and deteriorate or decay, or become infertile, or incapable of assimilating nourishment or seedless, lest the growth of trees and vegetation of land and water degenerate …,*
- *The guardian consecrated for the purpose of protecting the powers of tapu in respect to places where … ceremonies were performed, to gods …*(Best, 2005) (p. 109).

Kaitiaki acting directly or indirectly are also presented through the medium of ancestral spiritual beings, *tohunga* or sacred totem *taonga*. For example, having the *atua* (ancestor, supernatural being) as guardians of *tapu* places, *wairua* (spirit) as guardians of man, lizards as guardians of a highly sacred tree and the village, birds as a messenger and guardian of signs or even the use of *pou* (post) as protection *mauri*, carvings representing the gods (*whakairo*), and stones in gardens (see Fig. 20 for a Ngāti Rāhiri mauri stone) as mediums of a gathering place for the gods and as fertilizer for the care of growing crops (e.g. *Rongo mauri* preserved by the Wahanui family in Waikato) (Best, 2005; Kawharu, 2000). Moreover, Māori in their role as *kaitiaki* have an important contribution to biodiversity and management which according to Minhinnick (1989) leads to the protection of many *taonga* species including providing for the following (as cited in (Matunga, 1995):

- *Restoration of damaged ecological systems*
- *Restoration of ecological harmony*
- *Ensuring that resources and their usefulness increase*
- *Reducing risk to present and future generations*
- *Providing for the needs of present and future generations (p. 24).*

Figure 20: Ancient mauri stone of Ngāti Rāhiri origin, North Taranaki; this stone represents Rongo and serves to gain a propitious crop (Photo: N. Roskruge).

The act of *kaitiakitanga* is involved with several concepts that emphasizes the term with more obligation than authority. These concepts include *mana*, *mauri*, *tapu*, *rahui*, *manaaki* (hospitality) and *tuku* (transfer, gift, release) (Kawharu, 2000). It is important to note that *kaitiakitanga* embraces social and environmental dimensions where human participation and understanding of their connection to these concepts is critical in order to keep all elements (spiritual, physical, mental) in balance and capture conservation and protection of *taonga* species (Kawharu, 2000).

Kaitiakitanga is also connected to *rangātiratanga* (chieftainship). This connection asserts Māori occupation on their land as *tangata whenua* with the responsibility of maintaining their association with their resources under the affirmation of their *mana* (Kawharu, 2000). Several principles can define the act of *kaitiakitanga*:

- *Ahi ka, literally meaning keeping the fires burning, refers to the occupation of land by Māori as a metaphor to keep the fire alight,*
- *Physical markers (e.g. mountain, lakes, rivers, rocks and posts (pou paenga). Many tribal groups define themselves with reference to important physical markers e.g. Taranaki people to Mount Taranaki and "Ko Taupiri te maunga, ko Waikato te awa...: 'Taupiri is the mountain, Waikato is the river...', ko Hikurangi te maunga, ko Waiapu te awa, ko Ngāti Porou te iwi: 'Hikurangi is the mountain, Waiapu is the river, Ngāti Porou are the people"…,*
- *Naming land after ancestors (tapatapa whenua or taunaha whenua) and important events were another practical way of asserting kaitiakitanga rights,*
- *Taonga as a important marker (e.g. used in the burial of pito (navel, tummy button, section of umbilical cord nearest the baby's body) under taonga totem trees e.g. ti kouka signifying the act of both kaitiaki and kaitiakitanga,*
- *Sacred burial grounds (urupa) providing protection and recognising connection to the departed spiritual realms to become kaitiaki of the living* (ibid.).

A final aspect of *kaitiakitanga* is enabling Māori as *kaitiaki* to observe and identify signs from all the different elements of *kaitiaki*. The connection and spiritual significance that exists within this relationship allows Māori to carry out their duties as living *kaitiaki* of the land and develop socio-environmental ethics to manage resources and most importantly guide them to protecting their *taonga* species.

Chapter 7: Case Study Report: Uhi-Mānuka

Hurunui-Ō-Rangi, Ngāi Tāneroa Hapū, Ngāti Kahugunu ki Wairarapa.

"Kia u ki te pai"
"Cleave to that which is good"

Introduction

The case study approach in this research is the core contribution to the process of validating the role of *mātauranga* Māori and *tikanga* to the future management of the disease *myrtle rust* and the conservation of *taonga* plant species from this disease and other future fungal pressures. The majority of the case study took place at the ancestral reserve of Uhi-Mānuka (Figure 21) which is traditionally owned by the Ngāi Tāneroa Hapū, of the Hurunui-O-Rangi marae, of the Ngāti Kahungunu ki Wairarapa/Rangitāne tribe. Uhi-Mānuka is located within the Carter Scenic Reserve by the farming settlement of Gladstone (south of Masterton) and is also under the management of the Department of Conservation (DOC).

Figure 21: The ancestral site of Uhi-Mānuka with Mānuka trees predominantly set at the background (Photo: Suli Vunibola).

This case study was initiated by elders of the Ngāi Tāneroa hapū who collectively hold a vast mix of knowledge about the history and TEK values of the whole Ngāti Kahungunu ki Wairarapa region, their hapū and Uhi-Mānuka. The kuia Mrs Frances Reiri-Smith (Nanny Frances) is the primary kaitiaki contributor to this case study and through her dedication and support this research was able to holistically acquire a connection to Uhi-Mānuka, literally a place of heaven to her and her hapū and one that represents their ancestral past.

The information gathering procedure relevant to the management of Uhi-Mānuka and the natural world generally was sourced primarily from members of the hapū led by Nanny Frances. Following the introduction to the iwi and hapū the case study focusses on Uhi-Mānuka and is presented following a model developed by Roskruge (2007) based on an ethnobotanical model whereby information is presented as Te Ao Māori/Kosmos, Mātauranga/Corpus and Tikanga/Praxis. Te Ao Māori is focussed first on the whakapapa of Uhi-Mānuka and the associated iwi and hapū. Information is then focussed on the connection through the various traditional ecosystem services that Uhi-Mānuka provided to the people of Ngāi Tāneroa, followed by the *tikanga* associated with the resources that was sourced from Uhi-Mānuka, their connection to the different *taonga* species (tangible and intangible) within the reserve and the *mana* that connects them to their forefathers through Uhi-Mānuka.

The case study will elucidate localised TEK values of Ngāi Tāneroa and their connection to the conservation and preservation of Uhi-Mānuka from fungal pressures such as myrtle rust.

Study area

Ngāti Kahungunu – The Iwi

Ngāi Tāneroa is a hapū of the Ngāti Kahungunu ki te Wairarapa and RangiTāne tribes within the Ngāti Kahungunu federation of tribes (iwi). Historical accounts identify that the waka (canoe) Takitimu, made its journey down the east coast of the North Island of New Zealand with the command of Tamatea-arikinui. Rongokako, his son, married Muriwhenua and became parents to Tamatea-Ure-Haea whom together with Iwipupu had a son named Kahungunu (Whaanga, 2005a). The whakapapa of this relationship is described below.

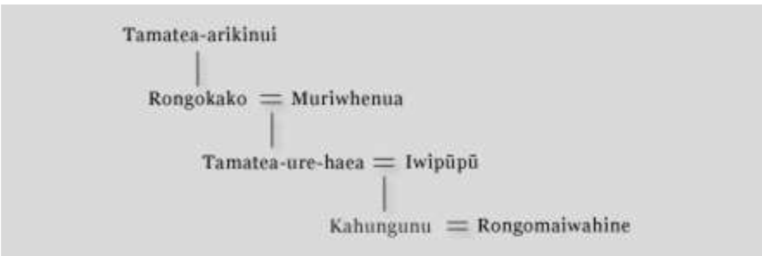

Figure 22*: The whakapapa of Kahungunu (M. Whaanga, 2005a).*

There are several versions of events relating to the traditional origins of the Kahungunu people. Their stories are closely connected to the journey of their ancestral waka, the Takitimu. The late Canon Wi Te Tau Huata (Ngāti Kahungunu) provided a whakapapa on the link between the federation of tribes of Kahungunu to the Takitimu waka (see Appendix 2). Several of these stories unique to the iwi are recorded by Ballara (1991). On one popular occasion, she noted that Tamatea-Ariki-nui was first to approach the Te Mahia and Ahuriri locations of the east coast. Records of whakapapa from the Māori Land Court confirm that Kahungunu and his siblings were children of Tamatea and his wives including Iwipupu and her sister Ihuparapara.

Ngāti Kahungunu is the third most populous and land holding iwi in Aotearoa, with boundaries spanning from the Wairoa district down to the Wairarapa region. The territory is divided into the three tribal boundaries of Wairoa, Heretaunga and Wairarapa (Figure 23) (Whaanga, 2005a). As an iwi, it is profoundly complex and richly dynamic, consisting of many geographically dispersed and socio-historically divergent groups that constitute parts of a larger supra-iwi structure and ideological whole.

