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Population Ecology of *Thelymitra matthewsii*  
Cheeseman Orchidaceae, in  
Northern New Zealand

A Thesis

Submitted in partial fulfillment

of

The Requirements for the Degree of

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Elizabeth Anne Fraser



THE UNIVERSITY OF  
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## Abstract

The terrestrial orchid *Thelymitra matthewsii* Cheeseman, uncommon in New Zealand, was studied to increase knowledge of the species life cycle, morphology and ecology. Results will enhance future conservation management for the species.

New information related to the morphology of *T. matthewsii* was obtained. The species was found to emerge in one of four discrete life stages of distinctive morphology and height range that remained constant for the season, not developing into a more advanced life stage. The leaf of the three pre adult life stages designated a hook, a spiral, and a non flowering stage, did not inflate at the base, but rose smoothly from the tuber. Apparent morphological differences in the column between descriptions of the Australian taxon and the small New Zealand sample examined suggested further study was needed.

Comprehensive monthly monitoring was carried out at five study sites in three locations in the Te Pahi area of the Far North, from 2002 to 2004. No patterns emerged in plant life stage succession, flowering, and presence or absence at labels reinforcing the concept that variability was a common component of the population census.

Seasonal and partial absence was a major component of the populations. An average of 32.8% of plants, over five study sites, were present throughout three seasons, while 66.9% were recorded as absent (not visible) at monitoring. New plants appearing in 2003 and 2004 showed a high percentage of subsequent absence (mean 85.7%).

To determine population stability, recruitment and absence were compared. Plant absence exceeded recruitment by 7% (mean plant absence 30.5%; mean recruitment 23.4%). Plants continued to appear during the monitoring period, and labeled plants increased two-fold over commencement numbers.

Adults recorded as 28% of labeled plants over three seasons, were out numbered by pre-flowering stages. Only 5% of population numbers exhibited succession from a smaller to a flowering plant. Life stage modeling indicated a life stage was more likely to be followed by the same stage than an expected successive stage.

*Thelymitra matthewsii* was found to be present in four substrates in the Far North. The survey of vegetation found the indigenous species *Kunzea ericoides* and the exotic *Hakea gibbosa* dominant for both height, and cover. Litter and bare ground dominated ground cover. Differences in vegetation and ground cover, of sites supporting *T. matthewsii* and comparison sites that did not, were minor and suggested that another factor, for example a suitable fungal partner, influenced the species presence or absence.

The results of the study indicated the present threat classification of *Thelymitra matthewsii* is inadequate in the light of the species relatively circumscribed, widely separated habitats, the small number of reproducing individuals and vulnerability to habitat modification.

## Acknowledgements

I have enjoyed this study. I have appreciated the research, the delving into papers by numerous accomplished authors in search of further knowledge, slightly unnerved by what I found I did not know. In the end however, I was somewhat comforted by the background of information that answered the same questions I had to ask. I have enjoyed the people I have been privileged to meet and associate with, most especially those who have given their time to assist me. Above all I have enjoyed working with this little plant that has still retained its magic for me.

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I would like to think that my enjoyment of the study and the acquisition of skills I have achieved will be an inspiration to my grand children that the furthering of knowledge can always be pursued. This study has shown me that if you look at a plant once it will not tell you much, and if you look at it only once a year, you will not learn much. All the photographs in this document were taken by the author.

Anne Fraser

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# CHAPTER ONE

## 1.1 Introduction

This research is focused on the population demography and ecology of *Thelymitra matthewsii*<sup>1</sup> Cheeseman, Orchidaceae, in New Zealand, with a view to contribute to the conservation management of this species. *Thelymitra matthewsii* is a slender terrestrial orchid found only in the Southern Hemisphere, and is indigenous in temperate regions of New Zealand and Australia. The orchid is uncommon in New Zealand and restricted to a few scattered populations in the Far North of the North Island.

In Australia the species occurs sporadically in Victoria and South Australia, and was considered by de Lange *et al.* (1999) to be con-specific with the New Zealand species. Uncertainty surrounded the reported occurrence of the species in Western Australia, and R. Herberle (pers. comm. 2002) considered that species to be allied to *T. varigata* as the habitat the species colonized was considered atypical for *T. matthewsii*. A personal communication from M. Clements (2004) Canberra, stated that the species presence was confirmed by a collection in Western Australia. However, in his new treatment of the orchids of Australia, Jones (2006) does not include *T. matthewsii* in Western Australia.

## 1.2 Conservation Status of *Thelymitra matthewsii*

*Thelymitra matthewsii* is recognized as a unique species in *Thelymitra* in New Zealand, with restricted distribution and distinctive diagnostic features. Coupled with the species' sporadic appearance and specialized habitat preference, is its vulnerability. The plant is relatively small and delicate, not easily seen, and could be subject to loss from indiscriminate trampling.

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<sup>1</sup> Nomenclature follows Moore and Edgar (1976)

Its preferred habitat on semi-stable dune ridges and slopes associated with shrub vegetation, exhibits the very characteristics which have seen large areas of similar vegetation type converted to pasture and forestry in New Zealand. Although within Department of Conservation administered estate, natural vegetation succession and dune migration pose threats to these largely remnant habitats and will make their continued maintenance difficult.

*Thelymitra matthewsii* was considered extinct in New Zealand (Given 1981; Johns and Molloy 1983) after the last collections c1914, by its discoverer R H Matthews' sons. The sighting of a single plant in 1987 in the North Cape Scientific reserve by D. McCrae, of Auckland, who, with others, conducted an orchid survey of Te Paki Farm Park, coincided with re-discovery in Australia (Peisley 1990) after a period of absence.

The Species Priority Ranking System of the Department of Conservation was used by Dopson *et al.* (1999) to classify *Thelymitra matthewsii* for threat. The system assigned species to categories derived from scores in five ranked categories. These categories were distinctiveness, status (population status), threat, vulnerability and values. In that context *T. matthewsii* was assigned Category A critical, (highest priority threatened plants for conservation action). The New Zealand taxon was classified as 'naturally uncommon' with a sub-heading of 'sparse' by de Lange *et al.* (1999). An update of Threatened Plant Status in New Zealand by de Lange *et al.* (2004) lists the species as 'non-resident, colonizing, threatened overseas'. The New Zealand Plant Conservation Network (2007) noted the species conservation assessment as incorrect, stating that evidence suggested that *T. matthewsii* should be listed as 'acutely threatened, nationally critical' because of habitat threats. In Australia the taxon is listed under the Flora and Fauna Act, Victoria 1993, as locally vulnerable (Foster and MacDonald 1999).

### **1.3 Aim of the Study.**

The aim of this study was to understand the life cycle of *Thelymitra matthewsii* from recognition of the un-described juvenile life stages, to the adult stage commonly referred to in formal literature (Cheeseman 1910, 1925; Cooper 1981; Moore and Edgar 1976; St George *et al.* 2001). Population demography, recording plant growth, and mapping of habitat and vegetation associations was conducted to determine the answers to the key questions below.

#### *1.3.1 Life cycle morphology*

- Are population numbers increasing or decreasing over time and space, or in composition i.e. proportion of adults and juveniles?
- If there is more than one life stage are they successive, from smallest to flowering?
- Is absence an indication of death?
- How permanent is absence?
- Does recruitment of new plants maintain populations?
- Is plant condition indicative of an outside influence, e.g. climatic or predatory?

#### *Habitat*

- Does some configuration of habitat and associated species contribute to or influence distribution of the orchid?
- What is the associated species richness, height and dominance?
- Is there a long term threat to the orchid's preferred habitat?

The objective of the study was to gain a complete picture of the life stages and ecology of *T. matthewsii* while recognizing the population's ephemeral nature, and to describe the juvenile life stages of the species. New information thus collated will be of value to aspects of conservation of this and other New Zealand orchid species.

#### **1.4 Review of Similar Studies**

In studies of small terrestrial orchid floras, many prompted by the rarity of some species, a number of long-term demographic monitoring of terrestrial orchids were initiated in Britain, Europe and America, some as early as World War Two (1944) (Tamm 1972). A selection of relevant studies of orchid species both in the Northern and Southern hemispheres since 1991, is listed in Table 1.1, by country, orchid species studied, year, duration and the main theme of the studies. Duration of some studies was not known. The studies used set plot sites, and most identified individual plants by triangulation from a permanent plot marker.

In a volume entitled *Population Ecology of Terrestrial Orchids*, the Editors, Wells and Willems (1991) gathered together papers presented at an International Orchid Symposium in the Netherlands in 1990. Themes of the Conference included long term population studies to gain insights into function, following the fate of individuals, use of a matrix model, flowering, fruiting and phenology.

The editors listed several important points from the conference. Most of the studies were in the Northern Hemisphere and Australia, some of which had continued for 25 years (among the longest species studies in herbaceous plants), highlighting the commitment necessary if worthwhile results are to be achieved. The authors reported that less than 20 species of terrestrial orchids world wide were the subject of demographic studies (Wells & Willems 1991).

A number of papers listed in Table 1.1 in 1998 were the result of contributions to a conference held in conjunction with the Botanical Society of the British Isles in 1995, titled 'Orchid Population Biology, Conservation and Challenges'.

**Table 1.1**  
**Summary of orchid population studies in the Northern and Southern Hemisphere since 1991**

<b>Author</b>	<b>Year</b>	<b>Species monitored</b>	<b>Location</b>	<b>Duration</b>	<b>Description</b>
Gregg	1991-	<i>Cleistes divaricata</i>	United States	6 yrs.	Population dynamics
Kull and Kull	1991	<i>Cypripedium calceolus</i>	Europe	12 yrs.	Demography
Light and Macconail	1991	<i>Epipactis helleborine</i>	Nth. America	5 yrs.	Population dynamics
Tamm	1991	<i>Orchis and Dactylorrhiza</i> sp.	Europe	1943-91	permanent plots
Vanhecke	1991	<i>Dactylorrhiza</i> species	Belgium	12 yrs	population dynamics
Wells and Cox	1991	<i>Ophreys apifera</i>	Britain	10 yrs.	Demographic study
Whigham and O Neill	1991	Terrestrial species	United States	10 yrs.	Flowers and fruit
Willems and Bik	1991	<i>Orchis simian</i>	Netherlands	20 yrs.	Population biology
Molloy	1993	<i>Thelymitra</i> species	New Zealand		habitat
Sydes and Calder	1993	<i>Thelymitra</i> species	Australia		population biology
Clarkson <i>et al.</i>	1994	<i>Corybas carseii</i>	New Zealand		habitat
Eckroyd	1995	<i>Caleana minor</i>	New Zealand		population study
Carey	1998	<i>Himantoglossum hircinum</i>	Britain		monitoring
Gillman and Dodd	1998	<i>Orchis</i> species	Britain	26 yrs.	Population dynamics
Hutchings <i>et al.</i>	1998	<i>Orchis militaris, O. morio</i>	Britain	21 yrs.	Habitat and demography
Ramsay and Stewart	1998	<i>Cypripedium calceolus</i>	Britain	23 yrs.	Re-establishment
Sanger and Waite	1998	<i>Ophreys sphegodes</i>	Britain	23 yrs.	Phenology
Waite and Farrell	1998	<i>Orchis</i> species	Britain	16 yrs.	Population biology
Wheeler <i>et al.</i>	1998	<i>Liparis loeslii</i> var <i>ovata</i>	Britain		population study
Willems and Melser	1998	<i>Coeloglossum viride</i>	Europe	7 yrs.	Population dynamics
Macdonald	1999	<i>Thelymitra matthewsii</i>	Australia	5-6 yrs.	Monitoring
Batty <i>et al.</i>	2001	terrestrial species	Australia		habitat
Merrett <i>et al.</i>	2001	<i>Calochilus robertsonii</i>	New Zealand	3 yrs.	Monitoring
Norton and de Lange	2001	<i>Corybas carseii</i>	New Zealand		habitat

Focused on temperate orchid species, the contributors emphasized the marked fluctuation of population size, their variability and capricious behaviour (Waite 1998). A summary of salient points from the studies listed in Table 1.1 follows below:

#### Orchid species demography

Papers which focused on orchid species demography, e.g. Wells and Cox (1991) who monitored *Ophrys apiphira* in Britain for 10 years, praised the value of regular long term monitoring of terrestrial populations, and stressed the importance of multiple census that recorded all plants in the populations. Kull and Kull (1991) who studied *Cypripedium calceolus*, also suggested that the analysis of population behaviour was enhanced by the collection of population data in long term permanent plots. These authors used a height measurement from the soil surface to record plant height, because they considered it to be more precise. Tamm (1991) monitoring genera *Orchis* and *Dactylorhiza* supported long term study and considered it essential to understand succession and obtain information pertinent to conservation of the species. The author also advocated non random plot selection to obtain sufficient data to represent a population capable of analysis. In the opinion of Molloy (1993) proper management of threatened plants could be better achieved with long term monitoring. His report on the raising of water levels in Lake Ohia, Northland, outlined likely loss of *Thelymitra* species common on Kauri stumps, as a result.

#### Orchid population biology

In papers focusing on population biology Willems and Bik (1991) studying *Orchis*; Willems and Melser (1998) monitoring *Coeloglossum*; and Sanger and Waite (1998) who monitored populations of *Ophrys* also stressed the necessity to understand ecology and observed that monthly monitoring enabled the study of plant phenology in detail. Significant differences in population size by year, and variation in plant and

flower morphology were points listed by Merrett *et al.* (2001) in their study of *Calochilus robertsonii* a New Zealand terrestrial orchid species. Gillman and Dodd (1998), assessed population size variability in orchid populations, finding that temporal variation in orchid populations ranged as greatly as values for birds, insects and mammals. Studies that addressed population variability also included Waite and Farrell (1998), who found dormancy, flowering frequency, recruitment and population decrease and increase variable over time in *Orchis militaris*. Wheeler (1998) who monitored *Liparis loeselii*, stressed the need for recording on several occasions in a growing season.

Light and MacConail (1991) who studied patterns of appearance in *Epipactis helleborine*, brought attention to ‘absence’ suggesting mycorrhizal involvement, and that patterns of appearance have received little attention in studies of orchids. Waite and Farrell (1998) cited fungal behaviour as a contributor to natural instability of the species they found in the population study of *Orchis militaris*. Whigham and O’Neill (1991) compared the genera *Tipularia* and *Liparis*, and stressed the need to include dormancy in population data, and the need for long term studies to interpret patterns of flowering and fruit set, but found no relationship between variations in climate and flower production.

Willems and Bik (1991) observed that 95% of plants recorded as missing were below ground that year during monthly monitoring of *Orchis simia*, and that plants needed three years above ground before producing a flowering stem. Wells and Cox (1991) observed that flowering, recruitment and mortality were variable in populations of *Ophreys apifera* and suggested that an orchid species was a pioneer species. Using matrices composed for transition (life stage change) Gregg (1991) reported that analysis of population behaviour in *Cleisthes divaricarta* showed there was not a set sequence and that results were different for populations and years.

Batty *et al.* (2001) investigated in situ seed baits to determine technique success and time needed, finding less than one percent of seeds capable of producing a plant able

to survive a dormant summer, when they studied the development of seed and fungal storage methods, for the conservation of Australian terrestrial orchid species.

#### Study site management factors

Waite and Farrell (1998) found site management important, as did Hutchings *et al.* (1998), (both studies of the rare *Orchis militaris*) who attributed the considerable increase in recruitment, flowering and seed production to site clearance, but were reluctant to ascribe the recruitment to disturbance alone. Macdonald (1999) observed that species required disturbance, but queried how much. Vanhecke (1991) in a study of *Dactylorhiza praetermissa* concluded constant habitat change showed how important local seed sources were for population maintenance, but it was clear that creation of open space, by whatever means can trigger a population increase.

A drop in numbers of the rare species *Caleana minor* in New Zealand, was in Eckroyd's (1995) opinion, due to habitat succession and loss of open space. The author strongly advocated conservation of rare orchid populations regardless of non-endemism. Enhancement of habitat by fire increased plant numbers and flowering of the orchid, *Corybas carsei*, according to Norton and de Lange (2001). Vegetation richness was improved and critical open space achieved, where habitat was overcome by associated plant succession. However the use of fire required careful monitoring. Clarkson *et al.* (1994) noted severely reduced numbers in the same species *Corybas carsei*, because of habitat change, and inherent in the provision of open space by fire or land clearance was the likely influx of adventitious weedy species.

Carey (1998) monitored population spread, and found that the movement of species, dispersal and population dynamics of *Himantoglossum hircinum* in a landscape, was controlled by the configuration of that landscape.

## Genetic analysis

Recent work continues in Australia, for example, using standard molecular techniques to construct phylogenetic trees as a means of determining genetic relationships between species and populations (Clements *et al.* 2002). In New Zealand, Peakall and Molloy (1998); Molloy and Dawson (1998); McCrae and Molloy (1998); used molecular techniques to determine speciation and amphidiploidy in *Thelymitra* species.

This study augments the comparatively low level of demographic studies using set sites and permanent markers to follow life stages of an orchid species, represented in New Zealand by the study of *C. robertsonii* by Merret *et al.* and Eckroyd's report on *Caleana minor* (Table 1.1). Studies of *Thelymitra* species, apart from the genetic work listed, included that of Sydes and Calder (1993) in their study of the reproductive ecology of *T. circumsepta* and *T. ixiodes* in Australia. Also in Australia, resolution of the *T. canaliculata* complex was accomplished by Jeanes (2000).

Most of the studies described in Table 1.1, were of terrestrial orchid species with scattered and reduced populations. The authors stressed the need for careful management strategies, and in particular preservation of habitat to ensure the conservation of threatened species.

## 1.5 Conservation Policy for Plants at Risk

Orchids are recognized globally as being in need of conservation for a variety of reasons, despite having a greater number of species than any other plant families (Dressler 1990). A total of 34 New Zealand orchid species, were listed by de Lange *et al.* (2004) as 4 acutely threatened species, 3 species chronically threatened, 23 species naturally uncommon, and 4 species for which data was incomplete. Threats include the phenomenon 'Orchidomania', (since the earliest destructive collecting, particularly of tropical species) targeted by commercial interests, and as additions to personal collections (Dressler 1990). The Convention on International Trade in

Endangered species of wild flora and fauna (CITES) was initiated to regulate the unacceptable exploitation of threatened species, and to reduce that threat because of exploitation (Dressler 1990).

The responsibility of protection of indigenous flora and fauna in New Zealand is vested in the Department of Conservation by the Conservation Act, 1987. The New Zealand Threatened Plants committee publishes assessments of the Conservation Status of indigenous flora in New Zealand. It was considered by de Lange (2000) that formal publication of the 1999 revision of conservation assessment would achieve greater international recognition of the status of New Zealand's Threatened plants.

A specialist panel of Threatened Plant Committee members, Department of Conservation, Universities and Research Institutes and the New Zealand Botanical Society committee, developed a new threat classification system (Molloy *et al.* 2002) unique to New Zealand's indigenous flora and fauna. Hitchmough *et al.* (2002) listed all threatened flora and fauna, and the vascular plants list was upgraded by de Lange *et al.* (2004).

## **1.6 Thesis Content**

The first three chapters of this thesis, the introduction, description of Orchidaceae and *Thelymitra*, and the physical setting of climate, geology and vegetation, provide the known background to the study. Morphology and phenology of the study species, elucidated by observation over the monitoring period, is presented in Chapter Four, with particular emphasis on the previously undescribed juvenile life stages of *T. matthewsii*. Answers to the questions concerning life cycle morphology were sought and presented in Chapter five, detailing the results of the monitoring of the species. An in depth study of the vegetation associated with *T. matthewsii*, described in chapter six, sought to determine the advantages or limitations of the orchid's ecology. Following the introductory chapter, results of the Research Study are presented in the order outlined below.

**Chapter Two:** The Orchidaceae and *Thelymitra*

This chapter briefly outlines the characteristics, ecology fossil history and taxonomy of the Orchidaceae and *Thelymitra*. The discovery, distribution and relationships of *Thelymitra* and *Thelymitra matthewsii* are included.

**Chapter Three:** Regional and Research Sites Description

The geology, climate and land tenure status of the location of *T. matthewsii* populations in the Far North of the North Island are described. The study sites and their location are individually documented.

**Chapter Four:** The Morphology, and Phenology of *T. matthewsii*

Life stages of the study species are examined and described, particularly putative juvenile stages and new information is included. Seed dispersal characteristics, floral morphology and phenology of the species complete this chapter.

**Chapter Five:** Population Demography

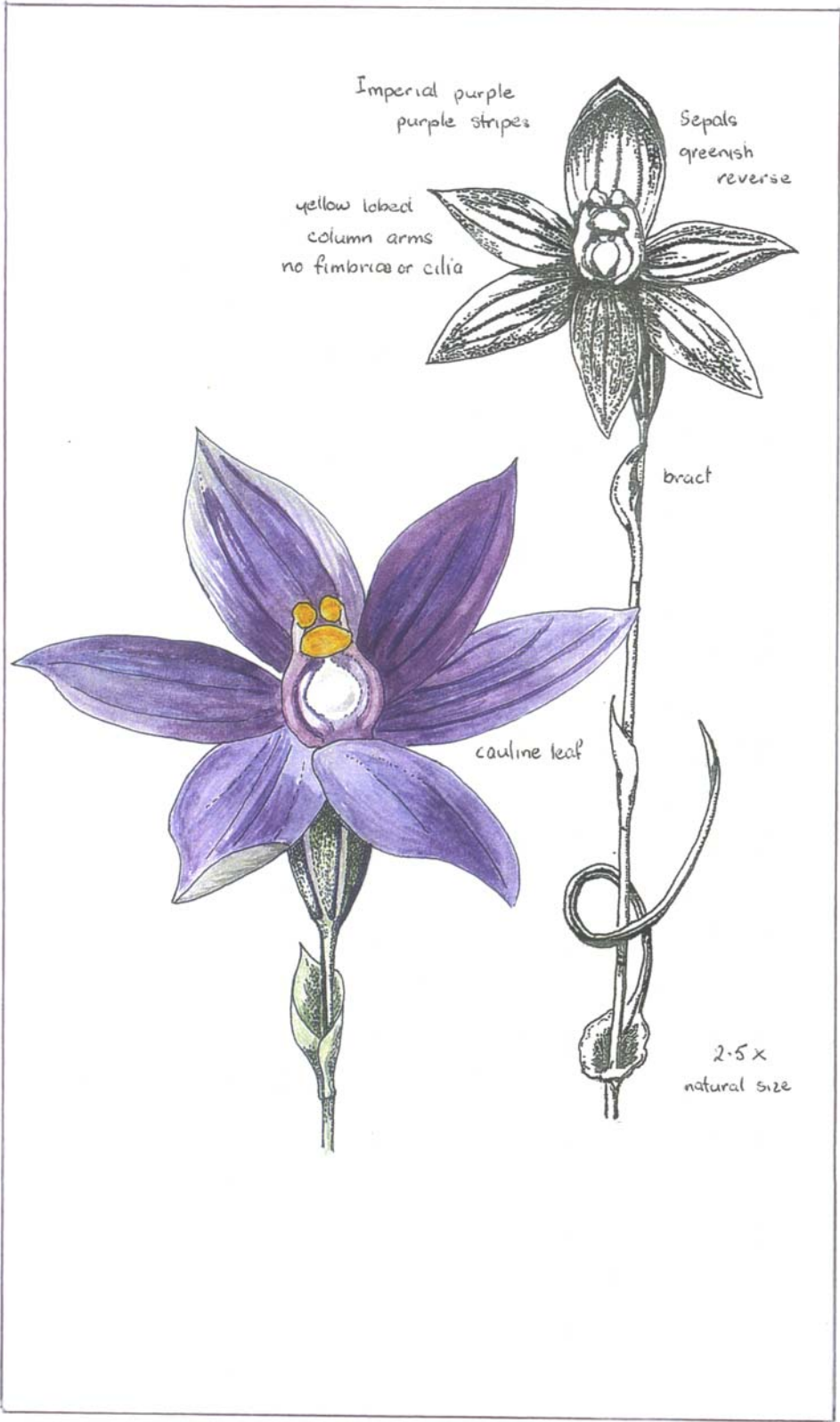
Analysis of collated data from monthly measurements of the study species over three years is presented in this chapter. Methods employed, life-stage structure of monitored plants at study sites is described, population presence and absence is assessed and compared. Seed bank investigation results are reported.

**Chapter Six:** Vegetation Survey

Collated data of vegetation and species content, height and cover at set site locations, supporting *T. matthewsii*, and three vegetation only sites are compared, and analysed for variation. Substrate percentages are included and evaluated.

## **Chapter Seven: Conclusion, and Management Observations**

An overview of enlightenment obtained by this research, to aspects of the life stages of an uncommon species of orchid, and its application to threat status, is presented in this final chapter. Future management options are suggested, guided by the information collated.



## CHAPTER TWO

### **Orchidaceae and *Thelymitra***

#### **2.1 Introduction**

This chapter introduces the morphology, ecology and classification of the family Orchidaceae and the genus *Thelymitra*. Historical references to the discovery, taxonomic history, and distribution of the genus are outlined. The discovery of *Thelymitra matthewsii* is included.

The Orchidaceae family is one of the largest groups of flowering plants in the world, exceeding all other families in numbers of species, (considered to be in excess of 30,000 species in ~ 850 genera), representing one tenth to one fourteenth of all flowering plants (Dressler 1990).

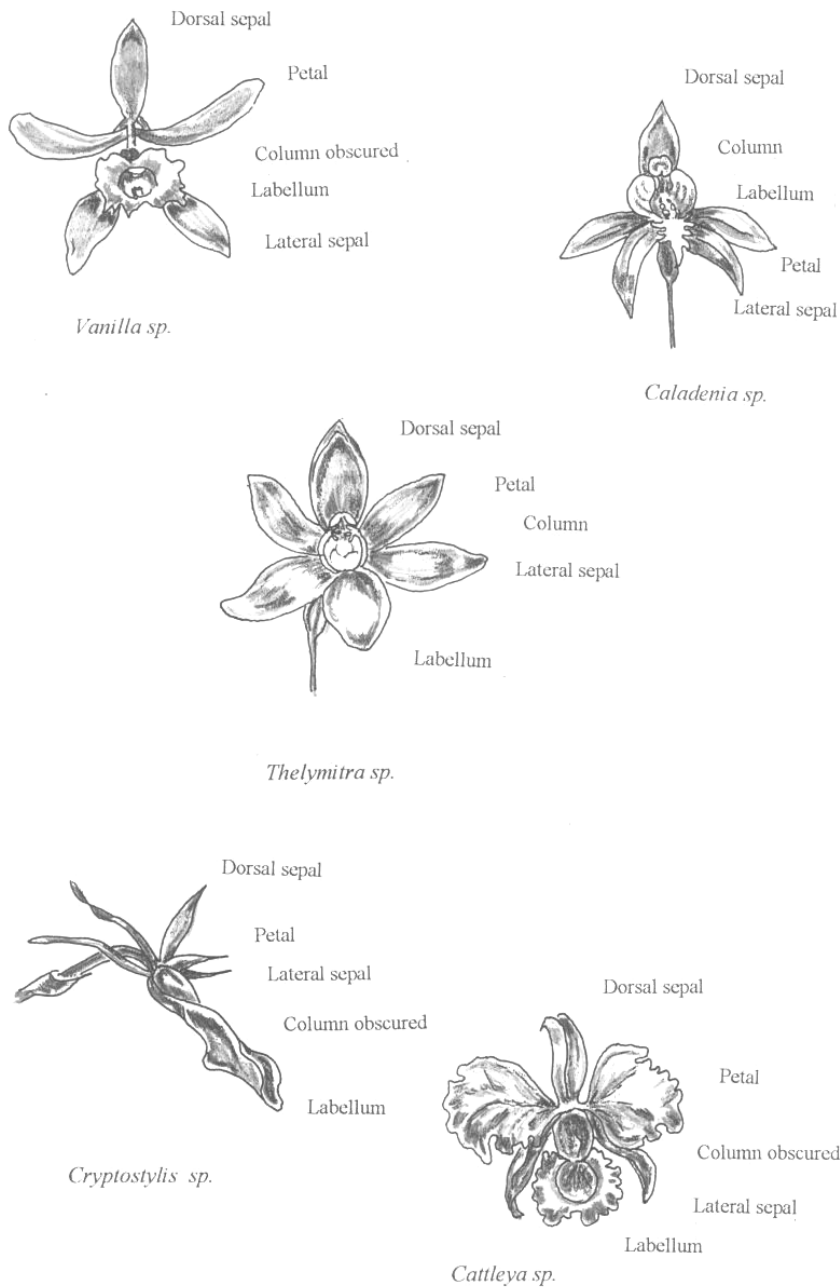
#### **2.2 The Family Orchidaceae**

##### Morphology

Characteristic of monocots, orchid floral parts are in threes. The leaves are usually simple and longitudinally veined (Johns and Molloy 1983) and arranged in two ranks. If only a single leaf is present, the inclusion of scale leaves and or stem sheaths completes the distichous orientation (Dressler 1990). Differences which set the orchids apart from other monocots are found in flower morphology. Most species have one fertile anther on one side of the flower, opposite the labellum. Varying degrees of union of the reproductive parts of the flower are characteristic of the orchids in which the male stamens are united with the female style to form the column or gynostenium. The floral parts are usually resupinate and zygomorphic (bilateral symmetry). Resupination is the term which describes the orientation of the orchid flower and Dressler (1990) asserted that the twisting of the pedicel occurred with respect to gravity. The rostellum develops from part of the stigma and aids pollen transference, which is presented in packages termed pollinia, made up of waxy adherent pollen grains, to be removed in one unit from the anther by pollinating

insects. Grains are more mealy and crumbly in self fertilizing or autogamous species (Jones 1993; 2006; Dressler 1990). The diversity of arrangement of the floral parts of orchid flowers is illustrated by the sketches in Fig 2.1

#### Floral Diversity in Orchidaceae



**Fig. 2.1** Examples of diversity in orchid floral morphology contrasted with the actinomorphic Thelymitra species (centre). Corresponding parts are labeled. Not to scale because of size differences.

Methods of pollination in orchids are as diverse as species forms and habitats (Dressler 1990). In species that are insect pollinated, pollinia are removed from one flower and deposited on the stigma of another. The structure of many species facilitates the operation, as in traps, with or without nectar reward; mimicry of insect sexes termed pseudocopulation; and adaptations in structure to accommodate specific pollinators, for example birds or long tongued species of insects (Dressler 1990; Molloy 1990). Self pollination or autogamy is common among orchids, particularly where a potential pollinator may be absent, but Dressler considered the condition was not obligate. Jones (1993) noted that autogamous orchid species may open the flowers in suitable weather conditions but insect visits would not change any advanced process of self pollination.

#### The historical record

Orchids were known to early writers in China, from the Western Chou Dynasty of 500 BC; by Confucius 551-479 BC, and to the Romans from writings by Pliny, AD 23-29 (Berliocchi 2001). The Greek philosopher and botanist Theophrastus 300-186 BC was responsible for applying the name *orchis* to an orchid species. The name *orchis* was derived from the Greek, *oxpu* which describes the resemblance of the tubers of terrestrial species to male testes (St George 1999). Dioscorides 50-70 AD a Greek herbalist, described orchid plants, one of which he named *Serapius*. This name was applied to the species of *Thelymitra* first found in New Zealand in 1769 by Forster, but not published (Berliocchi 2001)

#### Ecology of Orchidaceae

Orchids utilize varied habitats ranging from the coastal dunes to 4000m above sea-level, very near the limits of vegetation, excluding major deserts and permanent ice and snow. Although 90% of species are tropical or sub-tropical, in wet, montane and 'cloud' forests, orchids appear in most vegetation types. Many species have specific habitat requirements (Hoffman and Brown 1992; Jones *et al.* 1999) and growth forms manifested as epiphytic, terrestrial and saprophytic forms. Terrestrial and epiphytic

species can become established on rocks, as lithophytes, if growing conditions are suitable.

Successful survival strategies developed by orchid species include floral and sexual mimicry to attract pollinators; root physiology to maximize water retention as storage organs, i.e. tubers below ground and stem pseudo-bulbs at the surface (Hodgson *et al.* 1991) adaptation to available habitat, specialized mycorrhizal associations optimizing germination and growth, and enormous numbers of very small simple seeds. As well as being considered to have medicinal properties the tubers of terrestrial orchid species have long been utilized as food by indigenous people, including New Zealand Maori (St George 1992) and Colenso cited in St George (1989); in Europe, and by North American Indians and Australian Aboriginals (Berliocchi 2001).

#### Classification of Orchidaceae

The first orchid classification was by Lindley in 1826, based on a number of tribes (Dressler 1990). This was followed by a system of division into sub families devised by Schlechter, which was still largely in use in 1926 and further attempts to classify relationships in the Orchidaceae were presented by Garay (1960) and Arditti (1992) (cited by Dressler 1990). A more recent re-organisation was by Dressler (1993) building on the system introduced by Dressler and Dawson in 1960 (cited in Cameron *et al.* 1999). Further modification of his 1993 classification saw Dressler define the Orchidaceae in 70 sub-tribes, 22 tribes and 5 sub-families, based on the position and number of anthers in the flowers (Cameron *et al.* 1999). Prior to the present classification of Orchidaceae in Asparagales the family was included in Liliales of the Superorder Liliifloreae, together with lilies and iris species.

The Orchidaceae was removed from Liliales and placed with the Liliid Order Asparagales by Chase (2004), who cited support from work of Graham *et al.* and Pires *et al.* (in press). They found there was high boot-strap support (a method of determining reliability of a phylogeny result Hall 2001) for this revision, and that

orchids were a sister group to Asparagales, an Order which then contained the greatest number of species in the largest Monocot Family, the Orchidaceae (Chase 2004). Modern methods of determining relationships in Orchidaceae employed molecular analyses to construct phylogenies. Recent work includes that of Cameron *et al.* (1999) Douzery *et al.* (1999) Kores *et al.* (2001) Pridgeon *et al.* (2001) Clements *et al.* (2002) Fraudenstein *et al.* (2004) and Chase (2004).

#### The fossil record

The known fossil record of Orchidaceae was extremely meager (Schmid and Schmid 1977). Fossilization of soft tissue was always unlikely. A greater number of orchid species have fleshy flowers and leaves, and inhabit the heat and rain of tropical climates. Decay would be swift. Orchid pollen grains are not wind dispersed so are less likely to appear in fossil assemblages. Schmid and Schmid, (1977) concluded that orchid like Eocene fossils found by Massolongo in Italy and Pliocene remains discovered by Straus in 1954 in Germany, were the most likely contenders for the record. Johns and Molloy (1983), note that fossil orchid pollen grains were identified in ice-age sediments ~1.5 million years of age but did not cite locality or other details.

### **2.3 The Genus *Thelymitra***

#### Morphology

The terrestrial genus *Thelymitra* J R et G Forst. 1776 is unusual in Orchidaceae as the sepals and petals are virtually equal with very little, or no differentiation in the dorsal petal, which usually forms the labellum (Fig.2.2). Dressler (1990) considered the flower shape to be a form of floral mimicry, reminiscent of species of Iridaceae, in which genera flowers are often opened widely. If orchid species colonized the same habitat there would be a benefit from increased pollinator attraction to the highly visible Iridaceae flowers (Dressler 1990). The flowers of some species of *Thelymitra* open tardily one at a time, others open several flowers in the florescence. Cooper (1981) described the habit of *Thelymitra* species of opening fully only in sunlight, the

result of a lack of cover of the dorsal sepal over the anther, preventing disintegration of the pollinia by rain, which led to the species common names of ‘sun orchid’ or ‘twelve o’clock orchid’.

The genus is among the few orchids that have blue flowers and are the most colourful species of the New Zealand orchid flora, with as well as blue, paler and darker shades of lavender, pink and white flowers. Some of these are often overlaid with greenish shading on the outside surface of the sepals. Only two species of *Thelymitra* in New Zealand have a spotted perianth, *T. ixiodes* and *T. nervosa*.



*Fig. 2.2 The actinomorphic perianth of Thelymitra is well illustrated by T. longifolia, flowering in cultivation. The flowers of this species are commonly white but can be pink or pale blue.*

Some Australian species of *Thelymitra* are heavily blotched and striped with deeper colour and a striped perianth is also common in several New Zealand species, including *T. matthewsii*. The column is significant for identification, the position and

shape of the anther, and the appendages and ornamentation of the sterile stamens which flank it.

The anther cap, post anther lobe (an extension of the column behind the anther and closely associated with it) and column arm are terms exclusive to *Thelymitra* in the description of the column, and differ in different species (Moore and Edgar 1976; Molloy and Hatch 1990; St George and McCrae 1990). In some species of *Thelymitra* the post anther lobe may only be indicated by a band of small calli crowded at the back of the anther, and in other species it may be truncated and ornamented with tubercles (Moore and Edgar 1976).



Fig. 2.3 A photograph of *T. matthewsii* from the Far North, also shows the regular perianth configuration of the genus. The bright yellow anther, between the yellow lobes of the column arms makes the column of this species distinctive.

The structure and ornamentation of the upper column and its margin, are the key to identification (Fig 2.3). The stigma is raised from the base by a distinct pedestal. The orchid artist B. Irwin, of Tauranga, pointed out that the anther lies behind, rather than

above the stigma and is attached to the wall of the column, a configuration rendering *Thelymitra* unusual when compared with other orchid species (Irwin 1990).

*Thelymitra* species, may be insect pollinated or self pollinating (autogamous) suggested to be about 60% of species in New Zealand by Molloy (1990) and St George (1999). Cooper (1981) considered the tardy opening of *Thelymitra* flowers, in less than ideal conditions to protect the pollen, led to the differentiation of autogamy. Some self - pollinated species do open flowers in suitable conditions which suggested some form of a default system (Cooper 1981).

#### Ecology of *Thelymitra*

The terrestrial genus *Thelymitra* is essentially a Southern Hemisphere genus reaching its greatest species richness in Australia and New Zealand (Burns- Balogh and Bernhardt 1986; Calder *et al.* 1989; Sydes and Calder 1993). The genus is also recorded on Pacific Islands from New Caledonia and New Guinea to the Phillipines (Hoffman & Brown 1992; Jones 1993). Authors differ on the number of *Thelymitra* species, from 50 and less (Calder *et al.* 1989; Hoffman and Brown 1992; Jones 1993; Sydes and Calder 1993; St George 1999) to more than 80, (Hodgson *et al.* 1991; Hoffman & Brown 1992; Jones 1993; Rupp & Hatch 1946). The greater number of species is claimed for Australia but it is agreed that there are species endemic to both New Zealand and Australia; others are shared, and several are, as yet, not described (Moore and Edgar 1976; St George 1999; Molloy 1990). Orchids listed in the New Zealand Field guide include 23 *Thelymitra* species some of which have circumscribed distribution i.e. restricted to the Far north (9 species) or mountainous areas (2 species), the remainder widely distributed in diverse habitats (St George *et al.* 1996, 2001) from heath land to swampy areas.

