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Contents

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Articles

Cover Picture: Kowhai grown from seed collected by Banks on Cook's First Voyage, hand-coloured engraving, Curtis' Botanical Magazine, Sept. 1791.

Editorial

Horticulture Directions

Provided the lessons of this decade are heeded, horticulture's role in New Zealand could become considerable.

On the one hand is the profitability stemming from success with apples and kiwifruit. On the other hand are setbacks with wine grapes, blackcurrants, garlic, and some flower crops. In between are a variety of crops with exciting possibilities.

Highlighting belief in the potential is investment in horticulture. Nearly 10,000 holdings, or about one in seven, are involved in horticultural activity. And over recent years this has been increasing by an average of 600 annually.

A slowing down is likely in the short term, partly because of the current economic climate, but growth will continue because horticulture is profitable in comparison to traditional agriculture and has been relatively unfettered by government subsidies.

It is up to those of us concerned to work to ensure that future moves are made along the right paths, particularly in relation to the following issues.

Education and training, research and development, and appropriate investment in science and technology are linchpins to success, but there is discrepancy in their funding.

Secondary and continuing education have both been well endowed, but there have been cuts in government funding for research, advisory, and information services.

Market research is attracting appropriate action but needs to extend.

Noteworthy are forums where representatives from the Horticulture Exporters Council and producer groups meet to analyse the marketplace and feed their findings back to the producers.

The Stonefruit Export Council, Asparagus Council, and Boysenberry Product Group have led the way with such exercises.

MAF's commitments include its horticulture mission to the United States and Europe, involvement in the Japan Horticulture Market Research Study, and the proposed market information liaison unit within Advisory Services.

Industry organisation is too fragmented. Considering common interests, roles, and responsibilities, there are too many producer associations and product groups.

And the situation for many of the product groups representing newer non-traditional crops is that on their own they are weak, and they cannot get into the existing organisations. Funding and voting rights are major sticking points.

At the same time there are groups wanting out of their producer organisations, for example the Blueberry Growers Association wanting freedom from the Berryfruit Levy Act and the Berryfruit Growers Federation. And others such as the Nashi (Asian Pear) Growers Association want to stand alone, yet their logical place is as part of the Pipfruit Sector of the Fruit Fed.

Mechanisation of harvesting, grading, and packing operations to handle crops efficiently and also improvement of post-harvest storage and transport to get the produce to the markets in good condition require major effort.

The best prospects lie in meeting market demands for fresh produce that has good storageability and transportability.

At the same time we cannot deny the worthwhile contribution of perishable products requiring transport by air. Their seasonality can also command high prices.

Also worthwhile are exports of processed products in areas where New Zealand has a comparative advantage in growing and processing, i.e. peas, beans, sweetcorn, asparagus, and potatoes.

Regulation to bring order to the marketplace is wanted by most producer groups. They feel this would ensure that New Zealand horticulture did not compete within itself but instead with its competitors. Present government philosophy in this regard however is non interference.

The wide diversity of crops being explored with seemingly little appreciation of the costs of pioneering may seem a concern, but they will either prove or disprove the opportunities.

Overall, though, care must be taken not to squander resources.

MAF Advisory Services Division sees its role as leading effective change in horticulture by:

— adding value;
— improving effectiveness of managers and advisers throughout the horticulture industry;
— improving effectiveness of horticultural organisations;
— providing policy advice;
— improving Advisory Services Division's management practices.

To achieve these aims the division is identifying opportunities to make the best use of its available resources, a maxim that applies to the whole industry.