Figure23: *The three Ngāti Kahungunu areas within the tribal boundaries: Ngāti Kahungunu ki Te Wairoa, Ngāti Kahungunu ki Heretaunga & Ngāti Kahungunu ki Te Wairarapa (M. Whaanga, 2005b).*

Geographically, the region is characterized with mountain ranges, rugged terrains, steep hill country side that are broken by valleys, swamps, plains and lakes dominated by bracken or low bushes. Severe bush and forest covers are also often predominantly observed in gullies with tributaries from the mountains leading into major lakes and river systems. The eastern coastal foreshore is mainly demarcated with thick pumice dating back to the famous Taupo eruption and large and steep hill formation from the north east trending fault (Ballara, 1991). To the south of the Wairarapa lie beaches covered with white nicely moulded stones that is also an ancestral *urupa* (burial site) to some of the iwi's ancestors.

Ngāti Kahungunu ki Te Wairarapa and RangiTāne

Figure 24: *Map of Ngāti Kahungunu ki Wairarapa tribal region (Ngāti Kahungunu) (M. Whaanga, 2005b).*

Ngāti Kahungunu ki Wairarapa (Figure 24) is the third established tribal area of the Ngāti Kahungunu federation of tribes. The arrival of the descendants of Kahungunu in Wairarapa took place after their settlement in Heretaunga. The area of this tribe begins from Cape

Palliser and Turakirae in the south, following the central mountain range up to the Manawatu River, and back to the east coast. The occupation of the Wairarapa by the Ngāti Kahungunu tribes also explains the tradition of another Māori tribe called RangiTāne.

The Rangitāne tribe is descended from the eponymous ancestor RangiTāne, who is also known as Tāne-nui-a-rangi and Rangitāne-nui-a-rangi. Like the descendants of Kahungunu, descendants of Rangitāne ventured southwards where they occupied territory in the Manawatu, Tamaki-nui-a-rua, Wairau in the South Island and the Wairarapa. In the Wairarapa, there are claims and stories of a large degree of intermarriage between the two tribes. This is evident in the summary by Wi Hikawera Mahupuku where he stated:

> *The people who now occupy the land are descendants of both Rangitaane and Ngāti Kahungunu... Rangitaane and Ngāti Kahungunu were intermingled at that time* (Chrisp, 1993) (p. 44).

There are also significant differences between the affiliations of the two tribes within the Wairarapa. In most cases, many still hold strong to only one of the tribe. Therefore, they might only be affiliated to Ngāti Kahungunu me RangiTāne or Ngāti Kahungunu ki Wairarapa. This thesis however, will refer to the tribal association of the primary hapū and participants which is specifically to the Rangitāne tribe as determined by the whakamatau or learning of our kaitiaki, Nanny Frances Reiri-Smith.

Resources of the region

Food resources of the region were rich and varied. In abundance were staple starch food crops such as kumara, aruhe (fern roots), ti kouka, taro (mainly on the east coast), and hue (gourds). There was also abundance of berries such as karaka, matai and tawa. Bird species included tītī (muttonbirds), kereruū (pigeons) and kākā (bitterns) and several species of ducks. Kiore (rats) were also familiar and in the waterways included tuna (eels) which were dried for winter foods. Fish species included mullet, upokorokoro, ngaruroro (freshwater species of upokorokoro), fresh water shellfish, crayfish, kahawai, keke, paua, kina and other coastal shellfish.

The forest presented vital resources such as flax, raupō, and trees of different species that provided timber for construction, making canoes, weapons and tools. There were a vast inventory of plants (herbaceous and woody) sourced for medicinal purposes. Many of these resources were overexploited, endangered or put into extinction post European contact and the introduction of non-native species of animals and plants. Burtenshaw et al. (1999) list a comprehensive caltalogue of plant species accessed by Ngāti Kahungunu for the building of traditional buildings and the reconstruction of a Kahungunu wharepuni (sleeping house) for the Te Papa museum. These include a number of myrtaceae family, primarily of the rātā, mānuka and kānuka species.

Ngāi Tāneroa – The Hapū, The People

Ko Takitimu te Waka
Ko Pae Maunga a Tararua me Maungarake
Ko Ruamahanga te awa
Ko Hurunuiorangi te Marae
He uri o nga Hapū a Tāneroa me Ngāti Muretu a te taha o taku Mama,
me te taha o toku papa a Ngāti Kaiparuparu me Te Hina Ariki.
Nga Hapū o toku Iwi a
Ngāti Kahungunu me RangiTāne.
Ko Frances Reiri-Smith.

Ngāi Tāneroa is named after Tāneroa the daughter of Turi who was the captain of the Aotea waka of Taranaki. Because of this, the hapū is also connected with the people of Taranaki. How she came to be in the Wairarapa was retold and is mentioned here by Nanny Frances as follows;

> *The Tāne (man) given to her (Tāneroa) was Uhinga Ariki. Uhinga Ariki was a mōkai which is a pet of a tohunga (priest). The takitimu waka only brought priestly people who were only men. Uhinga Ariki was the youngest man on the Takitimu when it came to Aotearoa.*
>
> *And the tohunga that was put off onto the Wairarapa was called Tupai. He got off with several other people right on the coast of Wairarapa but without the mōkai Uhinga Ariki. Uhinga Ariki was still on the Takitimu and went into Patea in Taranaki.*
>
> *When he came into contact with the people of the Aotea waka, he took a shine to the daughter of Turi. Turi's wife was Rongorongo. Her sister was Rongomaiwahine was Uhinga Ariki's aunty. So they gave him Tāneroa. He couldn't accept the offer until he spoke to a tohunga. Tūpai his tohunga was back in Wairarapa on the coast. So he brought her back to Wairarapa (Reiri-Smith, personal communication, 9 June, 2019).*

Back in the Wairarapa, the young couple were blessed by the tohunga and he then named the hapū after Tāneroa. According to Nanny Frances, the practice of naming the hapū after a tohunga was not a common practice as this was of a very sacred and highly respected tradition. The tohunga gave all the mana with his blessings to the young couple who now carry on the linkage of the Ngāi Tāneroa people. The urupā (burial site) is also named after Tāneroa.[9]

Hurunui-ō-rangi – The Marae

Figure 25: Hurunui-ō-Rangi marae, Gladstone District, Wairarapa (Photo: S. Vunibola).

Hurunui-ō-rangi is the marae of the Ngāi Tāneroa hapū (Figure 25). This marae as told by Nanny Frances is also a place where other hapū of smaller numbers have been welcomed and traditionally included:

> *The marae is also known as Tekupenga-o-nga hapū o Hurunuiorangi which means the fishing net bringing every one of the smaller hapū into here so we retain all of that. Like my uncle, he's a Nga Mana which is this marae, his mum lives further out and they haven't intermarried with others but their relationship sub-tribe is decreasing and we've got a few numbers who don't have much land but they retained their mana and the name of their hapū, so we brought them in here to be part of the Hurunuiorangi (personal communication, 9 June, 2019).*

[9] Note other iwi or hapū may know this hapū by its synonym Ngāti Tāneroroa (see McEwen, 1986)

Another version was related to the discovery of a comet along the Ruamahanga River. Huru means a 'feather'. Hurunui-ō-rangi means belong to Ranginui. The comet is believed to have come through to the area and bounced along the river. It lit up the area and the toa (warriors) that were coming through the range came up to the flat land and named it Hurunui-ō-rangi relating the comet to a big feather of Ranginui; the sky father.

Uhi Mānuka – The ancestral site

Te Ao Māori (Kosmos)

Figure 26: The ancestral site of Uhi-Mānuka and case study participants (Photo: N. Roskruge).

Whakapapa

The whakapapa of Uhi-Mānuka became significant sometimes around the 1400s. The term *Uhi* means 'under' and so the name Uhi-Mānuka means 'under the Mānuka trees'. *He korero pakiwaitara* (The story behind it) as told here by Nanny Frances relates to the chasing of their ancestor or tupuna Raekaumoana and the belief that there was a curse from the situation that occurred in his quest for survival.

> *"Hidden by Mānuka and protective screams of Manu was Raekaumoana, te raNgāti ra as he was pursued by mauling warriors who were scared off by the Manu" (Frances Reiri- Smith, personal communication, 9 June, 2019).*

In her statement, Uhi-Mānuka began from when Raekaumoana, a chief of an *iwi* (tribe) from the Wellington area was being chased by another rival *iwi*. His route of escape was over the Wairarapa hills towards the Ngāi Tāneroa area. Raekaumoana was considered a very cheeky *tipuna* (ancestor) and had a special gift in that he had a way of talking to the birds by whistling. And on his quest for life, he managed to hide himself under the Mānuka trees. On this occasion and while he hid under the Mānuka trees, the warriors who were after him suddenly saw all the birds coming out of the trees with branches flying everywhere. All this happened without any wind.

Then there were sounds of calling coming out from the trees. This was Raekaumoana calling out the names of Tawhirimātea (the God of the winds), and the God of the *manu* (birds), Tāne-mahuta (who is also the God of the forest). The people of the other tribe heard this and knew that he was placing a *mākutu* (curse). This belief scared them and as a result they left the area and never pursued Raekaumoana any further.

The whakapapa of the ancestral site of Uhi-Mānuka is a clear example of the use of an ancestral story or event and the articulation of local belief systems to protect natural resources. The event of how Raekaumoana was hidden under the Mānuka trees and being protected by the *manu* from their actions exemplified the implementation of a cultural curse. It was this understanding that not only protected a tipuna of the hapū but also the resources that were thriving within this ecosystem. This connection contributes to the future generation of the resources and hapū of Ngāi Tāneroa.