## Classification of *Thelymitra*

The sub family Orchidoideae was re-organised by Dressler (1990) to encompass several tribes, one of which was the Diurideae. This revision referred *Thelymitra* to the sub tribe Diuridineae together with four Australasian genera, *Calochilus*, *Orthoceras*, *Diuris* and *Epiblema*, on the basis of soft mealy pollinia, coupled with the unique root-stem tuberoids (Dressler 1990). Diurideae is commonly considered to include ten sub tribes of approximately 43 genera containing > 900 species (Dressler 1990). Another attempt at classification of *Thelymitra* was by Dressler in 1993, who reinstated the genus in the sub tribe Thelymitrineae to accommodate the unusual 'hood' or mitra of the column, reported by Bernhardt *et al.* (1986) (cited in Clements *et al.* 2002).

Modern methods using expanded plastid DNA phylogeny and jack knife analysis (estimated support from data repetition as opposed to support from individual characters Hall 2001) was employed by Fraudenstein *et al.* (2004) in construction of orchid phylogeny. Their results, revising orchid relationships, mirrored those reported by Cameron *et al.* (1999) and increased support for some clades. The revised combination of *Lyperanthus*, *Chiloglottis*, *Calochilus* and *Thelymitra* was retained in Orchidoideae with 100% support (Fraudenstein *et al.* 2004).

### **2. 4 Discovery of *Thelymitra* in New Zealand**

The type species of the genus, *Thelymitra longifolia* Forst f. was collected by Banks and Solander at Tolaga Bay, in the Gisborne area in 1776, the first orchid species collected, on Cook's first voyage to New Zealand. The first written account of this New Zealand orchid species was in manuscript handwritten from working notes by Dr Solander. He described the orchid as *Serapius regularis*, and though illustrated in the Banksian Plates, it was not fully described and validly published (St George and

Hatch 1994; Cooper 1981). This was the first description of the species which would be known as *Thelymitra longifolia*.

In *Characteres Generum Plantarum* 1776, Forster *et. al.* Forster described with illustrations, *longifolia* 1. *THELYMITRA* J.G.A. Forster. They then, in 1786, in *Florae Insularum Australium Prodramus* included the species as *Serapius regularis* for *Thelymitra longifolia*, indicating that the name *Serapius regularis* was uplifted from the manuscript of Dr Solander, then deceased (St George and Hatch 1994).

## **2.5 The Discovery of *T. matthewsii* in New Zealand**

*Thelymitra matthewsii* was discovered by R.H. Matthews the eldest son of the Reverend Joseph Matthews, who was the founder of the first mission at Kaitaia. The plant was collected from the foot of low ranges west of Tongong Lake on the 12<sup>th</sup> December 1904 (Hatch 1989). The lake no longer exists; its location was towards the coastal dunes between Kaitaia and Ahipara, and long modified by draining for agriculture. The first specimens of the species were sent to Cheeseman for identification. The type locality is given as Mangonui County – low hills between Lake Tongong and the Coast, R. H. Matthews, by Cooper (1981) and Moore and Edgar (1976).

Matthews sent Cheeseman more specimens up to 1909 and was delighted to hear from him that the orchid was a new species (Fig. 2.5) and would be named for him (Hatch 1989). *T. matthewsii* was not recorded again after 1914 when Cheeseman received the last specimen from the Matthews' family, but Herbarium sheets at Auckland show that specimens were still collected until the mid 1920s, presumably by Matthews' family members.

The growth form of *T. matthewsii* differs from other species of the genus. The plant is smaller in stature and the spiral leaf, coiled near the base of the stem is distinctive, as

is the usually single flower compared with *T. aff longifolia*, which may open up to 25 flowers on a stem (Fig. 2.4, Fig. 2.5).



Fig.2.4 *Thelymitra aff longifolia*, photographed in the North Cape Scientific reserve, an example of a *Thelymitra* species mode of growth..



Fig.2.5 The mode of growth of *T. matthewsii*, illustrating the smaller stature, single flower, and coiled leaf. Shenstone Block.

The type locality is given as Mangonui County- low hills between Lake Tongongee and the coast, R. H .Matthews, by Moore and Edgar (1976). Cooper (1981) cited in Moore and Edgar (1976) lists the type as missing. Hatch (1952) cited in Moore and Edgar (1976) gives a lectotype, Lake Tongongee 1911 H. B.Matthews, but Moore and Edgar regard this as a neotype since the collection date is after publication date. Described as known only from a few specimens from approximately the same locality, Moore and Edgar also note ' none found in recent years' (to 1976), and report

the synonym, *Rogers in Trans. Roy. Soc. Stih. Aust No.54 1930, p42, T daltonii*. This is different spelling from Rupp and Hatch (1946), who give *T. D'Altonii*.

The New Zealand plant Conservation Network (NZPCN) reported that, following the erroneous listing of *Thelymitra matthewsii* as a variety of *T. spiralis* (Lindl.) by APNI (2007), (Australian Plant Name Index), NZPCN would follow the advice of J. Jeanes of Melbourne Royal Botanic Gardens, who disagreed with the decision.

A single specimen in seed near the abandoned Serpentine mine in the North Cape Scientific Reserve was discovered by D. McCrae during an orchid survey of the Te Paki Farm Park in 1987 in the Far North. More appearances of the orchid in this area, and in areas adjacent to the research sites in Te Paki Farm Park, but nowhere else in Northland, have been documented since the initial re-discovery in the North, prior to and as a result of this research study.

## **2.6 Summary**

The great variety of flower forms in the Orchidaceae was influenced by the plant's adaptation to diverse habitats, in a range of geographical regions, and attributable to their specific attractants to pollinators.

Recent DNA phylogenic analysis has strengthened support for the classification of orchids away from the historical inclusion with Liliales to Asparagales, considered a closer relationship by Chase (2004). Chase had reported that the position of orchids in Monocotyledons was always speculative and that the family was difficult to place clearly, even with DNA data. He considered however, that orchids fitted well with Asparagales morphologically. Cameron *et al* (1999) cited Dressler (1993), as conceding that orchid systematics still contained questions that were important and remained unanswered. The use of DNA techniques to elucidate relationships is receiving increased attention but the spate of changes at species level can be a cause of confusion. The genus *Thelymitra* has so far escaped attention apart from addition

of putative new species. The most recent classification places *Thelymitra* with terrestrial orchid genera which are represented in New Zealand and Australia.

The lack of fossil evidence of the Orchidaceae, due to the fleshy nature of the plants and the absence of resistance to decay, influences resolution of the time of the family's emergence, as a fossil record contributes to knowledge of the evolution and divergence of plant families. The orchid has a long history however from the writing of early herbalists and botanists. References appeared among some of the earliest recordings of plants in literature, due to the orchid's perceived medicinal properties, and as a traditional source of food (Berliocchi 2001).

It is clear that *Thelymitra* is distinctive among Orchidaceae. Terms describing column configuration are exclusive to *Thelymitra* as the column is the most diagnostic feature at species level. *Thelymitra longifolia* has significance in New Zealand floral history as a specimen of it was the first orchid collected and described. R. H. Matthews who discovered *T. matthewsii* near Kaitaia, (for whom the species is named) was an avid collector of orchids and several species were recorded by him, now rare in New Zealand and no longer present in the areas he surveyed. The re-discovery of the species in the Far North established that *T. matthewsii* was not extinct in New Zealand, as had been presumed before then.

The Genus *Thelymitra* stands out among the orchids with the flower's often clear blue colouring, comparatively uncommon in the Orchidaceae, and actinomorphic perianth which prompted Dressler (1990) to raise the question as to what evolutionary selection process resulted in their un-orchid like form.

## CHAPTER THREE

### **The Study Region**

#### **3.1 Introduction**

Plant species distribution is a combination of biotic and abiotic factors in a complex interaction. Climate can have an influence over time and space, for example drought periods or stormy weather causing large scale erosion. Geology plays a part in substrate and nutrient balance. Several key aspects of site suitability to a species were considered by (Mitchell 1991). When edaphic conditions were favourable, establishment of a species would still depend on stochastic and biological processes. The probability of these acting deleteriously together was low. Specific interaction between the components of what could be a suitable environment for a species becomes critical towards the margin of the species range. Local topography may have a strong influence on climatic features such as temperature and wind, and render many predictable sites unsuitable. If a species is site specific, for instance to temperature, at the southern limit of distribution the correct combination of factors becomes rare, so abundance is reduced (Mitchell 1991).

In this chapter the geology and climate of the study region of *Thelymitra matthewsii* are described. Land tenure and an in depth description of each of the study sites is included with a general reference to associated vegetation. The structure and species composition of the vegetation is addressed in the vegetation survey to be described in Chapter 6 of this thesis.

#### **3.2 Known distribution of *T. matthewsii***

The study species *Thelymitra matthewsii* was previously known only from records early in the 20<sup>th</sup> century and considered extinct in New Zealand (Given 1981; Johns and Molloy 1983) Historical references recorded the presence of the study species near Kaitaia, Northland, prior to 1914 and seventy three years later, in 1987 at the

North Cape. Previous to this re-discovery (McCrae 1988) the species was known only from these early records. Perusal of historic and current orchid texts, and examination of material held in the herbarium at Auckland Museum (AK) confirmed the known current distribution of the species was in the vicinity of Kaitaia in the Aupori Ecological Region and District.

### **3.3 Regional distribution.**

Visits by members of the New Zealand Native Orchid Group were being made annually from 1997 to the present (2007) to the Te Pahi region to examine the rich terrestrial orchid flora of the heath-lands, which support nearly all the species of New Zealand orchid genera, including those considered confined to Northland. As a result, three sites supporting populations of *Thelymitra matthewsii* were discovered, at ‘Rubbish Dump’ hill near the Cape Reinga road, in the Shenstone Block, part of Te Pahi farm Park, and near the West Coast, adjacent to the Cape Reinga Walkway, which were new localities for the species. Familiarity with the habitat requirements of the target species led to extensive assessment of apparently suitable habitat adjacent to the known areas in the Te Pahi region by the author and companions. No further population sites have been observed to date.

Matthews’ 1910 description of the collection site of the specimens sent to Cheeseman for identification described ‘low hills between the Lake (Tongongee) and the sea’ (Hatch 1989). Though now in pasture, the ‘low hills’ probably were on dune substrate and had heath vegetation cover (Elliot 1998) similar to the present locations of populations in the heath lands further north. Without confirmation of a reported recording of the species near Kaitaia in c. 2003 the species is still considered absent from there.

### 3.4 Regional description

The study region is located at the northern end of the Aupouri Peninsula, North Island, between Latitude 34° 23'S and 34° 33'S and longitude 172° 38' E and 173° 33'E a location referred to as the Far North. The region is traversed by the Cape Reinga and Spirits Bay roads. Other access is by walking track and off road vehicles tracks .A map, Fig. 3.1 details the location of the study region and includes the study sites (Topographical Map 260 MO2 and NO2 1999).

Some of the earliest descriptions of the vegetation of the Far North came from Missionary travelers, *Colenso 1839*, *Richard Taylor 1841* (Mead 1966) *Dieffenbach 1843* (Elliot 1988) and *R. H. Matthews* (Carse 1910). Their descriptions, including those of Cheeseman, all alluded to the dreariness of the country side in what was described as a little known area.

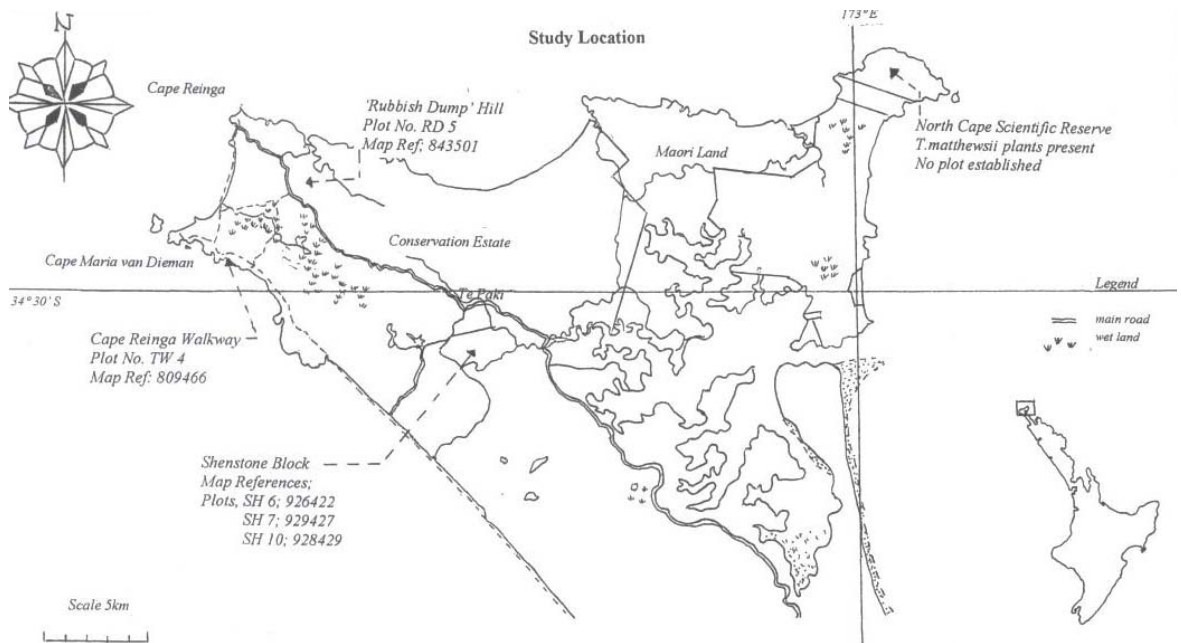


Fig. 3 1 Map of the Far North of the North Island showing location of sites supporting *T. matthewsii* plants monitored in the study. New Zealand Topographical map 260 MO2 and NO 2

Leitch (1970) cited Dieffenbach 1843, Hector 1866, and McKay's 1894 work among early geological observations of the Far North area. He also observed that Bartrum and Turner's 1928 stratigraphy was essentially the same as that currently recognized.

### 3.5 Regional Geology

The geology of the Far North of New Zealand is characterized by the long narrow tombolo of Pleistocene, semi and unconsolidated sands connecting the North Cape – Cape Reinga block and the main Northland area (Enright *et al.* 1988; Newham *et al.* 1993; Ogden *et al.* 1991; Ogden *et al.* 1993). Cretaceous to Tertiary in age the altered basalts and pillow lavas in the North Cape district were intruded by the faulted Kerr Pluton of serpentinitised peridotite, and gabbros cut by acid dykes (Leitch 1970; (Brook & Thrasher 1991). The wide-spread pillow lavas and absence of plant remains indicate a marine environment eruptive phase ( Leitch (1970).



Fig. 3.2 Wind and water eroded site on the lateritic soils of the North Cape Scientific Reserve. Field assistants are observing a plant of *Thelymitra matthewsii* located there.

A striking feature of the region is the dissected remnant plain up to 300m a. s. l. producing high rugged cliffs to the North and East. (Bartrum & Turner 1928) The long erosion period planed down the erupted beds and exposed the peridotites near North Cape (Fig 3.2). Following emergence in the North Cape and Cape Maria van Dieman areas, the older rocks were buried by extensive wind blown sand (Kear and Hay 1961; (Enright *et al.* 1988).

During the late Miocene the Peninsula was probably partly submerged by transgression of high sea-levels during inter-glacials and in the Pliocene the ancient archipelago of the far north was separated from Ahipara on the mainland by sea. Progradation of sand, a product of voluminous resources rafted along the coast by wave action linked the archipelago by sand bars (Healy & Kirk 1992; Schofield 1969).

The sand deposits of the Aupouri Peninsula were grouped into two broad lithostratigraphic complexes by Brook & Thrasher (1991). The older weakly cemented Pliocene to mid Pleistocene age sands of Aeolian origin, unconformably overlie the Cretaceous rocks. A younger sand unit overlies this unit and comprises mostly Aeolian dune consisting of topographically irregularly cemented sandy paleosols separating areas of weakly cemented sand. Sandy paleosols fix the upper exposed surface of the dunes. Where dunes are not cemented they have sharp crests and blow-outs are common. They are inferred to be a post glacial to late Holocene accumulation (Brook and Thrasher 1991).

Soils on the Tertiary volcanics are moderately well drained red brown clays. These deeply weathered rocks with deep clay sub soils are the result of the warm wet climate and easily broken down mineral constituents of the parent material. Instability of slope is a characteristic of these soils. Soils on the sandstones are podsolised poorly drained loams. Development of soils in the Quarternary sands and degree of podsolisation were governed by deposition age and drainage (Healy & Kirk 1992).

The podsolized soils commonly followed Kauri (*Agathis australis*) known to have been present over most of the Far North by the presence of kauri gum. Enright (1989) reported the soils were nutrient deficient and drainage was impeded by the organic horizon. The mineral deficiency of the soils encouraged heathland vegetation and the associations there that followed the forests were distinctive in New Zealand in structure and species composition (Enright 1989).

Common along the North West coast are Pleistocene coastal barriers that are leached and weathered, slightly lithified and exhibiting a distinctive orange brown mottled colouration. Healy and Kirk noted these barriers were relatively unusual compared with world shore lines (Healy and Kirk 1992). Quartz content of mainly angular grains, averaged 60% in the extensive North West coast lightly cemented dune sands. Mafic minerals accounted for ~ 1%. Potassium feldspar crystals were relatively abundant compared with dunes adjacent to 90 mile Beach (Schofield 1969). Clay content in the late Quarternary was found by Schofield to increase with age and decrease with depth.

### **3. 6 Regional Climate**

The climate of the North Cape and Cape Reinga region is strongly influenced by its modifying maritime location. The comparatively low elevation of less than 150m, of much of the tombolo forming the peninsula, its position north of 35 degrees South, contributes to the mild but often humid and windy climate (Dodson *et al.* 1988; Enright *et al.* 1988; Moir *et al.* 1986; Ogden *et al.* 1991).

About 50% of possible sun shine that could be recorded at a site is received in the region, generally uniformly throughout the North at 2000 hours bright sun, with maximum hours in December and January (Moir *et al.* 1986; Ogden *et al.* 1991). Moir (1986) showed the temperature range at Cape Reinga has the smallest variation of any New Zealand Station from 5.6 degrees C in January to 4.3 degrees C in June. Temperatures may be slightly above normal for long periods. Moir *et al.* reported

mean annual temperatures varied from 15.5-16 degrees C over the Aupouri peninsula, air temperature decreasing 0.6 degrees C on average for each 100m of elevation. This variation would affect the hilly country of the northern uplands which rise to 200m a.s.l.

Humidity was generally high in all seasons particularly in the West and average vapour pressure was lowest in winter and early spring, (Moir *et al.* 1986; Ogden *et al.* 1991) but was reported to vary greatly with air mass and source. Water vapour pressure and relative humidity are variables that indicate atmospheric moisture levels. Table 3.1 and Table 3.2 are reproduced from Moir, *et al.* (1986), showing comparative climatic data for the region compared with that at Kaitaia.

*Fig.3.1 Table of monthly percent of relative humidity including yearly averages, at Cape Reinga and Kaitaia Airport.*

Sites	Jan	Feb	May	June	Aug	Sep	Nov	Dec	Year av.
Cape Reinga %	85	86	86	87	85	86	85	84	85
Kaitaia airport %	75	79	87	89	87	82	77	75	82

Maximum rainfall was recorded from June to August. Monthly variability was a marked characteristic of Northland rainfall regime (Moir *et al.* 1986). Dry spells were not uncommon most likely in summer and autumn. Depressions which may originate as a tropical cyclone and track close to Northland create stormy winds and heavy rain contributing to extensive erosion in susceptible exposed areas (McCrae 1988).

Weather systems such as anti cyclones crossing New Zealand are more often to the south of Northland, with south easterly winds following the trough. Anti cyclone replacement occurs when the system becomes stationary and the following cold front

remains south of it. A succession of similar systems maintained cloudy weather and little or no rain. The winds tended to remain longer in the Easterly quarter. The wind change was to the South west when anti cyclones pass to the north of New Zealand (Moir *et al.* 1986).

Wind regimes differ with contrasting aspects. The high exposed volcanic massifs contrasted with the rolling dune formation contribute to the variable regime. The proportion of Easterly winds in the summer were about equal to the South westerly which is the predominant winter and spring air flow. Sea breezes added to the summer proportion particularly when a temperature gradient between land and sea occurs. In coastal locations, mean annual wind speeds were among the highest in New Zealand (Moir *et al.* 1986).

*Table 3.2 Table of strong winds (a) and calm (b) periods as a percentage of annual totals at Cape Reinga compared with that at Kaitaia Airport. e.g. 18% of strong winds recorded at Cape Reinga occurred in summer. Adapted from Moir et al. (1986)*

Sites		Summer	Autumn	Winter	Spring
Cape Reinga	a	18%	25%	31%	26%
	b	27%	28%	23%	22%
Kaitaia airport	a	19%	22%	31%	27%
	b	28%	28%	22%	22%

### **3.7 Regional Vegetation**

The pre european vegetation of the Far North was considered little known (Dodson *et al.* 1988; Enright *et al.* 1988). Pollen diagrams from swamp profiles in the region recorded conifer-angiosperm forest (including *Agathis* and *Nothofagus*) for the past 17000 years. Carbon dates reinforced the suggestion that the region could have been a site of refugia for forest species during the last glacial period (Newnham *et al.* 1991).

Evidence from the swamp pollen profiles indicated that the forests would have been Kauri hardwood forest. Kauri gum and *Metrosideros* wood fragments support the premise (Dodson *et al.* 1988). Also evident in the profiles was the charcoal of subsequent fires both pre and post human settlement, which probably contributed to the development of the heath land of sclerophyllus species and rushes. Slow regeneration of forest species and large areas of dune sand were almost certainly fire induced.



*Fig. 3.3 Mount Herangi, Cape Maria van Dieman. As sub fossil shells of snail species are common on the sandy slopes, (Enright et al 1988) forest vegetation would have been present. The slopes are being further denuded by encroaching sand.*

There was an historical increase in the frequency of fire during the last 600-800 years with a corresponding change from forest to grassland. Coastal dunes may have been destabilized by vegetation destruction (Dodson *et al.* 1988; Enright *et al.* 1988; Fleming 1989; Newnham *et al.* 1991; Ogden *et al.* 1993). The presence of sub fossil flax snail shells, *Placostylus ambiguus priseus* Powell, and wood remains from Te Paengarehia beach to Cape Maria van Dieman was considered by Enright *et al.* (1988) to reinforce the evidence that destruction of forest led to sand mobilization (Fig.3.3).

*Leptospermum sp.* dominant and generally species poor, heathlands are referred to as gum land scrub (Cockayne 1919; Enright *et al.* 1988; Dodson *et al.* 1988; Newnham *et al.* 1991; Ogden *et al.* 1993). The nature and botanical composition of the gum lands suggest it could be the climax vegetation. The term heath removes the implication that the vegetation was a succession to returning forest. (McLean *et al.* 1985) These authors considered there was a clear relationship between species composition and soil type. A difference is evident between vegetation on volcanic derived soils and sedimentary parent material. Species found as dominants on the volcanic clays of the uplands were species common to regenerating bush (Fig. 3.4) i.e. *Knightia*, *Phormium*, and *Myrsine* species and Araliaceae genera. Epacridaceae species and sedges are rare or do not appear in forest regeneration and are heath land species. A table of species at each monitored site is included in Chapter Six.



*Fig.3.4 Vegetation of a ridge on the volcanic uplands showing the 'island' effect of regeneration of predominantly pre-forest species, after fire*

The same relationship to soil type also occurs with adventive exotic species. For example, *Hakea gibbosa* and *H. sericea*, colonized sandstone but McLean *et al.* note that they did not occur together, and that *H. gibbosa* was almost completely absent from volcanic soils (McLean *et al.* 1985). The last two notes were contrary to observations in this study. This suggests a possibly more recent invasion of these species in the volcanic derived up land areas.

### **3.8 Land tenure**

The study sites are located within the Conservation Estate which includes Te Paki Farm Park an area of 23,000 ha (Malcolm 1986), in the Far North of the Aupouri peninsula. The Conservation Estate is administered by the Department of Conservation, Northland Conservancy, from Kaitaia Area Office and Te Paki Field Centre. The Conservation Estate extends to Cape Reinga, the traditional stepping off place of Maori spirits beginning their journey to the Underworld (Mitcalfe 1981), and includes the North Cape Scientific Reserve in the north east of the peninsula, separated from it by tracts of Maori land.

The Te Paki Area has been historically farmed. Consequently much of the local shrub land habitat was converted to pasture over a period of many years. The farmland is leased by the Department of Conservation to the Parengarenga Corporation, of Te Aupouri and Ngati Kuri, local Iwi of Muriwhenua, who employ a manager and farm staff. Reclamation of areas for pasture has ceased.

### **3.9 Study Sites Description**

#### **3.9.1 Methodology**

A permit to carry out the study was applied for and granted by the Department of Conservation, Kaitaia Area Office. Iwi were advised in accordance with requirements of the permit. Monthly reports of the work carried out at each visit were submitted to the Department of Conservation at Kaitaia and Te Paki Field Centre.

A survey of known areas supporting *T. matthewsi* plants was made at commencement of the study in 2002. Study sites TW4, RD5, SH6, SH7, SH10, were established where a reasonable number of plants within a manageable area were found. At two of these sites, TW4 near the coastal walkway and RD5 on the volcanic upland, study sites selected were the only populations present.

Notes were made of site location, aspect and altitude. Substrate and associated vegetation was observed and included in site data. The effect of adjacent topography was assessed. Photographs were taken to illustrate the location and habitat of the study sites. A map reference was substituted for GPS readings in the interest of future security for this species.

Comparable data for each site in the study is listed in Table 3.3. Three vegetation only sites not supporting *T. matthewsii* plants (TW5, RD6, and SH12) were included for a comparison of sites supporting the species and sites that did not. A full description of vegetation parameters for all the study sites is addressed in Chapter Six of this thesis.

### **3.9.2 Study Site TW 4**

This study site was established to encompass the only known population of the target species at this site in 2002. The site is located adjacent to, and on the coastal side of the Cape Reinga Walkway, North West towards Cape Maria van Dieman from the track junction near Te Paengarehia (Twilight) Beach. The site was orientated to the north but sheltered on the North and East by clumped, moderately dense, ~1m tall vegetation. It was therefore more shaded than other sites in the study, and had the lowest altitude of the study at 90m above sea level. The substrate was consolidated sand, the slightly lithified distinctively orange brown mottled Pleistocene coastal barrier, the substrate described by Healy and Kirk (1992) (Fig.3.5).

Table 3.3 Study sites, location, vegetation and substrate summary. \* Sites with *T. matthewsii* populations.

Site	Location	Aspect	Substrate	Vegetation
TW4 *	West of Cape Reinga Walkway	Facing NE	Consolidated old dune. Ground cover Moss, lichen Litter copius	Height 0.5 1m plus heath species. Densely sheltering shading site
RD5 *	Rubbish Dump hill Reinga road	Faces NE Erosion slope	Weathered volcanic clay. Water wash Ground cover Moss, lichen to 60%	Height 0.3 1m Heath species woody Dense NW side and scattered
SH6 *	Shenstone Block Te Pahi Farm Park	N facing Exposed dune crest	Bare sand. Consolidated sand boulders. Lichen common	Height low to 1m plus <i>Kunzea</i> /heath dense E side, otherwise scattered
SH7 *	Shenstone Block Te Pahi Farm Park	North facing dune slope	Bare sand, slope angle low. Major wind erosion. Litter heavy under margin vegetation	Height >1m, S and E, scattered elsewhere Heath, <i>Kunzea/Hakea</i> encroaching site
SH10 *	Shenstone Block Te Pahi Farm Park	N-NE facing Exposed dune crest	Bare rubbly sand light to mod. Consolidated. Adjacent to major wind erosion	Height <1m. Heath species. Dead branches common. Veg. more dense up-slope
TW5	West of Cape Reinga walkway	N facing open	Bare areas. Old hard surfaced dune sand Lichen, moss, dead branches	Height < 1m. Heath/Hakea sp. Density greatest N and W. Seedlings and annual weeds
RD6	Rubbish Dump hill Cape Reinga road	North facing mid-slope	Weathered volcanic clay. Water wash sediment. Moss, lichen, litter	Height < to > 1m . Heath sp. <i>Kunzea</i> .dense N&W seedlings common
SH12	Shenstone Block Te Pahi Farm Park	NE facing dune slope	Bare sand and litter sand boulders slope angle low Surface broken	Height < 1m. Heath species dense to scattered. Copius small species and seedlings

The elevated (115m) land form shelters the site TW4 from salt laden winds. The orchid plants colonise the compact substrate which is resistant to the insertion of labels to any depth.



*Fig.3.5 Part of the weathered indurated sandstones of old dunes aligned along the North West coast of the Far North of New Zealand.*

The site was comparatively sheltered although surrounding topography was low to the North and East, exposing the site to winds from those quarters. Drainage was impeded by the compacted substrate and run-off in heavy rain on adjacent slopes is considerable (personal observation).

The vegetation consisted of heath species with a coastal influence. Mosses and lichens were common at the site because of the shade effect of taller vegetation on the north and eastern sides.

### 3.9.3 Study Site RD 5

The site with the greater numbers of two small groups of plants was designated for the study site. The second group disappeared shortly afterwards under severe erosion. The site was situated on a small flat promontory near the top of an eroded sloping face on the volcanic up lands, the obverse of a ridge above Cape Reinga Road, locally referred to as ‘Rubbish Dump’ hill. (Fig.3.6) The site was exposed to the North and East and experiences frequent strong winds, and at 191m above sea level was the highest in the study. This site was the only one in the present study located on the deeply weathered feldspathic clays of volcanic origin. The clays are sticky when wet and bake hard when dry.



*Fig.3.6. Deeply weathered clays on exposed ridge slopes of Rubbish Dump hill adjacent to the Cape Reinga road. Te Pahi Farm Park pasture land visible in the distance.*

Constant winds were common and damage the substrate removing softer surface sediments. The site was naturally hot and dry in summer drought. Sea breezes were often present. Rainfall, particularly cyclonic conditions from the North and East

(Moir *et al.* 1986; McCrae 1988) cause wide-spread erosion, outwash sediments re-filling eroded areas. The vegetation composition of the surrounding area suggests species in a succession back to forest, for example broad leaf species and tree ferns but some heath land elements are present, Epacrids, *Morelotia* and the adventive *Hakea* species.

#### 3.9.4 Study Site SH 6

This site was one of the three remaining sites in the study which were located in the Shenstone Block an area of shrub land, part of Te Paki Farm Park (Fig. 3.7). Weakly consolidated recent dune sand ridges are interspersed with swamps. Many recent and stabilised blow-outs, an area, generally near a ridge where a broken surface allows the wind to escalate erosion (cf. Fig 3.8) scar the dune crests, burying vegetation with blown sand. The block is bounded by farmland except in the South where it is replaced by large mobile dunes devoid of vegetation. The vegetation of the Shenstone block was dominated by dense *Leptospermum scoparium* scrub interspersed with heath land species, and co-dominant *Hakea* species. The target orchid species was found in scattered groups throughout the area. Those sites supporting the greater number of plants within the site size were selected for study. Access is by Te Paki stream road, off road vehicle and walking tracks.

Study site SH 6 was an exposed site in a semi stabilized wind eroded blow at the crest of a dune ridge at an altitude of 116m. The site faces to the north and became very hot and dry when those climatic conditions prevailed.

The substrate was loose sand with weakly consolidated ‘boulders’ broken from the higher ground, scattered throughout. The site was relatively steep with an approximately 60 degree slope to the top of the blow, which shelters it from the south and east. The topography on the north and west fell down slope to a valley swamp.



*Fig.3.7 Lightly cemented younger dune crests and slopes exposed between groups of heath vegetation in the Shenstone Block Te Pahi Farm park.*

Vegetation in the study site was sparse and affected by the presumably extreme lack of nutrient in the sand. Some larger *Kunzia ericoides* mark the eastern edge of the site and lichens were prolific on the cemented sand.

#### **3.9.5 Study Site SH 7**

This site was also situated in a semi- stabilised sand blow out and over looks the farm on the slope of a dune ridge on the north eastern boundary of the Shenstone Block. This was a warm sheltered site which also dries out when soil moisture content is low. Open to the north and east the site was protected from southerly and westerly winds by the remnant banks of the wind blow. Blown sand filled the basin of the site which was gently sloping. The substrate was sand with the characteristic, weakly cemented, lichen colonised ‘boulders’ common to these locations. Dense, tall vegetation of heath species, *Kunzea ericoides*, *Cyathodes juniperina* and *Hakea*

*gibbosa* filled the sheltered side of the site and was encroaching into the plot area. The altitude was 118m above sea level.

### 3.9.6 Study Site SH 10

This was probably the most harshly situated site in the study, at the exposed top edge of a large semi-active sand blow (Fig. 3.8). The site was situated in full sun and experiences winds from all quarters, though less from the south, where a little shelter was afforded by the clumped low vegetation. The altitude was 120m, and the site was gently sloping.



*Fig.3.8 Typical habitat of the remaining study sites in partly stabilized blowout in the lightly cemented sand of the Shenstone Block Te Pahi Farm Park.*

The substrate, a type of ‘rubbly’ sand weakly consolidated, is easily broken down by trampling, and blown sand from the near-by sand blow is progressively burying

adjacent vegetation (Fig 3.9). Water washed sand fills the lower part of the eroded site which was on the slope of the dune.

Although the *T. matthewsii* was present in the North Cape Scientific Reserve, a study site could not be established there because of access difficulties at the commencement of this research project. Access to this remote site and to the monitored sites has been facilitated by Department of Conservation Staff at Kaitaia and Te Paki field Centre, and by the Manager of Te Paki Farm Park, since that time, to record the continued presence of *T. matthewsii* there.



*Fig.3.9 A view of recently blown sand, (within the period of monitoring) burying vegetation, but providing new habitat. A plant of T. matthewsii appears at the left of the fore ground vegetation. Also visible is a sand boulder common in the Shenstone habitats.*

### 3.10 Summary

The habitat, with which the monitored species in this study was associated, is consistent with historic and extant geological and climatic factors.

Historic early geological history of submarine volcanics, intruded and uplifted to form islands, later linked by the tombolo of wind borne, and ocean build-up of sand is represented today by the high and often rocky land to the North and northwest, and the gently rolling subdued topography of the long tombolo extending to mainland north at Awanui near Kaitaia.

Proximity to the sea and extension into lower latitudes influences a mild to warm climate, but also exposes the land to storms and strong winds. The result is a diversity of habitat exploited by terrestrial orchids, particularly in areas not yet modified by farming or forest planting and associated with a typical Mediterranean type heath land of shrub species on low nutrient soils.

Fires, both natural and from early colonization, are recognized as having had a modifying effect on historic vegetation, allowing mobilisation of sand by wind. Charcoal in pollen profiles attested to the presence of forest before heath land species became dominant.

All types of substrate in the area, lateritic and basic soils, volcanic clays, indurated sand stones and mobile and lightly consolidated dune sand were found to be exploited by *Thelymitra matthewsii* (Note table of site comparisons Table 3.3). Study sites were of necessity chosen arbitrarily to enclose populations that were known to be present to enable data that was meaningful for analysis, to be obtained.

This study has augmented the known populations of this distinctive species of orchid and evidence that it is only found in that area and tolerates every dry-land substrate in

the Far North, indicates that climatic warmth might be a deciding factor in its distribution.

Although a large percentage of the Far North heath lands have been converted to pasture, the remaining areas are under Conservation jurisdiction. It is imperative that what remains is conserved, not only because of the distinctive land forms in the area, but also for the characteristic vegetation, little of which remains elsewhere in New Zealand.

## CHAPTER FOUR

### **Morphology and Phenology of *Thelymitra matthewsii***

#### **4.1 Introduction.**

Plant morphology, including structure and diagnostic features, is a means of describing one species as distinct from another. In determining morphological features of a species, natural physical variation will be evident. Colour, for example, especially flower colour, is not a reliable diagnostic feature but is often taken into account. Characters that remain consistent within a species and are diagnostically reliable, such as column configuration in *Thelymitra*, is definitive, and identification can then be approached with confidence (Irwin 1990).

Features of morphology of orchids include growth habit, roots, stem and leaf, including stem bracts, flower structure and orientation, and shape and size of capsule. Dressler (1990) also stressed that details of structure were necessary for understanding ecological diversity, pollination and evolution in the Orchidaceae.

Phenology is the manifestation of the organism's response to the environment. Smith and Smith (2001) defined phenology as a study of the causes of seasonal changes, leaf unfolding, and flower blooming and the timing of these events, the biotic and abiotic effects, and the interrelation among species. The study of species phenology is achieved by a commitment to population census. The knowledge gained is enhanced by observations conducted over a period of time during the seasonal appearance of the species, and necessary for physiological study. It enables a sound understanding of population biology to be made on a factual rather than an anecdotal basis (Sanger and Waite 1998). Features of the phenology of a species, in relation to orchids, are the timing of emergence and senescence; flowering, utilization of potential or obligate pollinators and successful seed production, and tuber hibernation.

Extant descriptions of morphological characteristics of *Thelymitra matthewsii* reflect those published in formal literature, for example, Moore and Edgar (1976), who described a plant at flowering, the spiral leaf inflated about the stem and the striped flower. No reference is made to other life stages particularly those attributed to juveniles in which the leaf was found to be not inflated about the stem. These and phenological properties of *T. matthewsii* have been enhanced by observations throughout the study during the population demographic data collection and by the habitat study in the vegetation survey.

This chapter describes features of growth and morphology of *Thelymitra matthewsii* that have been elucidated by the population census described in Chapter Five, and by microscopic examination. New material is introduced to describe the morphology of putative juvenile stages of the species.