Robert Findlay
Chief Advisory Officer (Horticulture)
MAF Advisory Services
Wellington

21 October 1985

The Banks Lecture 1985
Botanical Illustration in New Zealand
The Kew Connection

Nancy M. Adams
National Museum of New Zealand, Wellington

On the 8 October 1769, the day that Banks and Solander stepped ashore at Te Oneroa in Poverty Bay, New Zealand's botanical history began. The first of our plants were gathered, described and laid in the pressing papers. At the same time the first botanical drawings were executed by Banks' young artist, Sydney Parkinson, who, as soon as the plants came aboard, set about recording them in water colour. His industry has been commended by all who chronicled Cook's First Voyage. At first he was able to keep up with the botanists in completing a painting, but as more and more plants were put before him he drew a rapid outline in pencil and coloured only some of the leaves, flowers or fruits. In the summer months from October 1769 to March 1770 Parkinson made 204 plant drawings, of these only 30 paintings were completed. (Fig. 1). The tragedy is that he did not live to do so as he died at the age of 25 in January 1771 shortly after the *Endeavour* left Batavia on the homeward voyage.

Had he lived to complete his work with Banks and Solander in London there could have been an altogether different and happier conclusion to the prodigious efforts made on the voyage. Solander, whose manuscript, *Primitiae Florae Novae-Zelandiae,* was completed would have had the honour of having the names he bestowed on our plants validated by publication. Banks, with Parkinson working alongside him, in all probability would have been spared the task of employing and overseeing the artists who finished Parkinson's botanical drawings and the engravers who prepared the copper plates for publication. (Fig. 2). Given Parkinson's industry the publication of Banks' projected volumes on the botany of the *Endeavour* voyage may have been achieved. Nevertheless much of this grand and costly scheme was accomplished. Five artists worked on the botanical paintings and an even larger team of eighteen engravers eventually completed over 700 copper plates of which 183 depict New Zealand plants. Many questions as to why the botanical descriptions and the accompanying engravings were never published have been asked and many reasons suggested. That it was an enormous loss to botany and New Zealand botany in particular, has never been questioned.

While Banks, Solander and the artists were engaged on the botany of the *Endeavour* voyage, Cook was preparing for a second voyage of discovery in the southern oceans. But for his well-known disagreement with the Comptroller of the Navy concerning excessive demands for space and staff, Banks could have again sailed with Cook. Instead Johann Reinhold Forster obtained the appointment as naturalist from King George III and took as his artist his son, George, who was just 20 years of age. Cook's ships, *Resolution* and *Discovery*, left England in 1772 and after months at sea put in to Dusky Sound in March 1773 where they spent six weeks. J. R. Forster's journal makes frequent reference to the plants they collected and the sketches made of them "by my son".

Dusky Sound yielded new plants for the Forsters as its vegetation is so different from the North Island coastal bays that Banks and Solander visited. Only in Queen Charlotte Sound where the ships of both voyages made lengthy visits did the botanical collections of both the Forsters and Banks and Solander overlap. On their return to England the Forsters published their botanical results, there were few illustrations most of a purely diagnostic nature. George planned to produce a volume of his drawings, copper plates were engraved but never published. In 1777, J. R. Forster sold George's botanical drawings to Sir Joseph Banks; these later went to the British Museum as part of the Banksian bequest. About 90 of them are of New Zealand plants.

Fig. 1. Kowhai, *Sophora tetraptera*, copper engraving prepared under Banks' supervision in London.

While the Forsters, in place of Banks were voyaging with Cook

Fig. 2. Kaka beak, *Clianthus puniceus*, engraved on copper from Sydney Parkinson's water colour painting of 1769.