Mānuka as the primary *taonga* plant species within Uhi-Mānuka.

The whakapapa of a range of native tree species including the Mānuka tree (*Leptospermum scoparium*) is given in Appendix 3. It is the primary myrtle tree species within Uhi-Mānuka. Also present in abundance is the Kānuka (*Kunzea ericoides*) species. These two species of myrtaceae are observed as siblings to the people of Ngāi Tāneroa. However, Mānuka is considered of a much higher status due to its traditional connection to the ancestral site of Uhi-Mānuka. Mānuka is also observed as a better resistant plant species that was able to survive two well-known natural phenomenon within the area.

The first being an earthquake that occurred in 1835. According to nanny Frances and from her conversation with a geologist working with DOC, this event opened up tectonic plates that were sitting underneath Uhi-Mānuka and created terraces that could still be seen today. The results of the shift in these tectonic plates also created waterways within the reserve and formed lakes and swamps as the water tables were brought up. Within the vicinity of these water areas thrived no other tree species but the Mānuka, kānuka and several varieties of the harakeke or New Zealand flax (*Phormium tenax*) (Figures 27 & 28). Many of these mānuka and kānuka tree species are the pioneer species within Uhi-Mānuka and have been in the reserve for many years

Figure 27: Harakeke and mānuka growing at a terrace flat, Uhi-Mānuka (Photo: S. Vunibola).

Figure 28: Harakeke growing in the swamps of Uhi-Mānuka. The Mānuka trees can be seen at the rear lefthand corner. They are also growing within the same swampy area (Photo: S. Vunibola).

The second scenario and according to Nanny Frances, relates to how the mānuka survived the great fire that went through the valley during the time of the earthquake [1835].

> *During the time of the earthquake, a big fire went through the valley. The event was prolific and the whole area was cleared. However, the only tree that successfully survived the fire was Mānuka. The mānuka were growing in the swamps in the gullies of Uhi-Mānuka and because they can withstand water logging areas, it also saved them from the fire* (F Reiri-Smith, personal communication, 9 June, 2019).

Mānuka have been found to withstand fire when their seedpods open up in such an event and are then carried by wind, birds and animals to grow as pioneer plant species. On the terraces, the Mānuka trees are fed by several puna (springs or wells). These puna are associated with Parekauiti (a female kaitiaki goddess) of the Ruamahanga River which feeds into Uhi-Mānuka.

> *Parekauiti is the kaitiaki who lives on the cliff face of the Ruamahanga. The pua that are present on the terraces of Uhi-Mānuka and where the Mānuka are growing, feeds into her…she is the source of purity for the water systems that feeds into the pua and the Mānuka. So we got to respect Uhi-Mānuka, keep her pristine, and the waterways clean, and make sure all plants that go up in it are all for rongoa*
> (F. Reiri-Smith, personal communication, 9 June, 2019).

The story of Parekauiti sourcing these puna into Uhi-Mānuka with water is related to the work of his brother, Ngangahuarau who placed established wells on the hills of the Wairarapa which today are a source of electricity to the town of Masterton. These differences in layout can be observed in the Ruamahanga and the terraces of Uhi-Mānuka.

Resources of Uhi-Mānuka

Uhi-Mānuka continues to provide diverse resources (see Table 7) to the hapū of Ngāi Tāneroa and support long term cultural survival. The majority of the plants are useful for rongoa practices, sustenance, weaving and other cultural artefacts, building materials and for ceremonial purposes. The rich biodiversity of the reserve ecosystem has supported much bird life, fresh water organisms and wild animals. These were also important for sustenance, spiritual and guardian connection in the past. The interrelatedness between the people of Ngāi Tāneroa and these resources has enabled the protection of both the values of mātauranga Māori and their whakapapa to Uhi-Mānuka.

Table7: Different resources provided by Uhi-Mānuka.

Rongoa	Food	Clothing Artefacts	Building materials	Ceremonial
Kawakawa	Ducks (Pārera)	Harakeke	Tōtara	Mānuka
Mānuka	Tuna	Kānuka	Mānuka	Tōtara
Māhoe	Poroporo	Hīnaki (fish trap)	Vines for binding	Kānuka
	Pūhā	Feathers	Rata	Kauri
	Birds (e.g. kererū)		Kānuka	

Mānuka honey is now a major component of the hapū local economy. Mānuka honey is sourced from various locations within the valley and other locations on the North Island. However, none is sourced directly from Uhi-Mānuka, mainly because of the spiritual and cultural connection they have to the site. This is a significant indication of respect to the values of the ancestral site.

Occupation of the Ngāi Tāneroa land area

The occupation of the Ngāi Tāneroa area began during the 1500's after the earthquake and the fire events. As observed in many parts of Aotearoa, many changes have occurred to the land and associated land-use post-European contact. This was the same for the surrounding areas owned by the hapū including Uhi-Mānuka. Due to the devastating fire, the land was cleared and barren with only the last remaining places where native trees were standing would be ones located on the gullies. In most parts, these still stand today.

The farmers began settling into the area and anguish among the hapū arose due to the new occupation and use of the land. Major changes were taking places before the 1900's including the establishment of extensive beef, sheep and dairy farming. Land was also subsequently modified to cater for wineries and orchards establishments.

The history of human settlement plays a major role in the evolution of traditional cultures and biodiversity. The evolution of people settling into the Ngāi Tāneroa rohe or area has modified the biodiversity of the region, their source of livelihood and Uhi-Mānuka. Extensive commercial agricultural and horticultural activities within the area have limited access of the hapū to their land. The process has also affected the quality of their waterways which have been the traditional source most of their freshwater produces.

> *This was in the 1900 and way back before then, we lost lots of lands to the settlers. We got beef, sheep and dairy farms all around. Their wastes are deposited directly to the river via runoffs and this has affected most of our kai from the river.*
>
> *We shared kai around to our people, our herbal materials was always out there, our tuna (eels) and koura (freshwater crayfish) was always sourced locally from kourarau (place of hundreds of koura) but today this is a challenging task to do (F Reiri-Smith, personal communication, 9 June, 2019).*

Whilst farmers are going about their own businesses, the hapū and whānau of this area are returning to their roots and pressure is being put on Uhi-Mānuka as a primary source of sustenance, rongoa, spiritual connection and protection. Additionally, many outside influences are now involved within the reserve as it is also being operated as a scenic reserve under the management of the Department of Conservation (DoC).

Mātauranga Māori (Corpus)

Local understanding of fungus and myrtle rust

Indigenous people have their own way of understanding the roles of fungi in the ecosystem. In most cases, the positive contribution of fungi to traditional practices was always a reason why people considered it positively. This was also similar to the Ngāi Tāneroa hapū.

> *The old people use to collect ergot grass for the black ergot mushroom on the grass to make meds for pain, migraines and stomach problems…and the puawai*

> [blossoms] *were mainly used for fermentation. People collect it and use for fermenting and curing eels (F. Reiri-Smith, personal communication 24 March, 2019).*

The understanding of myrtle rust within the hapū is comprehensively recognized. Their involvement on major projects with DoC in upgrading Uhi-Mānuka as a scenic reserve has also meant that the awareness surrounding the disease has been on par since its introduction. From a kaitiaki perspective, Nanny Frances believes that the disease is a huge threat to the cultural connection of the hapū to Uhi-Mānuka.

> *Myrtle rust poses a big threat to our sacred mānuka and kānuka trees among others in the same family. If they get affected, our birdlife will be affected enormously. Not only that, the purity of our mānuka and kānuka will be affected and this affects the holistic connection we have to Uhi-Mānuka. This would mean that we are not doing our work properly as kaitiaki of our land and the respect we should be having to our tupuna (F. Reiri-Smith, personal communication, 24 June 2019).*

Similar understanding of the threat of myrtle rust is recognized for hapū opportunity and the local economy. Mānuka honey producer, Danny Mason, reiterated the threats of the disease to all their mānuka and kānuka plants. The business operates in the North Island and has all feeding sources mainly around the Central Plateau (Taihape, Raetihi, Waiouru), Wellington, and the Wairarapa. They however, do not source from Uhi-Mānuka.

> *Oh yes, we are well aware of the disease and we've seen what it has done to the ones up Northland. Our head beekeeper is well connected and does a lot of work with MPI and so our strategy of safe keeping our mānuka and kānuka source areas is always there; monitoring mainly. But the disease hasn't been really affected any of our source areas because of the frost and where they are located. Our main issue is the weather which mainly hinders flowering and feeding season for the bees (D. Mason, personal communication, 10 June, 2019).*

Traditional Ecological Knowledge of Ngāi Tāneroa

An understanding of the traditional knowledge of the Ngāi Tāneroa hapū provides an important way to appreciate the relationship between their community and the biodiversity conservation of Uhi-Mānuka. Studies have proven that TEK held by indigenous people and long-time settlers is highly detailed and this will be reflected in the information obtained from the case study (F Reiri-Smith, personal communication, 19 July 2019).

The hapū consider the knowledge set which applies to Uhi-Mānuka as the same they identify for the hapū and Hurunui-o-rangi in general. It is critical to note that the knowledge and values exist because of each other so they cannot, and should not, be segregated from each other as they exist as a set of holistic set of understanding.

Kaitiaki (guardians)

"We are nothing without our manu" (Frances Reiri-Smith, Kuia, Ngāi Tāneroa).