#### **4.2 Methodology**

Two different life stages, a spiral stage and a non-flowering example of putative juvenile *Thelymitra matthewsii* plants were collected by digging them up on August 18<sup>th</sup> 2004. Collection was covered by the permit issued by the Department of Conservation, Kaitaia, for the research study. A white plastic label identified the collection site, as plants selected were outside the labeled population demography sites. Samples were placed in labeled zip lock bags with a small amount of substrate and held under refrigeration pending examination under a dissecting microscope at the University of Waikato Herbarium. Samples were examined using 40x Microscope magnification, and notes made of characters revealed.

Following examination and description, plants were photographed and kept under refrigeration in their original bags until the next monthly demography data collection in September, 2004. The plants were then returned to the collection sites and replanted. Copies of photographs of the juvenile life stages were submitted to Auckland Herbarium for inclusion in their collection.

These were entered as AK 19876 (Cameron 2004) (pers. comm.) A copy was included in the collection of voucher specimens submitted to the Waikato Herbarium as part of this study (Appendix 3).

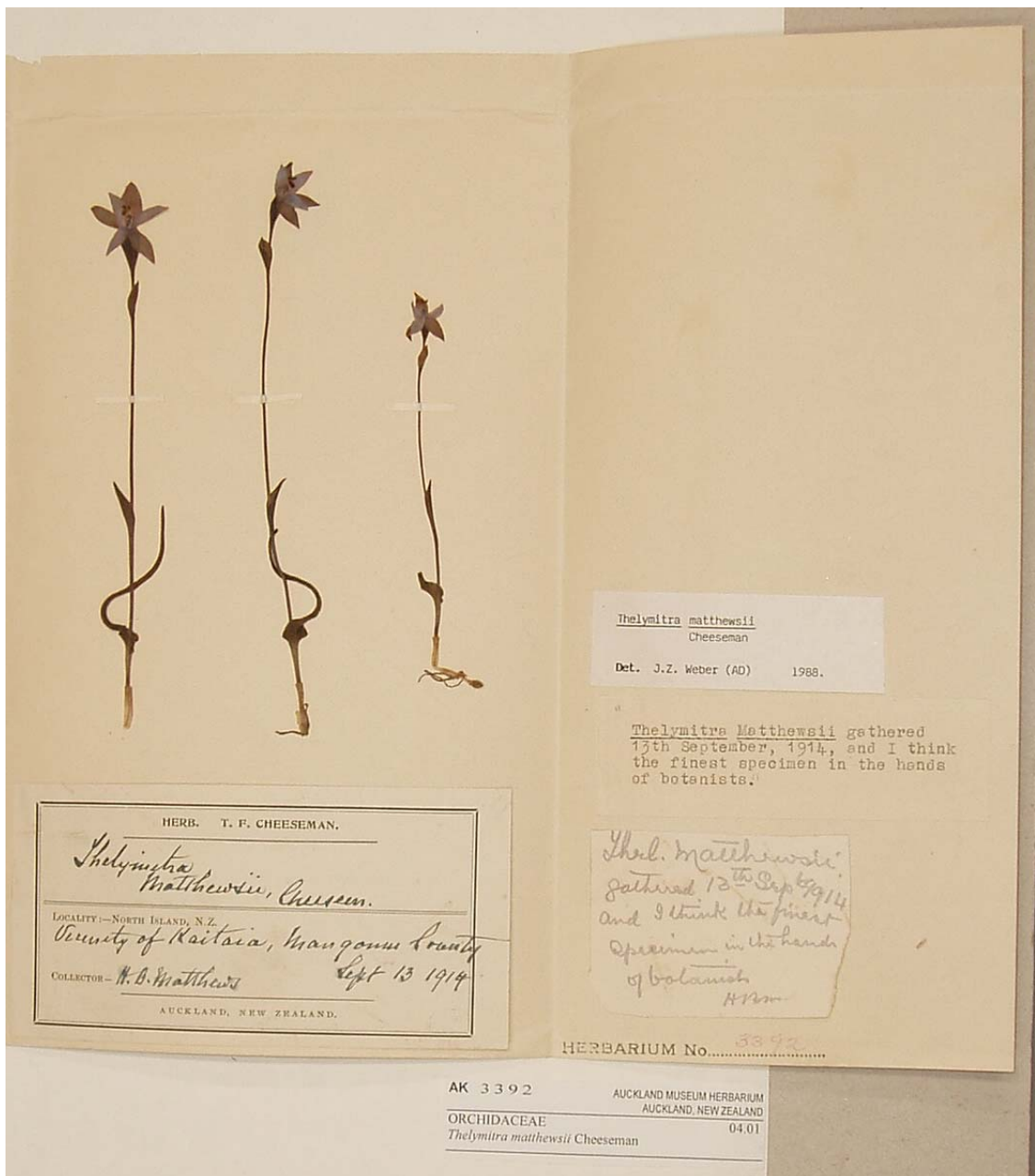


Fig.4.1 A Facsimile of Cheeseman's Herbarium sheet of *Thelymitra matthewsii* with courtesy of E.Cameron, Curator of the Auckland Museum Herbarium.

Details of Herbarium sheets of *Thelymitra matthewsii* held at Auckland Herbarium including those of Cheeseman's collection, (Fig 4.1) and studied with the Curator's assistance, are presented in Table 4.1.

*Table 4.1 Herbarium Sheets of T. matthewsii held at Auckland Herbarium, and studied for this research with the Curator's assistance.*

Accession No.	Collector	Date	Location
AK 25890 Eco code 04.01	H.B. Matthews	Sep. 1911	New Zealand North Island Aupouri Ecological Region and District Kaitaia
AK 3392 Eco code 04.01	H.B. Matthews	Sep 1914	New Zealand North Island Aupouri Ecological Region and District Kaitaia
AK 22817 Eco code 0401	R.H and H.B Matthews	Sep 1914	New Zealand North Island Aupouri Ecological Region and District. West of Lake Tangonge
AK 70809 Eco code 04.01	R.H and H.B. Matthews	Sep. 1914	New Zealand North Island Aupouri Ecological Region and District. West of Lake Tangonge
AK 225967 Eco code 03.01	E. K. Cameron	Oct. 1995	New Zealand North Island Aupouri Ecological Region and District. North Cape Scientific Reserve Surville Cliffs
AK 200219 Eco code 04.01	H.B. Matthews	Sep. 1923	New Zealand North Island Aupouri Ecological region and District. Kaitati
AK 25889 Eco code 04.01	H.B. Matthews	Nov. 1912	New Zealand North Island Aupouri Ecological Region and District. Kaitaia
AK 25891 Eco code 90.60	W.H Nicolls 211	Oct. 1933	Australia, Victoria Ararat

Flowers were not collected for description, but advantage was taken of a broken off stem carrying a bud, to provide an opportunity for examination and dissection under the microscope, at the University of Waikato Herbarium. Open flowers in the field had also been examined for characteristics during the research period, and notes compiled at data collection were sourced for observed morphological characters.

### 4.3 Results

The non flowering juvenile stages of *Thelymitra matthewsii* are described from microscopic examination.

**Sample one**, Fig 4.2 non flowering stage.

*Plant tubers*, Two, consisting of one previous season's and one present season's tubers. Previous season, 6.6mm long, 3.9mm diameter, slight signs of withering, root hairs sparse, texture glassy.

New season's tuber, size 7.17mm long, 4.8mm diameter, darker in colour. *Roots*, Three to four in number, orientated vertically, towards the surface, 15.76mm – 14.09mm long. Roots pale coloured, slightly fleshy. Stem from top of tuber to sheath junction 19.6mm.

*Leaf*: The single leaf is ***not inflated at the base*** but rises smoothly from the junction with the stem sheath that enclosed the growing point above the tuber, 1.2mm wide 35.6mm long. Loosely spiraled (three whorls), hairs reduced in upper part. Lamina margins thickened, not in-rolled.

The words “not inflated at the base’ are bold above to emphasise the difference between the juvenile leaf and the leaf of the flowering plant which is inflated at the base, the only condition given in formal descriptions of the plant.



*Fig 4.2 A photograph of the non-flowering juvenile life stage described above. The distinctive spiral leaf is evident and the plant is robust. This is the largest juvenile life stage. Scale = cm*

**Sample two**, a spiral life stage Fig 4.3

*Plant Tubers*, two, previous season, 4.96mm long, 3.05mm in diameter, slightly withered and darker in colour; new season's tuber, 5.84mm long, 3.9mm in diameter. Tubers smaller than in the previous life stage described above.

*Roots*. Four in number, 19.8 mm and 3.7 mm long, 0.9 mm in diameter. Stem from the top of the new tuber 15.0 mm, sheathed with tissue of previous tuber stem. Stem and roots partially hairy.

*Leaf*. The single leaf is not inflated at the base as above, 13mm long, lamina spiral turns shorter, 0.72mm diameter. Margins thickened not in-rolled, closely and densely covered with short white hairs, mainly on the edges.

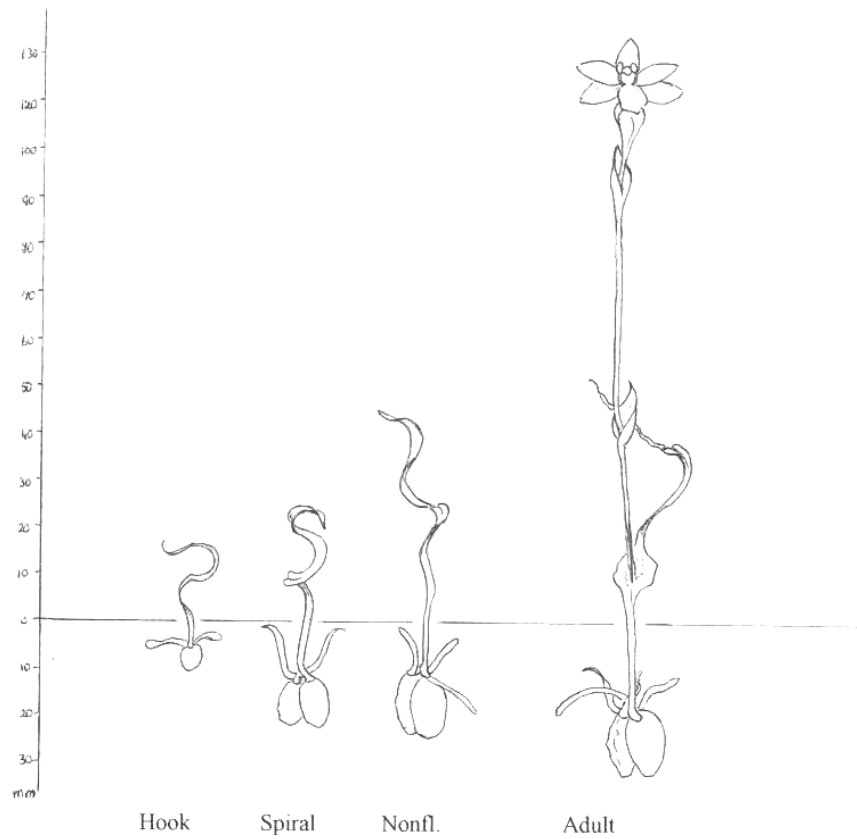


Fig 4.3 .The second collected juvenile, a spiral life stage, described above. The upward tending roots suggest search for moisture or mycorrhiza Note that the tubers are smaller than in the upper photograph and the spirals in the lamina shorter.

### **Morphology and Phenology of *T. matthewsii***

#### **Morphology**

This study has identified three pre-flowering life stages (Fig 4.4). The first life stage deemed to be the smallest tuber, puts up a slender leaf, hook like, without extra coils in the lamina. The next life stage present is considered to be an advanced stage, with presumably two tubers (Figs. 4.2 and 4.3), one extant and one of the previous season's production (Irwin 1990; Jones 1993; Cooper 1981). The leaf in this stage is coiled up to three times, not always in a perfect spiral but more closely coiled than in the larger non flowering stage, the third life stage, where the tubers were shown to be more robust (Fig 4.2).



*Fig4.4 Sketch of life stages of T. matthewsii as drawn from observation of life stages while monitoring the populations in Te Pahi Farm Park, by E.A.Fraser*

The leaf is also more robust, the coils more open and the plant achieved its greatest pre-flowering growth, up to 50mm in height. These pre-flowering juvenile stages have been found to alternate for several seasons and not produce an adult flowering individual.



*Fig.4.5 Life stages of T. matthewsii in the field. Two developing adult plants are visible at left, and the photograph includes non-flowering and spiral juvenile life stages. Cape Reinga walkway. The spiral life stage is smaller than the non flowering stage (0.6 natural size).*

The stages persist through a full growing season retaining and withering in initial morphology, therefore the plant does not develop into a more advanced life stage in a season (Figs. 4.5 and Fig. 4.6). These pre-flowering juvenile stages have been found to alternate between stages for several seasons and not produce an adult flowering individual. Demography results (Chapter 5) showed a small growth increment from emergence to senescence that did not obscure the emergent life form.



*Fig4.6 A view of the same group in Fig 4.5 showing the increase in adult height at monitoring two months later. The physical attributes of the juvenile stages have not changed. The label is ~60 mm above ground level.*

#### Morphology of flowering plants from field observation

Flowers appeared briefly, lasting open for one day. Colour varied slightly from a beautiful deep imperial purple, maturing to lavender blue. Petals and sepals were striped with a deeper colour and the dorsal side was shaded a pale mossy green, visible from the adaxial side of the flower.



*Fig4.7 Photograph of T. matthewsii, which shows to perfection, the colours of a newly opened flower. Figure shown is 0.75 natural size. Photographed in the Shenstone Block, September.*

Microscopic examination of the immature flower found broken off in the field revealed four very small, almost indistinguishable, glassy calli at the base of the anther cap and column arms. Jones (1993, 2006) described the column of *T. matthewsii* from Victoria and South Australia as having a dense ‘grape-like’ cluster

of calli (which he referred to as glands in 2006) at the back of the column, which was dissimilar to the observation made of the flowers examined.



*Fig.4.8 An adult plant with a maturing fertile capsule. Shenstone Block, Te Pahi Farm Park. (0.75 natural size)*

Capsules are top-shaped with the wider end above the centre, longitudinally ribbed and crowned with the withered perianth. They appear large for the slenderness of the stem which contributes to the species visibility at this stage of development. Stems

are pale and slender, the two stem bracts appearing large and projected slightly away from the stem. The upper bract is close to the ovary, the capsule elongating from it and enlarging after fertilization (Fig 4.8).

### Phenology

The species begins to emerge above the ground in the month of May, and continues to do so in the following months. Plants often appear as late as October.

The leaf of the adult plant producing a capsule is often blackened and disappears at dehiscence. Leaves of juvenile stages wither and turn brown as the season advances. They often lie dried and separated from, but at the site of the tuber. The incidence of withered leaves seems to increase with the approach of substrate to drought conditions

There is some evidence (personal observation) that plants flower later on the Scientific Reserve at North Cape. The initial rediscovery here (McCrae 1988) was of a fruiting plant in November. An open flower was seen there in 1995 by a group of Auckland Botanical Society members near the end of October (Herbarium Sheet Number AK225967 Table 4.1). Plants in the Te Paki area are senescent by then.

The small hook life stage was usually found clustered among plants present, or very occasionally a short distance away from the nearest previously monitored plant. There was some evidence during monitoring that seed was water dispersed, i.e. in sediment wash in run off areas and depressions, as in some sites plants have emerged in these deposition areas, suggesting that they might be favourable for colonization.

The flowering stem carrying a capsule does not elongate as some species of orchids do, for example species of the *Corybas* alliance (Johns and Molloy 1983; Irwin 1990; St George 1999) presumably to disperse seed to a greater advantage, but in *T.*

*matthewsii* stems were observed leaning away from directly above the mother tuber. Surveillance over a longer period of monitoring would establish whether this is a physiological trait. Capsules are recognizable as fertile from their rapid increase in size, following withering of the perianth of the flower.

When flowers are seen open, conditions are often windy, before midday when climatic conditions are warm and air would be considered dry. Windiness and light breezes commonly occur through out the region. No measurements of temperature or moisture content of the air, adjacent to open flowers were made. Adult plants colonizing positions exposed to drying sun and wind are shorter in stature and have more slender leaves and capsules than those in more sheltered micro-habitats.

Pollinia can be seen to be dislodged easily onto the stigma in windy conditions in open flowers. Pollination by insects has not been observed. Buds not seen as open flowers produce developed capsules. Molloy (1990) considered the species to be autogamous.

Neither the juvenile (pre-flowering) or the adult life stage have been observed with more than one leaf. Plants with two flower buds are rare. When seen the second bud often appears to be non-viable.

Mycorrhiza was not isolated in this study, so it is not known whether the species is mycorrhiza specific.

#### **4.4 Discussion**

The species is terrestrial, supported by a root-stem tuber. The mode of growth belongs to the group described by Dressler (1990) as sympodial, i.e. the shoot has limited growth and is succeeded by similar shoots. Root stem tuberoids, which Dressler (1990) considered an unusual structure, occur in a few orchid tribes

including the Diurideae, in which tribe, Dressler classified *Thelymitra*. The tuberoid structure is a storage organ and contains near the tip a stem apical shoot surrounded by the root structure sheath. Following the rudimentary resting phase the stem will grow from what is essentially a swollen root, and replacement tubers grow from an axillary bud. In many species the growing point is sheathed by the base of the leaf and there may be secondary sheaths without leaves Dressler (1990).

### *Flowers*

Formal texts, describe the flowering stage of *Thelymitra matthewsii* largely following Cheeseman's original description (Cheeseman 1910). Cheeseman appeared to have only received flowering plants from Matthews c 1905-1910, and later from his son c 1914, as '*pressed and in spirit*' (Hatch 1989). No mention was recorded of non-flowering or juvenile stages.

The colour of the flowers of *T. matthewsii* at opening could be likened to the gem known as imperial amethyst, which exhibits a red flash shifting the colour from a blue to a red purple. The colour fades to lavender blue as the flower matures. An analogy with this colour transition is contained in Findlay (2002) where the production of tyrian purple is described, an organic dye which with a biological reducing agent, on exposure to sunlight, became blue.

In discussing *T. matthewsii* and differences from *T. variagata* in Western Australia, Cheeseman (1910) observed that the plant's column wing was 'scarcely crested' on the back behind the anther (page 177), and his further description of *T. matthewsii* noted that there was occasional evidence of a slight crest at the back of the lateral lobes behind the anther. Jones (1993) regarded the calli, a dense grape like cluster at the back of the column as a means of distinguishing between *T. matthewsii* and *T. spiralis*, an Australian species which also has a spiral leaf.

The most obvious secondary characteristic of the plant is the configuration of the leaf. Descriptions of it vary slightly. Cheeseman's (1910) description was, Quote;"*Lamina one and a half, to two and a half inches long (1.5-2.5cm), much expanded at the base, then suddenly narrowed into a linear blade which is usually spirally twisted so as to coil around the stem*' page 177. Cheeseman (1910) reported Matthews informed him that the twist of the leaf **about the stem** was constant in all the specimens he had seen, observations that suggested Matthews only saw plants with flowering stems. Matthews described the leaf to Cheeseman as comparatively broad at the base tapering rapidly to a narrow point (Hatch 1989). Moore and Edgar (1976) described the leaf as flexuous, spirally twisted with a broad sheath. Subsequent New Zealand and Australian publications (Cooper 1981; Johns and Molloy 1983; St George *et al.* 1999; 1996; 2001) describe flowering plants, and the leaf as 'expanded'. Hatch (1952) reported that his description of *T. matthewsii* was adapted from Cheeseman and compared with photographs of the plant taken by Matthews.

Juvenile stages of *T. matthewsii* have been described in contemporary reports of trips by enthusiasts to the Far north to observe orchids, and published in The Native orchid Group Journals. Reports of the discovery of the species by McCrae (1988) failed to mention the coiled leaf but his observation that the plant was in seed indicates that it was an adult life stage, the large capsules on a slender stem facilitating discovery.

#### *Life stages*

Hatch (1952) described differences between adult and juvenile stages in the genus *Thelymitra*, not including *T. matthewsii*, as variable within species, young plants being morphologically similar, but smaller in all their parts than adult plants and less robust, with paler flowers in those which reached first flowering.

### *Pollination*

Evidence suggested there might be a connection between the opening of self pollinating *T. matthewsii* flowers, and wind conditions. Cheeseman (1880) observed that the pollen mass, to become in contact with the stigma of *Thelymitra* after opening of the flower and the anchoring of the pollinia to the stigma, that one means the pollinia is broken up is by the shaking of the flower in the wind.

During microscope examination of the immature flower, for this study, pollinia were unavoidably broken and pollen tubes could be seen immediately infiltrating the surface of the stigma. Describing the fertilization of *Thelymitra*, Cheeseman (1880) remarked on the rapid emission of pollen tubes into the stigma and considered that some species were regularly self fertilized in this manner. The construction of and the subsequent self preparation of the flower by the extension of the column, facilitated the contact between the pollinia and the stigma.

In a personal comment, Irwin (2007) of Tauranga (acknowledged as a meticulous artist of New Zealand orchids) elaborated on his understanding from microscopic examination, that there was a difference between pollination in *T. matthewsii*, where the pollinia are above the stigma instead of behind it, as in other *Thelymitra* species. Pollinia were attached at the bottom end by the stipe that links them to the rostellum. He had described the stigma as raised on a pedestal in *T. matthewsii*, an unusual position as it is commonly on the same level as the rostellum, the sticky receptacle for the pollinia, in the rest of the *Thelymitra* species in New Zealand. The maturing column was extended and the pollinia are lifted to hang above the stigma. Shaking by wind would then dislodge them onto the stigma. (Irwin 1990)

In his report of the survey of the orchids of Te Pahi and adjacent reserves McCrae (1988) suggested that exploration would follow existing routes. He did not report *T. matthewsii* from the Shenstone Block Te Pahi Farm Park, where it populates many areas both near access tracks and at dune crests, although he did list a number of

*Thelymitra* species among other orchid species observed there in flower and seed. Early exploration tended to be during the more favoured summer months. The timing of *Thelymitra matthewsii*'s emergence above ground at the onset of, and throughout winter, and its preference for isolated habitat within heath vegetation, away from established travel routes, contributed to lack of discovery. McCrae (1988) suggested that as the species flowered in August-September, no botanist would have ventured into the North then, and so there were no intervening records of discovery since that of Matthews' at Kaitaia 1905 and McCrae's own in 1987.

## Phenology

### *Emergence and senescence*

*Thelymitra* species in the wild, and under cultivation, are observed to emerge in autumn so that sufficient time for growth enables the tuber to become mature enough to support a flowering stem, and next season's replacement tuber, before beginning to die down, usually from September onwards (Irwin personal communication 2005: Hoffman & Brown 1992).

*T. matthewsii* appears to need a minimum of three pre-flowering seasons before a flowering stem is produced. The low percentage of true succession in the populations from the smallest to a flowering individual (Chapter 5) might be a reflection of the low nutrient level characteristic of heath habitat favoured by the species, requiring a longer period of resource accumulation in the tuber. The need for an orchid plant to reach a certain degree of maturity to be able to flower was discussed by (Chong *et al.* 1980). The juvenile period varied between species and the period between germination and flowering may take 4-7 years or longer. The authors' considered that this duration could be genetically controlled.

St George and McCrae (1990) pointed out the annual cycle of growth of terrestrial orchids begins with autumn rain and lower ground temperatures. Knowledge of the phenology of an orchid species was regarded as essential by Wells and Willems (1991) if responses to management of orchids under threat are able to be correlated.

### *Blackened leaves*

Numbers of *Thelymitra* species occur throughout the study areas and blackened leaves, which occurred readily in the *Thelymitra matthewsii* plants, have not been observed in these other species. Clyne (1970) reported *Lyperanthus nigricans* blackened before the plant was withered, and questioned whether it was a protective procedure, particularly from predation during ripening of the seed capsule. Wells and Cox (1991) found members of a population may only survive above ground for a short time and young plants with small and narrow leaves were affected by water stress, the leaves blackening and dying.

### *Habitat sediments*

The preference of *T. matthewsii* to occupy areas of sediment wash was evident throughout the study and was observed in all habitats where the species was seen. Molloy and Hatch (1990) in commenting on McCrae's discovery of *T. matthewsii* in the North Cape Scientific Reserve, after a long period of non observance, described the site as '*a small flattish site of accumulating slope-wash*'. The reader is directed to Fig 3.2, depicting a major area of deposition in the North Cape Scientific reserve, where a *T. matthewsii* plant in seed was found.

### *Seed dispersal*

The suspicion that the stem carrying the capsule may lean away from the site directly above the tuber at dehiscence (seed dispersal from the splitting capsule) may only be the result of weakening of the drying stem of the plant. The stance however, had been observed in several instances throughout the monitoring of the populations. Some evidence occurred during monitoring of stems of adult plants, having lost the capsule possibility from predation, remaining upright. Although photographed, no documentation to record detail of subsequent drying of the stems was made. The trait does not appear to be consistent in other species of *Thelymitra* which have largely been observed still upright bearing emptied capsules on dried stems (personal observation) although dried stems will, and do collapse eventually. Other species of

*Thelymitra* observed in this instance included *T. longifolia*; *T. aff. longifolia*; *T. carnea*; *T. aemula* etc.

#### *Mycorrhizal association*

The knowledge that orchids and mycorrhiza are associated is well known. Research established that seeds germinated successfully when a suitable fungus was present (Arditti 1982). Arditti also considered the important point was that non infected seedling metabolism was improved in the presence of a symbiotic infection. Since adult plant's roots are normally infected association of seedlings among adults is more likely to result in successful growth.

Hadley (1980) in Arditti (1982) reported that the new seasons' roots of terrestrial orchid species must source their own new mycorrhiza association. It is suggested that the upward trending roots shown in the microscopic description of the juvenile plants in this study, suggest acquisition of mycorrhiza might be near the surface, most likely in the upper few centimeters of the substrate, near the litter layer. Leeson *et al.* (1991) carried out a destructive sampling of *Dactylorhiza fuchsii* to study the phenology of the species and found on uplifting the plant, roots accompanying the tuber were directed towards the surface. (Hoffman and Brown 1992) pointed out the vulnerability of proto-corms and first tubers being near the surface. This finding also suggests mycorrhiza is established near the surface, as inoculation is needed before proto corms can grow into plants.

#### **4.5 Summary**

It was evident from observations made of *Thelymitra matthewsii* plants during this study and described in this chapter, that there were clear differences between the adult leaf and those of the non-flowering or juvenile life stage, and between the development of these non-flowering stages.

The differences were constant in all plants seen and establish that the species does exhibit four distinct life stages and is the only species of *Thelymitra* in New Zealand to do so. This new information supplements formal descriptions of the species, in which only the flowering plant's characteristics were described.

Descriptions of the species in Australia seemed to include slight differences in morphology, in particular the 'grape like' calli at the back of the anther (Jones 2006) which, in the author's experience is not similar to observations of *Thelymitra matthewsii* flowers during this study. Open flowers were not common in the populations, both those monitored and adjacent populations, so that only a few flowers have been examined to determine the presence of calli. If the feature proves to be stable it indicates a difference in *T. matthewsii* plants in New Zealand.

The monthly monitoring of the target species over a period of three seasons enabled a number of observations of the morphology and phenology to be confirmed. Timing of flowering and number of flowers in the populations was unpredictable, and all life stages continued to emerge haphazardly through the season, although emergence of adults as new plants was recorded rarely. Adults are immediately recognizable on emergence. The base of the emerging leaf is inflated about the bud, which is apparent in the centre.

Pollination mechanisms of *T. matthewsii* exhibit differences from *Thelymitra* species in New Zealand in placement of the stigma, rostellum, and pollinia and the provision of a stipe (Irwin 2007). The species is considered to be self pollinating and fertile capsules are commonly recognisable among the populations where adults are present.

Some traits seemed to be directed at pollinators although the species is reported as self pollinating. The wide open nature of the mature flowers for example on a slender stem the colour (or lack of colour) of which blended with the substrate, and the leaf some times blackened or withered to appear un-noticeable, so that the flower

commanded attention. Blackening or withering of the leaf therefore, could be the result of water stress, natural decline of the leaf, or a guise against predation.

There was a tendency for the stem carrying a mature capsule to appear to have leaned away from the site of its tuber as it dried and the capsule dehisced, in several instances. To confirm this as a unique trait would need vigilance over a long period.

Established orchid plants are known to maintain an association with mycorrhiza. The successful growth of seedlings among those plants points to their acquisition of a suitable fungal partner to establish a mycorrhizal association. The orientation of new seasons roots towards the surface, seen in the juvenile plants uplifted for this study could indicate a declination towards inoculation with mycorrhiza which may be more prevalent near the surface litter layer. The configuration might also suggest a search for moisture. The plants were in sandy soil and it is commonly known that bare loose soil conserves moisture.

Armed with the knowledge of morphology and phenology of *T. matthewsii*, engendered by this study, an opportunity to observe the plants in Australia is recommended.

## CHAPTER FIVE

### Population Demography

#### 5.1 Introduction

More than 30 years have elapsed since Harper and White (1974) wrote that one of the major tasks of plant demography was the measurement, description and explanation of changes in the numbers of individuals that form a population. Most of the work studied for this research (Table 1.1) stressed the importance of vigilance in monitoring. Kery and Gregg (2003) considered spatial and temporal abundance of a species was clarified by population demography. Mehrhoff (1989) reported that the objective of demographic studies was to understand and predict the changes in plant populations through appearances and disappearances and increase and decline in numbers, and noted a need to study observed differences of growth and decline in orchid populations. Shefferson *et al.* (2001) considered that central to the assessment of population trends in plants was accurate demographic monitoring, that took account of unpredictable phenomena such as seed and adult dormancy in orchid populations, otherwise population size and predicted survival could be underestimated.

In order to understand, and be able to apply insights into, and predict future orchid population behaviour, a commitment to data collection over a number of years was needed if worthwhile results were to be achieved (Wells & Willems 1991). The data gained greater value when observation of individuals was collated regularly over a period of time rather than at one observation, at flowering time, for example (Tamm *et al.* 1991).

Population dynamics may be usefully described from numbers of seedlings, vegetative and flowering plants. Oostermeijer *et al.* (1994) defined dynamic populations as those with a large proportion of juvenile life stages; senile populations

in which there were only adults, and populations declared stable where all life states were present, a proportion of dominant adults and a lower number of juveniles.

This chapter has determined population structure and composition in terms of numbers of plants present or absent at labels, and the number and relationships of the life stages, using data obtained through monthly monitoring of five populations over three seasons of growth. This chapter will thus present answers to the questions concerning life cycle morphology in Section 1.3.1 Chapter one.

## **5.2 Methodology**

### **5.2.1 Seed bank**

Samples of substrate were selected for examination under a microscope to discover the likely presence of *Thelymitra matthewsii* seed in the seed bank. The seed bank was defined as areas near established plants, down slope of established plants, in likely wind directions and sites with habitat qualities that equated existing colonies.

Substrate was cored 6-7 cm in depth using a 420gr standard tin, from which both ends had been removed. Twenty seven soil samples were collected. A knife slipped under the tin retained as much as possible of the sample, as the soil at most sites was too loose to retain body. Samples were placed in numbered labeled zip lock bags and a plastic label was inserted where the sample was selected in the field. Samples were refrigerated until, and following examination.

A sub-sample of 10gm was examined under magnification of 40x, using a dissecting binocular microscope. A small sample of seeds of a *Thelymitra* species (*Thelymitra longifolia*) were mixed with sand grains and enclosed in a petri dish for comparison and to facilitate recognition.

### 5.2.2 Genetic analysis

Small sections (5mm) of *Thelymitra matthewsii* leaf samples were collected in 2003 and 2004, under permit, placed in numbered zip lock bags containing silica gel crystals and kept refrigerated. Samples were obtained from within plots supporting labeled plants and augmented with samples from scattered plants close by. Eight to ten samples were accessed from each monitored site in the study.

Samples were processed in The Pacific Biosystematics Laboratory, University of Waikato for the extraction of DNA, using protocols modified from (Doyle and Doyle 1987). Some initial trials were conducted using leaf material of *Thelymitra longifolia*.

### 5.2.3 Population survey

Data was collected from plants labeled in five sites established in 2002, at sites which contained a number of *Thelymitra matthewsii* plants. Sites are described in Chapter Three of this Thesis.

An area 3.5 x 3.5 metres, (12.5 m<sup>2</sup>) was outlined to standardize the sites as the populations were of irregular configuration. Corner stakes were left in place and made further reference possible when required.

Each plant at each selected site was labeled with a white plastic label inserted with care as close as possible to avoid tuber damage and in a manner to identify the position of that tuber in subsequent seasons (Fig 5.1). Labels displayed the site designation, and the plant number; SH6.1, SH6.2, continuing in numerical order for all the plants present. Numbers were applied to the labels with a durable pen on both sides at the top and on the portion to be inserted in the ground.

A census was taken for each labeled plant in each of the following categories;

1. Plant height, (in non flowering plants essentially leaf height) using a retractable steel rule for rigidity.

2. Presence and absence at labels.

3. Condition, marked one to four, where one was healthy; two, some defect like insect damage or withered tip; three, plant withered; and four, plant dead

4. Life stages were designated as a 'hook', a small slightly curved leaf; a 'spiral', a distinctively spirally curled leaf; a 'non - flowering' stage in which the spiral leaf was more open and the life stage more robust; and an 'adult' a flowering plant. In this case the flowering stem was recorded as plant height. A bud was noted for adult plants and designated fertile if a swelling capsule was evident at October monitoring.

Data was called to an assistant who entered it into prepared sheets in the field. All measuring and category assessment was done by the same person. Data collection was maintained in July, August and September in 2002; in July, August, September and October in 2003, and in June, July, August, September and October in 2004. Data was collected as for 2002 for labeled plants, with the addition of the category, presence and absence, at labels in 2003 and 2004.

Seasonal increment in 2003 and 2004 in the form of plants not previously recorded were labeled in the same manner as described for 2002, with the addition of the prefix 'N' preceding the plant number, and continuing consecutively as the new plants were observed. Defective labels were replaced as necessary. Monitoring was carried out as near as possible to the same date each month the sites were visited.

No numbers were discarded or re-issued, and labels out of the ground were recorded as such.



Fig. 5.1 Close up of method of labeling of *T. matthewsii* plants. Initials and first number indicate the study site and the second number the plant. Some labels display N for new plants as described in the text. Site at RD5.

## 5.3 Results

### 5.3.1 Seed bank

No orchid seed was observed in any of the samples. It is probable that the samples were taken too deep and therefore contained too much volume, and the sub sample was too small at a ratio of one.

### 5.3.2 Genetic analysis

DNA extraction using leaf tissue from randomly selected *T. matthewsii* plants was unsuccessful. No result capable of analysis was obtained. The lack of success was attributed to the very small samples (< 6mm leaf tissue), and lack of a source protocol specific to *Thelymitra*, although extraction was achieved using leaf tissue of *T. longifolia* (a much larger sample) and one final print-out was obtained by a Technician in the Lab.

### 5.3.3 Population demography

#### 5.3.3.1 Plant numbers

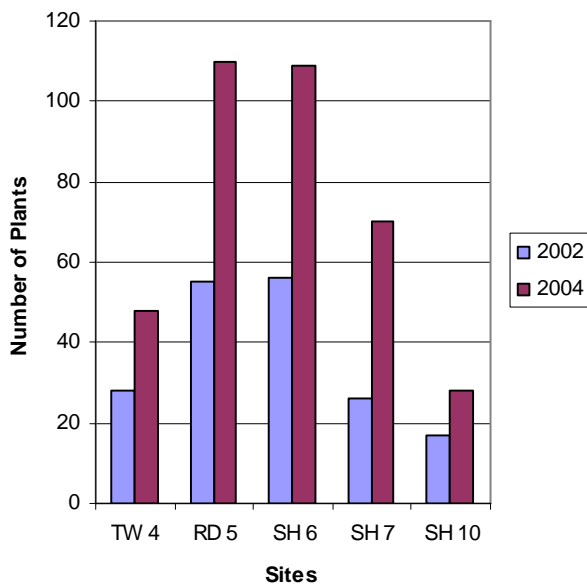
A total of three hundred and sixty five numbered labels were placed beside plants throughout the study, at five sites in three locations (Table 5.1)

Population size varied between monitored sites. Two of the sites were established with a larger number of plants, as a starting population, (study sites RD5 and SH6) and maintained that margin throughout monitoring.

Table 5.1 Numbers of *T. matthewsii* plants labeled at five study sites in three seasons. Totals at the end of each season's monitoring.

Sites	TW4	RD5	SH6	SH7	SH10
2002	28	55	56	26	17
2003	40	75	94	46	23
2004	48	110	109	70	28

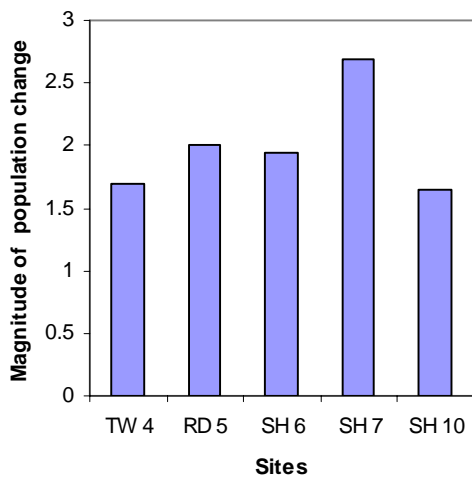
The relative numbers of plants at commencement of the study (2002), and at cessation of data collection in 2004, in each of the populations at all sites is shown in Fig.5.2. Increment throughout 2003 and 2004 is included in the total shown for 2004.



*Fig 5.2 Numbers of plants labeled at commencement of the study (2002) and the number labeled by the third season of monitoring (2004) at the five study sites set up for the research.*

Using summarized population growth data from field data tables (Appendix Two), analysis of population numbers showed that all the populations increased the number of plants that appeared during monitoring, by a factor of approximately 2 times. Magnitude mean was 1.99. The best and least performing populations in proportion to all population sites, were in the same locality, in the sandy substrates of the Shenstone Block (Sites SH6, SH7 and SH10) Fig 5.3.

Although with smaller starting (2002) populations than SH6 and RD5, with greater numbers of plants, the three study sites with smaller populations (TW4, SH7, SH10) were similarly productive in increased plant numbers.