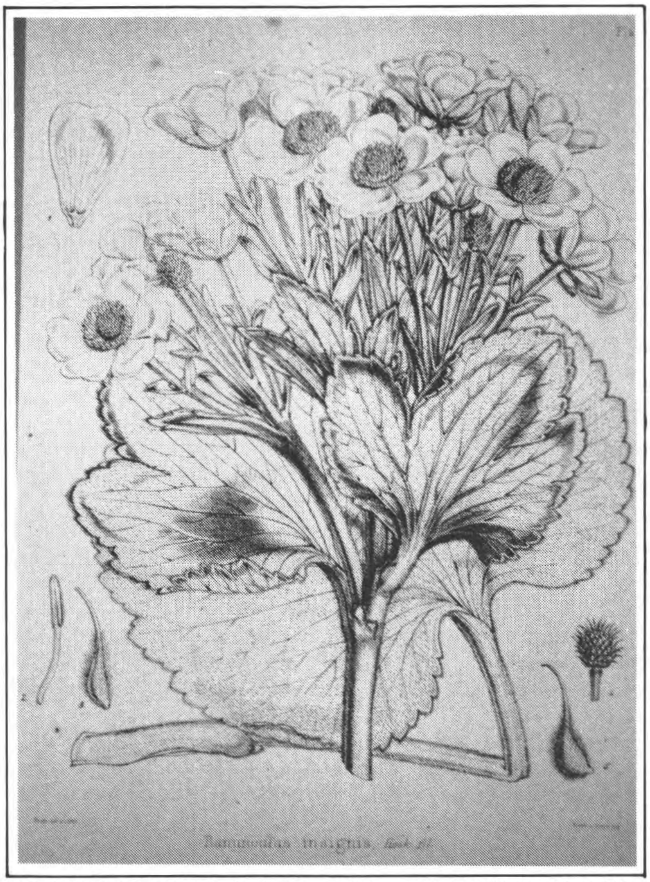

Fig. 3. *Ranunculus insignis*, drawn and lithographed by Walter Hood Fitch for J. D. Hooker's Flora Novae-Zelandiae.

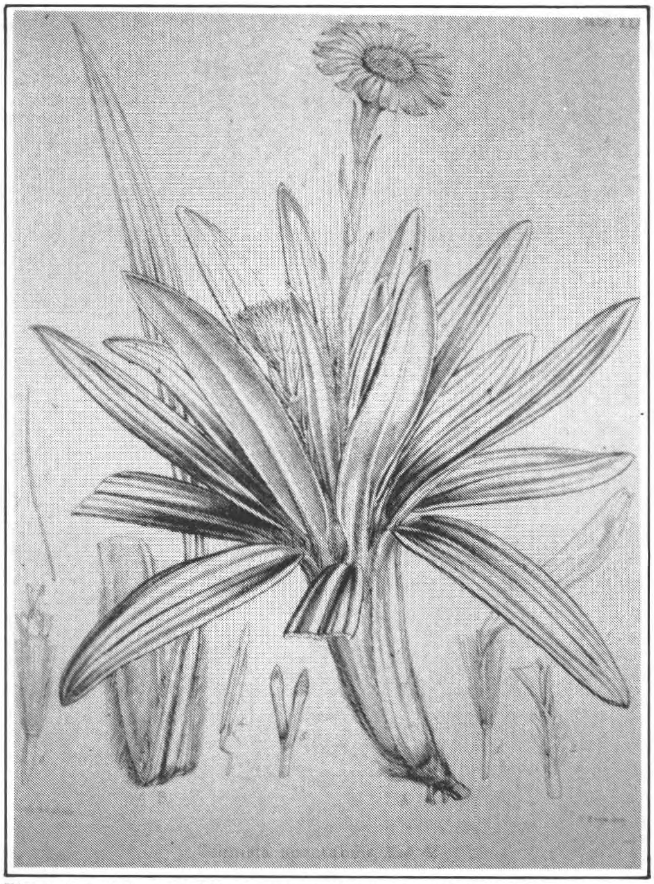

Fig. 4. *Celmisia spectabilis*, drawn and lithographed by Walter Fitch for the Flora Novae-Zelandiae.

in the southern oceans, the supervision of the gardens in the Royal Estates at Kew were bestowed upon Banks by King George III. In the choice of Banks, the botanical impetus that stemmed from Cook's *Endeavour* voyage was reinforced. For Banks it was an opportunity to bring plants from many parts of the world into cultivation. Already some plants from seeds he collected in New Zealand were established and, by the mid 1780s, Kowhai had flowered. It was illustrated in Curtis's botanical magazine of 1791. (see cover page).