To be a Kaitiaki is to act as a guardian. The protection and the enhancement of the dynamics of the different ecosystem functions that Uhi-Mānuka provides are all interrelated. The role of being a kaitiaki through this link means they are part of a wider system that is strengthened by a holistic connection.

The birdlife within Uhi-Mānuka is regarded as one important cultural connection Uhi-Mānuka provides to the hapū. The mānuka and kānuka are homes and a primary food source to the different species of birds within the reserve. In natural terms, the birds are always observed feeding off these trees for food. Culturally, this act is seen as a form of kaitiakitanga.

> *The kererū (pigeon) (Figure 29) is the kaitiaki of these mānuka and kānuka. They are the carer and nurturer of these trees. They feed and also allow the flowers to open for the bees to come in and have a feed as well. We are nothing without our manu; they are our kaitiaki (Frances, personal communication, 9 June, 2019).*

A kaitiaki should be humbled and should bring together members of the hapū in the management process. From the hapū worldview, the role of kaitiaki is not and should not be perceived as an obligation. Being a kaitiaki should be observed as a humble honour as the role links a member of the hapū to other elements of the land. The role of kaitiaki should be seen as of that of a kereru or manu in general, and that is to be a nurturer for protecting the trees and making succession plans for growth. This is also applicable to the management and protection of the hapū mātauranga Māori.

Kaitiaki is a whole wairua connection. According to Nanny Frances, the mauri is the essence to what supports a person through to their wairua. For example, the concepts of 'wairua toa' and 'wairua noa' are different sets of spirits that are related to men and women. Certain parts of Uhi-Mānuka are sacred and tapu for women to access but only men. Through wairua-noa, women are able to break these sanctions and are able to perform their roles as kaitiaki successfully.

Figure 29: A kererū sits by an old mānuka pou-pou tree. A clear example of the spiritual connection between kaitiaki and pou-pou. It is also considered a tohu which is a sign. For the purpose of this photo and when it was taken, this represented the acceptance and protection of our work entourage into the whānau land (Photo credit: M. Tora, 2019).

Pou-pou (pou)

The pou (poupou) refers to the main post in the palisade of a pā or marae. Pou are usually carved to signify the sacredness and spiritual connection of Māori to their atua (Gods) (see Figure 30 as an example). They are often considered as totems. There are different versions of pou and they are erected at different places on the land for different purposes. A primary concept of a pou relates to the action of a sentinel or whakaaraara to provide protection of taonga resources in the act of guardianship. Depending on how they are perceived, the holistic connection Māori have to the meaning of the erected pou creates a trust that confirms the protection of the land, the people and all minute elements within.

The concept of pou-pou was expressed in a dual dimension based on the Ngāi Tāneroa worldview. These concepts are directly related to the holistic protection of Uhi-Mānuka. Firstly, the story is of a pou that was named after their tupuna, Nukupewapewa. The actions of Nukupewapewa were responsible for bringing peace and reconciliation among the people of Te Ātiawa under Wharepouri's command and Ngāti Kahungunu ki Wairarapa under the leadership of Nukupewapewa.

> *Nukupewapewa was a crafty tupuna. He took Wharepouri's wife and daughter when they invaded his marae but he escaped. Nukupewapewa treated the two ladies well and never took them as slaves; he later returned them back to Wharepouri, where the wife told Wharepouri how nicely they were treated by their captors. Based on this, Wharepouri came back and declared peace in the valley (F. Reiri-Smith, personal communication, 24 March, 2019).*

This pou was erected as one of the four pillars around the original Hurunui-ō-rangi marae. Based on Colenso's records and story told by Nanny Frances, his observation of the pou erected around the corners of Hurunui-ō-rangi made him try to convert Māori in the area to Christianity. He then wrote some interesting stories about the people and how they were industrious people. In his observations, the corner pou were looking out, and they were peace related and were the protector of what was inside the marae. The rest were looking in to indicate protection over the sanctuary on the ends. There are plans for erecting similar pou at Hurunui-o-rangi marae in the future.

The second story is related to the structure of succession and support within Uhi-Mānuka. Uhi-Mānuka holds some of the oldest tree species (upwards of 100 years or more) that have been regarded and blessed by the hapū as the pou within the reserve (see Figures 29 & 31). Their role is primarily to protect the younger and all other low dwelling tree and plants species from harsh environmental impacts (e.g. frost and wind) as well as diseases. These trees among the mānuka and kānuka includes tōtara (*Podocarpus totara*), kahikatea (*Dacrycarpus dacrydioides*), and matai (*Prumnopitys taxifolia*).

> *These are hundred years old. They are their grandfathers and grandmothers, and those ones further in beside them are their uncles and aunties. This is a model of whānau. That's how you can look at it. All the pou-pou are surrounding the younger ones and giving them support and protection (F. Reiri-Smith, personal communication, 24 March, 2019).*

The ideas behind pou from the worldview of the hapū reflect the results of support and protection of taonga resources as peace is restored in a changing environment. Sustainable management practices are achieved through the actions of support and this is perceived likewise within Uhi-Mānuka.

Figure 30: Guardian pou at Te koha o te whenua, Rangitāne (Photo: M. Tora, 2016).

Figure 31: A totara, mānuka and kānuka, of hundred years old, and regarded by the hapū as the pou-pou trees that protect and support the growth of other younger trees around them (Photo: Suli Vunibola, 2019).

Sacred connection

The connection between cultural ideologies and traditional beliefs contributes to biodiversity. The ideologies that exist within the Ngāi Tāneroa hapū play a major role in the conservation of taonga resources of Uhi-Mānuka. Stories or beliefs in the presence of supreme beings and natural forces have allowed the protection of taonga species such as mānuka. The sacred groves of mānuka trees clustered together almost always have a spiritual association that fosters reverence from the locals. Stories would often reflect the presence of a taniwha behind clusters of mānuka trees or the harakeke. These would be registered with the cultural stories of the hapū about the area in the story and will always be evaded as a result. This means the areas are always left untouched.

These belief system and its values contribute into the development of ethics that guides the decision making system of the utilisation of resources or access to certain important areas (for e.g. within the mānuka groves for harvesting) of Uhi-Mānuka. Similar connections also exist in many indigenous cultures around the Pacific and results in the protection and management of their biodiversity.

Rahui (restrictions)

The implementation of rahui is still practiced within Uhi-Mānuka. Many have been emplaced for years and were protective orders employed mainly on sacred taonga trees that are blessed with a karakia and given all the mana to be the guardian and protector for other trees around them. The practice of rahui is done in several pockets of Uhi-Mānuka and unlike the process of a tapu; women are not allowed to access these areas at all.

In some other areas, women cannot access it if they are undergoing their menstrual cycle. The understanding surrounding this is associated with the purity and integrity of all traditional rahui systems emplaced to protect the natural resources that supports livelihood of the hapū.

Karakia (prayers/incantations)

Karakia is a big part of Māori practice and so is important for biodiversity and management. In her comment, Nanny Frances stated that the practice of karakia acknowledges and connects the people to their wairua and the land they stand on. It also allows the safeguard of all human activities that are to be undertaken and ensures the successful completion of the proposed activities.

Future plans are being proposed for the management of Uhi-Mānuka where several shareholders will be taking part in (e.g. DOC, Correction Service, Ngāi Tāneroa hapū). A big component of the proposed work is the emphasis to be put around the practice of karakia to ensure all work is successfully achieved without any ambiguities and that the wairua and tupuna of the land are acknowledged and respected throughout the course of the work.

Hukahuka (frosts)

There is minimal evidence of impacts of major diseases on mānuka and kānuka at Uhi-Mānuka. The location and the environmental events that took place at Uhi-Mānuka are understood to be contributing causes. Due to the earthquake event in 1835, Uhi-Mānuka was further entrenched into what is today a much lower gully then it was before the earthquake. The surrounding hills around Uhi-Mānuka also allow it to be a good nesting place for native biodiversity. There are less opportunities of encountering harsh climatic conditions within its spatial infrastructure.

However, frost or hukahuka has been accredited as the main factor of the protection of mānuka and kānuka from diseases on Uhi-Mānuka. This knowledge has been passed down to the hapū by their elders. The evidence of this knowledge exists in the practices of restoring mānuka and kānuka trees within Uhi-Mānuka and the surrounding areas. Elaborated here by Nanny Frances, she reflected on the planting methods and knowledge of mānuka on the hills.

> *The mānuka and kānuka are the two strong ones in this region. When planting, we were always told to plant both in the gully because the frost doesn't get to them so much there. The same was done when planting on the hills. We would plant the mānuka on the east side of the hill because the sun rises from the East. So where productivity comes from has been from the rise on the hill side where the frost actually kills all the problems associated with diseases and allows high quality mānuka productivity.*

Furthermore, Danny Mason (Ngāi Tāneroa) also added that frost has also been a major factor behind the safeguarding of their mānuka. Their only problem is the change in weather patterns from the impacts of climate change. This has hindered the actions of bees and the flowering season. However, the network they have as an Indigenous Māori business group that utilises the cultural resources of their hapū means they have a strong base of communication where knowledge of these changes are shared and thus is assisting with the protection of their mānuka trees, the bee hives and their produce.