*Fig. 5.3 Number of times original labeled plants were exceeded in the populations indicating the magnitude of population change.*

The greatest increase, which returned just under 2.7 times the number of originally labeled plants, was at one of the sites, SH7 in the Shenstone Block. The site adjacent to the Cape Walkway, TW4, registered an increase of 1.7 times, and the remaining monitored site, SH 10, again in the Shenstone Block, registered an increase 1.64 times the initial number of labeled plants. The similarity of increase in plant numbers, relative to the inaugural numbers labeled in the sites is evident in the result. Fig 5.3 illustrates the number of labels placed beside plants over three seasons and does not take account of plant presence and absence.

#### 5.3.3.2 Plant increment

The increase in plant numbers is made up of new recruits which appeared monthly throughout monitoring, and were not labeled at the previous monitoring.

Monthly increments for each of the three seasons of monitoring are presented in Fig. 5.4 for each individual study site. The graph includes the number of plants present at commencement of the study in June 2002. Numbers of new plants still appeared in October, (the month when most plants had become senescent at the end of the life cycle) in isolated instances; i.e. not continuously. The population SH10, at a site in

the Shenstone Block had the smallest number of plants and recorded a relatively small decrease.

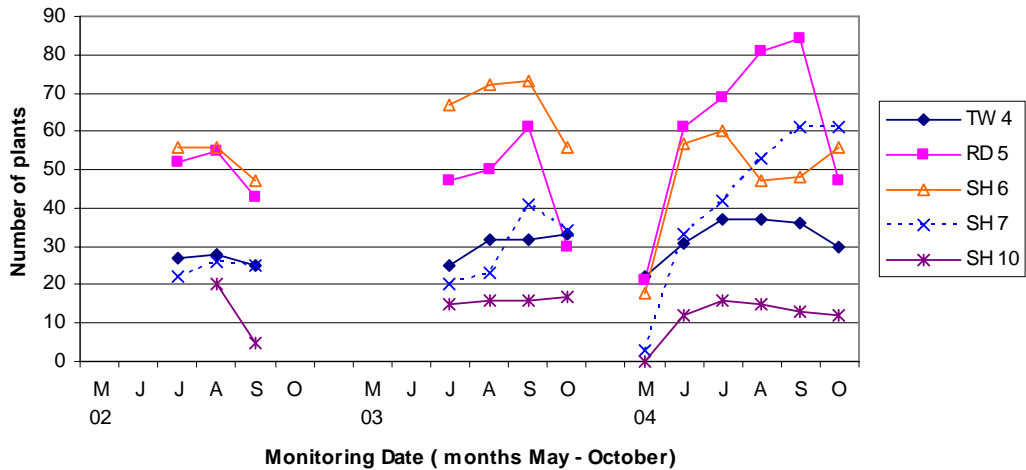


Fig.5.4 Monthly increment in populations at all sites in three seasons. An early monitoring in May appears in results for 2004 following discovery of earlier emergence than previously recorded.

The number of plants recorded in September was maintained at October monitoring in study site SH7 and increased in SH6, contrary to the usual result, of a reduction in numbers of plants present at this final monitoring for the season. Study sites TW4 RD5 and SH10 recorded a customary decrease.

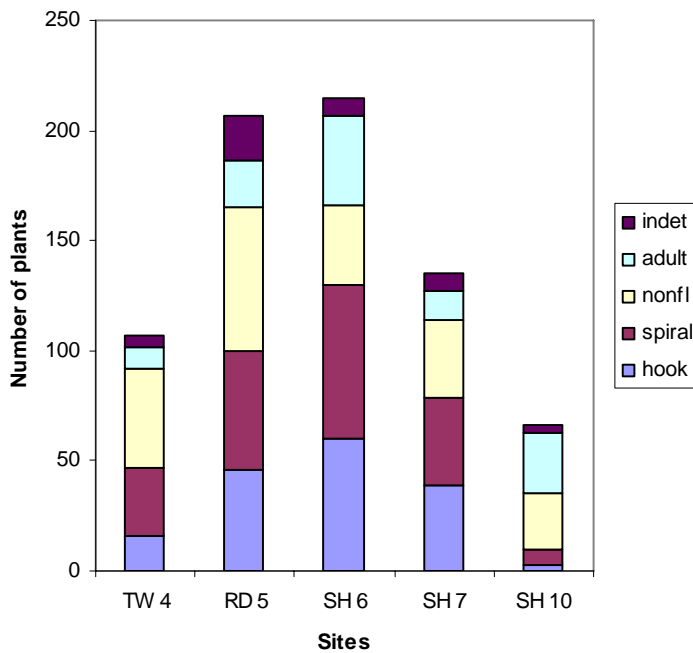
The actual number of plants recorded at labels in each of the monitored populations is shown in Table 5.1A listing presence in each season at each plot site. The characteristic disappearance of plants in September and October is evident in the sometimes sharp drop in numbers recorded at or near this time. A steep drop occurred in the population at the site designated SH10 in 2002, representing 75% of plants originally labeled. Results were variable from one population to another with constant fluctuation, both trailing and exceeding recorded presence in both 2002 and 2003.

Table 5.2 Table of monthly presence (A) and absence (B) of plants at labels, at all sites over three seasons. Numbers represent recordings in months, M- May, Jn –June, J- July, A- August, S-Sep, O- October.

Site	Year	Presence (A)						Absence (B)						
		M	Jn	J	A	S	O	M	Jn	J	A	S	O	
TW4	02			26	28	25							3	
	03			25	32	31	33			7	7		9	11
	04	22	31	38	37	36	31	11	13	11	11		13	17
RD5	02			52	55	43							12	
	03			48	50	61	31			15	16		14	46
	04	21	61	69	81	84	46	52	29	24	24	24	24	64
SH6	02			51	51	37							18	
	03			68	72	73	56			14	15		23	35
	04	18	57	60	47	48	53	75	40	39	55	56	56	56
SH7	02			22	26	25								
	03			20	33	42	34			3	4		4	12
	04	3	33	43	54	61	61	48	17	7	9		5	9
SH10	02				17	5							12	
	03			15	16	16	17			4	3		4	3
	04	0	11	15	15	14	12	28	10	11	12	14	14	16

### 5.3.3.3 Life stages

The populations were found to be composed of four distinct life stages, designated, for the purpose of the study, as a hook, a spiral, a non-flowering stage and an adult stage which supported a bud (Chapter Four Fig 4.4). The numbers of plants in each life stage in each of the monitored populations is show in Figure 5.5. The group labeled 'indet' indicates a number of life stages which were inconclusive and formed an indeterminate set, because different life stages, called in error, could not be recorded for a plant at a specific label, in one season.



*Fig 5.5 Numbers of plants in each of the life stages, hook, spiral, non-flowering and adult, at all sites for three seasons. Numbers are cumulative and indicated proportion of life stages. 'indet' see text.*

These data suggest that the numbers in life stages considered to be juveniles (non flowering, spiral, hook), exceeded those of adult plants in all populations. Life stage results are expanded into individual life stages in individual population sites in Fig. 5.6 a-d, which show individual results for new plants, (plants which had not received a label at a previous monthly monitoring) and show that new plants also appeared in greater numbers of juvenile plants. Adult plants were a minority compared with juvenile plant numbers at TW4, RD5, SH6, and SH7, but in SH10, adults accounted for 60% of population over three seasons (Fig 5.5). The disparity is obvious in Fig 5.6 showing the numbers of new plants appearing as adults. Note that site SH10 recorded no juveniles and only adults in 2004.

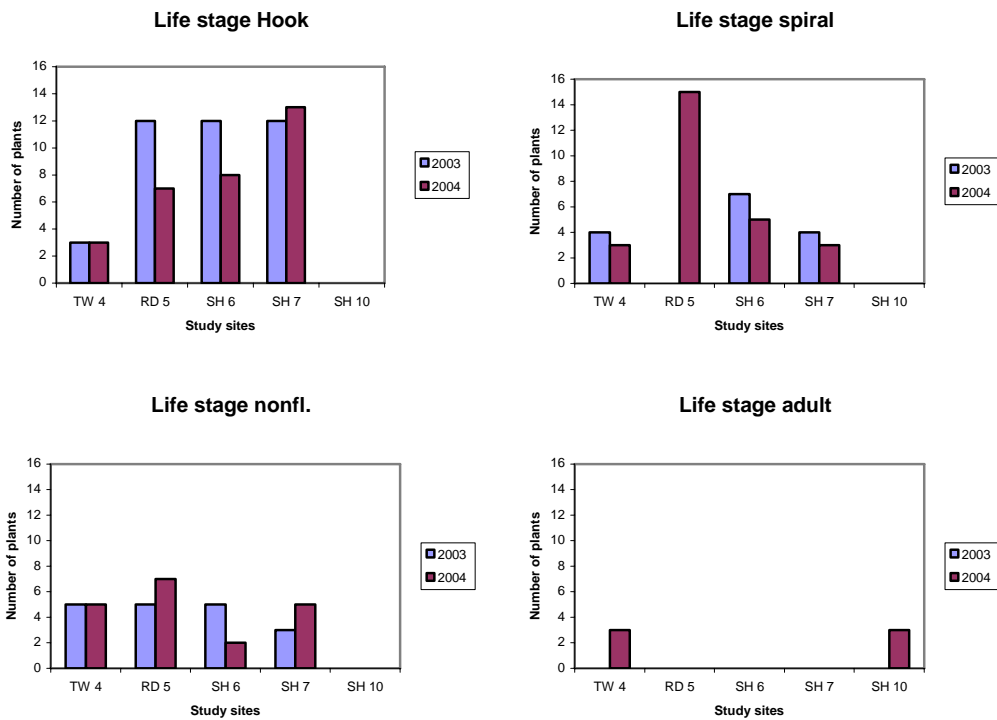
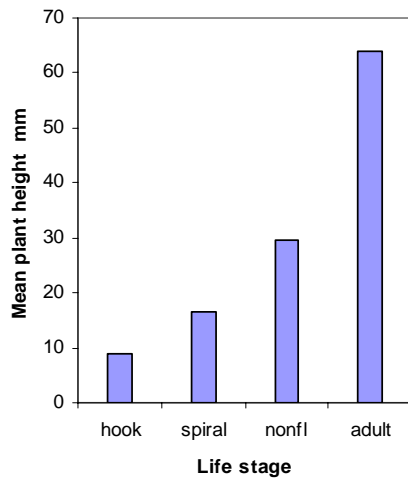


Fig.5.6 a-d Life stages of new plants recorded in 2003 and 2004.

#### 5.3.3.4 Plant height

As monitoring progressed it became apparent that there was a relative maximum height range characteristic of each life stage. Minimum height recorded was related to time of monitoring. A comparison of combined height means for each life stage is illustrated in Fig.5.7 a; showing the characteristic separation of life stage height.

Maximum and minimum height ranges for each life stage are shown in Fig.5.7b for each study site.



*Fig 5.7a Combined height means for each life stage at all sites, over three seasons monitoring (2002-2004) illustrating the increase in height of advanced life stages.*

The seasonal results of life stage height combined in each site Fig.5.8b illustrate the consistent height parameter defining each life stage. Despite different substrate, indurated sand, clays derived from volcanics, and lightly consolidated dune sand, life stages remained within a comparable mean.

#### 5.3.3.5 Life stage occurrence and succession

The occurrence of the different life stages proved to be very erratic. To adequately describe this phenomenon a series of categories was drawn up to cover the sequences of life stage appearance. Table 5.3 was compiled from monitoring data to incorporate seasonal diversity. A labeled plant could be assigned a different life stage category from the table in each season.

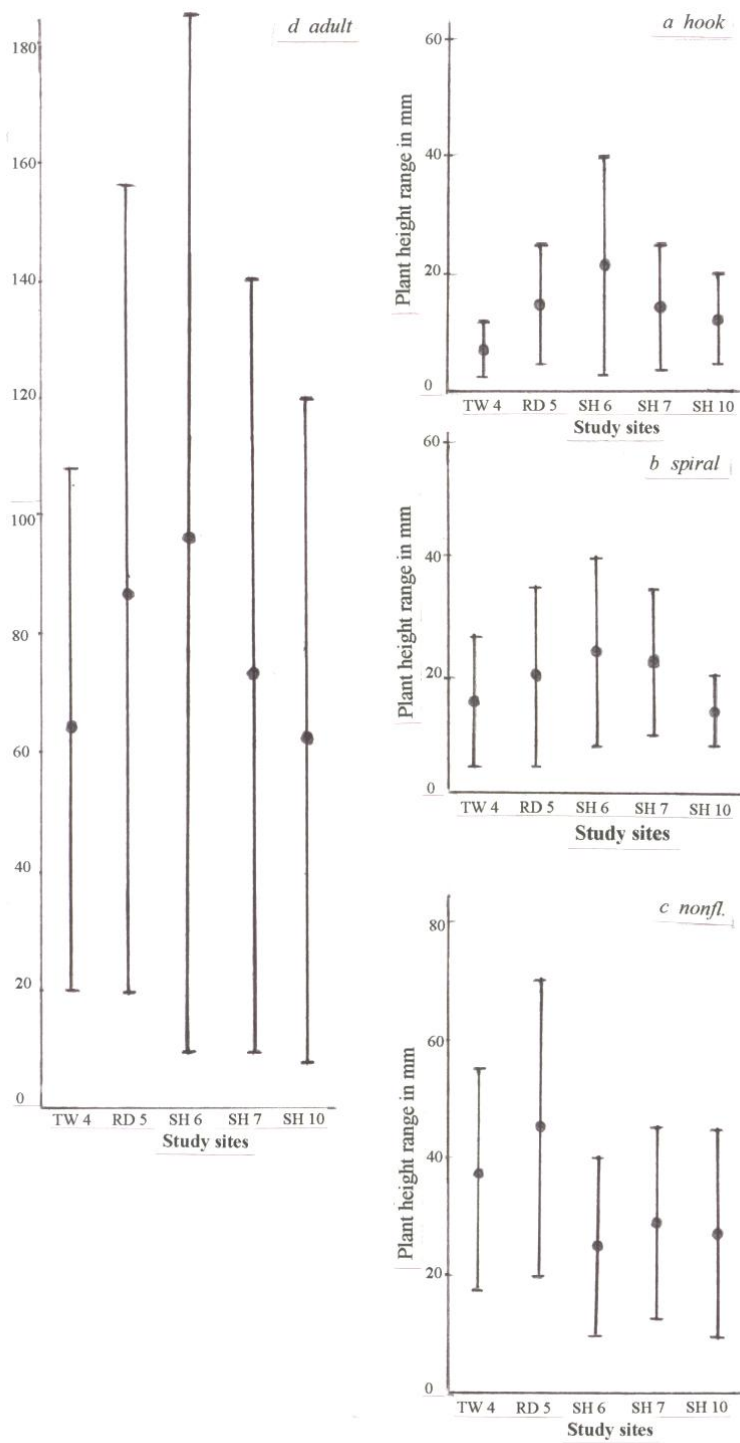


Fig.5.7b Life stage height mean, height range maximum and minimum in mm in each life stage. Seasonal results combined in each site.

Table 5.3 Table of life stage categories constructed to describe variation in the life stages of monitored plants.

Category		Description
1	a	One of four life stages eg Hook for all three seasons
	b	One life stage eg spiral in one or two seasons
2		Two successive life stages in three seasons eg Spiral - non flowering
3	a	Two non successive life stages
	b	Three non successive life stages
4	a	'ordered' life stage Hook, spiral, non flowering
	b	Spiral, non flowering, adult
5		Adult once
6		Adult more than once
7		Indeterminate (called in error)
8		Absent (not present at monitoring)

Seasonal variations, in life stages are summarized with the original plant numbers for comparison in Table 5.4. The original numbers were the plants initially labeled at the commencement of the study, and the life stage recorded then was the starting life stage.

Individuals with one life stage could record the same life stage for three seasons, or two seasons, and absence for one or two seasons. An individual described as having two life stages in three seasons (excluding new plants) must have been absent one whole season and could have been present partially in two seasons. Plants with three different life stages were less common than plants recording two, but constituted a better survival rate being present more often at monthly monitoring.

Using Table 5.4, of 182 original plants, 62 or one third, had one life stage and 120 had two or three life stages, which may or may not be different. Of these 4% showed succession, from juvenile (spiral, non flowering, adult) to flowering stage, and 1% showed succession from smallest to a more advanced juvenile plant (hook, spiral, non flowering).

Table 5.4 Numbers of plants qualified by life stage categories from Table 5.3. Plants with > 1 life stage expressed as a percentage of commencement plants. Mean 51.4%

Study Sites	TW4	RD5	SH6	SH7	SH10
Original plants	28	55	56	26	17
Plants in categories 1a & 1b	11	14	56	7	9
Plants in categories 2 and 3a	14	28	23	17	7
Plants in categories 3b and 4b	3	13	12	2	1
Percent of plants >1 life stage	60.7%	74.5%	62.5%	73.1%	47.0%

Results range from a small number of plants in which the life stages were different each monitoring season at the site of SH7, and at site SH10. Numbers of plants with only two life stage categories are similarly shown in Table 5.4. (Categories 2 and 3a Table 5.3) Proportions are similar between the smaller populations, (TW4, SH7, SH10) and the larger populations at sites of RD5 and SH6. Two life stages usually incorporated an adult stage or absence (non appearance), and absence was common in three life stages. Life stage categories 3a and 3b, (Table 5.3) were most common, 33% of plants were thus described, excluding new plants.

An ‘ordered’ succession of life stages, (hook, spiral, non flowering, adult) categories 4a and 4b, (Table 5.3), from smallest to adult was the least common, a mean of 4% of plants described by the category 4b; and category 4a occurred only once in all populations (Table 5.5). Plants with seasonal variation results compared to all labeled plants, shows that ‘non ordered’ life stage variation occurred in from 50% to 80% of plants.

Table 5.5 Numbers of monitored plants, which were described by category 4b “ordered succession”, spiral, non-flowering, adult, and category 4a, hook, spiral, non-flowering, in three seasons in all populations

Study sites	TW4	RD5	SH6	SH7	SH10
Total plants	48	110	109	70	28
Nos. of plants In category 4b	2	5	5	1	0
Percent of total Plants	7.14%	4.54%	4.58%	1.42%	0%
Nos. of plants In category 4a	0	0	1	0	0

New plants were not included separately in the above table and were best described by category 1a. The category 1a (Table 5.3) recorded predominately one life stage category throughout, as would be expected if present for one season. Successive and non-successive life stages in second season new plants were about equal, and some of these included adults. None reached three life stages as new plants were present only one or two seasons.

#### 5.3.3.6 Number of adult plants

A survey was made of the occurrence of adults in the populations, the result showing a low number in each population in relation to all labeled plants (Fig.5.9). There was a relatively high percentage of adults in the SH10 population, 15 of the 17 labeled plants (88%) of commencement population, appearing as adults. Seven of these plants re-appeared as adults in the second season, and of these, two for the third time. Re-appearance of a plant twice as an adult was not un common, and ranged between 9% and 24% (Mean 14%) when compared with adult appearance in all labeled plants.

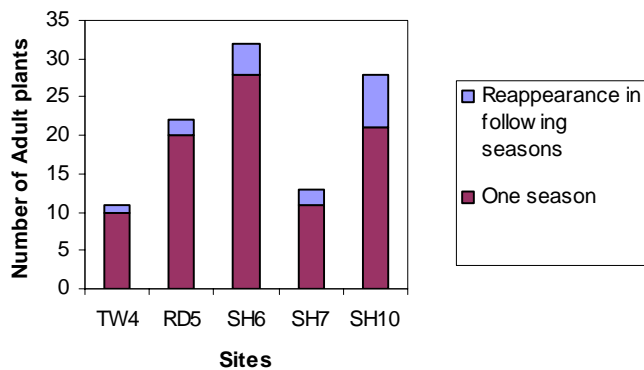


Fig.5.8 Number of adult plants that appeared more than once, at one label, in all sites.

#### 5.3.3.7 Plant absence

Monthly absence of plants at labels during monitoring (Table 5.2B), is compared with numbers of plants present (Table 5.2A). Absence could encompass late emergence, resting or dormancy, or death.

Absence of plants at labels increased near the end of the above ground stage of the life cycle, beginning in September and reaching greatest numbers in October. Recordings for the month of May were included but as will be explained in the discussion section of this chapter, were not added to growth analysis results because early emergent plants had not been included in the previous two seasons.

It can be seen from the table that a gradual lowering of numbers of individuals recording absence occurred early in the season as plants continued to appear above ground during the growing seasons. (Note that a plant number could be counted twice for analysis through the season of growth, due to monthly variations in presence above ground, and absence, not above ground).

Labels with absent plants included late emergence, decline, and labels dislodged from the soil. Death cannot be confidently declared until the plant has been absent for a period of time. The permanence of mortality cannot be estimated with confidence on

the basis of this small research sample in terms of time, and it cannot be assumed that absence indicated death as some plants have re-appeared after absence

The incidence of absence was complex. For example plants at labels may be present one season and absent the next, or both following seasons. Plants recorded at labels may also be absent and re-appear in a season, or present and disappear. Analysis of absence therefore was approached by using a series of categories which described the degree of seasonal presence and absence in labeled plants (Table 5.6).

Table 5.6 Table of absence categories to describe the degree of seasonal presence and absence, in labeled plants.

Category	Description
1	Absent one season
2	Absent two seasons
3	Present one season
4	Present two seasons
5	Present three seasons
6	Absent and re-appeared
7	Present then absent 1 <sup>st</sup> season
8	Present then absent 2 <sup>nd</sup> season
9	Present then absent 3 <sup>rd</sup> season

Since plants at labels were observed in monthly intervals of three in 2002, through four in 2003, to six monthly monitoring visits in 2004, presence or absence recorded at each monitoring produced a compound result which served to highlight the variability of the populations. In Table 5.7 plant numbers in Category 5, present three seasons, show that presence was recorded at that label for 13 monthly monitoring visits, representing 29.6% of total plants labeled (which was an average of 32.8% of plants at each site). The remaining 70.3% of total labeled plants had an absence factor at one, or more than one point of recording, or more than once within three seasons.

Table 5.7 Seasonal variation described using categories from Table 5.6. Numbers expressed as a percentage of original (commencement) labeled populations. Numbers of plants in each category included at all sites in three seasons.

Study sites	TW4	RD5	SH6	SH7	SH10	Total pl.
Labeled plants In populations	28	55	56	26	17	182
Plants in category 5(pres.3 seasons)	13 45.4%	13 23.6%	9 16.1%	16 61.5%	3 17.6%	54
Plants with an absence factor in three seasons	15 46.4%	42 76.3%	47 83.9%	10 38.4%	14 82.25%	128

These results include the commencement numbers of plants only, as population increase in following seasons, was for two and one season only. (2003, 2004)  
An average of 66.8% of plants (range 38.4-83.9%) over five study sites recorded absence in three seasons.

Table 5.8 Number of times in study sites, that absence in categories 1, 2 and categories 6 – 9 (Table 5.6) could be applied. Note that plants can qualify for more than one category over three seasons and be counted more than once.

Study sites	TW 4	RD 5	SH 6	SH 7	SH 10	Total
Seasonal absence, Cat. 1,2	6 21.4%	15 27.2%	21 37.5%	4 15.4%	6 35.2%	52 27.3% mean
Partial absence Categories 6-9	10 35.7%	34 61.8%	38 67.8%	7 26.9%	14 82.3%	103 54.9% Mean
Totals	16 57.1%	49 89%	59 >100%	11 28.3%	20 >100%	152 78.5%

Comparison of numbers of seasonal and partial absence is presented in Table 5.8 using categories from Table 5.6. Two of the totals exceeded 100% indicating that plants were recorded absent several times.

Partial absence, i.e. absent at one or more recording visits a season, was more common than seasonal absence, where recordings for a label showed that that individual was absent for the whole season.

Table 5.9 Total percent of populations of original and new plants that had an absence category, in three seasons at all sites.

Plot sites	TW4	RD5	SH6	SH7	SH10
Original plants	28	55	56	26	17
Number of plants recording absence	15	42	47	10	14
Percent	53.5%	76.3%	83.9%	38.4%	82.3%
New plants	20	55	53	44	11
Number of plants recording absence	16	53	42	36	10
Percent	80%	96.3%	79.2%	81.8%	90.9%

The seasonal percentage of plants at labels with different absence categories using Table 5.6 is shown for plants at commencement, and new plants (plants that were not labeled at a previous monthly monitoring) in Table 5.9. Absence at each study site was compared for the seasons 2003 and 2004. (Absence occurred towards the end of monitoring for plants labeled at the commencement of the study in 2002, and was therefore, not seasonal)

New plants were present for only one or two seasons and showed a high percent of absence, mean 85.7%, compared with a mean of 66.9% for original (commencement) plants recording an absence category.

#### 5.3.3.8 New plants

It was important to realize that new plants were present for two (03 and 04) and one season (03). Plants were not recorded as 'new' before 2003, although a few had emerged at the end of monitoring in 2002. Of new plants recording partial survival (having a degree of absence) approximately 15.3% disappeared in August or

September, the remaining 84.7% usually having disappeared at monitoring in October.

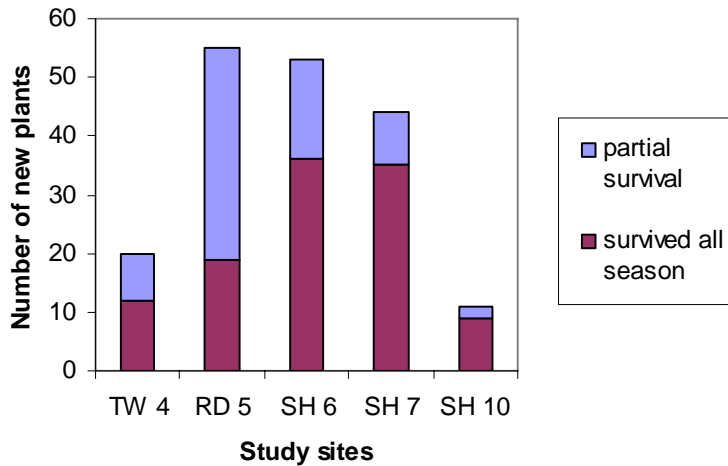


Fig.5.9 Seasonal and partial survival of new plants, all sites in 2003 and 2004

Of 183 new plants recorded in 2003 and 2004, 146 plants or 79.8% survived all season and 131 plants or 71.5% were absent at one or more recordings. Of 94 plants new in 2003, 25 plants (26.6%) were present without absence for two seasons (Fig.5.9).

#### 5.3.3.9 Plant condition

Condition of plants at monitoring on a scale of 1-4 was applied to determine population health and record ill-health and likely predation. The percentage of plants in each population recording condition 1, a healthy plant without imperfections, over three seasons is shown in Fig 5.10. The majority of plants (80 – 95%) were consistently healthy, with a notable lower number of adults recording condition one. This variation is shown in Fig. 5.10 a departure from the general trend of condition 1 being apparent in the results for adults. Plant health generally declined towards the end of the growing season in October.

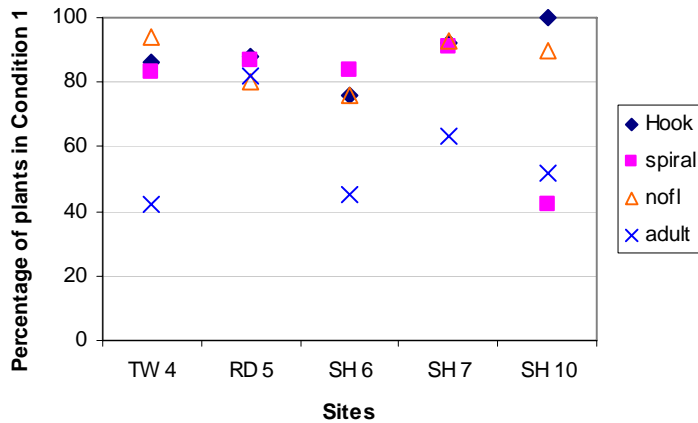


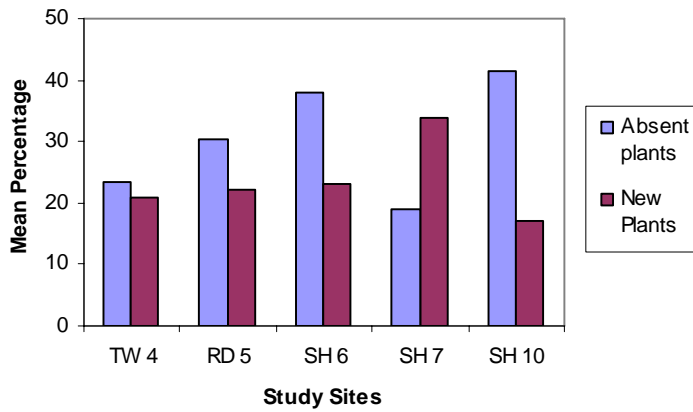
Fig. 5.10 Percentage means of all life stages at all sites recording a condition factor of 1.

#### 5.3.3.10 Plant recruitment and loss

The difference between recruitment and loss proved difficult to assess, since absence, considered as loss was variable. To achieve an indication of comparison all recordings of absence at monitoring were counted, and expressed as a percentage of the total monitoring record. Presence and absence of new plants was counted and absence added to commencement absence record. Total new plants were then expressed as a percentage of total monitoring. Fig 5.11 compares the percentage of absence of the total monitoring record, (loss) with the percentage of new plants (recruitment). Therefore recruitment equaled new plants, and loss, (absence) of original and new plants

Mean absence (not visibly present) percent (30.5%) exceeded recruitment percent (23.4%) by 7%. Absence in this study was considered to include plants which could be dormant or dead. There was a smaller majority of absence at study sites TW4, adjacent to the walkway near the coast and RD5 on volcanic substrate in the north, compared with the study sites in the dune substrates of the Shenstone Block. These

dune sites showed the greatest percentage of absence, apart from site SH7 also a dune site, which recorded greater recruitment than absence.



*Fig.5.11 Percentage of absence compared with percentage of new plants in populations as a measure of population stability.*

One recruitment result, at study site SH10, did not achieve the mean of 23.4%. This result is reflected in Fig.5.11 where recruitment did not equal absence in all but the one site SH7, where recruitment exceeded absence by 15%. It was important to realize that new plants were present for only two seasons, 2003 and 2004, or the one season following, 2004.

#### 5.3.3.11 Early emergence of plants

To determine whether early emergence of plants affected the longevity of an individual, results from growth data compare the numbers of plants emerging early in a growing season (May) and their persistence, shown in Table 5.10, which also shows the number of plants which were eventually recorded for that season.

The mean for the percentage of plants emerging early in May 2004 at each of the study sites and persisting all season was 60%. This compares with the percentage of plants present for three seasons at individual sites, with an average of 32.8% for all sites (Table 5.7).

Life stages of 56 plants recorded appearing in May proved variable. No hook life stage was recorded and a small proportion of indeterminate records was included. Twenty-one adults were recorded, representing 37% of plants which appeared early. Non flowering life stage were concentrated in two sites TW4 and RD5 registering 39% of early plants. Spiral life stage accounted for 23%. In the Shenstone block, study site SH10 recorded no early emerged plants and SH7, 3 plants only (1 adult, and 2 non flowering) and SH6 no non flowering life stages.

A comparison with plants which emerged in June 2004 shows similar results. Adult life stage comprised 27% of the emerging populations and non flowering life stage, 22.8%. A predominance of spiral life stages at 41.7% and a small percentage of hook life stages (7.6%) suggested the intermediate life stages were beginning to emerge.

Table 5.10 Numbers of plants in all monitored populations that emerged early in the season, in May 2004, and the percentage that persisted all season.

Study sites	TW4	RD5	SH6	SH7	SH10
Plants emerged Early	21	20	22	3	0
% persisting all season	90%	65%	45%	100%	0%
Total plants 2004	48	110	109	70	28

Plants emerging early in May and which persisted all season, were previously labeled established plants reappearing, none were unlabeled new recruits. Ten new (unlabeled) plants which emerged in June persisted all season.

### 5.3.3.12 Life stage modeling

If succession was random, the percentage for each of five life stages, appearing in successive seasons as a larger plant would be expected to be 20%. The life stage matrix presented in Table 5.11 shows percentage values that each life stage would progress to a larger stage in excess of 20%, and indicates a significant variation.

Table 5.11 Life stage matrix depicting succession percentages of *T. matthewsii* plants at all sites ( scores in bold >20%)

%	hook	Spiral	Nonfl.	Adult	Abs.
hook	<b>33</b>	<b>25</b>	14	4	20
spiral	11	<b>31</b>	<b>33</b>	8	15
Nonfl.	3	12	17	<b>34</b>	13
adult	2	14	<b>22</b>	<b>28</b>	<b>34</b>
Absence	20	15	13	<b>34</b>	<b>94</b>

A life stage model is presented in Fig.5.12 showing the actual succession of life stages from recorded data using the matrix values.

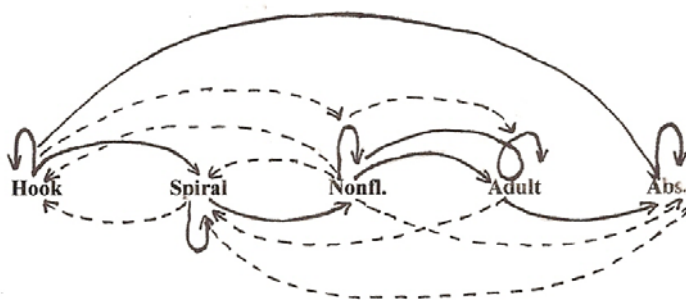


Fig 5.12 Life stage model illustrating likelihood of life stage succession in the following season:  
 —— most likely (>20%); ----- less likely (<20%).

A hook life stage was more likely to reappear as a hook or a spiral and ~ 10 times less likely as an adult. The spiral life stage was ~ 3 times more likely to reappear as a spiral or non flowering stage than a hook, with the smallest percentage chance of reappearing as an adult. A non flowering stage was ~ 10 times more likely to reappear as a non flowering plant or slightly less than 10 times as an adult, while an adult life stage was least likely to reappear as a hook, and more likely to appear as an adult or the non flowering stage. Absence percentage was highest for the hook life stage in the pre-flowering stages, high in the adult stage, and approaching 100% following absence in the previous season.

## **5.4. Discussion**

### 5.4.1 Seed bank

Results suggest that the substrate samples collected to determine the presence of a seed bank of *Thelymitra matthewsii*, were too large in volume and collected too deeply. Although aimed at apparently favourable sites throughout the areas occupied by populations of *Thelymitra matthewsii*, the soil samples were probably too spatially separated and too far from extant populations with too few sub samples.

Bigwood and Inouye (1988) considered seed bank studies should keep soil volumes constant, and cited Major and Potts'(1966) contention that too few samples are analysed in seed bank studies. The authors recommended the collection of numbers of smaller samples, or more sub-sampling if units were large, (preferably as large as possible) to obtain precision, but warned that sampling in rare populations was not possible, to achieve a small standard error. The author's conclusion from their study of a field with a variable cover of scattered plant species, was that seed banks in general were clustered in distribution without any trend or pattern and biological or environmental factors could influence distribution.

The end of season withering of the above ground plant of *T. matthewsii* is largely completed by October, although capsules, following anthesis, do not dehisce until later.

Batty *et al.* (2001) interpreted the entry of dormancy by October of orchids in a Mediterranean climate, characteristic of the type of environment colonized by the target species, to avoid the dry summer. The authors contended that the seed bank in this type of environment lasted less than one year, so seed that did not germinate, would perish. The volume of orchid seed reaching the seed bank was expected to be much smaller than that for other taxa. The authors contended that fungal activity was essentially patchy within the presumed seed bank habitat, activity being confined to the vicinity of the host. This variability of fungal activity could mean failure of the seeds to establish, even if an area appeared favourable. Colonisation, without the fungal partner would be unsuccessful. The pattern of adult orchid distribution was strongly dependent on the pattern of their symbiotic fungi, and the ability of an orchid seed to germinate in a region might be dependent on the presence or absence of a suitable symbiont. It was a feature of the populations of *T. matthewsii* in the Te Pahi area that the populations appeared to be selective of sites for colonization that suggested the influence of some as yet, undetermined factors.

In some cases other factors, such as effective seed dispersal might affect the pattern of orchid distribution rather than a fungus being available. Howe and Smallwood (1982) contended that distribution of adult plants closely reflected seed dispersal. In their results Bigwood and Inouye (1988) reported all seeds showed clustered distribution, without trend, and were highly irregular, suggesting some biological or environmental effect. Orchids produce large numbers of very small seeds which could be dispersed widely or be affected by topography of the habitat and fall near the existing population.

Owen *et al.* (2001) sampled seed bank and seed rain in sand dune communities of the Outer Hebrides, obtaining cores for seed bank sampling and specially designed seed traps installed to determine species content of seed rain. Both sets of samples were grown on to identify species. Seed bank samples were collected on the premise that viable seeds were concentrated in the top 2-3 cm of the soil including the litter layer, although in sand dunes, the authors considered seed may percolate lower. In rare instances during monitoring for this study, the small hook life stage plants of *T. matthewsii* were noted exposed in sandy substrate, the tuber barely covered. This suggests that seed is close to the surface and contrary to the above authors' premise that seed might percolate through sand, although wind scour could also expose the tuber.

The populations of *T. matthewsii* monitored in this study and observation of adjacent populations showed consistent recruitment attributed to local seed dispersal.

It is a common, but not scientifically proven, assertion that seed of much of New Zealand's orchid flora, including *T. matthewsii* has been blown across the Tasman Sea from Australia by westerly winds. Westerly winds were also regarded as a vehicle for the transport of aeolian dust, and smoke from major fires from Australia, the implication being that orchid seed could also be transported. Although Jordan (2001) considered most dispersal trans - Tasman was probably west to east he conceded that dispersal from east to west also occurred and cited Mcphail (1997) and Swanson and Bremer's (1997) work that species were dispersed from New Zealand to Australia. From examination of deep sea cores taken in the Tasman Sea, Hesse (1994) found the dust plume (presumed a likely vehicle for the transport of seed) from South East Australia lay to the south of the Subtropical Ridge and flux declined eastward across the Tasman Sea.

Arditti and Ghani (2000) agreed that the internal air spaces in orchid seed enabled them to float on air or water for long periods. Arditti pointed out that after Burgell (1936), who studied orchid seed flotation in air, few if any further studies had been

carried out and quantitative information was unavailable. Arditti and Ghani quoted Close's 1978 assertion that orchid seeds had traveled the 2000km between Australia and New Zealand, in a table of travel distance of some orchid seeds, qualified by the observation that the reported distances were included, as orchid seeds may have, and /or still do, travel between indicated land masses. Sites of populations of *T. matthewsii* in this study are separated by distance and geographical features and suggest the populations are a natural occurrence of the species.