Banks continued to supervise the gardens and hothouses or stoves, as he called them, until his death in 1820. With the death of Banks and George III in the same year the gardens gradually lost their status of a botanic garden and the collections of rare, imported plants suffered accordingly. By 1830 all was in danger of being abandoned, but vigorous lobbying by eminent people backed by public opinion intervened and in 1841 a director was appointed. In the choice of William Jackson Hooker, who as a youth was a protege of Banks, a link with New Zealand was again forged. At the time of W. J. Hooker's appointment to Kew, his second son, Joseph Dalton Hooker had already been to New Zealand on Sir James Clark Ross' *Erebus* & *Terror* expedition to the southern oceans. J. D. Hooker aged 22 and a recent medical graduate, was assistant surgeon on the *Erebus*. David Lyall also 22 held the same post on the *Terror*. Both were expected to combine their medical duties with the study of natural history and particularly botany.

The expedition reached the Auckland Islands and anchored in Port Ross on 11 November 1840, briefly visited Campbell Island and departed for the ice in mid December. During the following year *Erebus* and *Terror* spent 3 months at the Bay of Islands from August until November 1841. On his botanical excursions in the Bay, Hooker was accompanied by William Colenso. The *Erebus* and *Terror* reached England in September 1842 and immediately arrangements were made to publish a flora of the antarctic voyage. For this purpose Joseph Hooker was maintained on two years' half pay. The first of Hooker's six volumes of the botany of the antarctic voyage, Flora Antarctica I, published in 1845, illustrates the plants collected at the Auckland and Campbell Islands by Hooker and Lyall. The drawings are based mainly on those Hooker made himself during the voyage and, as in all the following volumes, were lithographed by Walter Hood Fitch.

Before coming to Kew, W. J. Hooker had been Professor of Botany at Glasgow, where, in order to augment his sometimes inadequate salary based on the number of students enrolled, he took two boys into his household whom he tutored between 1822 and 1827. These boys were Robert Monteith, son of Henry Monteith of Monteith's Print and Dye works and Frank Garden, son of Monteith's partner. Through this association a young apprentice calico designer in Monteith's drawing shop, Walter Fitch, was introduced to W. J. Hooker who fostered the seventeen year-old's-interest in botany and botanical drawing. He became so proficient that in 1834 Hooker bought out the lad's apprenticeship and employed him as a lithographer and botanical illustrator.

In 1855 the two volumes of the Flora Novae-Zelandiae had been published also illustrated by Fitch's lithographs based on his own drawings of specimens sent by many botanists mainly Colenso, Munro, Sinclair, and others who had settled in New Zealand or, like Bidwill, the Cunningham brothers and David Lyall, who had made extended visits. Thus the boy taken from Monteith's drawing shop gave us not pretty designs on calico, but the first widely-disseminated illustrations of New Zealand plants. (Figs. 3 & 4).

Between 1853 and 1855 as the parts of the Flora Novae-Zelandiae were appearing, another boy from Monteith's, John Buchanan, had settled in New Zealand and had begun collecting plants to send home to Glasgow. As Buchanan was about two years younger than Fitch their paths may not have crossed, but Buchanan's training as a calico designer would have been very similar — the careful delineation of leaf, flower and fruit leading to a desire to know more about the structure of plants and subsequently to formal botanical studies. For Buchanan it was the decline of the textile trade and the failure of numerous print and dye works that caused him and many fellow craftsmen to leave the Glasgow area and settle in Otago. Buchanan arrived in Dunedin in February 1852 only months after J. D. Hooker's companion on the antarctic voyage, David Lyall, had departed from New Zealand. Lyall had spent three years on the coast, mostly in the southern part of the South Island as surgeon on H.M.S. *Acheron* during the hydrographic survey of 1848-1851. He made large plant collections for Kew and from Fiordland sent some leaves of the *Ranunculus* that was later to bear his name.

It was Buchanan who was to provide J. D. Hooker with the first water colour painting of *Ranunculus lyallii*. However Buchanan did meet the Scottish botanist, Dr Lauder Lindsay who spent several months in Otago during 1861-62. After his return to Britain, Lindsay published a small volume on the botany of Otago illustrated by four plates drawn and lithographed by W. H. Fitch.