Tikanga Māori (Praxis)

The hapū of Ngāi Tāneroa have retained mātauranga Māori that was passed down to them by their tupuna with most of these values and practices still existing today. Cultural biodiversity conservation and taonga resource management among the hapū have primarily been based around common post-European contact issues of land occupation and land modification. While there are still evidence of engagement in traditional agricultural practices and upholding values within the hapū, they are now faced with another challenge of having to adapt to a new biological change that presents a big threat into one of their last standing ancestral ground; Uhi-Mānuka.

Myrtle rust is used here as an example of a problem that affects trees. The threat of the disease provides an insight into how the hapū are preparing themselves as a unit to safeguard their taonga mānuka and kānuka trees and the biodiversity of Uhi-Mānuka. The hapū are also involved with DOC in the management and restoration of Uhi-Mānuka. Ngāi Tāneroa is likewise currently planning to establish an area within Uhi-Mānuka as a knowledge learning area to support future generations.

This case study has gathered information which elucidates the connection between the structure and processes that are present within the hapū. They are presented here as sets of tikanga Māori specific to the hapū and are addressed as examples of traditional tools that illustrates the awareness of the hapū in protecting and managing their taonga resource. Critical to note that these tools are not the answer to the issue but are examples of how the hapū are interacting with the trees and their resources to manage and protect them.

The hapū informants have identified the 'Whānau Framework' (Royal, 2007) as the best model they are aware of that captures their relationship to the Mānuka resource. The Whānau framework is based on the growth of the harakeke or the New Zealand flax (*Phormium tenax*) as a metaphor for representing the holistic approach to management. Harakeke is one of the important taonga plant species within Uhi-Mānuka and provides many cultural services to the hapū. The whakataukī or proverb of this thesis is set to capture this situation: *Whakapuputia mai o Mānuka, kia kore ai te whati* (Cluster the branches of the Mānuka, so they will not break off).

Table 8: Examples of tikanga practices as traditional tools related to conservation.

Tikanga		Tohu	Implications to role as kaitiaki	Implications for biodiversity
Monitoring		Indicator species (e.g. ramarama *Lophomyrtus bullata*, common sp. to first get infected)	Understanding spread mechanisms and presence of the disease Understanding signs and symptoms More awareness about the disease	Early detection Early implementation of rahui or tapu Development of restoration programs and polices
		Weather pattern	Understanding conditions for spread of disease	Understanding risks of spread of disease
		Birds behaviour (timing, population, presence	Understanding approaching natural phenomenon	Awareness
			Understanding issue of food reserves within the reserve	
		Flowering (volume, timing, how prolific)	Understanding time of harvest of culturally connected resources (e.g. fish or shells from the sea)	Awareness
Replanting		Increase spp. population	Adding value to the land	Succession plan Manipulation of regeneration cycles Restoration
Transplanting		Shifting to healthier and safe environment for more support of growth		
Seed saving		Maturity of plant	Enhancing seed saving knowledge Understanding of seed capabilities (physiology and morphology) Protecting whakapapa	Future security
Rahui		Sacred	Tapu Inaccessible	Preservation
		Pito burial site	Spiritual connection to land	Protection
Clean up		Unwanted growth	Respect to the atua and tupuna	Preservation Restoration
Cultural ideology		Values (Ahi ka)	Understanding of role	Promotes stewardship for the future
			Otherworldliness	Promotes limited conservation efforts
Informal networking		Interconnectedness	Strengthening of relationship to hapū and the land	Conservation
Giving back to the hapū		Sustainability	Respect	Sustainable long term succession plan

Tikanga Māori and conservation

Table 8 provides a summary of the key tikanga Māori tools. These tools were articulated based on human ecosystem relationship between the hapū and Uhi-mānuka. It represents the ideas of the combination of social institution and cultural or custom foster conservation ethics that exist within the hapū as represented by the lead respondent. There is much more information known than what the table pervays, much of it in a very localised form. For example, the Ramarama tree which is widely recognised as an indicator species for any new issues/incursions. Ramarama is so named for its ability to radiate light from the leaves (Riley, 1994) but also for its value as a wood for making toys and tools.

One remaining point highlighted by the hapū informants is the urgency that now exists around being able to share this knowledge within their own community as well as appropriately in a wider context. The succeeding generations have a different relationship with the resource, a different level of intimacy with the mātauranga associated with the resource and live in a world of technology that has superceded the traditional processes of learning. The urgency to value what is known by the elders is apparent.

Case study summary

This case study is a strong example of the diversity of knowledge held within traditional communities. Above all else, the whakapapa status reinforces the relationship of the people to the resource. The relationship is also the basis for the knowledge or mātauranga that has been built aligned to the resource. This mātauranga is often contained within a very localised version, retained in formats such as whakapapa or stories which align to the people in a very personal way. Within the mātauranga there are often clues to understanding the natural world and its environmental factors and the impacts of new biology on existing flora and fauna. The potential impact of myrtle rust on Uhi-Mānuka fits this scenario well. Of particular interest to this thesis are two key points; that the Mānuka trees and other myrtaceae in Uhi-Mānuka are representative of local germplasm so have DNA value and taonga status to the iwi and hapū; and that there is an association of the weather phenomenon of frost/hukapapa in the continued survival of these taonga species.

Chapter 8: Discussion

Introduction

The demand for better representation of cultural consideration in resource management is increasingly evident. In recent years, debates have centered on the extent of Māori concerns and capacity in conservation and also in ethnobotany. More precisely, these arguments are focused on the recognition of the values of mātauranga Māori and tikanga in conservation policies and the involvement of Māori in their implementation.

This thesis has focussed on indigenous knowledge and the recent myrtle rust (*Austropuccinia psidii*) incursion in New Zealand to review the literature on the disease specifically, and to create a localised case study within the Ngāti Kahungunu region where tradition and traditional knowledge are apparent. The review and other outcomes clearly show that neither [western] science nor Mātauranga Māori exist in a mutually exclusive state. They have the ability to inform and contribute to each other and therefore have considerable value both as individual contributors and ostensibly as a collaboration.

The case study firstly highlights the importance of whakapapa, mātauranga Māori, tikanga Māori, and the practice of kaitiaki to ethnobotany, and the development of indigenous biosecurity measures (tools) to protect culturally important plant species. This cultural expression consolidates the relationship of the people to the resource, one which has been generations in the making. The case study is centred within the ancestral reserve of Uhi-Mānuka which is traditionally owned by the Ngāi Tāneroa hapū and sets as an example of a site that is under threat of the disease. The traditional tools introduced in the case study reflect the knowledge that exists and has been passed down through generations within the hapū. Evidence of these tools also reflects the importance of their position as kaitiaki of the natural world, Papatūānuku in cultural terms. In summary, the hapū;

1. have an intimate connection with their land and natural resources
2. are first hand observants of the changes that occur to the resources on their land
3. benefits from the ecosystem services (provisional, regulating, cultural and supporting) the land provides, and
4. Have full time access on a day-to-day basis to the land/resource.

It is critical to understand the cultural values of Uhi-Mānuka and the plant species under threat from myrtle rust, their biodiversity role and the relationship of the Māori community as reflected by the case study. The kaitiaki become the primary component of management and related policy development. Additionally, the hapū have a close working relationship with DoC and are engaged in various restoration projects aligned to the overall landscape of the ancestral reserve.

Local Māori TEK of the environment and conservation

Mātauranga Māori is not a new body of knowledge: it has been passed down through generations and has a practical history. The values associated with the practices have enabled the Ngāi Tāneroa hapū to protect Uhi-Mānuka throughout the generations supported by their relationship with the ancestral reserve.

TEK possessed by the hapū is place-based and is intimately linked to the biodiversity of Uhi-Mānuka. The application of this knowledge may have similarities across other iwi but it is unique to the ancestral site which also plays a major role as a vessel of where all knowledge is preserved. The knowledge is perceived within their hapū worldview and allows them to classify, use, live with and appreciate the flora and fauna within the reserve. It also acts as a means that attaches their spiritual relationship and cultural history to the land. In a clear context of management, this intimate connection of the hapū to the land through Māori TEK forms the basis of their management practices (tikanga) that they can employ to manage the taonga resources within and including Uhi-Mānuka from biological threats.

Mātauranga Māori plays an important role in contemporary conservation and policies. The range of values reflected in the case study is generated from long-term observations of Uhi-Mānuka and the surrounding environment by the hapū. They include a complex understanding of the connection between different aspects of the ecosystem, changes in climate conditions and history of human settlement within the area. The combination of these aspects of observations can provide important insight into long-term management plans. Ticktin and Spoon (2010) stated that TEK today provides key insights into how changes of global warming and history of human settlement have shaped biodiversity and impacted many elements of the landscape. These are pivotal for policy development and future management practices. Hapū knowledge therefore forms the basis of valuable tools that can function in enhancing future insight into long term threats of biological invasion such as myrtle rust and human impacts which are a big component of introduction of such incursions.

An important component of Māori TEK as a tool for conservation of taonga species or resources lies in the forms they are encoded within the different elements of the ecosystem. For example, these could be in the form of language, stories, songs, prayers, dances, ceremonies, and other traditional rituals they have to a taonga resource site. Another value to be distinguished is the genetic value and history that taonga tree species embrace. At Uhi-Mānuka, the connection between these values and people allows the application of plants for cultural uses such as rongoa (herbal medicines) or building, thatching or weaving. Thus, it is essential for resource managers to understand the importance of conservation of cultural and biological diversity, as these two elements are fundamentally interrelated.