Arditti and Ghani reiterated that it was a mistake to assume that flotation in air was the only means of travel for orchid seeds. If transported in mud on the legs of birds, mycorrhiza could well be included, and orchid establishment assured. It would avoid loss of viability and likely desiccation in long air flotation. *Thelymitra* seed was not included in any of the flotation tables presented in Arditti and Ghani (2000). The likely hood of seed of *T. matthewsii* being transported from the small and isolated populations of the species in Victoria, Australia is very uncertain, particularly as other orchid species found in the area have not been recorded as present in New Zealand (eg. *Caladenia species*) and *Thelymitra matthewsii* is not found in wet and consequently muddy habitat, but in dry heath land.

In reporting a survey of the Te Paki Farm Park, McCrae (1988) observed that the Northland peninsula's sub-tropical climate and "dust-trap" effect was the reason the orchid flora had a high Australian content, but did not elaborate the 'dust trap' definition. The author also pointed out that the northland area is buffeted by mainly westerly winds and that the North Cape massif receives winds from all directions.

#### 5.4.2 Population demography

##### Study site location

Location of the permanent study sites where plants could be labeled was largely determined by the best groups of plants in a manageable sized site. The populations

are naturally scattered and strongly ephemeral. In two of the locations, TW4 near the coastal walkway, and RD5 on the northern upland were the only occurrence of the orchid at the commencement of the study. Study site suitable for monitoring could not be randomly chosen because of the population's ephemeral habit, consequently it is acknowledged that a degree of bias could be said to be present in the results. The data obtained from monitoring does represent the chosen sites and is considered to be sufficiently representative as to be applicable to other populations of the species in the same habitats.

Tamm (1991) reported that study sites were not selected randomly in his study of several orchid species. Chosen representative samples of the populations that could be analysed, were desirable because of the major effect on the populations vegetation succession had had, as a result of land use change.

#### Population numbers

Merhoff (1989) summed up the objective of many ecological studies, to understand and predict the changes in plant populations through appearance and disappearance, and increase and decline in numbers.

Population numbers monitored in this study of *Thelymitra matthewsii* were quite low, both in individual populations and collectively, and the period of monitoring was short, compared with published studies in other orchid floras. Table 1.1 listed the majority of Northern Hemisphere species studied and their duration. Studies of New Zealand orchids were of short duration and fewer in number than those initiated in the Northern hemisphere. The length of time recorded for the studies testified to the dedication of the researchers and the importance of monitoring the species described, as most were species in need of conservation. Willems and Melsers (1998) pointed out that appropriate conservation measure for populations were enhanced by an understanding of the demography and the species life history.

Wells and Cox (1991) were of the opinion that the proportion of the population that appears above ground briefly, for example seedlings, surviving for only a few months and disappearing from the population will distort population estimates if not recorded with regular observation. Hutchings (1987) attributed the possibility of plants being missed and not recorded, to the increased experience of the recorders, and therefore the study accuracy was not compromised when all plants were recorded.

In the sampling of populations Kery and Gregg (2003) considered that detectability by persons sampling was important, since failure to incorporate a plant's non-appearance into estimation of demographic results could introduce a bias into the information obtained. The authors found detectability was different for life states and tagged and un-tagged plants, small plants being most likely to be missed, but there was no difference in the degree of detection achieved by the two observers in their experiment, to determine whether all plants were accounted for in the monitoring.

Since this study species, *T. matthewsii* plants are quite small and measurement of growth, presence or absence at labels and new recruits, required close scrutiny, this study was carried out with confidence that all plants present at time of monitoring were noted and recorded. It was considered unlikely that plants were missed at any month's data collection, since in that same close scrutiny, adjacent un-labeled plants were immediately seen. With this study it was considered important from the point of consistency in calling life stages, that the same operator performed data collection throughout. Integrity of labeling was maintained during the study. No numbers were removed or re-issued and labels out of the ground were recorded as 'out of the ground' in the population census.

#### Plant Increase

The increase in plant numbers was made up of new recruits (dormant or newly emerging individuals) which appeared monthly throughout monitoring and were not previously labeled.

The results showed that the populations at all sites increased two-fold over the period of monitoring, for example, labels placed beside plants present in site TW4 in 2002 numbered 28 and increased to 48 in 2004. Similarly, numbers of plants in site RD5 in 2002 numbered 53 and in 2004, 109 labels had been placed beside plants. The natural increase was anomalous in the light of previous casual observations of the plant by the author, in 1997-2000, prior to the present study. These observations found that although plants of *T. matthewsii* might be present in some numbers in one season, in marked sites, in the following season there would be no sign of them. None would have emerged despite different age groups in the previously observed populations which had been marked in various ways, so were identifiable. This was not an isolated instance but occurred at all known sites. Thus the persistence and increase of plants in the monitored populations was contrary to previous observations. Increase in population numbers of the five populations monitored, averaged two times the commencement populations, and the larger populations at sites RD4 and SH6 did not change the result.

It was postulated that due to light disturbance at monitoring in the form of careful stepping among plants to read labels and obtain growth data (at times requiring a level of athletic prowess) substrate surfaces were disturbed, encouraging germination or the emergence of dormant and resting tubers. During their study, Waite and Farrell (1998) found that their studied site became more favourable and increased the growth and persistence of the species. Disturbance is known to advantage orchid species. Gillman and Dodd (1998) suggested that plant numbers in orchid populations are highly variable spatially. Abundance in one location and absence nearby is apparent. An element of soil compaction resulting from visits during monitoring was regarded as having a biological effect on the populations monitored by Cahill *et al.* (2002) and trampling, though not in wet heath land, was found by Oostermeijer *et al.* (1994) to provide suitable sites for the germination of the rare *Gentiana pneumonanthe* following extensive grazing.

Hutchings and Mendoza (1998) found the removal of a yew tree and clearing of vegetation by mowing and raking equaled to disturbance and led to increased flowering, raising plant numbers by increased germination. Increased recruitment after the felling of the tree may have been the result of encouragement of dormant plants to emerge. The authors were unable to provide a firm conclusion as to the origin of the new recruits but agreed that recruitment was possible if the clearance regime allowed more seeds to reach the soil.

### Life stages

The smallest life stage, deemed to be the first emergent with the smallest tuber was designated a hook. Plants size increased with the next life stage the spiral, and the final pre-flowering plant, the non flowering life stage was larger and more robust than either of the preceding stages. Each life stage mean height measured just under twice the height of the previous life stage to it. Adult plants setting fertile capsules were in the minority in populations numbers. A sufficient number of adults were seen as important for future presence of *T. matthewsii*. That the populations are seeding naturally was evident from the increased recruitment during monitoring and the incidence of scattered populations adjacent to most of the monitored sites. Although juvenile plants would probably maintain populations in subsequent seasons, there was a high mortality in new recruits of hook life stage, especially near the end of the growing season, evident from the number of plants not seen during monitoring and recording in the month of October.

Population increase was largely made up of the 'hook' life stage. Other life stages were less common, and the only new plants i.e. plants which had not been labeled previously, emerging as adults, were recorded at one monitored site in 2004. This was their first appearance, so for the previous two seasons no other life stage preceded them. Further study under controlled growth conditions in a glass house would be needed to observe life stage sequence and duration.

The results showed that both life stage sequence and presence and absence of individuals are extremely variable. Plant life stages are static for the season. The life stage that emerges does not develop into an advanced stage during that season. Succession of life stages from smallest to flowering size was not mandatory. The incidence of occurrence in the upper order of the life stages, spiral, non-flowering, adult, over three seasons was recorded as 4% of total monitored plants. As described in the results above, the lower order of hook, spiral, non-flowering over three seasons, occurred only once.

Merhoff (1989) noted progression between states was not fixed. There were multiple transitions between the designated states, and unmarked plants were present even to the flowering stage. He found dormancy and new recruitment impossible to identify. In Merhoff's study, of the endangered orchid *Isotria medeoloides*, individuals were classified yearly as belonging to one of four reproductive states, flowering, aborted bud / sterile, absent, dormant with no above ground growth, or dead.

In this study of *Thelymitra matthewsii* succession, very few adults were followed by the first juvenile stage but most often by absence in the following season. Some individual numbered labels produced flowering stems for two seasons and a very few, for a third season. This phenomenon occurred in the most exposed site and suggests some environmental aspect may have triggered the necessity to produce seed.

During the study some occurrences of plants emerged close together, usually adults, but occasionally an adult and another life stage were seen, generally outside the study sites in extant populations but only rarely in the season. Kingsley Dixon (1991) contended that seven species of *Thelymitra* in West Australia relied on seed increase in populations and eleven were known to have distal tuber reproduction. A daughter tuber is produced by the parent tuber from bud out- growth underground, which may be proximal, ie. close to the parent tuber, or distal, developed at the end of the stoloniferous growth. In comparing seedling and clonal reproduction of West

Australian terrestrial orchid species Kingsley Dixon (1991) showed that many terrestrial species establish seedlings adjacent to a parent plant. New recruits appearing in the *T. matthewsii* populations as hook life stages, were deemed to be seedlings, as they were found clustered amongst further developed, therefore presumed older, life stages. It could not be determined whether these were new tubers produced by a previous stage as the plants could not be dug up.

Vegetative reproduction did not appear likely in the *T. matthewsii* populations. There was no sign of either proximal or distal development of another tuber or stoloniferous growth in plants collected for microscopic examination (see Chapter Four). Excavation of many growing plants to examine possible vegetative reproduction would be undesirable given the uncommon status of this species, although Light and MacConaill (1998) reported that they had no evidence that excavation of an orchid species, *Epipactis hellerborine* had an adverse effect on subsequent appearance.

#### Plant health

Plants were monitored for condition during collection of life cycle data. Most plants of pre flowering life stages recorded a condition of 1 which indicated a healthy plant. Between 80 and 95% were consistently healthy over the monitoring period. Yellowed, withered and blackened plants were marked accordingly. A greater number of adult plants were recorded in these categories, the leaves of adults often blackened at flowering (refer to discussion, Chapter Four).

#### Plant absence

Numbers in new recruits and plants absent in the monitored populations in this study fluctuated throughout the season. There is a general overall decline in October in plant numbers as absence increases at the end of the growing season. Population increase is largely at its peak in August-September. Above ground absence is a phenomenon of terrestrial orchid populations that suggests the tuber receives support from mycorrhizal activity to enable it to appear the following season (Light and

MacConaill 1998). In the report of his study of *Ophreys sphegodes*, Hutchings (1987) felt that the system of analysis used in the study in which plants not present in the population were described as absent rather than dead maintained confidence in the results, even if there were some omissions of plants during recording. In this study of *Thelymitra matthewsii*, absence of plants at labels was meticulously recorded, as the un-predictable absence and re-appearance of plants at any label showed the variability of the populations of this species. Some plants disappeared in the second season and did not reappear, but the duration of the study was not long enough to consider an apparent loss conclusive. 29% of plants labeled appeared at all monitoring over three seasons. The remaining 70% had an absence factor; absent for two seasons, or absent and reappeared, or present and then absent in the second or third season. As sites were monitored monthly, conclusive evidence of presence or absence was obtained.

Monitoring established that plants of *T. matthewsii* emerged earlier than previously thought. The study was initiated in July 2002, and the orchid was monitored until September. Since some plants were seen to be present after monitoring in September in the 2003 season, data collection was extended to include the month of October. During a visit to the study site locations, to map associated vegetation in May 2004, it was observed that the orchid plants had begun to emerge at some labels, much earlier than previously thought. Numbers at labels were recorded but no growth data was taken.

In this earlier appearance of *T. matthewsii* plants, monthly recording needed to consider absence with caution. Non-appearance at previously established labels could not be considered to constitute absence as the tubers may still produce growth later in the season. Willems and Melsers (1998) found that high recruitment in a given year was followed by high mortality in the following year, and the percentage of plants flowering contributed to the population's decline. The authors concluded that the plants of *Coeloglossom* species had disappeared after an absence of one year.

Willems and Bik (1991) thought three years absence was more likely to indicate death.

The populations were assessed for stability by comparing recruitment and loss. Recruitment (which covered all labels provided for plants not previously labeled at the previous monitoring) consisted of new plants recorded over 2003 and 2004 growing season, and loss embraced all absences in both commencement populations and absences in new plants. Results were expressed as a percentage of total monitoring. Absence exceeded recruitment by 7% over all. One site, SH7 in the Shenstone Block, was the only population where recruitment was greater than loss.

#### Life stage modeling

The life stage matrix was compiled from the percentage of the total monitored plants in which each of the four life stages re appeared in the following season. The results showed that the higher percentage occurred in the same life stage with the exception of the non flowering and the adult stages, which showed a regression to a less developed stage. In her study of the orchid *Cleisthes divaricata* Gregg (1998) found the sequence of life states was not set and difference in matrices for populations was often striking.

## 5.5 Summary

The results of analysis of data obtained from the demographic monitoring of *Thelymitra matthewsii* over three growing seasons has been unable to elucidate any pattern to emergence, life stage succession, flowering, plant condition, or presence and absence of plants at numbered labels. This result was consistent with the findings of authors of similar studies of terrestrial orchid species (see Table 1, 1 and Chapter one). Orchid populations are recorded as traditionally variable, and while some climatic events, wind-borne sand burial, major substrate disturbance, cold or salt bearing winds, could have a seasonal effect on the presence of *Thelymitra matthewsii*

in the Far North, physiological traits, particularly emergence and absence, and life stage succession remained variable throughout the monitoring period.

An important point of interest during the monitoring was the unexplained persistence and two-fold increase in plant numbers in all populations in the study. This was contrary to the trend in non monitored, but casually observed, populations which appeared to be extremely ephemeral, composed of a few or more plants which were absent at subsequent observation. The life stages that emerged as a result of the presumed disturbance were dominated by the first life stage related to the size of the tuber, a 'hook', but not exclusively.

The study identified three discrete pre-flowering life stages, designated hook, spiral, non flowering, and the adult life stage. The plants were found to remain in the life stage in which they emerged, for the full growing season. This attribute appears to be confined to *T. matthewsii* in New Zealand as no contrary data was identified. It was also established from plant height data that there was a discrete (i.e. different) growth height maximum for each pre-flowering life stage that was consistent enough to identify that life stage from recorded data.

One study site SH7 in the Shenstone Block returned the highest magnitude of population change over the other study sites, population numbers increasing 2.7 times the commencement numbers i.e. from 26 plants in 2002 to 70 plants in 2004. This site recorded the highest percentage of plants present for all of the three seasons and the lowest percentage of plants with an absence factor over all sites. A high percentage of new recruits survived all season, at site SH7, which was equaled by site SH6, also in the Shenstone Block. SH7 was the only site at which new plants exceeded absence, due in part to the lower absence factor, than at other sites. The site registered the second highest healthy result for adults, a life stage which often recorded a lower condition factor. The site on the clay substrate of RD5, Rubbish Dump hill recorded

the most consistent result, the greatest number of plants that remained healthy, in plant condition, for all life stages.

The result of the one monitoring of early emergence of plants was too incomplete to conclude that above ground appearance in May strongly influenced the life cycle. The greater numbers of more mature plants i.e. adults and non flowering life stages suggested that these life stages might need to spend a longer period above ground. The results also indicated similar percentages of adults and non flowering plants appearing in May in these life stages to those recorded in June, with a stronger increase in the spiral life stage. A life stage model indicated that a plant was likely to reappear in the same life stage and reinforced the conclusion that succession was not obligatory.

Results from analysis of data obtained from monitoring suggested there was no measurable difference in results between the different substrate types of the study sites. The lack of seed in the seed-bank was not regarded as definitive, several variables were considered to have had an effect on the result, including sample and sub-sample size, unnecessary depth of samples and the unpredictable nature of seed dispersal.

The conclusion was that the populations of *Thelymitra matthewsii* located at 'Rubbish Dump' hill, Cape Reinga road, the study site adjacent to the Cape Walkway, and sites in the Shenstone Block, part of Te Paki Farm park, showed a natural variability consistent with recorded studies of terrestrial orchid populations. However the populations of *T. matthewsii* could not be regarded as stable or common, despite recruitment and persistence of numbers in the monitored populations.

## CHAPTER SIX

### **Vegetation Analysis**

#### **6.1 Introduction.**

Vertical stratification, determined by plant life form, is a distinctive feature of a plant community. Plant size, branching habit and leaf area, influence light gradients and are influenced by it. The canopy, comprising the uppermost layer of foliage has a major effect on the lower levels of the community, particularly where foliage is dense. The nature of the herb layer is the result of moisture and nutrient content, aspect and light availability (Smith and Smith 2001).

Terrestrial orchids are vulnerable to conditions affecting their habitat. Adverse changes include associated vegetation succession, invasion of aggressive weed species, and abiotic factors, such as fire or wind blown sand for example. A change in land use, i.e. conversion to pasture, is a certain loss of habitat.

Terrestrial orchid species in New Zealand have been particularly vulnerable to habitat loss through changed land use. Their preferred habitat was the open light shrub land referred to as gum land in the north or 'scrub' throughout New Zealand. Vast areas have been exploited, converted to pasture and more recently to forestry. In most regions only remnants of this vegetation type remain.

The gum lands or 'heath lands' of the Far North comprise one of the largest contiguous areas of its type and supports representatives of most New Zealand terrestrial orchid species. A heath land is composed of Ericaceous species on generally nutrient poor soils, with a winter wet and drying out in summer climate regime.

Dixon (1991) likened the orchid rich regions of South Western Australia to a Mediterranean type climate, the winters cool and wet and the summers hot and dry. Heath land vegetation and open woodland are characteristic vegetation groups. The Far North of New Zealand was regarded by Dodson *et al.* (1988) as the only area with a maritime climate at this moderately low latitude, in New Zealand.

Smith and Smith (2001) postulated that the eventual survival of a species would be in jeopardy if environmental conditions, including habitat, to which the species has become adapted, are subject to change. Although disturbance has been shown to be beneficial to orchid populations, survival is reliant on the timing of the disturbance. Cockayne (1919) observed that most species of terrestrial orchids thrive under a disturbance regime, or a physical change of substrate such as fire, slope disturbance, blown sand and even road construction.

This chapter looks at the vegetation of the Far North plant communities in relation to the *Thelymitra matthewsii* populations. A comparison is made in species and substrate variables of areas colonized by the orchid, and some that are not, to determine whether a singular factor or combination of factors dictates the presence of the orchid.

## **6.2 Methodology**

Study sites supporting labeled orchid plants and reference, vegetation only, sites chosen to reflect the characteristics of the monitored sites not supporting the species, were measured to 3.5 meters square (see Chapter Five). A 30m surveyor's tape was anchored at a selected corner, the remaining corners marked with a short stick placed at 3.5m, 7m, and 10.5m finishing at 14m enclosing a square. One marker was retained for future reference following completion of the survey.

The enclosed area was further divided into 50cm squares, creating columns from left to right and rows from top to bottom for recording purposes. Row 1, Column 1 square

was in the top left hand corner, and Row 7, Column 7 square in the bottom right. The bottom line nearest the operator was designated the front edge of the site.

The initial use of cross strings to delineate the squares, proved to be difficult to negotiate in movement around the area and maintain a tidy grid owing to wind, and variation in species height. It was found that two or three stakes of sufficient length could be used, being moved across and down the area as required, with constant reference to the perimeter tape to keep the square measurements correct. Subsequently, a hand held square constructed of bamboo to measure a 50cm square, proved to be the most useful and quickest method.

Plant cover was measured across both widest axes, using a retractable steel rule which gave flexibility and rigidity when inserted through vegetation to measure height. Where possible, stem diameter was obtained, of necessity, at a height close to the ground. Data was entered into prepared sheets. Data recorded species name, the measured axes i.e. 20x30cm, the height in centimeters, stem diameter in mm (where it was recorded), and the relative position in the square i.e. centre, bottom left, top right, for example.

Ground cover, estimated as a percentage of the 50cm square, of litter, bare ground, moss and lichen were visually assessed and entered into site profiles on graph paper. All measurements and assessments were made by the same operator, to ensure continuity of measurements and observations.

Diagrammatic representation of the vegetation cover data for each study site was drawn to scale on graph paper. Plant cover measurement was converted to  $\text{cm}^2$  and drawn in the positions recorded for each 50cm square. Percentage results for ground cover was converted to  $\text{cm}^2$  and drawn in. Orchid maps, showing the placement of individuals within the study area were also constructed from field notes (See Appendix Three).

An Herbarium of voucher specimens, of vegetation and ground cover species encountered in the study areas were dried in a plant press, mounted on sheets currently in use in the Herbarium collection, and lodged in the University of Waikato Herbarium (WAIK). A list of the voucher specimens included in the Herbarium is presented in Appendix One. Vegetation survey of the sites containing labeled orchid plants was carried out when the orchid was dormant below ground.

## 6.3 Results

### 6.3.1 Species richness

A total of 29 indigenous and adventive shrub species were recorded in the sites selected for the vegetation survey, including lichen and moss and associated orchid species. Three reference sites without the target species, *Thelymitra matthewsii*, were included. The associated species and the study sites in which they were recorded, are listed in Table 6.1. The results indicate the number of measures (an individual plant could be measured across more than one rows or columns) taken for each species at the left of the table, at each site, and the number of seedlings observed, marked with an asterisk as part of the first figure; eg. 7 recordings of *Cyathodes juniperina*<sup>1</sup> at site SH 6 included 3 seedlings, so 4 measures of height and cover were incorporated into data analysis. Numbers of species for which height and cover data were recorded, excluded the latter groups, seedlings, and the non-measurable *Cassytha paniculata*.

The monitored sites, (which supported *Thelymitra matthewsii*) contained from eight to fourteen shrub species measured for height and cover for data collection. In the vegetation reference sites which did not contain the orchid, nine to fourteen shrub species were measured.

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<sup>1</sup> *Cyathodes juniperina* = *Leptocophylla juniperina*

Table 6.1 Measured individuals of shrub and associated vegetation at all study sites. Numbers indicate measures recorded. + present but not measured. – not present. \* number of seedlings included. # denotes sites with orchids.

Species	Study Sites							
	SH 6 #	SH 7 #	SH 10 #	SH 12	TW 4 #	TW 5	RD 5 #	RD 6
<b>Indigenous Dicots</b>								
<i>Cassinia leptophylla</i>	-	-	-	-	4	8	-	-
<i>Coprosma lucida</i>	- 5*	-	1	-	-	-	-	-
<i>Coprosma rhamoides</i>	-	-	1*	1	-	-	5	1*
<i>Corokia cotoneaster</i>	-	-	-	-	-	2	1*	-
<i>Cyathodes juniperina</i>	7 3*	10 2*	17	3	-	-	9 2*	30 10*
<i>Gaultheria antipoda</i>	-	-	-	-	-	-	-	-
<i>Gonocarpus incana</i>	-	-	-	-	-	-	8	5
<i>Kunzea ericoides</i>	28 5*	19 11*	18 15*	20 3*	50 16*	20 10*	22 8*	52 19*
<i>Leptospermum scoparium</i>	- 1*	-	1*	-	6	67 23*	12	10 9*
<i>Leucopogon fasciculatus</i>	8	1	-	3	31 7*	8 4*	1	6 3*
<i>L. fraseri</i>	10 2*	11	6 2*	34 16*	29 3*	26 8*	1*	11 10*
<i>Pimelea prostrate var erecta</i>	-	-	-	-	-	8 4*	-	-
<i>Pomaderris kumarahou</i>	2 1*	3*	3	-	-	-	-	-
<i>Pomaderris ericifolia</i>	-	-	-	-	-	-	3	-
<i>Cassytha paniculata</i>	+	+	+	+	+	+	+	+
<b>Indigenous Monocots</b>								
<i>Carex brevifolius</i>	-	-	-	-	-	-	-	-
<i>Dianella nigra</i>	-	-	-	-	-	-	1*	5 2*
<i>Morelottia affinis</i>	16 11*	35 10*	18 9*	30 13*	8	7	20 10*	24 13*
<i>Phormium tenax</i>	-	-	-	-	1	1	-	1
<i>Rhytidosperma sp.</i>	-	-	-	-	10 3*	16 4*	47 12*	25 24*
<b>Exotic species</b>								
<i>Centurium erythraea</i>	-	-	-	-	-	1 1*	-	-
<i>Hypochoeris glabra</i>	-	-	-	-	-	14*	-	1*
<i>Hakea gibbosa</i>	22	18	34	13	36 2*	6	1	14
<i>H. sericea</i>	8 4*	52 21*	12	46 6*	-	-	-	-
<i>Oxalis corniculata</i>	-	-	-	-	-	-	-	-
<i>Ulex europea</i>	-	1*	-	-	-	-	-	-

### 6.3.2 Height classes

The number of shrub plant measurements qualifying in selected height classes, were totalled for all occurrences of each species in a selected height class, within individual sites, and presented graphically in Fig.6.1 a-b.

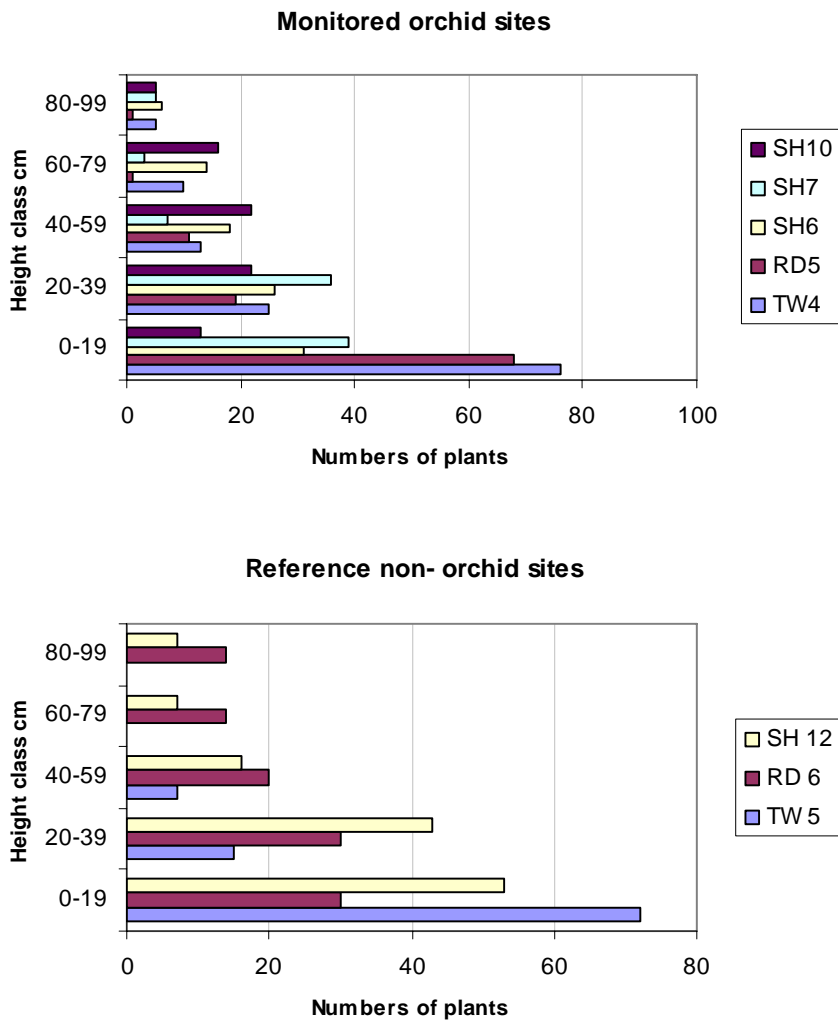


Fig. 6.1a-b Numbers of plants in 20cm increment height classes, all species at all sites, monitored and non-monitored.

Results were characterized by a large number of measurements in the 0 – 19cm height range, in both monitored and reference sites, an average of 44.6% of total measurements (range 16-76%) over eight sites. Shrub species >100cm in height were

present at all five orchid habitat sites and one reference site. Study site TW4 registered 9.8% of vegetation in excess of 100cm height. Addition of the next height class (80-90cm height) increased the percentage to 13.3% of vegetation in the upper height classes at this site. The only vegetation reference site to record vegetation in the >100cm height class, was study site RD6. Proximity to the coast and the effect of wind shear was evident in the high number of measures (72) recorded at the site TW5 in the 0-19 height class compared with an average of 45.5 measures over all eight sites.

### 6.3.3 Vegetation Cover

Total area measurement of the sites was standardized at 12.5 meters squared. Vegetation cover, calculated to meters squared, exceeded the site measure because of the layering effect of species height, i.e. one plant over-shadowed another. Ground cover, also calculated as meters squared, was classified as litter, which included dead branches, bare ground (devoid of vegetation), and lichen and moss.

Vegetation height and species dominance, and substrate cover results of the vegetation survey at monitored and non-monitored sites, on the different substrates populated by *T. matthewsii* is described in more detail.

Study site on volcanic clay, 'Rubbish Dump' hill. Fig. 6.2

#### *i. Vegetation*

The site containing the monitored orchid populations listed fourteen shrub species, one of which was adventive. (Table 6.1). *Kunzea ericoides* was the dominant species in terms of cover at the site but was exceeded in height by *Leptospermum scoparium* (height 140cm) and the adventive species, *Hakea gibbosa* (height 85cm). Seedlings of the plants measured for cover were less in number than in the reference sites. Total vegetation cover omitting seedlings, was 4.42m<sup>2</sup>, where the orchid was monitored.



Fig 6.2 The weathered clay substrate of Rubbish Dump hill supports study site RD 5. The site is outlined with the tape in this view, to indicate the site size.

At the site without *T. matthewsii*, in the same locality, thirteen species and one adventive species were recorded. *Kunzea ericoides* was dominant for cover, but exceeded in height by *Hakea gibbosa* ( height 114cm), and *Dianella nigra* (height 80cm, drawn up through adjacent vegetation). Seedlings were common and total vegetation cover, omitting seedlings was 6.62m<sup>2</sup> .

#### ii. Substrate cover

Substrate cover results for the study site RD5, recorded the largest area of bare ground for all the sites, at 8.97m<sup>2</sup>, followed by litter cover 3.22m<sup>2</sup> and a minimal amount of moss.

In comparison the site without the orchid RD6, recorded 8.51m<sup>2</sup> of bare ground, 3.53m<sup>2</sup> covered by litter and 0.19m<sup>2</sup> of moss cover, measures which were similar to the site where *T. matthewsii* was present.

### iii. Species height

Maximum height recorded for all species was 140cm (*Leptospermum scoparium* mean 37.18cm), and at the non-monitored site 114cm (*Hakea gibbosa* mean height 83.76cm).

Study site on compacted old- dunes, Cape Reinga Walkway Fig. 6.3



Fig. 6.3 The study site TW 4 on the sandstone near the Cape Reinga walkway. The front edge of the site is near the camera. and establishes the rows and columns used in the vegetation survey.

### i. Vegetation

The study site TW4, supporting the orchid, *T. matthewsii*, contained eight shrub species, one of which was adventive, and included one grass species (Table 6.1). The dominant species in height and cover were the adventive *Hakea gibbosa*, (height 140cm) and *Kunzea ericoides*. Slightly less cover was recorded for *Leucopogon fasciculatus*. Total cover was 10.17 m<sup>2</sup> of vegetation at the monitored site.

At the non-monitored site TW5, *Leptospermum scoparium* was dominant in cover because of the large number of smaller and prostrate habit of the plants. Vegetation cover at this reference site was low at 3.99 m<sup>2</sup>.

*ii. Substrate cover*

Area covered by litter was high at the monitored site at 9.02 m<sup>2</sup> and bare ground consequently low at 2.58 m<sup>2</sup>. A small lichen result and slightly higher moss cover was recorded. In contrast at the reference site substrate covered by litter was low at 2.64 m<sup>2</sup> and bare ground recorded higher at 8.72 m<sup>2</sup> at the comparison site. Lichen was greater recording 0.86 m<sup>2</sup>, and moss presence was minimal.

*iii. Species height*

The species *Kunzea ericoides* and *Hakea gibbosa* were equally dominant at the monitored site, and reached 140 cm in height.

At the site without the orchid *T. matthewsii*, *Hakea gibbosa* was again dominant but with a lower maximum height class of 59cm. There was uniformity in the heights recorded for the majority of the remaining species present at this site, heights recorded from 10cm -38cm possibly showing the effect of wind shear.

Study sites on lightly compacted sand, Shenstone Block Fig 6.4, Fig.6.5 and Fig. 6.6.

*i. Vegetation*

The number of shrub species recorded at the three monitored sites in the Shenstone block ranged from eight to eleven (Table 6.1). Seven shrub species, the adventive species *Hakea gibbosa* and *H. sericea* and five indigenous species were present at all sites. *Kunzea ericoides* and *H. gibbosa* were equally dominant in cover at site SH6. The adventive species, *H. gibbosa* and *H. sericea* were dominant at SH7. *H. gibbosa* prevailed with a high cover result at the third monitored site, SH 10, followed by *Cyathodes juniperina*. Total vegetation cover registered 4.6m<sup>2</sup> at SH6, 5.15m<sup>2</sup> at SH7, and 8.38m<sup>2</sup> at SH10.



*Fig.6.4 The study site SH 6 on the sandy dune ridge in the Shenstone Block. From the photograph Lichen can be seen to be common at this site.*

At the non-monitored site SH12, without the target orchid species, seven of the nine species recorded were also recorded for the monitored sites. Total vegetation cover registered 7.71 m<sup>2</sup> at the non-monitored site.



*Fig.6.5 The second Shenstone Block study site SH 7 showing the same sandy substrate and tall vegetation at one side, a characteristic of this site.*

*ii. Substrate cover*

Assessment of substrate cover at the Shenstone sites, showed bare ground fairly uniform at  $7.20\text{m}^2$  and  $7.84\text{m}^2$  for two monitored sites, SH6 and SH7 respectively, and  $4.69\text{m}^2$  of bare ground at the third monitored site SH10.

Conversely, litter cover registered lower results at  $3.35\text{m}^2$ , and  $4.37\text{m}^2$ , respectively and a higher recording of litter at the third site SH10 of  $7.50\text{m}^2$ . Lichen was prominent in substrate cover at one monitored site SH6, recording the highest reading for all sites at  $1.69\text{m}^2$ . Moss presence was minimal.

The non monitored reference site registered  $7.59\text{m}^2$  of bare ground,  $4.40\text{m}^2$  of litter, and low lichen and moss.



Fig. 6.6 The exposed ground at study site SH 10 the third study site in the Shenstone Block showing the fewer plants present. This site is at the head of a major sand blow.

### iii Species height.

Species height was more variable at the sites with sand substrates in the Shenstone Block that were subject to climatic exposure. At the monitored sites *Kunzea ericoides* (height range 25-115cm) *Hakea gibbosa* (height range 67-140cm) and *H. sericea* (height range 26-110cm) were dominant, followed by *Cyathodes juniperina* (height range 53-90cm) prominent in all three sites.

*Leucopogon fasciculatus* (height 85cm) was a height dominant at the reference site, followed by *Hakea gibbosa* (77cm) and *Kunzea ericoides* (70cm).

### 6.3.4 Species diversity

Table 6.2 illustrates relative diversity and cover that was recorded during the survey, including ground cover, and other orchid species. Indigenous and exotic species diversity percentage is compared and shows indigenous species of > 80% in all but

two of the sites, SH7 and TW5 where there is a small increase in exotic species percent.

Table 6.2 Table of shrub species diversity, indigenous and exotic percentage of total vegetation; maximum vegetation height in meters ; vegetation cover and exotic species cover percentage in meters squared; ground cover in meters squared and as a percentage of total ground cover, at all sites, in the locations studied. \* Denotes sites supporting *Thelymitra matthewsii*.

Location	Shenstone Block				Walkway		Rubbish Dump hill	
Sites	SH 6*	SH 7*	SH10*	SH12	TW4*	TW 5	RD 5*	RD 6
Spp, diversity	13	13	11	13	13	14	18	17
Indig. Diversity	84.6%	76.9%	84.8%	81.8%	92.3%	71.4%	94.4%	88.23%
Exotic diversity	15.3%	23.1%	18.18%	15.4%	7.7%	28.6%	5.5%	11.8%
Max.vegt. height	1.15 m	1.4 m	1.0 m	0.85 m	1.4 m	0.59 m	1.4 m	1.14 m
Vegtn. Cover m <sup>2</sup>	4.46	5.15	8.4	7.71	10.17	3.99	4.42	6.62
Exotic cover m <sup>2</sup>	1.99%	3.58	5.2	3.66	4.78	0.71	0.15	1.53
Bare ground m <sup>2</sup>	7.2	7.84	4.69	7.59	2.58	8.72	8.97	8.51
Litter m <sup>2</sup>	3.35	4.37	7.5	4.4	9.02	2.64	3.22	3.53
Lich. / moss m <sup>2</sup>	1.69	0.032	0.05	0.25	0.65	0.88	0.05	0.19
Bare ground %	58.7%	64%	38.3%	61.95%	21.06%	71.2%	73.2%	69.5%
Litter %	27.3%	35.7%	61.2%	35.9%	73.6%	21.5%	26.3%	28.8%
Lich. / moss %	13.8%	0.3%	0.4%	2.04%	5.3%	7.2%	0.4%	1.6%

Of a total number of twenty four species recorded, four species, *Kunzea ericoides*, *Leucopogon fraseri*, *Morelotia affinis* and the adventive, *Hakea gibbosa* appeared at all sites, at both monitored sites supporting *T. matthewsii* and comparison sites where the orchid was absent. Since moss results were very small, lichen and moss are combined in the analysis.

### 6.3.5 Species dominance

The dominant species at each site were deemed to be those for which cover in m<sup>2</sup> exceeded that recorded for companion species and were consistently dominant in more than one site. Figure 6.7 illustrates the dominance and occurrence of those

species registering the higher cover results. For example the three species *Kunzea ericoides* *Morelotia affinis* and *Hakea gibbosa* can be seen to be present at all sites. *Leptospermum scoparium* peaks in the coastal site of TW5. *Hakea sericea* is more prevalent on the sandy substrates of the Shenstone sites at the left of the Figure. *Cyathodes juniperina* is more common on the clay Rubbish Dump hill uplands.