At the time of Lauder Lindsay's visit, after almost ten years' residence in Otago, Buchanan was still in the wilderness, quite literally so, as he had been employed on the exploratory surveys of the unknown hinterland and had been prospecting for gold in the central Otago ranges. All this was to change dramatically in consequence of his having, over the years, sent packages of mosses to his friend John Ross, a doctor at Bushby, near Glasgow. Dr Ross had passed some of these collections to William Wilson the author of the section on mosses in the Flora Novae-Zelandiae. Through this link with J. D. Hooker, Dr Ross heard of Dr James Hector's appointment with the Otago Provincial Government to make a geological survey of the province. Dr Ross hastened to put forward Buchanan's name as a suitable botanical collector and this was done at a dinner given by Wilson that was attended by both J. D. Hooker and Hector. On his arrival in Dunedin in 1862, Hector advertised for Buchanan but it wasn't until September (after his miner's right for the Tuapeka goldfield had expired) that Buchanan was employed privately by Hector to collect in North East Valley near Dunedin. Here he made his first known drawings of native flowering plants captioned and dated as Hector required.

During the next three years Buchanan, now over 40 years of age, reached the peak of his artistic ability and made much of the opportunities given him to collect the plants from the remote mountains of the province. As part of a small, enthusiastic, hard travelling team led by a man of great ability and generosity of mind, Buchanan's output was considerable. Not only did he draw the plants from Hector's two major expeditions overland, but also his famous topographical studies of Milford Sound, Lakes Wanaka and Wakatipu and Dusky Sound. For the geologists he produced superb, toned, wash drawings of plant and animal fossils, in addition to maps and geological sections. It is not difficult to see here a parallel with the excitement of Banks, Solander and Parkinson, an excitement tempered by scientific discipline and team effort. Perhaps Buchanan recognised this empathy as he was later to name a newly-discovered rata, *Metrosideros parkinsonii*, after the young artist who died at such an early age, his talents unfulfilled.

Buchanan however, was to live a long life and until his retirement remained on Hector's staff at the colonial museum and geological survey established in Wellington in 1865. In 1867, also under Hector's management, the New Zealand Institute was constituted and two years later the first volume of its transactions was published. For eighteen years Buchanan was to be responsible for its lithographic plates many of which portrayed native plants for the first time. (*Senecio hectori* Fig. 5)

Also between 1865 and 1867 J. D. Hooker's handbook of the New Zealand flora was published incorporating many of the plants collected by Buchanan on Hector's exploration of West Otago and Fiordland. It was not illustrated. What an opportunity lost for a collaboration between the two "old boys" of Monteith's drawing shop. Fitch with his facility to make life-like drawings of pressed specimens and Buchanan who collected and drew in the field