The traditional decision system utilized in this research to present the knowledge that exists within the hapū and its role in protecting Uhi-Mānuka from any future incursion of fungal diseases is based on the triadic approach of Te Ao Māori, mātauranga Māori and Tikanga Māori as proposed by Roskruge (2007). This approach applies a kaupapa Māori driven method that recognizes the cultural layers or tatai that exist and allows better understanding of the cultural values at a level of comprehension mutually exclusive to both the indigenous and scientific communities. The criteria within the triadic traditional decisions system have provided a consistent approach to identifying and discussing the knowledge relevant to ethnobotany, biosecurity, and taonga conservation as well as management, and for modeling purposes.

The knowledge behind hukahuka (frost)

The thesis has reflected on literature covering the scientific management of myrtle rust. However, a critical contribution of the case study and the knowledge recorded from the hapū is their traditional understanding of the role of frosts. Aside from any scientific explanation, in a more cultural sense, the understanding of frost on the ecosystem is based on generations of observation and an intimate connection to nature. From their perspective hukahuka are a clear contributor to the defence of Uhi-Mānuka from external issues.

The succession plan ideology

The implementation of the succession plan for hapū input to Uhi-Mānuka relates to the development of an intergenerational support system of native flora and fauna. From the perspective of the Ngāi Tāneroa hapū, this system ensures the integrity of growth, protection and preservation among the different generations of trees within the reserve. The pou-pou concept introduced in the case study is an integral part of this system and succession plan in that under their presence, the younger trees are well protected and supported. In conceptualising this system further, it can be applied that the system also supports the biodiversity of faunal taonga particularly birdlife. The presence of manu within the reserve is a tohu of good hope and they represent the protection of the ecosystem as kaitiaki. Therefore, the succession plan from a cultural perspective encompasses all traditional ideologies of guardianship and holistic support.

Informal network

The use and integration of management regimes based on mātauranga Māori and ecosystem−based management concepts are clearly lacking across Aotearoa. The case study drew considerable input from a system of informal networks that exist both within the hapū and also within the wider Māori community. These networks contribute to a platform of knowledge transmission and intergeneration support that is a familiar activity for Māori and many other indigenous communities. This informal network connects members of the hapū and also allows to other hapū, iwi and non-Māori organisations such as DoC and MPI to fit in respectively. This allows for the flow of information from both internal and external directions and more recently for access to technology to support this knowledge exchange. The same networks will be an asset to the process of collaboration between science and mātauranga in the future.

Myrtle rust and Māori input to management

The whakapapa of Myrtle Rust from both a western and traditional science perspective is very extensive and numerous studies present an account for its impact around the world. Myrtle rust has caused significant population declines in many species of the *Myrtaceae* plant family with detrimental economic impacts on countries such as Brazil, Jamaica and most recently in Australia. The thesis will not attempt to analyse the disease from a science perspective but utilises that status of knowledge to inform how Māori might mitigate future risks. This has set the scene into the current situation of the disease incursion in Aotearoa and its threat to Māori. Culturally, myrtle rust is a high biosecurity priority for Māori and it is clear there are purposeful intentions for Māori involvement in any response; whether it be governance (decision making); operational management (e.g. surveillance); public education/awareness; and research. What underlines these intentions is the recognition of the values of Māori knowledge into the management process.

The disease sets a clear example of how these evolutionary practices of traditional management can merge through a relationship between kaupapa Māori and Science. The case study whānau reiterated a whakatauki or proverb, *Nā te rourou, nāku te rourou, ka ora ai te iwi* - literally meaning 'with your basket and mine we shall be healthy'. To date there has been varying levels of success with managing biosecurity incursions across all of Aotearoa as some rohe (regions) are very involved and aware of the threats and spread of this disease and others whilst other areas lack awareness.

Nonetheless, having Māori actively involved in the response and management process has increased the capacity and effectiveness of some activities. For instance, surveillance and reporting of the myrtle rust incursion has been significant and further contributed to the establishment of the Māori Biosecurity Network Te Tira Whakamātaki which is now spearheading further awareness in the Māori community. They are representative of cultural interests alongside other groups such as Tahuri Whenua and various iwi or hapū who are activity emerging and participating within New Zealand relative to this issue and others like it e.g. Kauri dieback.

Māori inputs have been increasing across the system as both capacity and awareness of the issues intensify. With the growth of the Māori economy and asset base through investment and Treaty of Waitangi settlements (between Crown (government) and iwi), the biosecurity threat to Māori assets and investments is much more apparent. This threat is also shared among other stakeholders, landowners, agencies and primary industries. Māori have consistently prioritised biosecurity issues as being 'high' given the many different impacts and threats to Māori values whether they be economic, environmental, social or cultural. As that priority is gradually becoming recognised by biosecurity agencies (e.g. MPI; District Councils and DOC), Māori have increasingly become engaged to participate across different parts of the biosecurity system in diverse ways including policy and practical inputs. The Māori Biosecurity Network – Te Tira Whakamātaki (TTW) – is an important initiative and kaupapa that has been established from a Pan-Māori space (i.e. not tribally driven) working to ensure Māori perspectives, participation and partnerships are part of the biosecurity system. TTW have also worked to facilitate various agencies and programmes coming together and continue to engage with mana whenua (Māori communities) on biosecurity responses to myrtle rust.

National biosecurity and Māori

Globally the rise in trade and tourism has significantly increased the risk pathways and frequency (increase in volumes of trade and commodities) for new and emerging pathogens/diseases to be introduced and spread to new locations including the Pacific and New Zealand. There needs to be a corresponding increase in biosecurity controls, funding and new tools to help New Zealand and other Pacific nations with the detection of unwanted pathogens arriving at their borders. This should take advantage of existing relationships across the Pacific and throughout New Zealand represented through whakapapa in the first instance. Not only better detection and surveillance is required but better tools to help eradicate or mitigate risk as early as possible or more improved tools to manage diseases effectively if they become established.

Mātauranga Māori is a major tool in traditional management approaches. Historically, this knowledge has enabled Māori to manage their natural environment represented as Ranginui and Papatūānuku the progenitors of this world. The Māori environmental worldview, as with many other indigenous communities, connects them directly to all flora and fauna through whakapapa. This whakapapa representation includes all their beliefs, stories, experiences and practices of the natural world (Whaanga & Wehi, 2017). It is important to remember that in Te Ao Māori, absolutely all things are connected, and whakapapa is one of the methods used to illustrate this point (Roskruge, 2007).

In the concept of taonga conservation, such understanding can be expressed in terms of preserving the unique connection of one’s selfhood, and the relationship of people to the land through the utilisation of the services of *mātauranga* Māori, *tikanga* and *kaitiakitanga*. The case study of Uhi-Mānuka reflects strongly on all these concepts through the activities of the Ngāi Tāneroa hapū. With the risk of an exotic disease incursion the hapū have to build a thorough understanding of the disease alongside their current mātauranga as their relationship with Uhi-Mānuka is threatened.

Traditional Resource Management (TRM) - Tikanga and conservation

Traditional resource management observed in this thesis and reflected from the case study as tikanga Māori refers to what kaitiaki have developed and employ to manage their taonga resources. Many of these tikanga were passed down generationally and provide models for sustainable resource use. This thesis argues and supports culture as the main mediator of the connection between people and nature. For Māori, the case study of Uhi-Mānuka illustrates the intimate connection between the hapū and the resources of the ancestral site. The triadic model applied draws together all the values instilled within Te ao Māori, mātauranga Māori and tikanga Māori. Their application has influenced the decision making system aligned to Uhi-Mānuka. This has also led to the act of stewardship by the older generations of the hapū in creating an intergenerational space among their papakainga to enhance learning by the younger generations of their localized knowledge of managing and protecting their ancestral site; evidence of knowledge transmission and critical in TRM.

The implementation of a succession plan by the hapū in restoring biodiversity at Uhi-Mānuka emphasizes the manipulation of the landscape to protect taonga species. The protected landscape approach elucidated by Brown, Mitchell and Beresford (2005), links important avenues of nature to culture and community. This supports the actions that the hapū has employed in their collaboration with DoC.

Protected cultural landscapes such as Uhi-Mānuka have co-evolved with the Ngāi Tāneroa hapū and thus the protection of the resources within the reserve is primarily based on their interaction. Uhi-Mānuka serves as a living model for sustainable use and management, and protection of taonga resources and biodiversity with the involvement of both the hapū and DoC. The collaboration further enables the development of management logic. This logic will allow the development of critical and resourceful ethics that acknowledges the cultural values of the people and together with their belief system governs the way resources are utilized, conserved and protected.

Future implementation of mātauranga Māori – the Whānau Framework

To appreciate the links between tikanga Māori and conservation, the understanding of the nature and diversity of the values of mātauranga Māori is necessary. Recognising the connection that exists within the hapū on concepts of bio-cultural conservation will contribute to future management and protection of Uhi-Mānuka. The case study through its consultation with the hapū has identified the 'Whānau Framework' as the best model to carry out this purpose to the future.