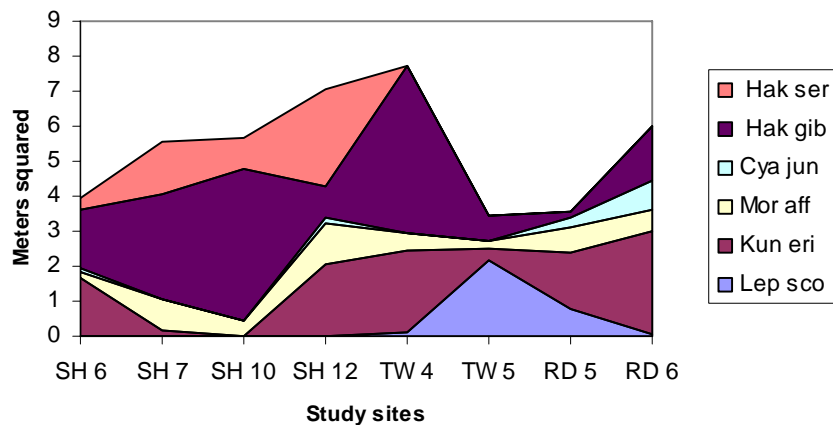


Fig 6.7 Dominant species cover in m<sup>2</sup> at all sites both monitored and comparison sites. For species names see Table 6.1.

Vegetation cover in meters squared, and ground cover results for litter, bare ground, lichen and moss in meters squared for all sites in the survey are shown in Figure 6.8

Litter mirrors the vegetation density as expected, and where litter is reduced total bare ground is increased. At monitored sites, lichen results varied between 1.69m<sup>2</sup> at SH6 and 0.03 m<sup>2</sup> at SH 7. Moss occurred in greatest proportion at TW4 at 0.56m<sup>2</sup> and was recorded as low as < 0.05m<sup>2</sup> at the remaining sites containing the orchid.

At non monitored sites TW5 recorded 0.86m<sup>2</sup> of lichen, RD 6 recorded zero lichen and SH12 0.21m<sup>2</sup>. Moss occurred at TW4, (0.56m<sup>2</sup>) RD6 (0.19m<sup>2</sup>) and at the remaining non monitored site, results were < 0.04m<sup>2</sup> of moss.

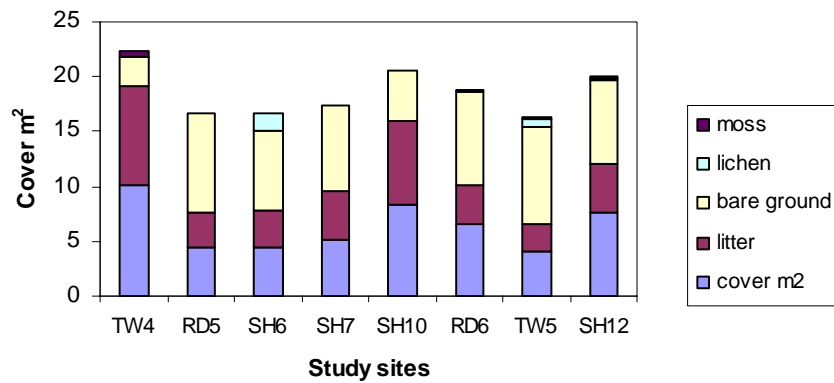


Fig.6.8 Graph depicting vegetation cover (in m<sup>2</sup>) compared with ground cover in m<sup>2</sup> for all sites in the survey.

### 6.3.6 Cluster analysis

The results of the cluster analysis models using the statistical program STATISTICA tree clustering are presented in Figs.6.9 and 6.10. Variables used were vegetation cover in m<sup>2</sup> at individual sites, the species in Table 6.1 and Fig 6.8, which returned the highest proportion of cover in m<sup>2</sup> in each of the studied sites, both with *T. matthewsii* and sites chosen for reference.

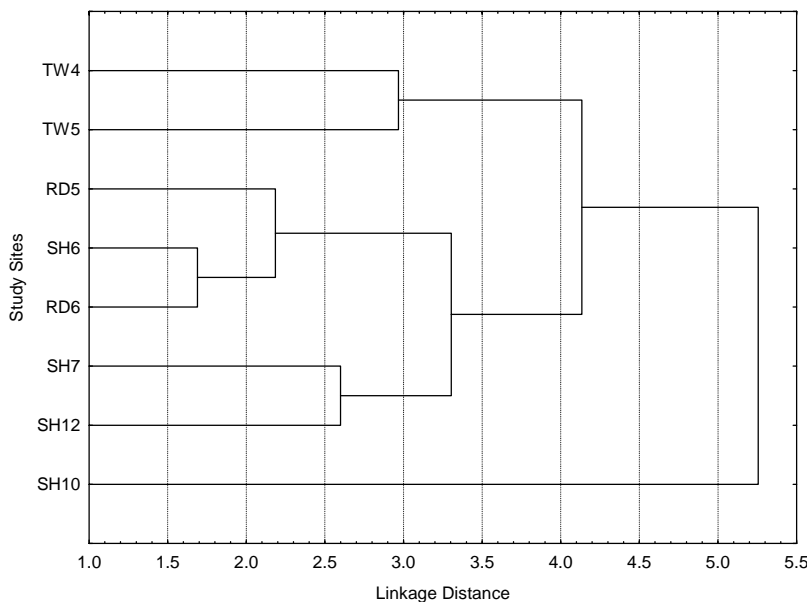


Fig 6.9 Cluster analysis results using Euclidean distances and vegetation variables

Ground cover results (Fig 6.8) in m<sup>2</sup> for litter, bare ground, lichen and moss combined, were the second set of variables used for all sites in the study. City block (Manhattan) distance was initially employed, as the possibility of out-liers affecting the result is reduced, and furthest neighbours, or complete linkage, to determine which clusters can be linked.

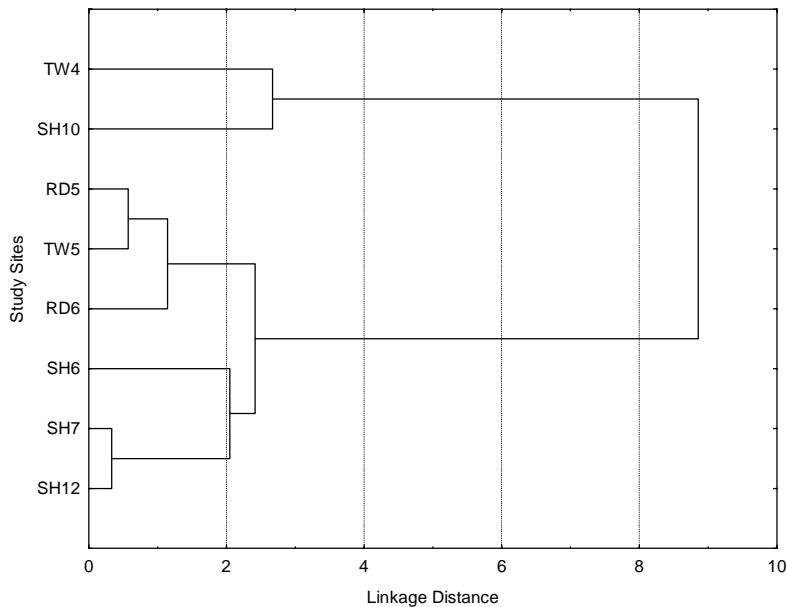


Fig 6.10 Cluster analysis results using Euclidean distances and ground cover variables.

A second analysis, using the same variables as before, vegetation cover and ground cover in a second graph, this time employing Euclidean distance, produced a very similar result. One *T. matthewsii* inhabited site was paired with one non-inhabited site in three instances, pairing sites in the same locality. One of the orchid inhabited sites was widely different from the group, which was consistent with this habitat in the Shenstone Block.

The result was less conclusive for the ground cover, using Euclidean distance but again showed a central group and an outlier. The sites without *T. matthewsii* were integrated into the main grouping, the outliers being sites with the orchid.

## 6.4 Discussion

### Population numbers and species richness

The vegetation at the study sites was found to conform to the identification of it as heath land, both in species composition and community characteristics with low species diversity and low species richness. Specht's (1979) identification of heath vegetation of eastern Australian States was of low, variably dense vegetation, not reaching 2m in height, and usually in low nutrient substrates. Maximum vegetation height in this study included in Table 6.2 illustrates the general height extent of the measured vegetation.

Research of historical and extant literature verified that heath land habitat was considered eminently suitable for tuberous, commonly terrestrial, orchids.

Twenty five Genera of orchids were included in the list of typical species of Australian heath lands by Specht (1979). Orchidaceae was identified as a plant family of which many species belong to heath communities. Carse (1910) described the 'moorland' of the north as home to 18 of the 21 genera of orchids in New Zealand and 35 of the 57 species, including 8-9 *Thelymitra* species. Cockayne (1919) considered the habitats amongst manuka were excellent sites for orchids, seen by him as curious plants, greatly esteemed for their beauty and rarity, and often thought to be valuable. Wardle (1991) observed that gum land heath was a rich habitat for orchids and Esler and Rumbal (1975) quoted twenty species. Orchid species observed during the monitoring of *Thelymitra matthewsii* included *Thelymitra* species, *Genoplesium* and *Caladenia* at the sites surveyed, and as with the shrubs present, many other genera were observed while traversing the surrounding vegetation. The heath land communities of the Far North are considered by Native Orchid Group members to be one of the best areas to observe a number of orchid genera.

The vegetation of the Auckland gum lands was considered by Cockayne (1919) as the most varied, with ~ 81 species. His description of the components of the vegetation

could still describe much of the present remaining Northland heath communities, although he ascribed pungent mingi-mingi, *Cyathodes acerosa* (*C. juniperina*) and *Cassinia* sp. to the South Island. This study confirmed the presence of *Cassinia leptophylla* at the study sites adjacent to the walk way near the coast. *Cyathodes juniperina* was among the dominant species for cover and was recorded present at five of the eight study sites surveyed, and a frequency of 7.7%.

Enright *et al.* (1988) described New Zealand heath lands as species poor, the dominant species on sand sites *Leptospermum scoparium*, and on the volcanic soils, *Kunzea ericoides*, and included reference to the invasive exotics, *Hakea* species and *Ulex* (gorse). This study confirmed this observation and noted the increased presence of pre forest species on the volcanic clay soils. *Kunzea ericoides* rated high in cover value on both the clay substrate and the older and more recent dunes. Other early descriptions of the Northern heath lands were of Diffenbach's (1843) description of Aupouri, quoted by Elliot (1998), as scantily vegetated with low scrub and fern and clumps of wiry grass. A total of 42 species were reported by Dawson *et al.* (1988) in their study of the heath vegetation. Several species not recorded in the study sites, and regarded as components of heath vegetation were observed, some times prolifically, adjacent to and en route to monitored sites.

Levels of phosphorus in soil nutrients were propounded by Specht (1979) to have the most influence on the distribution of heath land in Australia and prophesied that because of the wide spread infertile soils in the Tertiary, heath land would have occupied much of that continent. No nutrient content of substrate was investigated in this study but is seen as an adjunct to further study and resolution of reasons for the species scattered presence.

The paucity of shrub species in the heath lands is also thought to be related to fire, as an inherent modifying agent and inducement of the heath vegetation, a concept

supported by several authors, (Dawson *et al.* 1988; Dodson *et al.* 1988; Enright *et al.* 1988; Newnham *et al.* 1991; Ogden *et al.* 1993).

It could be deduced from pollen analysis, according to Wardle (1991) that fire has had an effect on the heath communities for at least 16,000 years and the gum land heath had evolved from a mosaic of forest and early dry or wet heath species. Northland heath is usually classified as derived vegetation, following forest destruction (Enright 1989). Patchiness in vegetation cover, evidenced by taller pre forest species in gullies surrounded by heath regeneration species attests to the effect of fire in the northern clay lands adjacent to Rubbish Dump hill.

Other studies citing pollen as evidence that forest was once present included Enright *et al.* (1988) whose study of pollen cores from the Te Werahi wetland at Te Paki, showed an historical increase in the presence of *Pomaderris* and *Dracophyllum* species. Dodson *et al.* (1988) included forest remnants such as Kauri gum as evidence of previous kauri forest. Kauri gum is still seen though rarely in the area.

There was a general consensus that both historical and more recent fires following the arrival of humans contributed to the destruction of vegetation near the coasts, and the expansion of dune complexes, (Enright *et al.* 1988; Newnham *et al.* 1991; Ogden *et al.* 1993). Dune habitats were an integral part of this study as a larger number of plants of *T. matthewsii* were present on the stabilized dunes on which shrub vegetation was established. Hesp (2001) identified fore dunes as formed by Aeolian deposition of sand within vegetation. Older dune surfaces were described by Pegman and Rapson (2005) as having substrate stability with decreased sand movement, salt spray and an accumulation of organic detritus, and therefore nutrition for shrub species.

Ballance (1988) observed that where vegetation was reduced or destroyed, blow outs could occur in previously stable dune ridges. Healy and Kirk (1992) agreed that destruction of vegetation, fundamental to binding loose sand, introduced wind

erosion. Though fixed by vegetation, Brook and Thrasher (1991) considered the dune surfaces lacked a developed paleosol. The extensive inland dune areas adjacent to 90 mile beach, which were within the area of this study, sea ward of the cemented fore dunes, were considered to be late Holocene in age, and deposition was probably c 6500 yrs BP (Brook and Thrasher 1991). *Thelymitra matthewsii* was not found in comparable habitats to those studied, inland from the extensive dune field of 90 mile beach.

Several blow outs were a feature of the vicinity of the study sites particularly near the populations of the target species in the Shenstone block, and blown sand has impinged on known occurrences of the orchid. As described in Chapter four of this thesis, however, plants of *T. matthewsii* have already been observed in these new habitats.

The distinctive orange brown and mottled colour of the coastal sand barriers of Healy and Kirk (1992) and their slight lithification was reported by the authors' to be relatively unusual in world wide shore lines. This substrate supports several populations of *T. matthewsii*, numbers of which have increased over the period of monitoring, and two of the study sites were surveyed there. The monitored population at this site has increased in numbers markedly, and several new colonies exist nearby.

#### Species height classes

Height class data in this study agreed with Specht (1979) in his identification of a < 2m height measure in heath populations. Maximum species height in the study was recorded at 1.4m and ~1m in six of the eight sites studied. The distribution of shrubs more than a meter in height clustered together on one or two margins of the surveyed sites supporting *T. matthewsii* populations was a characteristic of four of the five sites. The remaining monitored sites contained species in the 80-99cm height class. Only one of the comparison sites that did not support the orchid contained the taller shrubs.

The high number of measures qualifying for the low height classes as noted in the results was consistent with heath communities and was more apparent in the exposed sites and near the coast where plants of *Leptospermum scoparium* were commonly prostrate as represented in Figure 6.7, which also illustrated the peak in cover of *Leptospermum scoparium* at the coastal sites.

*Thelymitra matthewsii* did not occupy areas where carex and sedge species were common in association with woody shrubs, a characteristic of much of the northern heath, but preferred open ground between low shrub areas, areas frequently becoming colonized by *Hakea spp.* *Hakea gibbosa* forms low to medium height compact bushes in the open, but *Hakea sericea* tends to sprawl, so while providing some shelter and shade, does commandeer a disproportionate amount of space. Seedlings of this species are common.

#### Diversity and frequency of shrub species

Diversity and frequency are related to both population numbers and dominance, as explored above. Research has shown that authors of papers describing heath populations agreed that *Leptospermum scoparium* was a dominant constituent of the community, especially on the sand substrate country, and that *Kunzea ericoides* replaced it on soils derived from volcanics. Dawson *et al.* (1988) suggested *Kunzea ericoides* was a seral stage to forest, and in this study more forest type under story species were recorded on the clay soils of Rubbish Dump hill.

The abundance of *Hakea spp.* in heath areas surveyed in his study was noted by Enright (1989) and he pointed out the absence of endemic Proteacea, (*Knightia excelsa*). This species was observed in this study to occur in fire modified heath land adjacent to the study sites in this area, that appear to be returning to forest. Frequency percentage data from this study recorded equal scores from *Kunzea ericoides* and *Hakea gibbosa* and these species were also frequently dominant for height.

Specht (1979) found species recorded in SE and WA Australia heath lands to be restricted in number, and actual occupation permitted an average of 22-36 species to develop in an area of 8 m<sup>2</sup>. Vegetation was not measured to this extent in this study but the vegetation survey recorded 15 species in 12.5m<sup>2</sup>. Extension of measured areas would probably increase species numbers but most likely not diversity, and would increase the proportion of open or bare ground.

Other species, common to heath communities, though not included in results, from their absence in the site, were present and observable adjacent to the surveyed sites such as abundant *Pomaderris kumeraho*, seen only as seedlings in the monitored sites, *Dracophyllum sp.* Epacris, Gaultheria and numbers of Carex and monocot species.

#### Vegetation dominance

Dawson *et al.* (1988) saw fire as a component of the far north environment that may have had a maintenance role in heath land. The authors reported 42 species in the vegetation as mentioned in the section describing population numbers, dominated in low nutrient soils by *L. scoparium*. The heath on volcanic soil, however was dominated by *K. ericoides* and suggested a seral stage to forest.

This study recorded more forest under-story species present on the clay substrates of Rubbish Dump hill. If the influence of the dominant exotic species in the vegetation cover was removed, it was thought another indigenous species would not become dominant. Indigenous species already prominent in cover value would probably increase over less dominant species. Specht (1979) reported that species diversity decreases as regeneration expands, and dominant species exerted a competitive effect. Enright. (1989) observed that both species of *Hakea* were present on sand based substrate, but rarely together, and *H. gibbosa* was absent from volcanic soils, *H. sericea* being common on these clays. This study recorded *H. gibbosa* from sites surveyed on volcanic derived clays of Rubbish Dump hill. Both species occurred

more commonly together in the light compacted sands of the Shenstone Block dune ridges, and *H. gibbosa* was common on the indurated sand stones near the walkway, usually in association with *K. ericoides*.

#### Ground cover

Litter content of ground cover was naturally higher where vegetation was dense. *Hakea spp.* particularly, shed needles and branches more readily and dead plants were often present. A lichen species was a feature of the open sand areas of the study sites on the dune exposures in the Shenstone Block. Lichen was confined to the lightly compacted sand in 'boulders' and ledges and did not impact on the orchid. The presence of litter, including dead branches, on the periphery of vegetation, were favoured sites for all life stages of *T. matthewsii* in many instances and suggested the advantage of shelter or that mycorrhiza might be more attainable there.

Wardle (1991) drew attention to the presence under stunted shrubs of Kanuka and Manuka and *Cyathodes spp.*, of a ground cover of lichen in dry exposed sites. This study found moss was more likely to be present where some shade from the exposed side of the site was available, and the less permeable substrate of the lithified and mottled sands near the walkway were a more desirable habitat than the open, dry, presumably fast draining sites. *T. matthewsii* was present amongst moss that was close to the surface and not over-topping the orchid, but was not found in sites where water might lie, or in swamp conditions.

Few cryptograms were reported from Australian heaths by Specht (1979). Plant cover will alter physical conditions in the habitat near the ground, altering soil nutrient from litter and drying the soil (Nye and Moore 1982) and the authors considered a bare surface conserved more moisture in the soil.

The presence of wet-land communities of rushes, *Glychenia spp.* and *Lycopodium spp.* among taller shrubs, stagnant water in gum holes and perched swamps in some

areas in the Shenstone Block suggest a water table might be present beneath the seemingly dry sand areas, that maintains the shrub communities. *T. matthewsii* was absent from these habitats.

#### Cluster analysis

The objective of this analysis was to determine whether the sites that did not support the target orchid species differed greatly from those that did. In the results there was little evidence that the comparison sites stood out from the monitored sites.

Fowler *et al.* (2001) described cluster analysis as a technique for the classification of samples into groups of similar individuals. The technique is usually used with multivariate sampling. A measure of difference is generated between a pair of sample units and identification of similar units is found utilizing the distance measures. The results showed two of the sites to be linked but a great distance from other sites linked in a homogenous group. The most significant result was the coupling of one site supporting *T. matthewsii* with the site without the species but in the same locality.

It is postulated as an observation of this study that the reason the orchid does not appear at sites at which there are no obvious differences compared with those where it does, may be influenced by mycorrhizal presence or absence. Several heath land species establish mycorrhizal associations and these may be varieties that benefit orchid species commonly found in the same communities. (Specht 1979) considered mycorrhiza were certain to be in the roots of some plant families including Myrtaceae.

Specht mentioned that there was a suggestion that the chances of inoculation of taller tree species in dry heath lands in Australia with mycorrhiza may be reduced by the extreme infertility of some sands and therefore prevent the species inclusion in the heath communities. This latter fact might indicate a patchy soil moisture distribution and consequently patchy rhizosphere population which might impinge on the

presence of *T. matthewsii*, accounting for the species absence in what equate to be suitable sites for colonization. Patchy colonization of the dune areas is a feature of *T. matthewsii* populations and large areas of similar habitat do not support the species.

## 6.5 Summary

No physical evidence was found that the configuration of the habitat, vegetation height and dominance of the associated species, and presence and composition of the ground cover, contributed adversely to the distribution of *Thelymitra matthewsii*. Results from the analysis of vegetation data at each of the sites where the species was monitored, and at reference sites where the species was absent, supported this contention. The populations remained present and increased from new recruits in the sites where they were established in the monitored sites, but did not appear in the reference sites, which suggests some other factor, or factors, influence the species presence.

Research showed species richness was found, in the eight sites studied, to be relatively uniform, conforming to the general paucity of species reported in descriptions of heath land. Some different species were recorded on the clays derived from volcanic substrate, from the coastal cemented and lightly cemented dune sands, and this is in accordance with published studies. For example *Leptospermum scoparium* was more common the sands than on the clays.

The dominant species in terms of cover from measurement data were *Kunzea ericoides* and *Hakea gibbosa* equally dominant, followed in order by *Morelotia affinis* ( which appeared at all eight sites), *Leucopogon fraseri* and *Hakea sericea*, and with equal dominance, *Cyathodes juniperina* and *Leptospermum scoparium*. Species height was dominated by the lower height classes, in some cases boosted by the prostrate form of growth. The co-dominance of introduced exotic *Hakea spp.* may be one aspect of the vegetation that could have a long term affect on the preferred

habitat of *T. matthewsii*. In the case of fire, the resulting explosion of seedlings would be disastrous for the species content of the heath environment as a whole.

Although there are a proportion of shrub seedlings present at the sites surveyed it is considered that the impact of these will be long term because of the slow growth of heath species in the low nutrient substrates. There was some evidence that proximity of shelter afforded by associated vegetation species, was advantageous to the orchid populations.

It is postulated that there is some evidence that the presence or absence of mycorrhiza may have an effect on the establishment of *T. matthewsii* populations at any one site. The conclusion was that *T. matthewsii* will continue to colonise sites suitable to it, where one habitat is lost, perhaps from over growth of vegetation leading to a closed canopy, new areas built up from wind or water erosion will be acceptable to new populations, providing there are still some adult plants to provide seed. The retention of habitat to accommodate the natural persistence of these is of the utmost importance.

## CHAPTER SEVEN

### **Conclusion**

#### **7.1 Introduction**

This research project has advanced knowledge of the life stages the ecology and morphology of *Thelymitra matthewsii* from monthly monitoring and demographic analysis. The aim of the study was to understand the life cycle of the species and promote recognition of the previously un-described juvenile life stages. Partly achieved by the monitoring of the populations, understanding of the life cycle must be regarded as incomplete due to the relatively short monitoring period of three growing seasons. Some questions were not fully resolved, such as duration of the life cycle and the permanence of absence.

This study collated population dynamics data, recording plant presence and absence, (plants not observed at monitoring), life stages and growth, increment and health. Results confirmed the variability of the populations in all these categories. Associated vegetation diversity, and its likely effect on the future presence of the orchid was explored to determine answers to questions posed by the study. No major differences emerged between sites with the target species and sites without.

#### **7.2 Background to the Study**

Comparable work

Orchid population studies from 1991-2001 stressed the need for multiple observations of the target species as orchid populations were commonly ephemeral and their appearance variable in time and space, factors relevant to this study. No comprehensive study incorporating population monitoring of a *Thelymitra* species had been carried out in New Zealand, prior to this research.

## Orchidaceae and *Thelymitra*

The great variety of flower forms in the Orchidaceae was influenced by the plant's adaptation to diverse habitats in a range of geographical regions, and attributable to specific attractants to pollinators.

Recent DNA phylogenetic analysis strengthened support for the classification of orchids away from the historical inclusion with Liliales to Asparagales, considered to be a closer relationship. The most recent classification of *Thelymitra* places the genus with terrestrial orchid genera which are represented in New Zealand and Australia.

It was clear from morphological characters that *Thelymitra* was distinctive among Orchidaceae. Terms describing column configuration are exclusive to *Thelymitra* as the column is the most diagnostic feature at species level. *Thelymitra longifolia* had significance in New Zealand floral history as it was the first orchid collected and described following Cook's voyage in 1776. The genus *Thelymitra* stood out among orchids, the often clear blue colour of the flowers, comparatively uncommon in the Orchidaceae.

### The physical setting

The geological and climatic descriptions pointed out the unique configuration of the Far North, a narrow tombolo built of sand, wind blown from ocean deposition, linking older uplifted volcanics of submarine origin. Proximity to the sea and lower northern latitude contributed to a milder climate than experienced in the rest of New Zealand, subject however, to strong winds and heavy rain in tropical storms.

Considered to have been long subjected to natural and anthropogenic fires the vegetation associated with *T. matthewsii* was found to be characteristic of heath shrub communities, consistent with Mediterranean type heath land. Warm and summer dry, with low species richness, heath land in the North was dominated by indigenous *Kunzea ericoides* and *Leptospermum scoparium*.

Characteristically of low stature and patchy distribution, more recently invaded by aggressive exotic species, with remnant pre-forest species in wetter gullies, the 'sameness' of the vegetation was commonly perceived as uninviting for travelers. The isolation and the winter growth cycle of *T. matthewsii* contributed to the long unreported presence of the species and its undiscovered possible presence throughout the north.

*T. matthewsii* was found in four dry-land substrates in the Far North - the lateritic and basic soils pluton of the North Cape Scientific Reserve and the deeply weathered clays derived from uplifted submarine volcanics of the northern uplands. The sand based substrates were the indurated sandstones of the old dunes, bordering the west coast, and the lightly consolidated and mobile dunes of the Shenstone block, inland from the Te Pahi stream mouth.

### **7.3 Morphology and phenology of *T. matthewsii***

The monthly monitoring over a period of three seasons enabled a number of morphological and phenological traits to be confirmed. Timing of flowering and number of flowers in the populations was not consistent, and all life stages continued to emerge haphazardly through the season. It was evident from observations made of the orchid during the study that clear differences existed between the leaf of the adult plant and the leaf of the pre adult or juvenile life stages, newly identified by this study.

This new material is presented from microscope examination and description of leaf form in the pre-flowering life stages which rise smoothly from the tuber, as they were not previously described in formal literature. This new information is important for identification of the species, particularly for the likelihood of new unrecorded populations being discovered by amateur enthusiasts. The leaf lamina in the adult is expanded at the base then narrowed into a spiral about the stem. The spiral leaf form, the growth specific pre-flowering stage, and the distinctive column configuration are

the features which set *Thelymitra matthewsii* apart from other *Thelymitra* species in New Zealand.

Descriptions of the species in Australia included reference to ‘grape like’ calli at the back of the anther, which was not clearly seen in flowers examined in this study. As open flowers were not common during monitoring only a few could be examined for the presence of the calli, which, if absent, could indicate a difference in *T. matthewsii* flowers in New Zealand. As observation of *T. matthewsii* flowers has so far been minimal this feature has not been confirmed and further study is needed to clarify a likely dissimilarity.

#### **7.4 Population demography**

The results of analysis of data, obtained as a result of the monitoring of the target species over three growing seasons, did not identify any pattern to emergence of plants, life stage succession, flowering time, plant condition, or the presence and absence of plants at labels. These results followed findings of similar studies of terrestrial orchid species in Chapter one of this thesis. It was an assumption of this study that the reappearance of a plant was the continued provision of seasonal tubers following label insertion at that site, at commencement of the study.

Variation in life stage allocation in populations, and succession in subsequent growing seasons, and the un-predictable nature of the flowering of the adult plants was constantly recorded by the demography results. During the monitoring period, plants continued to appear in the sites chosen for the study, and labeled plants increased two-fold over numbers of labeled plants present at commencement of the study. These are important observations as they were contrary to previously observed *T. matthewsii* population behaviour.

The species was found to have four distinct life stages, from a small, single, hook-like leaf, and two more spiral, single-leaved pre adult stages, to the adult plant, which

supported the usually single, flower. The life stage in which *T. matthewsii* emerges at the beginning of the above ground stage is static for that season. A small increment in growth was registered and the plant withers at the close of seasonal growth in that life stage. As a result of the monthly monitoring of the species, it was found that the three pre adult life stages had an individual height class which was consistent enough to encompass all occurrences of that life stage, discreetly separating them in all the monitored populations. In the adult life stage growth increment increased until the bud matured.

The populations were composed of numbers of different life stages. Recruitment, in the form of new plants not previously labeled, was more often the smallest emergent, a hook life stage. Appendix Two, of summarized plant growth data, shows the numbers of plants and percentage recorded for each life stage in each of the populations in the seasons monitored. In a random sample, for example, life stages recorded in population RD5 in 2004, 13.6% plants appeared as hooks; 28.6% as spirals; 29.09% were the non flowering stage; 9.09% appeared as adults and 18.2% of absence was recorded. Indeterminate life stages were recorded as 6.3%. A proportion of labeled plants in populations appearing as adults, re-appeared as adults the following season, and a very few for the third time. Adults were generally outnumbered by pre flowering life stages. Succession from smaller to a flowering plant over three seasons, was not mandatory, only 5% of populations exhibiting this factor.

The populations were maintained by the smallest juveniles commonly interspersed with more advanced life stages. Seasonal and partial absence was a major component of the populations. An average of 32.8% of plants over five study sites were present at every monitoring during the three seasons of study, while 66.9% were absent in one or more seasons. All plants were labeled and present at commencement of the study, and absence (recorded as not present at labels) from then was variable, plants being absent for one or two complete seasons, appear and disappear, or record

absence, and reappear. A high degree of absence was recorded in new plants (mean 85.7%) appearing in 2003 and 2004 over all study sites.

To determine population stability, recruitment and absence were compared. Plant absence exceeded recruitment by 7% (mean of plant absence 30.5%; mean of plant recruitment 23.4%). There was a smaller majority of absence at the study site on the volcanic clay in the northern highlands and the site on consolidated dune sand near the West Coast, compared with two of the study sites in the lightly consolidated and mobile sands of the Shenstone Block. The third study site in this locality however recorded a recruitment majority over absence, the only site to do so.

Plant health was assessed, assigning a number from 1-4 to indicate health to decline, and resulted in 80-95% of plants monitored recording a healthy condition. Plant health generally declined towards the end of the growing season and adult health was notably lower than in other life stages.

A model, constructed from a matrix of likely succession of life stages from one season to the next, indicated that a life stage, appearing in one season was more likely to be followed the next season by the same life stage. Succession to other life stages occurred but was less likely, and succession to absence was high in the smallest juvenile and adult classes..

The duration from seed to flowering was unknown, and the mycorrhizal association, regarded as common to all terrestrial orchid species establishment, was not investigated. An attempt to isolate DNA from populations at each of the study sites to determine relationships between the scattered and isolated populations was unsuccessful. Seed bank analysis failed to identify seed within samples of substrate taken from colonized and likely habitats.

## 7.5 Habitat

Questions relating to habitat configuration, species richness, and likely effect on the orchid populations were addressed by the study. Species diversity was remarkably uniform at all of the sites surveyed, with a small introduction of pre forest species on the clays of the northern volcanics.

No major differences were determined in associated shrub species height and cover, and ground cover percentages, between monitored sites supporting *T. matthewsii* populations, and between these and comparison sites not supporting the target orchid species, an indication that habitat availability was not limiting to the orchid's distribution. Differences in vegetation and ground cover and physical aspects of sites supporting *T. matthewsii* and comparison sites that did not, were minor. Population absence might suggest another factor, for example a suitable fungal partner, influenced the species presence or absence at a site. The coupling of an occupied site with a comparison site in cluster analysis results reinforced the premise of likely mycorrhizal involvement.

The sometimes severe weather experienced in the Far North in the form of depressions bringing heavy rain and gales causes severe erosion and blown sand in the softer substrates. While some habitat, and with it some populations would be lost to encroachment of blown sand, already occurring in the younger less consolidated dunes, new habitat would also be developing. The orchid was documented as colonizing new blown sand and erosion sediments, in the short period of time of this study.

### **Conservation recommendations**

Some points relating to conservation of the species emerged from the results of the study. The conservation status of *Thelymitra matthewsii* was recently regarded as needing re-assessment and a review was suggested, based on available data.

#### National threat classification

The species classification in New Zealand threatened plant literature was as a vagrant colonizer. It is contended in this study, that the species has been in New Zealand as long as other species of *Thelymitra*. No scientific evidence supporting proof of trans-oceanic dispersal was found to be currently available. The present threat classification of *Thelymitra matthewsii* was inadequate in the light of confinement of the species to the Far North in New Zealand, in relatively circumscribed, ephemeral populations in widely separated habitats. The classification did not address the species vulnerability to that habitat loss, and the sparseness and spatial separation of the populations.

Population data obtained from this study, matched with the categories listed under threatened taxa (Molloy *et al.* 2002) revealed the following results;

**Total population size:** numbers of recorded mature individuals 103 in five sub populations. It is presumed that a similar number of individuals capable of reproduction (mature individuals) could occur in the non monitored populations sparsely peripheral to those monitored.

**Area of occupancy:** monitored area of occupancy 60sq m in five sites. The five monitored sites equaled 12 sq m per site. Reference to the site maps (Appendix Three) of *T. matthewsii* distribution in the sites monitored, indicated that the species did not occupy the whole 12 sq m.

**Fragmentation of populations:** Known populations were widely geographically separate at sub population level, scattered and sparse peripherally, in non monitored populations.

Sites chosen for monitoring in the Shenstone Block were those which supported the best numbers of plants in a population that could return data for analysis. Other sites

supporting fewer groups of the species were considered less useful for obtaining population data as these occupied areas of <1square meter, and were scattered throughout up to six suitable habitats i.e. bare sandy areas favoured by the species. Collectively the number of mature individuals recorded at the three monitored sites in the Shenstone block over three seasons totaled 72.

The site monitored on Rubbish Dump hill, together with < five peripheral plants of *T. matthewsii*, was now the only occurrence of the species in this locality. (A small second population with very few plants had disappeared). Twenty one mature individuals were recorded over three seasons. The monitored site adjacent to the Cape Reinga walkway was the only population at the commencement of the study in that area with <5 square meters occupied by *T. matthewsii* recording 10 mature individuals. A small number of peripheral groups have occupied the surrounding habitat.

**Decline in total population:** In this study, absence at labels (i.e. not visible at monitoring and recorded as such) exceeded new plants by 7%.

**Decline in habitat:** Not now threatened by land clearance (providing land tenure does not change) but likely to be threatened by vegetation succession, sand dune advance and blown sand.

**Predicted decline due to existing threat:** Difficult to quantify because of the typically ephemeral nature of the species.

Results also include the Qualifiers which are listed in Molloy *et al.* (2002) as an integral part of the classification when a taxon meets a threatened category;

**CD**, Conservation dependent; **TO**, threatened overseas; **RF**, recruitment failure; **OL**, The species is now only found at one geographically distinct area, the Far North of New Zealand.

#### Future management

The retention in secure land tenure, and preservation of suitable habitat is seen as a priority to ensure the continued presence of this broadly site- specific species. Habitat

predisposition to fire and vegetation succession, particularly of invasive adventive species will present ongoing complications in management

Sand blows, the increased escalation of wind eroded hollows in less compacted dunes are probably initiated by surface damage, and stock trampling particularly, could exacerbate the severity of the erosion. Vigilance in the exclusion of farm stock from the Shenstone Block in particular, and to some extent, the Walkway populations is suggested as being important.

There will be a need to monitor open space, preferably at dune tops and slopes with a northerly aspect as these appear to be preferred population sites, and some form of light, managed disturbance may be necessary to encourage renewal of population life stages, in the form of germination and emergence of dormant tubers.

Further work in the form of *in vitro* trials germinating seed in the Laboratory, and assisted germination in the field by the placement of seed parcels adjacent to adult plants or within populations, was seen as advantageous for the future. Identification of associated mycorrhiza may also guarantee the successful germination trials in the laboratory. The growing on of propagules could provide material for DNA and isozyme analysis if needed, and was seen as essential to observing and defining the time scale of the life cycle, from seed to flower. The maintenance of monitoring of the labeled plants was considered to have a continued benefit, as the short period of the present research has not revealed all facets of the growth cycle and the behaviour of populations.

The known extant populations of *Thelymitra matthewsii* are all within Department of Conservation Estate, administered by the Kaitaia Area Office and Te Paki Field Centre, of the Northern Conservancy. Local iwi play a part in administration and are involved in land use projects in the area. Tourism escalates in the summer months with a broad base of tramping, fishing, camping, botanical and bird watching tours

and sight seeing. Some of these activities will impinge on orchid habitat with increased demand, as provision of access, for example. Tourism is regarded as being important for the North but a commitment to natural values should temper future activity

Under the present regime, the orchid and its specialized habitat is in good hands, as demonstrated by the Department of Conservation's interest and support throughout the project. A change in land use strategy or management regime, in these isolated, climatically sensitive, highly suitable habitats for terrestrial orchid species, is a threat which could see many orchid species lost to future generations. This is particularly true of *T. matthewsii*, as the species is not recorded as occurring anywhere else in New Zealand, and is now absent from the earliest discovered sites.

## BIBLIOGRAPHY

- APNI Australian Plant Name Index. [www.andb.gov.au/cpbr/databases/apni](http://www.andb.gov.au/cpbr/databases/apni).
- Arditti J.(1984) Orchid seed germination and seedling culture. In: *A manual. Orchid reviews and perspectives* (ed. J. Arditti). Comstock Publishing Association, Cornell University press, London.
- Arditti J.and Ghani A. K. A.(2000) Tansley Review.Numerical and physical properties of orchid seeds and their biological implications. *New Phytologist* 145: 367-421.
- Ballance P. F. (1988) Late Cenozoic time lines and calc- alkaline volcanic arcs in northern New Zealand - further discussion. *Journal of the Royal Society of New Zealand* 18: 347-358.
- Batty A. L., Dixon K. W., Brundett M. & Sivasithamparam K. (2001) Constraints to symbiotic germination of terrestrial orchid seed in a Mediterranean bushland. *New Phytologist* 152: 511-520.
- Berliocchi L.(2001) *The orchid in lore and legend*. Timber press Inc., Portland, Oregon.
- Bernhardt P and Burns- Balogh P.(1986) Floral mimesis in *Thelymitra nuda* (Orchidaceae). *Plant Systematics and evolution* 151: 187-202.
- Bigwood D. W.and Inouye D. W.(1988) Spatial pattern analysis of seed banks: An improved method and optimised sampling. *Ecology* 69: 497-507.
- Brook F. J. and Thrasher G. P.(1991) Cretaceous and Cenozoic geology of Northernmost New Zealand.*New Zealand DSIR Geology and Geophysics* 41.
- Burns- Balogh P.and Bernhardt P.(1986) Floral evolution and phylogeny in the tribe Thelymitreae (Orchidaceae) : Neottioideae. *Plant Systematics and evolution* 159: 19-47.
- Cahill J. F. Castelli P. and Casper B.(2002) Separate effects of human visitation and touch on plant growth and herbivory in an old-field community. *American Journal of Botany* 89: 1401-1409.
- Calder D. M., Cropper S. C. and Tonkinson D.(1989) The ecology of *Thelymitra epipactoides* F.Muell. (Orchidaceae)in Victoria, Australia, and the implications for management of the species. *Australian Journal of Botany* 37: 19-32.
- Cameron K. M., Chase M. W., Whitton W. M., Kores P. J., Jarrell D. C., Albert V. A., Yukawa T., Hills H. G. Goldman D. H.(1999) Aphylogenic analysis of the Orchidaceae.Evidence from RBCL nucleotide sequences. *American Journal of Botany* 86: 208-224.
- Carey P. D.(1998) Modelling the spread of *Himantoglossum hircinum* (L.) Spreng)at a site in the south of England. Orchid population biology: conservation and challenges.Edited by S. Waite. *Botanical Journal of the Linnean Society* 126: 159-171.
- Carse H.(1910) On the flora of the Maunganui County. *Transactions of the New Zealand Institute*> xlviii (43).

- Chase M. W. (2004) Monocot relationships: and over-view. *American Journal of Botany* 91: 1645-1655.
- Cheeseman T. F.(1880) On the fertilisation of *Thelymitra*. *Transactions of the New Zealand Institute* 13: 291- 296.
- Cheeseman T. F.(1910) New species of plants. *Thelymitra matthewsii*. In: *Cheeseman on orchids* (Ed. I. St George).New Zealand Orchid Group Historical series. pp. 177-178
- Cheeseman T. F(1925) *Manual of the New Zealand Flora*. Government Printer, Wellington.
- Chong J. G., Strauss M. S.and Arditti J (1980) Flower induction and Physiology in orchids. In: *Orchid biology* (Ed. J. Arditti). Comstock Publishing Association Cornell University Press, London.
- Clarkson B., De Lange P. J. and Clarkson B. (1994) Ecology and conservation of *Corybas carsei* in restiad bogs. *New Zealand Native Orchid Journal*.No 52
- Clements M., Jones D. L., Sharma I. K., Nightingale M. E., Garratt M. J., Fitzgerald K. J., Mackenzie A. M. Molloy B. P. J. (2002) Phylogenics of Diurideae (Orchidaceae) based on the internal transcribed spacer (ITS) regions of nuclear ribosomal DNA. *Lindleyana* 17: 135-171.
- Clyne D. (1970) *Australian ground orchids*. Landsdown Press Pty Ltd, Melbourne.
- Cockayne L(1919) *New Zealand plants and their story 2nd edition*.Government printer, Wellington.
- Cooper D. (1981) *A Field guide to New Zealand native orchids*. Milburn and Co. Ltd., Wellington N Z.
- Dawson J. (1988) *Forest vines to snow tussocks. the story of New Zealand plants*.Victoria University press, Wellington.
- de Lange P. J. (2000) Threatened and uncommon indigenous orchids of New Zealand. *New Zealand Native Orchid journal* 76: 12-23.
- de Lange P. J., Heenan P. B., Given D. R., Norton D. A., Ogle C. C., Johnson P. N. Cameron E. K. (1999) Threatened and uncommon plants in New Zealand. *New Zealand Journal of Botany* 37: 603-628.
- de Lange P. J., Norton D. A., Heenan P. B., Courtney S. P., Molloy B. P. J., Ogle C. C., Rance B. D., Johnson P. N. R H. (2004) Threatened and uncommon plants of New Zealand. *New Zealand Journal of Botany* 42: 45-76.
- Dixon K. W.(1991) *Seeder/clonal concepts in West Australia orchids. Population ecology of terrestrial orchids* (Eds Wells and Willems )SPB Academic publishing, The Hague.
- Dodson J. R., Enright N. J. McLean R. F.(1988) A late Quarternary vegetation history for Far Northern New Zealand. *New Zealand Journal of Biogeography* 15: 647-656.

- Dopson S. R., De Lange P. J., Ogle C. C., Rance B. D., Courtney S. P. & Molloy J. (1999) Conservation requirements of New Zealand's nationally threatened vascular plants. In: *Biodiversity Recovery Unit*. Department of Conservation, Wellington. No 13 pp1-194
- Douzery E. J. P., Pridgeon A. M., Kurzweil H., Kores P. J., Linder H. P. Chase M. W. (1999) Molecular phylogenetics of *Diseae* (Orchidaceae): A contribution from nuclear ribosomal ITS sequences. *American Journal of Botany* 86: 887-899.
- Doyle J.J. and Doyle J. L.(1987) A rapid DNA isolation procedure for small quantities of fresh leaf tissue. *Phytochemical Bulletin* 19: 11-15.
- Dressler R. L.(1990) *The Orchids.Natural history and classification* Harvard University press. U.S.A.and London.
- Eckroyd C. E. (1995) *Caleana minor*: will it survive in New Zealand. *New Zealand Native Orchid journal*: 5-12.
- Elliot M. B. (1998) Late Quarternary pollen records of vegetation and climate change from Kaitaia Bog for Northern New Zealand. *Review of Paleobotany and Palnology* 99: 189-202.
- Enright N. J.(1989) Heathland vegetation of the Spirits Bay area, Far Northern New Zealand. *New Zealand Journal of Ecology* 12: 63-75.
- Enright N. J., McLean R. F. & Dodson J. R. (1988) Late Holocene development of two wetlands in the Te Pahi region, far northern New Zealand. *Journal of the Royal Society of New Zealand* 18: 369-382.
- Esler A. E.and Rumbal P. J.(1975) Gumland vegetation at Kaikohe, Northland. *New Zealand Journal of Botany* 13: 425-436.
- Findlay V(2002) *Colour.Travels through the paint box*. Hodder and Stoughton, London.
- Fleming C. A.(1989) *The Geological history of New Zealand and its life*.Auckland University press, Auckland.
- Foster E. & MacDonald M. (1999) *Orchids of the Anglesea District A field guide*.Inverted logic, Victoria Australia.
- Fowler J.Cohen L. Jarvis P.(2001) *Practical Statistics for field biology*. J. Wiley and Sons, Chichester.
- Fraudenstein J. V., Van Den Berg C., Goldman D. H., Kores P. J., Molvray M. Chase M. W. (2004) An expanded plastid DNA phylogeny of Orchidaceae and analysis of Jackknife branch support strategy. *American Journal of Botany* 91: 149-157.
- Gillman M. P. & Dodd M. E.(1998) The variability of orchid population size. Orchid population biology: conservation and challenges.Edited by S.Waite. *Botanical Journal of the Linnean Society* 126: 63-74.
- Given D. R. (1981) Threatened plants of New Zealand: Documentation in a series of islands.John Wiley and Sons Ltd.

- Gregg K.(1991) Variation in behaviour of four populations of the orchid *Cleisthes divaricata*, and assessment using transition matrix models. In: *Population ecology of terrestrial orchids* (Eds. T. C. Wells & J. H. Willems).S P B Academic Publishing, The Hague.
- Hadley G.(1980) *Orchid Mycorrhiza*.Comstock Publishers Association Cornell University Press, London.
- Hall B. G. (2001) *Phylogenetic trees made easy A how-to manual for molecular biologists*. Sinauer Associates,USA.
- Harper J. L. and White P. J.(1974) *The demography of plants*, London.
- Hatch E. D. (1952) The New Zealand forms of *Thelymitra* J.R. and G. Forster and appendices. *Transactions of the Royal Society* Vol 80.
- Hatch E. D. (1989) Orchid extracts from the Matthews Correspondence. In: *New Zealand Native orchid Group Historical Series* (Ed. I. St George). New Zealand Native Orchid Group, Dunedin.
- Healy T.R. and Kirk R.M.(1992) Coasts. In: *Land forms of New Zealand* (Ed. Soons J. M. and Selby, M.J.) pp. 161-185. Longman Paul.
- Hesp P. A.(2001) The Manawatu dunefield.Environmental change and human impacts.*New Zealand Geographer* 57.
- Hesse P. P.(1994) The record of continental dust from Australia in Tasman Sea sediments. *Quaternary Science reviews* 13: 257-272.
- Hitchmough R. A. (2002) *New Zealand threat classification system lists .Classifying species according to threat of extinction*.Biodiversity Recovery Unit Department of Conservation, Wellington.
- Hodgson M., Paine R. & Anderson N. (1991) A guide to orchids of the world.Harper Collins, Australia.
- Hoffman N.and Brown A(1992) Orchids of South West Australia .University of Western Australia Press, Nedlands, Western Australia.
- Howe H.F.and Smallwood J(1982) Ecology of seed dispersal. *Annual review of ecology and systematics* 13: 201-208.
- Hutchings M. J.(1987) The population biology of the early spider orchid, *Ophreys sphegodes* Mill. 1. A demographic study from 1975-1984. *Journal of Ecology* 75: 711-727.
- Hutchings M. J.,Mendoza A. Havers W. (1998) Demographic properties of an outlier population of *Orchis militaris* L (Orchidaceae) in England. Orchid population biology: conservation and challenges.Edited by S. Waite. *Botanical Journal of the Linnean Society* 126: 95-107.
- Irwin B.(1990)The structure of orchids. In: *The New Zealand orchids natural history and cultivation* (Eds. I. St George & D. P. McCrae) New Zealand Native orchid group, Dunedin.pp24-36

- Jeanes J. A.(2000)Two new species of Thelymitra (Orchidaceae) from South eastern Australia. *Muelleria* 14: 1-7.
- Johns J. and Molloy B. P.J.(1983) *Native Orchids of New Zealand*.A H and A W Reed Ltd, Wellington, and Auckland.
- Jones D. L.(1993) *Native Orchids of Australia*. Reed.Part of William Heinmann Australia.
- Jones D. L.(2006) *Complete guide to the orchids of Australia including the island territories*. Reed New Holland Australia Pty. Ltd.,Sydney.
- Jones D. L., Wapstra H., Tonelli P. Harris S.(1999) *The Orchids of Tasmania*.The Miegunyah Press Melbourne University press, Melbourne.
- Jordan G. T.(2001) An investigation of long distance dispersal based on species native to both Tasmania and New Zealand. *Australian Journal of Botany* 49: 333-340.
- Kear D. & Hay R. F. (1961) Sheet 1 North Cape (1st Ed.) Geological map of New Zealand 1:250000. In: *Geological map of New Zealand*.Department of Scientific and Industrial Research, Wellington.
- Kery M. and Gregg K. (2003) Effects of life state on detectability in a demographic study of the terrestrial orchid *Cleistes bifaria*. *Journal of Ecology* 91: 265-273.
- Kores P. J., Molvray M., Weston P. H., Hopper S. D., Brown A., Cameron K. M. Chase M. W. (2001)A phylogenetic analysis of Diurideae (Orchidaceae) based on plastid DNA sequence data. *American Journal of Botany* 88: 1903-1914.
- Kull T. and Kull K.(1991) Preliminary results from a study of populations of *Cypripedium calceolus* in Estonia. In: *Population ecology of terrestrial orchids* (Eds. T. C. Wells and J. H. Willems).SPB Publisher.The Hague.pp.69-76
- Leeson E. Haynes C. Wells T. C.(1991) Studies of the phenology and dry matter allocation of *Dactylorhiza fuchsii*. In: *Population ecology of terrestrial orchids* (Eds. T. C. Wells and J. H. Willems).SPB Academic Publishers, The Hague.pp125-138
- Leitch E. C.(1970) Contributions to the geology of northernmost New Zealand. 2. The stratigraphy of the North Cape district.*Transactions of the Royal Society of New Zealand. Earth science* 8: 45-68.
- Light M. H. S. and MacConaill M. (1991) Patterns of appearance in *Epipactis helleborine* (L.) Crantz. In: *Population ecology of terrestrial orchids* (Eds. T. C. Wells & J. H. Willems). SPB Academic Publishing, The Hague.pp.3-26
- Malcolm J.(1986) Te Paki Northland New Zealand.Department of Conservation.
- McCrae D. P. (1988) A survey of the orchid flora of Te Paki Farm Park. In: *Te Paki Farm Park Flora survey (part)* Department of Conservation.pp1-52
- McCrae D. P. & Molloy B. P. J.(1998) The artificial reconstruction of the natural New Zealand hybrid *Thelymitra x dentata* (Orchidaceae). *Royal Society Miscellaneous series*: 121-125.

- McLean R. F., Enright N. J., Mitchell N. D. Braggins J.(1985) Wetlands and heathlands of the Te Pahi region. Final report to the New Zealand Department of Lands and Survey on the Te Pahi Farm Park draft management plan. .
- Mead A. D.(1966) Richard Taylor Missionary Trumper. A H and A W Reed, Wellington.
- Mehrhoff L. A. (1989) The Dynamics of declining populations of an endangered orchid *Isotria medeoloides*. *Ecology* 70: 783-786.
- Merrett M., Eckroyd C. E. Cashmore P.(2001) Ecology of *Calochilus robertsonii* (Orchidaceae) from Rotorua, New Zealand. *The Orchadian* 13.
- Mitcalfe B.(1981)The North. Corromandel Press.
- Mitchell N. D.(1991) The derivation of climate surfaces for New Zealand and their application to the bioclimatic analysis of Kauri (Agathis). *Journal of the Royal Society of New Zealand* 21: 13-24.
- Moir R. W., Collen B. & Thompson C. S.(1986) The climate and weather of Northland. In: *New Zealand Meteorological Service Miscellaneous Publications 115 (2) 2nd edition*.
- Molloy B. P. J.(1990) Pollination systems of New Zealand native orchids. In: *The New Zealand orchids natural history and cultivation* (Eds. I. St George & D. P. McCrae). New Zealand Native Orchid group, Dunedin. pp.36-72
- Molloy B.P.J.(1993) Management of native orchids, Lake Ohia, Northland. *Conservation Advisory Science notes*. No 11.
- Molloy B.P.J .and Dawson M. I.(1998) Speciation in *Thelymitra* (Orchidaceae) by natural hybridism and amphidiploidy. *Royal Society Miscellaneous series*.
- Molloy B. P. J. and Hatch E. D. (1990) *Thelymitra tholiformis* (Orchidaceae) - a new species endemic to New Zealand. *New Zealand Journal of Botany* 28: 105- 114.
- Molloy J., Bell B., Clout M., de Lange P. J., Gibbs G. W., Given D. R., Norton D. A., Smith N. Stephens T. (2002) Classifying species according to threat of extinction A system for New Zealand. In: *Threatened species occasional publication 22*. Department of Conservation, Wellington.
- Moore L.B. and Edgar E.(1976) *Flora of New Zealand*. Government Printer, Wellington.
- Newham R., Ogden J. and Mildenhall D.(1993) A vegetation history of the Far North of New Zealand during the late Otira (last) glaciation. *Quaternary research* 39: 361-372.
- Norton D. A. and De Lange P. J.(2001) Fire and threatened species management in a Waikato wetland. In: *New Zealand Native Orchid journal* (ed. I. St George) pp. 23-26, Wellington.
- Nye P. H.(1982) Green Planet. The story of plant Life on Earth (Ed. D. M. Moore). Cambridge University Press, Cambridge.
- NZPCN (2007)Threatened species. In: *Flora of New Zealand*. w w w.nzpcn.org.nz

- Ogden J., Newham R., Palmer J. G., Serra R. G. Mitchell N. D. (1991) Climatic implications of macro and microfossil assemblages from Pleistocene Deposits in Northern New Zealand. *Quaternary research* 39: 107-119.
- Ogden J., Newham R., Palmer J. G., Serra R. G. Mitchell N. D. (1993) Climatic implications of macro and micro-fossil assemblages from late Pleistocene deposits in northern New Zealand. . *Quaternary research* 39: 107-119.
- Oostermeijer J. G. B., Van't Veer R. & Den Nijs J. C. M. (1994) Population structure of the rare long-lived perennial *Gentiana pneumonanthe* in relation to vegetation and management in the Netherlands. *Journal of applied ecology* 31: 428-438.
- Owen N. W., Kent M. Dale M. P. (2001) Spatial and temporal variability in seed dynamics of machair sand-dune plant communities, the Outer Hebrides, Scotland. *Journal of Biogeography* 28: 565-588.
- Peakall R. and Molloy B. P. J. (1998) Isozyme evidence for the amphidiploid origin of *Thelymitra decora* (Orchidaceae). *Royal Society Miscellaneous series*: 115-119.
- Pegman A. P. and Rapson G. L. (2005) Plant succession and dune dynamics on actively prograding dunes, Whatipu Beach, Northern New Zealand. *New Zealand Journal of Botany* 43: 223-244.
- Peisley A. B. (1990) *Thelymitra matthewsii* the spiral sun orchid. *Orchids in New Zealand incorporating the New Zealand orchid review* 16: 46-48.
- Pridgeon A. M., Solano R. and Chase M. W. (2001) Phylogenetic relationships in Pleurothallidinae (Orchidaceae): combined evidence from nuclear and plastid DNA sequences. *American Journal of Botany* 88: 2286-2308.
- Rupp H. M. R. and Hatch E. D. (1946) Relation of the orchid flora of Australia to that of New Zealand. *Linnean Society of New South Wales*: 53-61.
- Sanger N. P. and Waite S. (1998) The phenology of *Ophreys sphegodes* (the early spider orchid): what annual censuses can miss. *Orchid population biology: conservation and challenges*. Edited by S. Waite. *Botanical Journal of the Linnean Society* 126: 75-81.
- Schofield J. C. (1969) Coastal sands of Northland and Auckland. *New Zealand Journal of Geology and Geophysics* 13: 767-824.
- Shefferson R. P., Sandercock B. K., Proper J., Bessinger S. R. (2001) Estimating dormancy and survival of a rare herbaceous perennial using mark-recapture models. *Ecology* 82: 145-156.
- Smith R.L. and Smith T.M. (2001) *Ecology and Field biology 6th edition*. Benjamin Cummings. An imprint of Addison Wesley Longman, USA.
- Specht R. L. (1979) Heathlands and related shrublands. *Ecosystems of the World* 9A.
- St George I. (1989) Colenso on Orchids. In: *New Zealand Native orchid Group Historical Series* (Ed. I. St George). New Zealand orchid Group, Dunedin.
- St George I. (1992) Wild orchids of the far south of New Zealand. New Zealand Native Orchid Group, Wellington.

St George I. (1999) *The Nature Guide to New Zealand Native orchids*. Godwit Book, Random House. Auckland.

St George I. Irwin B. Hatch E. D. (1996) *Field Guide to the New Zealand orchids*. New Zealand Native Orchid Group, Wellington.

St George I., Irwin B., Hatch E. D. & Scanlen E.(2001) *Field Guide to the New Zealand orchids* New Zealand Native Orchid Group Wellington.

St George I.and McCrae D. P.(1990)*The New Zealand Orchids.Natural history and cultivation*.New Zealand native orchid group, Dunedin.

Sydes M. M.and Calder D. M. (1993) Comparative reproductive biology of two sun-orchids, the vulnerable *Thelymitra circumsepta* and the wide spread *T. ixioides* (Orchidaceae). *Australian Journal of Botany* 41: 577-589.

Tamm C. O.(1972) Survival and flowering of some perennial herbs. 2 The behaviour of some orchids on permanent plots. *Oikos* 23: 23-28.

Tamm C. O.(1991) Behaviour of some orchid populations in a changing environment, observations on permanent plots. In: *Population ecology of terrestrial orchids* (Eds. T. C. Wells and J. H. Willems) SPB Academic Publisher, The Hague.pp. 1-14

Vanhecke L. E. M.(1991)Population dynamics of *Dactylorhiza praetermissa* in relation to topography and inundation. In: *Population ecology of terrestrial orchids* (Eds. T. C. E. Wells and J. H. Willems) SPB, The Hague.pp.15-32

Waite S.(1998) Foreword. In: *Botanical Journal of the Linnean Society* Academic press, London.p.1

Waite S.and Farrell L.(1998) Population biology of the rare military orchid (*Orchis militaris* L.) at an established site in Suffolk, England. *Orchid population biology: conservation and challenges*.Edited by S.Waite *Botanical Journal of the Linnean Society* 126: 109-121.

Wardle P.(1991) *Vegetation of New Zealand*.Cambridge University press, Cambridge.

Wells T.C .and Cox R. (1991) *Demographic and biological studies on *Ophreys apifera*: some results from a ten year study*.Population Ecology of terrestrial orchids (Eds. Wells T.C.E. and Willems J.H. SPB Academic Publishing, The Hague.

Wells T.C. and Willems J. H. (1991) *Population Ecology of Terrestrial Orchids*. SPB Academic Publisher The Hague.

Wheeler B. D., Lambley P. W. & Geeson J. (1998) *Liparis loeselii* (L.) Rich. in Eastern England: constraints on distribution and population development. *Orchid population biology: conservation and challenges*. Edited by S.Waite. *Botanical Journal of the Linnean Society* 126: 141-158.

Whigham D.F and O'Neill J.(1991)The dynamics of flowering and fruit production in two eastern North American terrestrial orchids, *Tipularia discolor* and *Liparis lilifolia*. In: *Population ecology of terrestrial orchids* (Eds. T. C. Wells and J. H. Willems) SPB Academic Publishing, The Hague. pp 89-102

Willems J. H. and Bik L. (1991) Long term dynamics in a population of *Orchis simia* in the Netherlands. In: *Population Biology of Terrestrial orchids* (Eds. T. C. Wells and J. H. Willems) SPB Academic publishing, The Hague. pp. 34-46

Willems J. H. and Melser C. (1998) Population dynamics and life history of *Coeloglossum viride* (L.) Hartm.: an endangered orchid species in the Netherlands. Orchid population biology: conservation and challenges. Edited by S. Waite. *Botanical Journal of the Linnean Society* 126: 83-93.

## APPENDIX ONE

List of voucher specimens lodged (yet to be catalogued) in the University of Waikato Herbarium (WAIK) of vegetation associated with *Thelymitra matthewsii* at the study locations in the Far North of the Aupouri Peninsula.

### Indigenous Dicotyledons

<i>Cassinia leptophylla</i>	(Forst f.)	R.Br.	Compositae
<i>Cassytha paniculata</i>		R.Br.	Lauraceae
<i>Coprosma lucida</i>		J.R.et G.Forst.	Rubiaceae
<i>Coprosma rhamnoides</i>		A.Cunn.	Rubiaceae
<i>Corokia cotoneaster</i>		Raoul	Cornaceae
<i>Cyathodes juniperina</i>		J.R.et G.Forst.	Epacridaceae
<i>Gaultheria antipoda</i>		Forst.f.	Ericaceae
<i>Geniostoma rupestre</i>		A.Rich.	Loganiaceae
<i>Gonocarpus incana</i>		A.Cunn.	Haloragaceae
<i>Kunzea ericoides</i>		A.Rich.	Myrtaceae
<i>Leptospermum scoparium</i>		J.R.et Forst.	Myrtaceae
<i>Leucopogon fasciculatus</i>		(Forst.f.) Allan com nov	Epacridaceae
<i>Leucopogon fraserii</i>		(A. Cunn.) Allan com nov	Epacridaceae
<i>Pimela prostrate</i> var <i>erecta</i>		J.R.Forst. Cheeseman	Thymelaeaceae
<i>Pomaderris kumerahou</i>		A.Cunn.	Rhamnaceae
<i>Pomaderris phyllicifolia</i> var <i>ericifolia</i>		Hook. Moore com nov	Rhamnaceae

### Indigenous Monocotyledons

<i>Morelotia affinis</i>	(Brong)	Blake	Cyperaceae
<i>Rhytiostoma unarede</i>	(Raoul)	Connor et Edgar	Graminea
<i>Thelymitra matthewsii</i>	Cheesem.	(photos only)	Orchidaceae

### Non Indigenous or Adventive

<i>Hakea gibbosa</i>		Cav.	Proteaceae
<i>Hakea sericea</i>		Schrader et Wendt.	Proteaceae
<i>Ornithopus pinnatus</i>	(Miller)	Druce	Fabaceae

## APPENDIX TWO

### **Summarised Plant Growth Data from Field Data Plus Explanation of terms**

The following five sheets of plant growth data were summarized for each individual study site using the same format, from a large base of field data obtained by monthly visits over a period of three seasons, from 2002 to 2004. The study sites were individually identified e.g. TW 4, Rd 5, SH 6, SH 7, SH 10.

The **life stages** are those into which degrees of growth seem best to fit, which did not change through the season, apart from adult plants which are immediately recognisable.

**Tagged plants** refer to the permanent labels assigned to each plant at commencement of monitoring, **months** when visits were made.

**New plants** were those which appeared after the initial labeling.

Height measurements are in mm. **Height range** registers the lowest and highest measure for each occurrence of the life stage. **Means** were calculated from total heights recorded for each life stage for the season, over a number of occurrences. Observations regarded as **absent** included those plants which were absent all season (seas.) and those which had a degree of absence at some stage of monitoring (part.)

**Indet** Implies indecision in assigning the life stage designation at the time of observation and recording. **% life stage** indicates the number of plants which were recorded in each of the life stages, including absence and indeterminate stages, as a percentage of the total population.

**Condition.** Numbers one to four were assigned at recording, to each labeled plant as a measure of plant health. Number one was applied to plants without any blemish and the figures included in the summarized data indicate the percentage of plants in that life stage, observed in that season, to which it could be applied. The remaining percentage to 100% included blemished, withered and dead plants. This indication of 'dead' was applied if the plant was still present, but not viable

**Appendix Two**

**Summarised Plant Growth Data from Field Data**

Life Stages Constant in one Season

Year	Tagged plants/ months		Hook	Spiral	Non fl.	Adult	Absent	Indet.
2002	28	Jly Aug Sep	7	14	6	1	0	
		Height range	3-10	5-20	18-55	25-103		
		Height mean	5.8	12.5	36.0	72.6		
		Condition 1	84%	87%	94%	0%		
		% life stage	25%	50%	21.4%	3.5%		
2003	40	Jly Au Sep Oct	3	4	13	1	6	1
		New Plants	5	3	2	1		1
		Height Range	8-18	5-27	12-34	30-100		
		Height mean	7.0	12.84	23.5	82.0		
		Condition 1	83%	75%	92%	50%		83%
		% life stage	20%	17.5%	37.5%	5%	15%	5%
2004	48	Jn Jly Au Sep Oc	2	4	10	4	11	3
		New Plants	0	5	5	4		0
		Height range	8-12	5-22	20-50	20-108		
		Height means	9.36	14.36	32.0	50.21		
		Condition 1	90%	87.5%	95%	74.2%		84.6%
		% life stage	4.2%	18.75%	31.25%	16.6%	22.9%	6.25%

**STUDY SITE T W 4**

**Appendix Two**

**Summarised Plant Growth Data from Field Data**

**Life Stages Constant in one Season**

Year	Tagged plants/ months	Hook	Spiral	Non fl.	Adult	Absent	Indet.	
2002	55	Jly Aug Sep	11	24	9	7	0	5
		Height range	5-25	10-40	25-70	20-120		0
		Height mean	11.7	23.9	37.0	76.5		8-30
		Condition 1	96%	72%	70.8%	85.7%		20.0
		% life stage	20%	43.6%	12%	12.7%		91% 7.3%
2003	75	Jly Au Sep Oct	7	5	23	4	11	7
		New Plants	13	1	3	0		
		Height Range	5-20	5-29	20-55	20-135		8-33
		Height mean	10.4	19.2	34.5	83.5		18.7
		Condition 1	82%	94%	84%	86.6%		75.8%
	% life stage	25.3%	9.3%	34.6%	5.3%	16%	9.3%	
2004	110	Jn Jly Au Sep O	9	11	25	10	20	5
		New Plants	17	15	7	0		
		Height range	5.25	5.35	20-45	20-156		5-35
		Height means	10.0	17.3	23.0	71.4		15.8
		Condition 1	91.4%	96.7%	88%	76.3%		96.6%
	% life stage	13.6%	23.6%	29.09%	9.09%	18.2%	6.3%	

**STUDY SITE R D 5**

**Appendix Two****Summarised Plant Growth Data from Field Data**

## Life Stages Constant in one Season

Year	Tagged plants/ months	Hook	Spiral	Non fl.	Adult	Absent	Indet
2002	56	Jly Aug Sep	13	26	10	3	4
		Height range	3-20	8-30	20-40	10-170	0
		Height mean	10	18.8	30.8	78.8	3-45
		Condition 1	77%	94.3%	88.4%	55.5%	14.3
		% life stage					80%
2003	94	Jly Au Sep Oct	10	14	12	9	12
		New Plants	11	18	5	1	0
		Height Range	5-12	10-30	15.40	10-140	3.30
		Height mean	8.5	17.3	28.2	56	17
		Condition 1	79%	79.3%	66%	26.6%	80%
	% life stage	22.3%	34.04%	18.08%	9.5%	3.1%	
2004	109	Jn Jly Au Sep O	16	18	7	19	28
		New Plants	14	16	4	8	42
		Height range	5-40	10-40	10-35	10-185	5-10
		Height mean	10.2	15.6	22.4	56	9
		Condition	76.4%	79.4%	75%	55%	100%
	% life stage	22%	21.1%	8.25%	17.4%	30.3%	0.(%)

**STUDY SITE SH 6**

**Appendix Two**

**Summarised Plant Growth Data from Field Data**

Life Stages Constant in one Season

Year	Tagged plants/ months	Hook	Spiral	Non fl.	Adult	Absent	Indet	
2002	26	Jly Aug Sep	4	11	7	3	0	1
		Height range	4-20	10-30	20-40	10-140		20-35
		Height mean	9	21	29.6	68.5		28.3
		Condition 1	91%	100%	100%	55.5%		100%
		% life stage	15.4%	42.3%	26.9%	11.5%		3.8%
2003	46	Jly Au Sep Oct	3	7	13	2	2	0
		New Plants	12	4	2	0		1
		Height Range	5.18	10-30	13-45	20-100		15-25
		Height mean	6.8	19	27.2	70.6		17.6
		Condition 1	91%	80.6%	89%	75%		66.6%
		% life stage	32.6%	23.9%	32.6%	4.4%	4.4%	2.2%
2004	70	Jn Jly Au Sep Oc	7	17	8	8	5	4
		New Plants	13	3	5	0		0
		Height range	5-25	10-28	15-40	15-135		5-30
		Height mean	12	16	28.4	47.8		15.5
		Condition 1	94.3%	92.8%	92.3%	59.3%		100%
		% life stage	28.5%	28.6%	28.3%	11.4%	7.2%	5.8%

**STUDY SITE SH 7**

**Appendix Two**

**Summarised Plant Growth Data from Field Data**

Life Stages Constant in one Season

Year	Tagged plants/ months	Hook	Spiral	Non fl.	Adult	Absent	Indet.
2002	17	Jly Aug Sep Height range Height mean Condition 1 % life stage	1 5 5 100% 5.8%	0     	3 25-35 28 100% 17.6%	13 23-120 57 68.7% 76.4%	
2003	23	Jly Au Sep Oct New Plants Height Range Height mean Condition 1 % life stage	0 1 5 5 100% 4.3%	1 2 8-15 11.8 66.6% 13.04%	6 2 10-45 29 77.4% 34.7%	7 0 8-112 53.4 16.6% 30.4%	3     13.04%
2004	28	Jn Jly Au Sep Oc New Plants Height range Height mean Condition 1 % life stage	0 1 10-20 15 100% 3.6%	3 1 10-20 15.4 57% 14.3%	4 1 15-45 26.6 92.8% 17.8%	5 3 10-120 45.5 65.5% 28.5%	9 0  11.5 66.6% 32.2% 3.6%

**STUDY SITE SH 10**

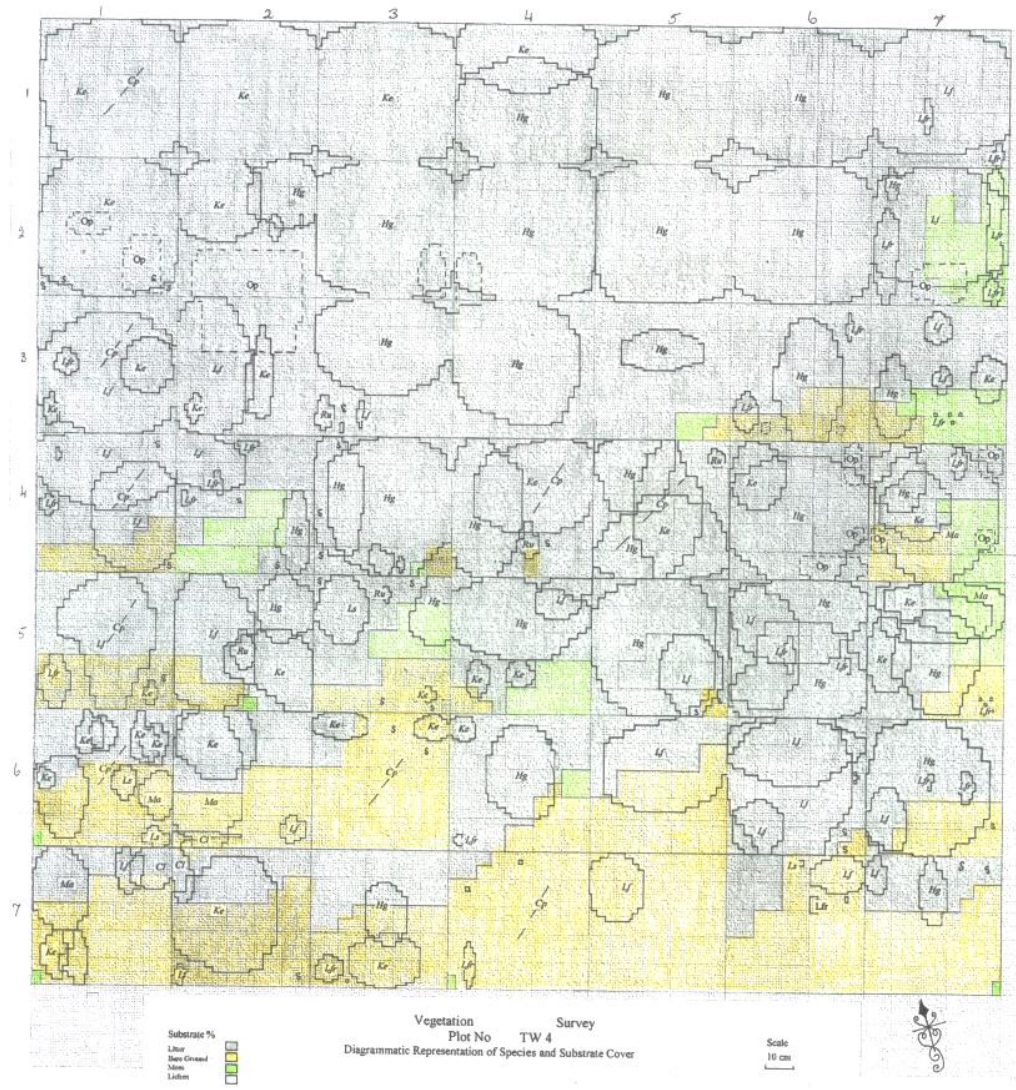
## APPENDIX THREE

### **Maps of Vegetation Associated with *Thelymitra matthewsii* at Five Monitored Sites and Three Comparison Sites, and Five Maps of Seasonal appearance of *T. matthewsii* at Monitored sites**

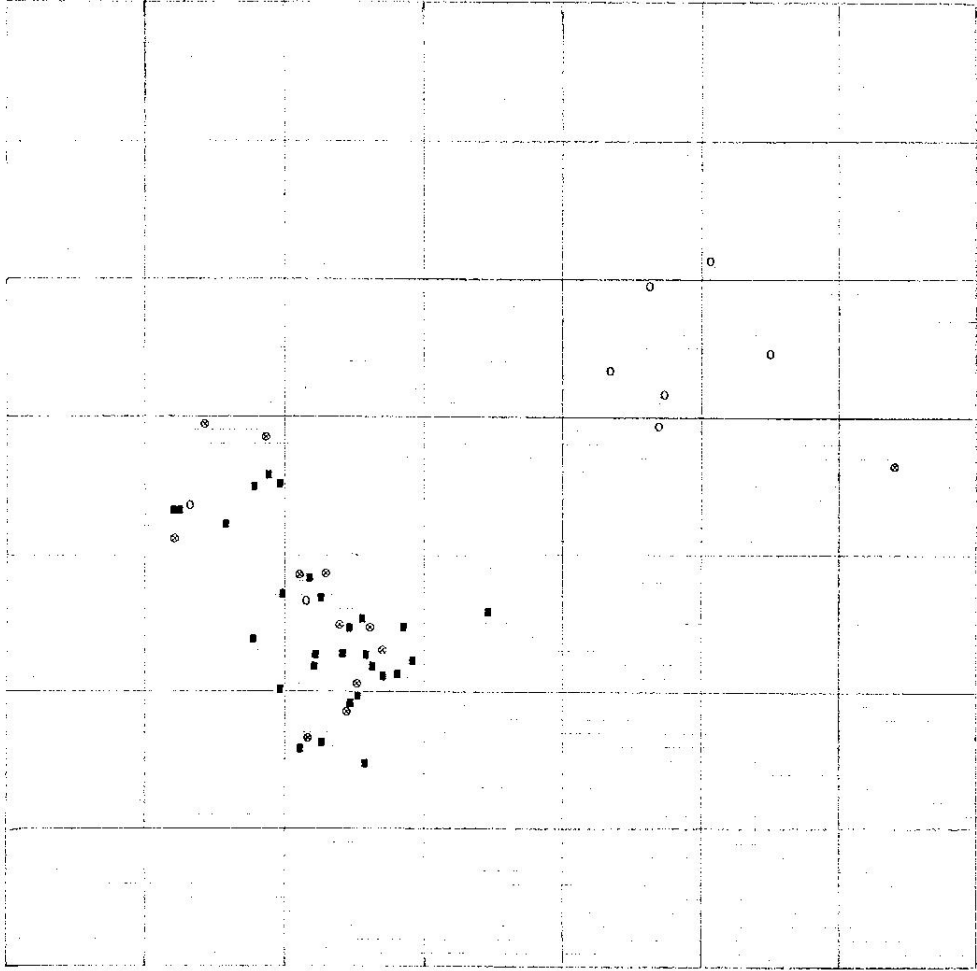
#### **Explanation of Symbols indicating Measured Plants in Maps.**