The Whānau framework is based on the growth of the harakeke or the New Zealand flax (*Phormium tenax*). Harakeke is one of the important taonga plant species within Uhi-Mānuka and provides many cultural services to the hapū. As well as providing habitat to animals, fresh water organisms and food for birds, like the mānuka and kānuka, they are resistant plants within the waterlogging swamps of Uhi-Mānuka. To the hapū, the growth and structure of the harakeke relates to the concept of family support.

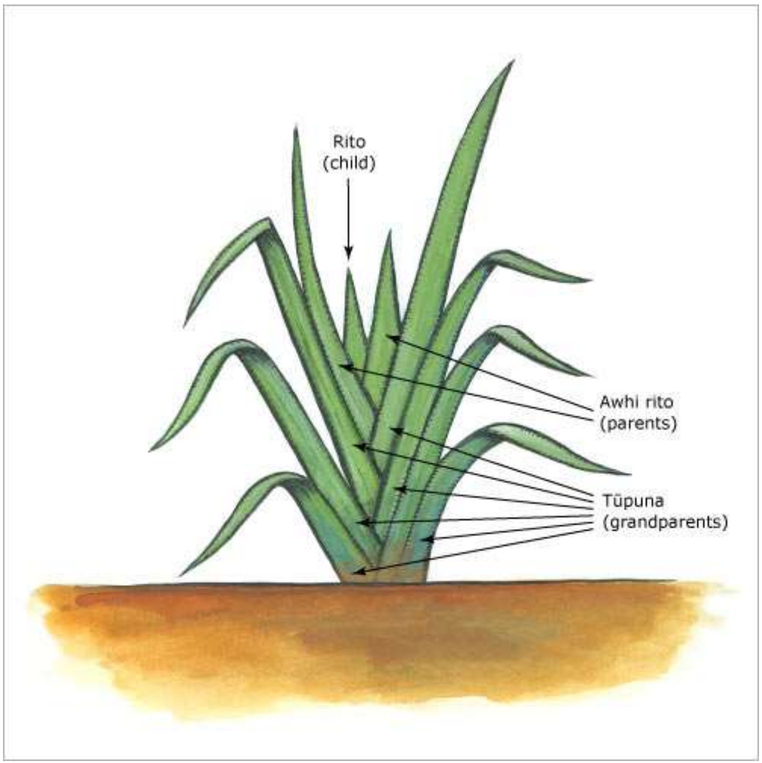

Figure 32: The harakeke growth structure representing the whānau framework (Royal, 2007a)

The growth of the harakeke (Figure 32) as a family unit is represented with the tupuna (grandparents and ancestors) growing as the outside leaves which surrounds the awhi rito (the parents), who curve up their rito (child) within them as the shoot in the middle. This structure means the rito is well protected by the solid foundation of their parents, grandparents and ancestors holding onto from the outside.

The projection of ensuring the sustainability of the succession plan for the future requires extensive investment of support into the younger generations today. This also recognises their contribution into the management system in carrying on the knowledge of protecting Uhi-Mānuka and the conservation of the mānuka from future fungal pressures. The whānau framework is represented in this case study as the base of where this support springs from. Ngāi Tāneroa, through their kuia Nanny Frances have introduced a whakatauki or proverb that captures this situation: *Whakapuputia mai o Mānuka, kia kore ai te whati* (Cluster the branches of the Mānuka, so they will not break off).

Within the Whānau framework, the concept of 'pou-pou' is applicable to support the role of kaitiaki into the succession plan. As pillars of strength, the pou-pou concept represents the role of guardianship for the different generations of trees within Uhi-Mānuka. Likewise, the younger generation of the hapū need guidance to learning and upholding management as future kaitiaki. In a traditional context the pou-pou are a conduit between the spiritual and physical realms and support kaitiaki and contribute to kaitiakitanga in practise. The pou-pou are a continuous support element in the absence of people being present. Figuratively, a whare without solid pou to hold up the house will lose its integrity and eventually collapse. The tapawhā concept presented in Figure 3 (Page 25) is a succinct representation of this concept. The older generation within the hapū are another form of pou-pou, in this case, nurturing the younger generations on mātauranga Māori and tikanga for the future protection of Uhi-Mānuka. If this connection is not maintained the succession strategy will collapse and become void. Paramount within this strategy is the transmission of mātauranga Māori, tikanga, the skills and experience of management and therefore a platform to assist with this must be available.

The Ngāi Tāneroa hapū is a solid representation of a cultural unit thriving under the Whānau framework. The hapū has invested into a strategy that sees intergenerational and interrelatedness of interests as paramount to success. The result is clearly evident because:

1. Uhi-Mānuka stands today as one of the non-affected reserves from the disease myrtle rust through a cultural system that already existed
2. a succession plan is practiced within the reserve through their replanting program which also involves DoC as the main collaborator with the hapū
3. the Hurunui-ō-rangi marae papakainga purposefully consist of intergenerational occupants supporting a high possibility of knowledge transmission across age groups within a close spatial range
4. the local mānuka honey economy thrives on the strong informal network that exists
5. the interconnectedness between the hapū and all natural and cultural elements of Uhi-Mānuka creates a holistic system.

These factors all illustrate a future platform for better consultation of management practices to mitigate any disease risk through the application of mātauranga. With keen foresight, the hapū is currently planning to establish an area within Uhi-Mānuka as a knowledge learning area. This proposal is part of their future actions in providing an enabling environment where mātauranga Māori will be shared, more consultation can occur and where the implementation of [management] tikanga can be delivered on a place-based structure. The Whānau framework introduced is a key contributor to upholding the cultural values and mātauranga Māori as tools for management and protection of Uhi-Mānuka, and in particular the development of any mitigation strategy for fungal risk.

The diversity of Māori knowledge held within Ngāi Tāneroa, their relationship with DoC, and the opportunity to draw from existing science reflects a model that would enhance contemporary management of taonga resources from fungal threats such as myrtle rust. The Whānau framework discussed is based on local knowledge which highlights the interconnectedness of all elements within the Ngāi Tāneroa hapū and their landscape. It also highlights the role of succession plans to assist future management needs. Monitoring plays a major role within indigenous management and has been identified in this thesis as a key contributor to understanding change and mitigating potential threats. Likewise, the implementation of this understanding adds to the toolbox available to resource managers in assisting agencies respond to any biosecurity breach. The strategies developed through the Whānau framework will enhance participation with further education and awareness by responsible stakeholders from the science sector including DoC.

Myrtle rust has a high biosecurity priority for Māori and likewise the primary sectors of Aotearoa. The opportunity to utilise mātauranga Māori in a local management plan is conveyed in this thesis and supports the notion of Māori involvement. It is clear that bringing both Western and indigenous science into the development of mitigation strategies will add to the toolbox for resource managers. However, each science draws from a unique estate of knowledge which has to be prepared to think outside the existing comfort zone to be fully effective.

Chapter 9: Conclusion

The proverb stated in the title of this thesis recognizes the status of plant knowledge in te Ao Māori. It provides a foundation to understanding how Māori can participate in resource management against biological threats which are becoming increasingly common.

The science around myrtle rust and the mitigation of any incursion threats is clearly aligned to western paradigms. The information presented in this thesis outlines an extensive understanding of the intricacies of the disease as understood by the science community. However, this science alone has not been able to halt the spread or risk of myrtle rust into new geographical regions. Therefore, the future management of the risk of myrtle rust incursions needs to look at alternative approaches for the development of sustainable management tools.

The holistic approach of traditional biodiversity management using mātauranga and tikanga Māori has much to offer to conservation of taonga resources, especially the mitigation of biological threats. The Māori worldview of the environment encompasses all elements beyond the physical attributes of an ecosystem that thrives through traditional kaitiaki inputs.

Plant pathogens are inherently difficult to detect and their impacts can be devastating on biota making their control a significant future (and current) biosecurity priority. Additionally, contemporary and emerging issues such as climate change and the human assisted movement of pathogens exacerbates the issues and potentially reduces the efficacy of current management tools. More collaboration is needed to develop innovative tools to help adapt to these issues and support biosecurity policy and management.

The study of ethnobotany is defined as the study of the relationship between people and plants. It stands as an important field of storing the values of both fields of knowledge. The case study of Uhi-Mānuka exemplifies how the use of knowledge can play an important role in connecting all elements of the environment and community. As demonstrated in this research, whakapapa is the integral part of all traditional Māori institutions which govern and guide the rights to use, access and manage taonga resources. The layers of knowledge and information presented in this thesis is a result (and evidence) of the successful interconnectedness that exists within an indigenous community – namely Ngāi Tāneroa.

What is important to draw from this case study is that whakapapa is an expression of how all elements of knowledge are encoded in the natural world. TEK enables indigenous people to develop their own perceptions of these codes to either enforce changes or enhance materials to protect such resources and knowledge.

The case study then expounded concepts of tikanga Māori that reflect the implementation of whakapapa connections. This is a major illustration of the importance of Māori knowledge and evidence of its history of existence, the survival of the knowledge through the generations, and also in its implementation and contribution to the ecosystem. It also materializes experiences of the past to draw on for current issues and assist with developing future management procedures.

The traditional tools (for example the role of hukahuka in planmt protection) elucidated in the Ngāi Tāneroa case study and the Whānau framework introduced in the discussion have the capability to fit with different spheres of knowledge for management. They support the engagement of various stakeholders in ensuring the sustainability of any succession plan developed for Uhi-Mānuka is sustainable. They also represent the various layers of knowledge represented and merged in the decision-making.