<i>Cassinia leptophylla</i>	Cl	<i>Leucopogon fasciculatus</i>	Lf
<i>Cassutha paniculata</i>	Cp	<i>Leucopogon fraseri</i>	Lfr
<i>Coprosma lucida</i>	Clu	<i>Morelotia affinis</i>	Ma
<i>Coprosma rhamnoides</i>	Cr	<i>Pomaderris ericifolia</i>	Pe
<i>Cyathodes juniperina</i>	Cj	<i>Pteridium esculentum</i>	Pes
<i>Kunzea ericoides</i>	Ke	<i>Rhytidosperma unarede</i>	Ru
<i>Leptospermum scoparium</i>	Ls	<i>Hakea gibbosa</i>	Hg
<i>Morelotai affinis</i>	Ma	<i>Hakea sericea</i>	Hs

Appendix Three: Site TW4 Vegetation Survey. Diagrammatic representation of shrub species and substrate cover. Scale 4mm = 10cm



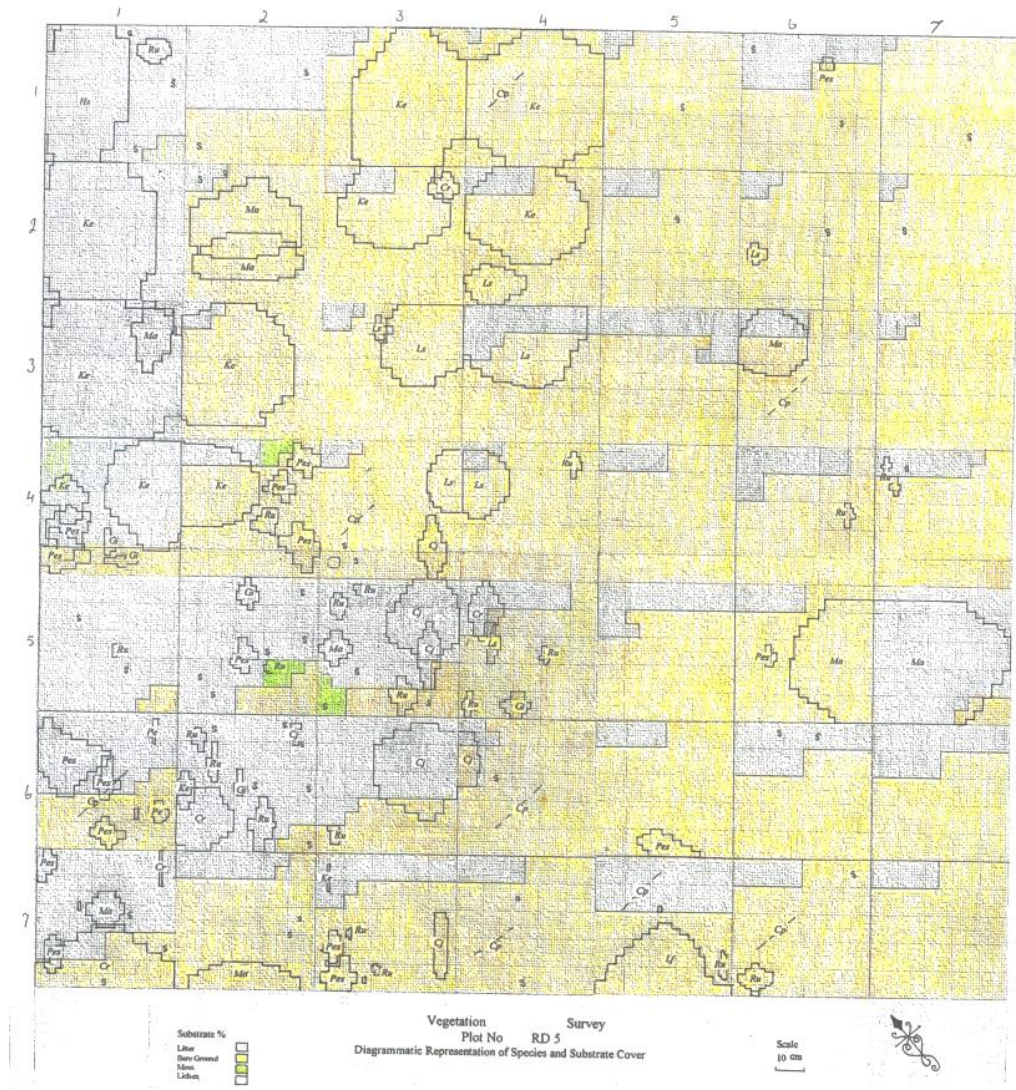
Appendix Three: Site TW4 Seasonal appearance of *Thelymitra matthewsii*. Labeled *T. matthewsii* plants 2002 – 2004



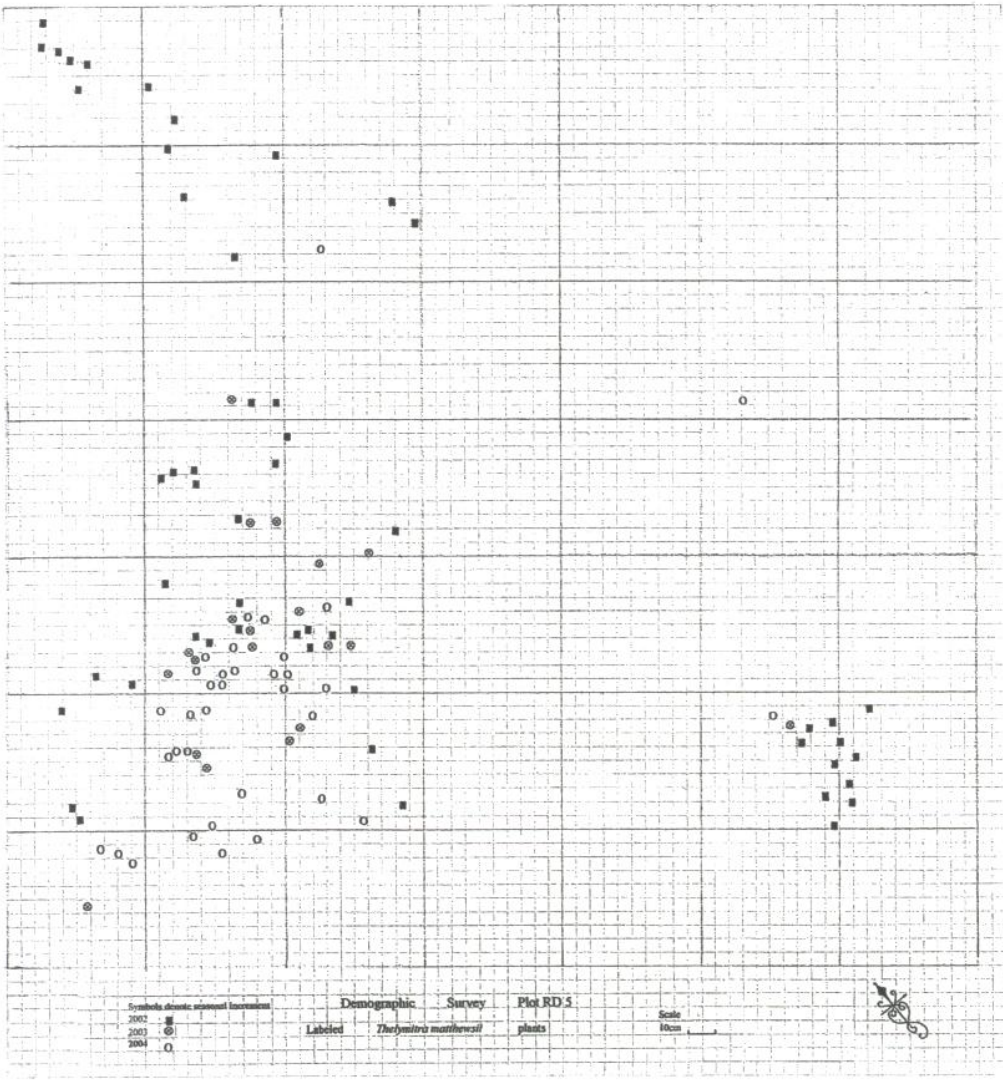
Symbols denote seasonal occurrence	Demographic	Survey	Plot TW 4	Scale
2002 ■				10cm
2003 ●	Labeled	<i>Thelymitra matthewsii</i>	plants	
2004 ○				



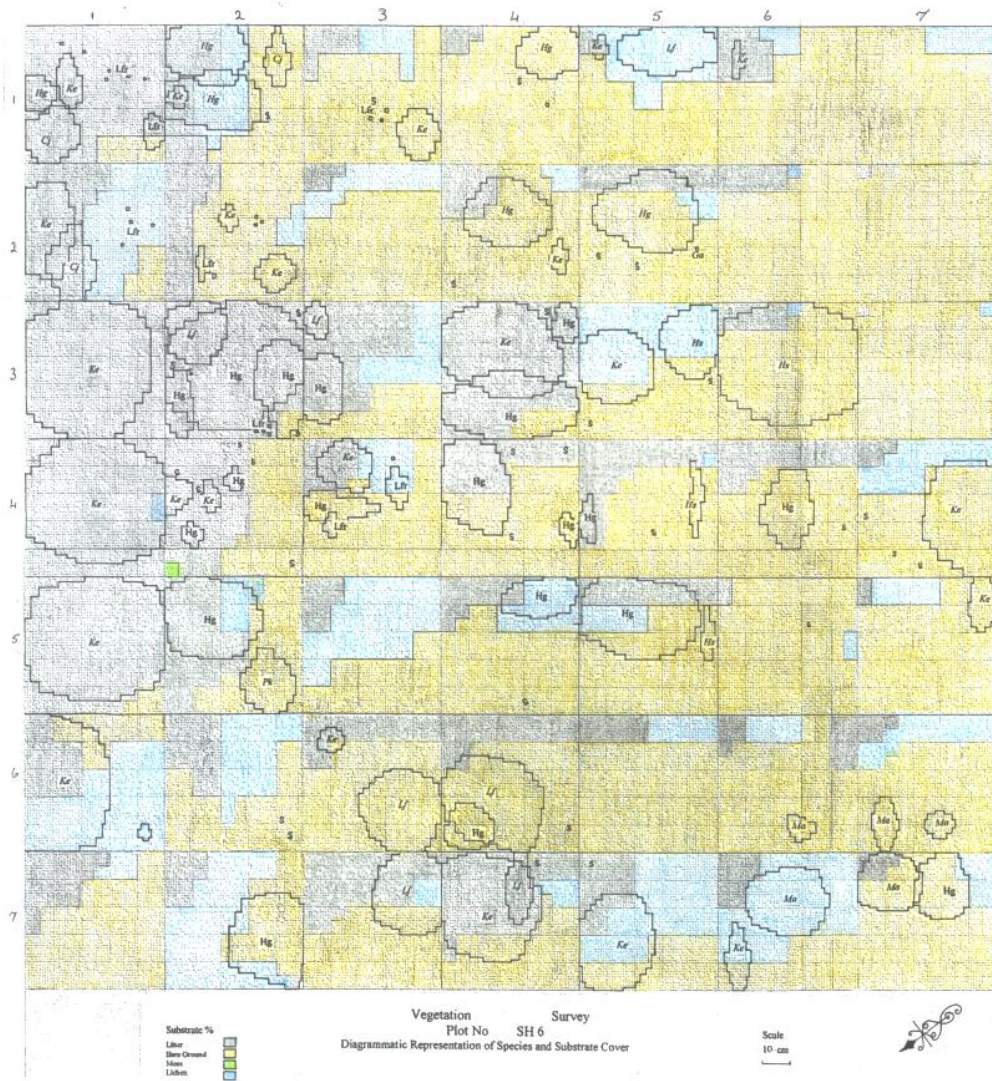
Appendix Three: Site RD5 Vegetation Survey. Diagrammatic representation of shrub species and substrate cover. Scale 4mm = 10cm



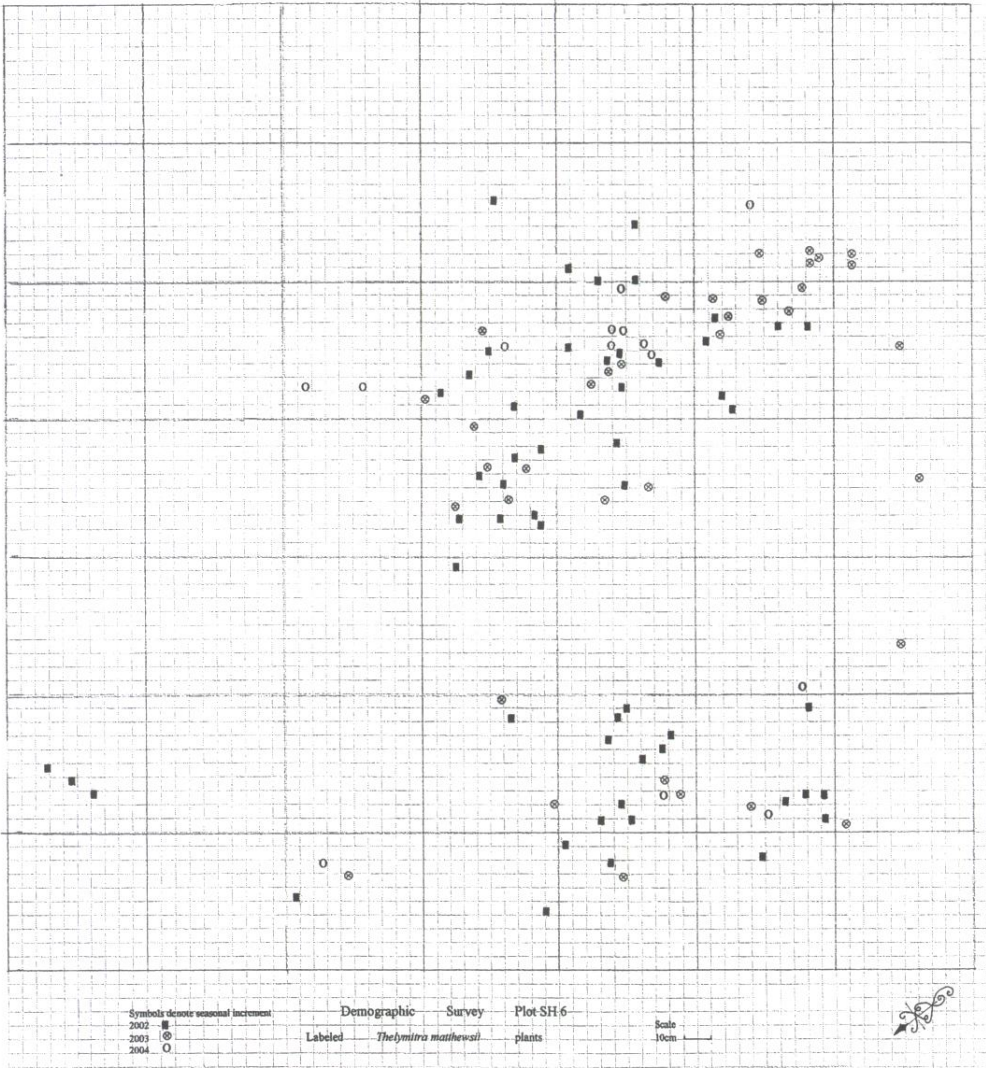
Appendix Three: Site RD5 Seasonal appearance of *Thelymitra matthewsii*. Labeled *T. matthewsii* plants 2002 – 2004



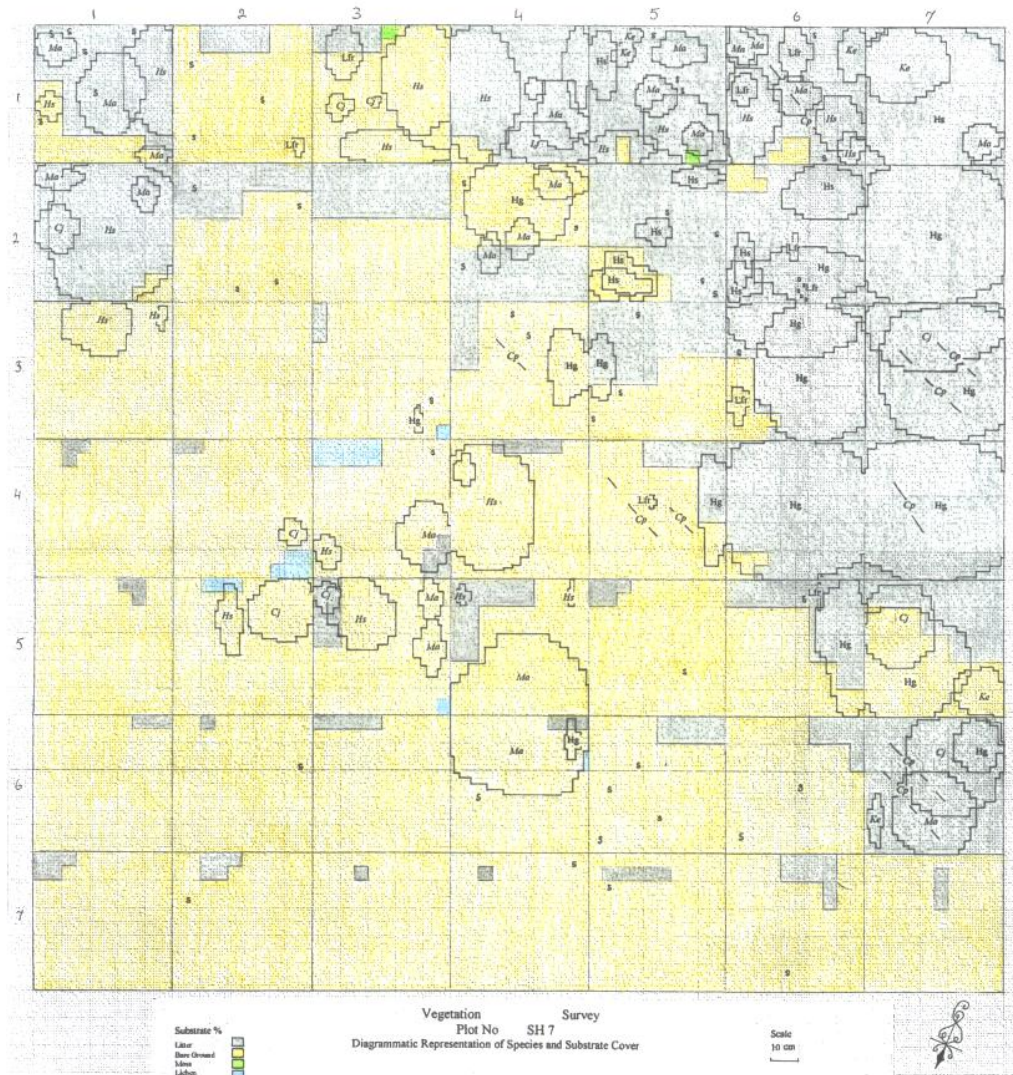
Appendix Three: Site SH6 Vegetation Survey. Diagrammatic representation of shrub species and substrate cover. Scale 4mm = 10cm



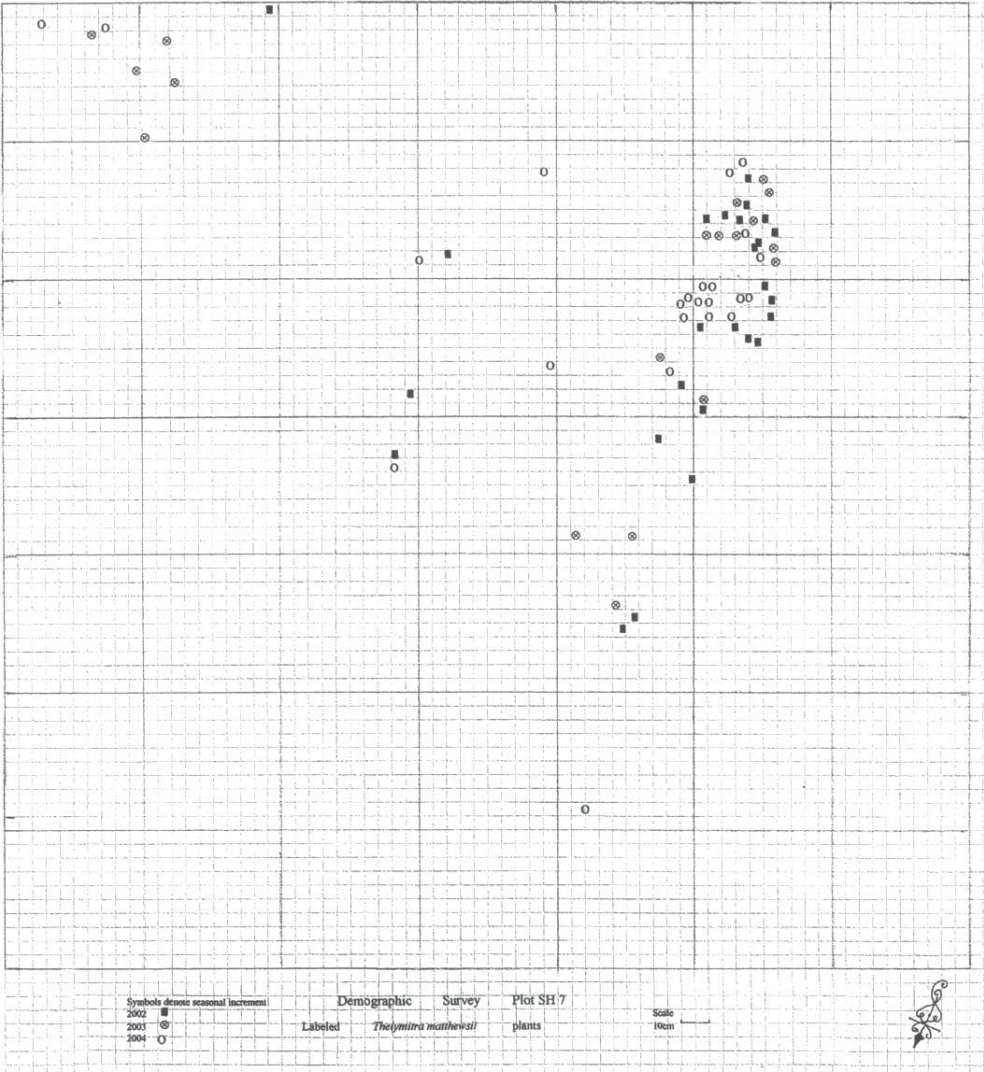
Appendix Three: Site SH6 Seasonal appearance of *Thelymitra matthewsii*. Labeled *T. matthewsii* plants 2002 – 2004



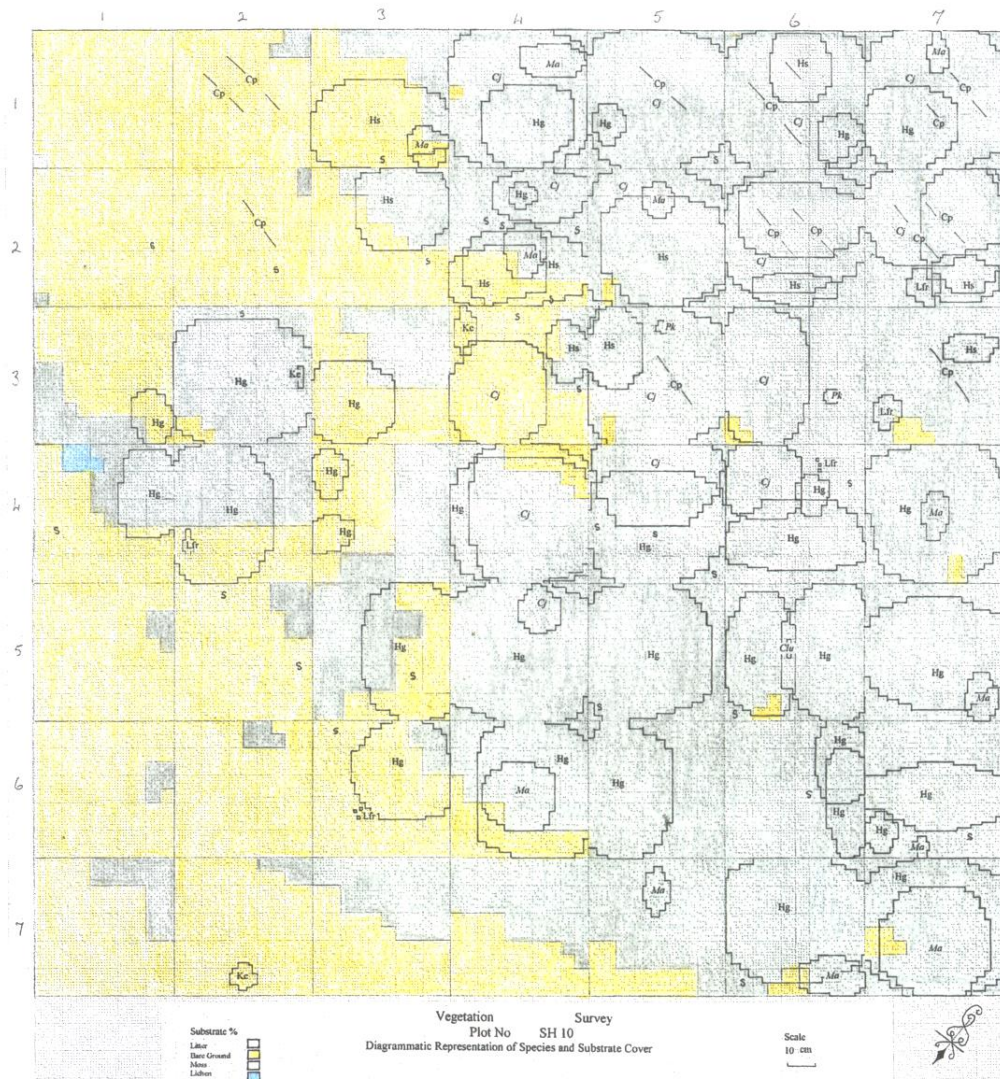
Appendix Three: Site SH7 Vegetation survey. Diagrammatic representation of shrub species and substrate cover. Scale 4mm = 10cm



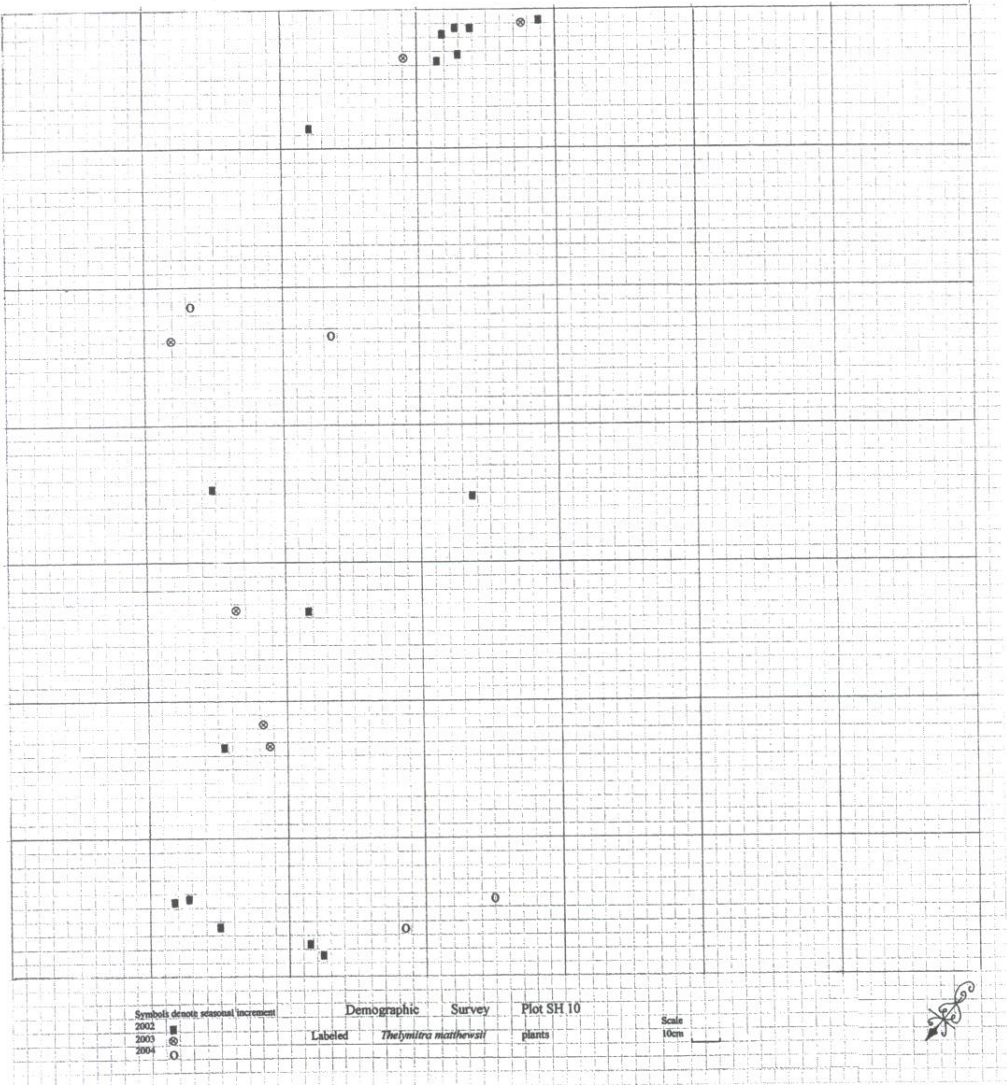
Appendix Three: Site SH7 Seasonal appearance of *Thelymitra matthewsii*. Labeled *T. matthewsii* plants 2002 – 2004



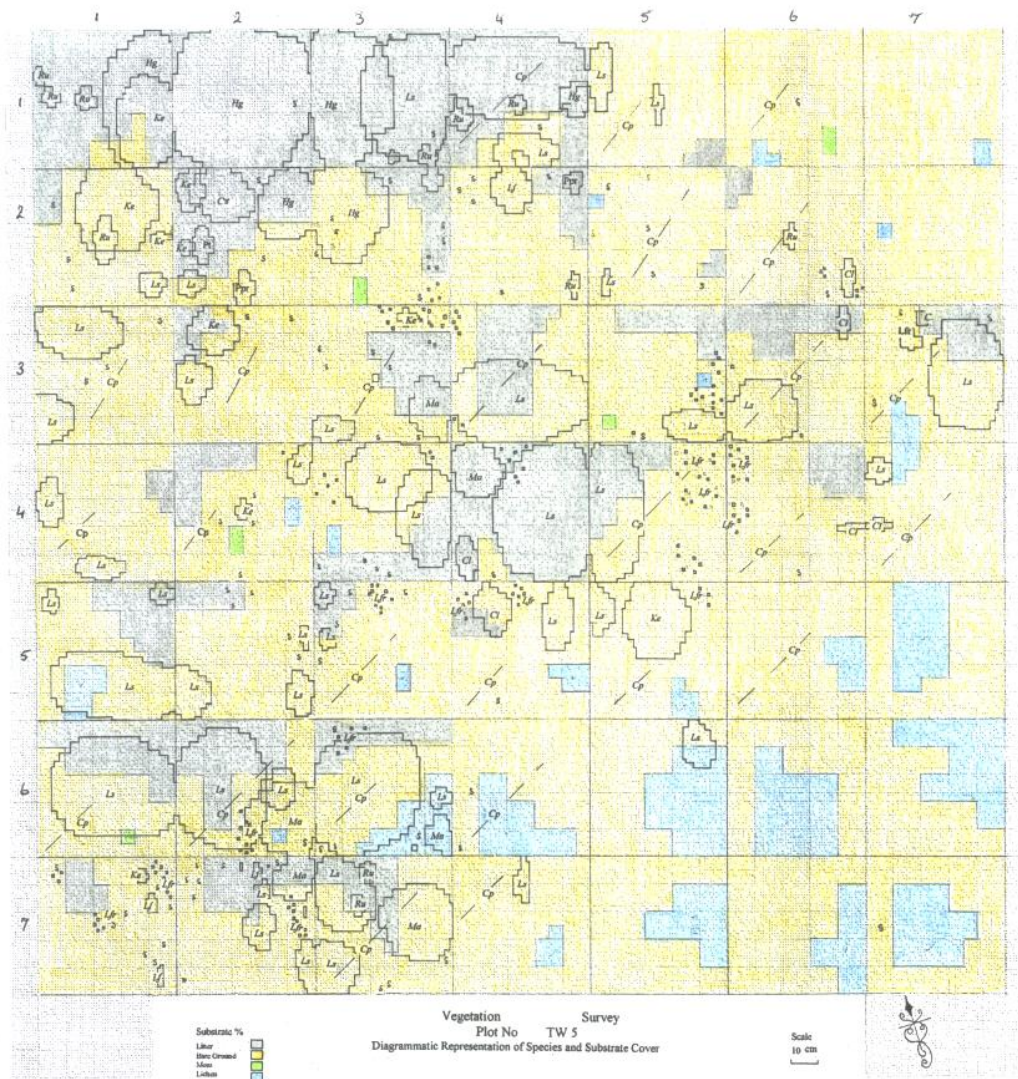
Appendix Three: Site SH10 Vegetation survey. Diagrammatic representation of shrub species and substrate cover. Scale 4mm = 10cm



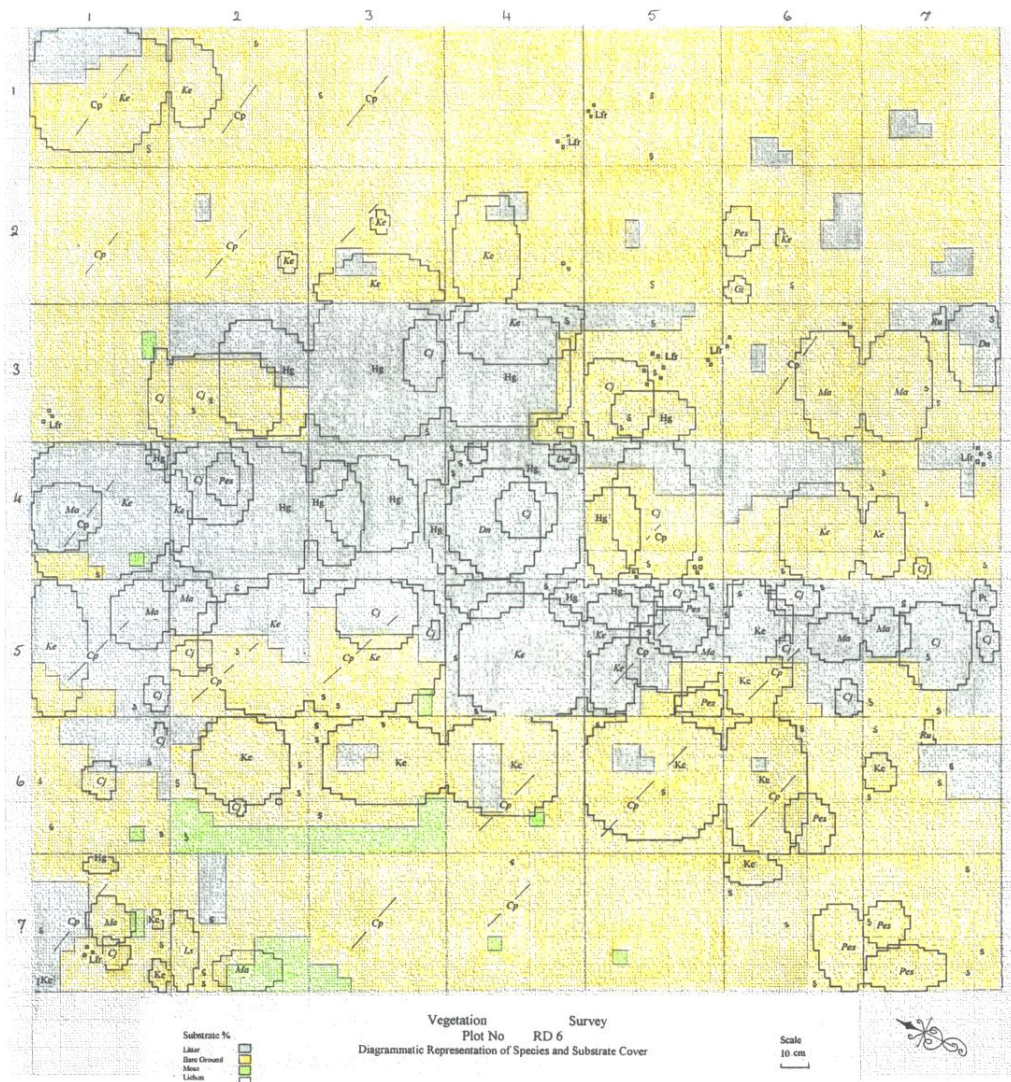
Appendix Three: Site SH10 Seasonal appearance of *Thelymitra matthewsii*. Labeled *T. matthewsii* plants 2002 – 2004



Appendix Three: Site TW5 Comparison site. Diagrammatic representation of shrub species and substrate cover. Scale 4mm = 10cm



Appendix Three: Site RD6 Comparison site. Diagrammatic representation of shrub species and substrate cover. Scale 4mm = 10cm



Appendix Three: Site SH12 Comparison site. Diagrammatic representation of shrub species and substrate cover. Scale 4mm = 10cm