The most telling statement coming from the hapū is the urgency they perceive for the transmission of knowledge within their own community as well as appropriately in a wider context. The succeeding generations have a different relationship with the resource than the preceding one; a different level of intimacy with the mātauranga associated with the resource and they live in a world of technology that has superseded the traditional processes of learning. The urgency to value what is known by the elders is apparent.

The future is clearly best served by defining a process whereby the science and traditional knowledge systems come together and work on a broad approach to mitigating the threat of disease incursion – timeliness and relationships will be the key to its success. It is not about the lack of knowledge from either system, but how they can complement each other through a process of collaboration and application.

Glossary

Atua......................................God/s
Hapū.....................................subtribe
Hukahuka ....frost
Iwi..tribe
Karakia..................................prayers, incantations
Kaitiaki / kaitiakitanga...........Guardian / act of guardianship
(Nga) kōpurawhetu ....fungi/fungus
Kuia......................................female elder
Mana ....status – determined through the gods
Manaakitanga ....hospitality
Manu ....bird
Mātauranga..........................traditional knowledge
Matemate ....disease/s
Mauri....................................'essence' – also what quantifies quality
Puna ....spring
Pirinoa ....parasite
Pou ....post
Rahui ....temporary prohibition
Rohe ....area, location
Taonga..................................treasure
Tapu ....literally 'sacred'
Te Taiao................................The natural environment/resource
Tikanga ....cultural practise
Tipuna/Tiipuna ....ancestor/ancestors
Tohunga ....cultural expert
Whakaaraara........................sentinel
Whakapapa ....genealogical descent including the concept of species assemblages
Whakataukī ....proverbial saying
Whānau ....family
Whānaungatanga.................familial ties
Whenua................................land, placenta

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Personal Communications

Danny Mason (Ngāi Tāneroa) – June 2019
Shirley Ratahi (Tuhoe) – June 2019
Frances Reiri-Smith (Kuia, Ngāi Tāneroa) – Various dates, March, April and June 2019
Nick Roskruge (Ngāti Rāhiri me Ngāti Porou) – various dates
Althea Vercoe (Tuhoe, Rongoa practitioner) – June 2019
Suliasi Vunibola (Fiji, PhD candidate, Massey University) – March 2019

Appendices

Appendix 1 – Ethics approval

Roskruge, Nick

Subject: FW: Human Ethics Notification - 4000020106

From: humanethics@massey.ac.nz [mailto:humanethics@massey.ac.nz]
Sent: Friday, 12 October 2018 11:46 a.m.
To: Mesulame.Tora.1@uni.massey.ac.nz; Roskruge, Nick
Cc: Human Ethics
Subject: Human Ethics Notification - 4000020106

HoU Review Group

Ethics Notification Number: 4000020106
Title: How is indigenous knowledge applied in the management of fungal incursions on native flora in New Zealand: A case study on Myrtle Rust (Austropuccinia psidii)

Thank you for your notification which you have assessed as Low Risk.

Your project has been recorded in our system which is reported in the Annual Report of the Massey University Human Ethics Committee.

The low risk notification for this project is valid for a maximum of three years.

Please note that travel undertaken by students must be approved by the supervisor and the relevant Pro Vice-Chancellor and be in accordance with the Policy and Procedures for Course-Related Student Travel Overseas. In addition, the supervisor must advise the University's Insurance Officer.

A reminder to include the following statement on all public documents:

"This project has been evaluated by peer review and judged to be low risk. Consequently it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research.
If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact Professor Craig Johnson, Director (Research Ethics), email humanethics@massey.ac.nz.
"

Please note that if a sponsoring organisation, funding authority or a journal in which you wish to publish require evidence of committee approval (with an approval number), you will have to complete the application form again answering yes to the publication question to provide more information to go before one of the University's Human Ethics Committees. You should also note that such an approval can only be provided prior to the commencement of the research.

You are reminded that staff researchers and supervisors are fully responsible for ensuring that the information in the low risk notification has met the requirements and guidelines for submission of a low risk notification.

If you wish to print an official copy of this letter, please login to the RIMS system, and under the Reporting section, View Reports you will find a link to run the LR Report.

Yours sincerely

Professor Craig Johnson
Chair, Human Ethics Chairs' Committee and Director (Research Ethics)

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Appendix 2 – Takitimu whakapapa

Te Hononga-Marei-Kura O Ngāti Kahungunu - Takitimu
The noble linkages of the Ngāti Kahungunu tribe and Takitimu waka
Written by the late Canon Wi Te Tau Huata

Tamatea-Ariki-Nui Mai-Tawhiti o te waka TAKITIMU
Ka puta ko Rongokako, Rongorongo
Ka moe ia Turi, te Ariki-nui o te waka AOTEA!
Rongokako ka moe ia Muriwhenua Te Au-pouri, o te waka KURAHAUPO!

Tamatea-Ariki-Nui Mai-Tawhiti of the waka TAKITIMU
begat Rongokako and Rongorongo
Rongorongo married Turi, High Chief of the waka AOTEA!
Rongokako married Muriwhenua of Te Au-pouri, of the waka KURAHAUPO!

Tama-tea-ure-haea, Kapo-wairua, Pokai-whenua, Pokai-moana!
Ka moe ia Iwi-pupu, te kura o Paikea-Porourangi!
Ka puta ko Kahungunu-Orongotea,
Ka moe ia ana wahine tokowaru!

[Rongokako and Muriwhenua begat Tamatea of many names]
Tama-tea-ure-haea, Kapo-wairua, Pokai-whenua, Pokai-moana!
Tamatea married Iwi-pupu, the jewel of Paikea-Porourangi!
[from whom descend the Ngāti Porou tribe]
Who begat Kahungunu-Orongotea,
Who married eight women!

1. Hine-tapu-o-Kaitaia, Mamari, Mamaru, Tinana, Mahuhu-ki-te-rangi, Nga-toki-mata-whaorua
2. Te-hau-Taruku-o-Opotiki, o te waka MATAATUA!
3. Rua-rau-Hanga o Whangara,
4. Rua-rere-Tai-o-Popoia, Turanga-nui-a-Kiwa, [the waka] HOROUTA
5. Hine-Pu-ari-ari o Whare-onga-onga,
6. Kahu-kura-wai-a-Raia o te Mahanga, [of the waka] TAINUI!
7. Rongo-mai-wahine o Nukutaurua o te waka KURAHAUPO!

Ka puta ko Rongo-mai-Papa
Ka moe ia Tuhourangi o te waka TE ARAWA!
Ka puta ko Tau-hei-Kuri
Ka moe ia Tama-tai-Pu-noa o te waka MATAATUA!

[Kahungunu and Rongo-mai-wahine]
Begat Rongo-mai-Papa
Who married Tuhourangi of the waka TE ARAWA!
And begat Tau-hei-Kuri
Who married Tama-tai-Pu-noa of the waka MATAATUA!

Kahungunu [and Rongomaiwahine]
[begat] Kahu-Kuranui
[who begat] Rakai-Hiku-roa
]who begat] Tu-puru-puru
[who begat] Rangi-Tu-ehu
[who begat] Tuaka

[who begat] Mahinarangi
Ka moe ia [who married] Turongo o te waka TAINUI!

Ka puta [who begat] Raukawa, Kurawari
Ka moe ia [who married] Whare-rere o te waka TOKOMARU!

8. Pou-Whare-kura, Te Whanganui-o-Ruawharo, o te waka TAKITIMU! [the 8th wife of Kahungunu]

Te hononga-marei-kura o AOTEA - TAKITIMU
[the noble linkage between Aotea waka and Takitimu waka]

Turi te Ariki-nui o te waka AOTEA
Ka moe ia Rongo-rongo, tamahine a Tamatea Ariki-nui o te waka TAKITIMU

Turi High Chief of the Aotea waka
Married Rongo-rongo, daughter of Tamatea Ariki-nui of the waka Takitimu

Te hononga-marei-kura o TE ARAWA - TAKITIMU
[the noble linkage between Te Arawa waka and Takitimu waka]

Tama-te-Kapua [captain of Te Arawa waka]
[begat] Kahu-Mata-ma-Moe
[begat] Tawake-moe-ta-Hanga
[begat] Uenuku-mai-Rarotonga
[begat] Rangitihi
[begat] Tuohurangi = Rongomai-papa

Te hononga-marei-kura o MATAATUA - TAKITIMU
[the noble linkage between Mataatua waka and Takitimu waka]

Toroa [captain of Mataatua waka]
Rua-i-Honga
Te Tahinga-o-te-Ra
Awanui-a-Rangi
Ira-Peke
Awatope
Ahokawa = Hau-Manga
Tama-tai-Pu-noa = Tau-hei-Kuri

Te hononga-marei-kura o TAINUI - TAKITIMU
[the noble linkage between Tainui waka and Takitimu waka]

Hotu-roa [captain of Tainui waka]
Hotu-ope
Hotu-matapu
Motai
Ue-rata
Raka-maomao
Kakati
Turongo = Mahinarangi (Himona.R.N., 1995).

Appendix 3

Whakapapa of a range of New Zealand Native Tree species including Mānuka (as related by Nanny Francis Reiri-Smith, Ngāi Tāneroa, and cited here from the works of Best, 1976)