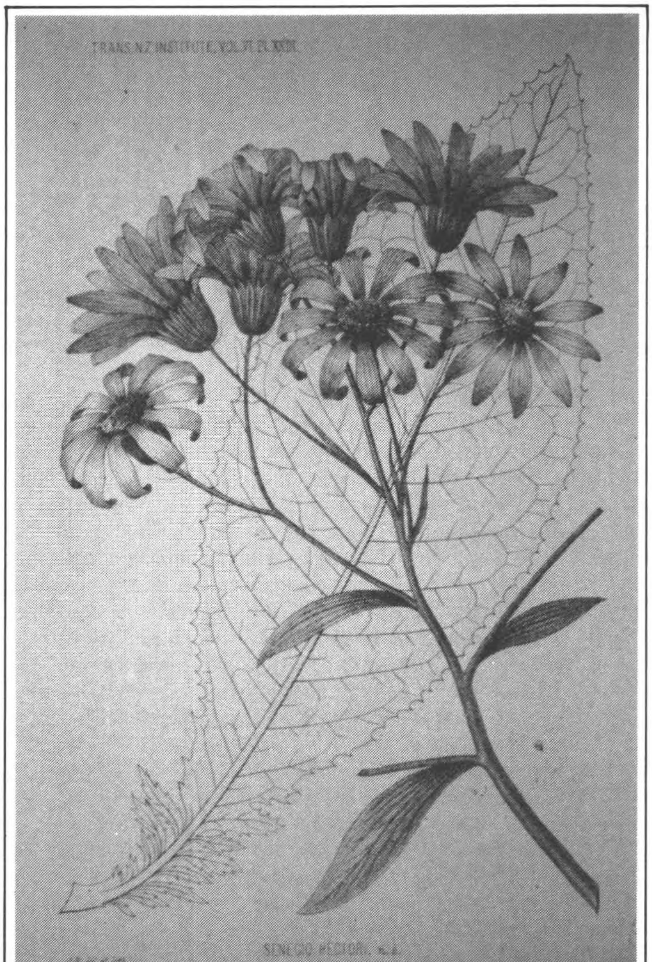

Fig. 5. *Senecio hectori*, lithograph by John Buchanan in the Transactions of the New Zealand Institute, Vol. 6, 1874.

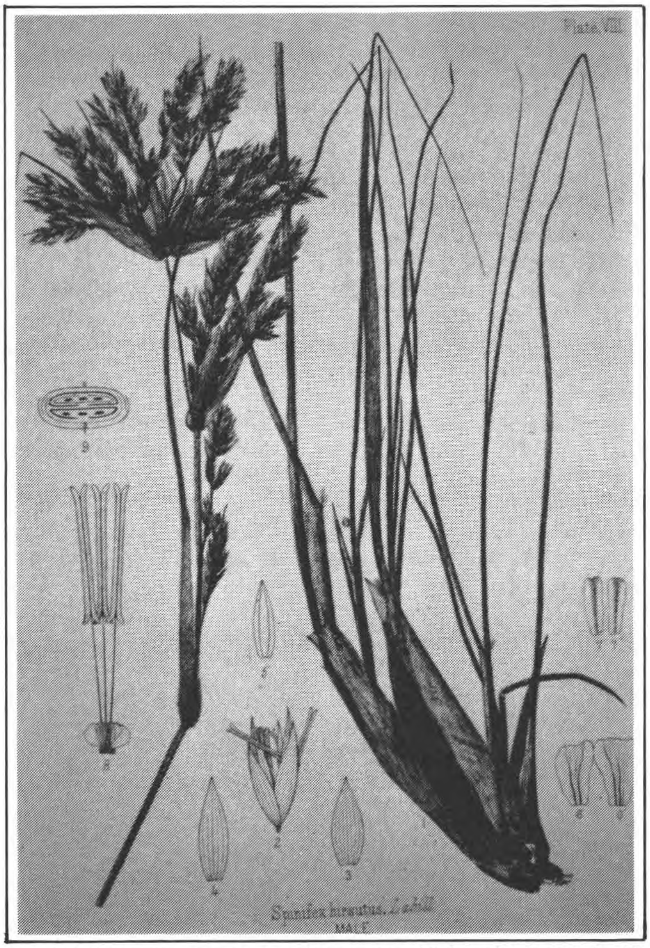

Fig. 6. *Spinifex hirsuta*, nature print on stone by John Buchanan, for his Indigenous Grasses of New Zealand, Vol. 1, 1877.

Fig. 7. *Microlaena avenacea,* nature print with additional details drawn onto the stone, John Buchanan's Indigenous Grasses, 1877.

might have together provided the illustrations for which New Zealand had to wait another fifty years. Not that botany came to a standstill after the handbook; for throughout the 1870s, the colonial museum, botanic garden and the New Zealand Institute in their small way provided the colony with services paralleling those of Kew and the British museum. One of these, arising from a suggestion made by Sir George Grey, was a reference work on native grasses. Between 1877 and 1880 Buchanan's three folio volumes "The Indigenous Grasses of New Zealand", were published, the first major botanical work wholly produced in New Zealand. The illustrations were nature printed, a technique possibile only if the plants used were flexible and lay more or less in one plane. The inked grasses were pressed onto lithographic stones and therefore printed life-size. (Figs. 6 & 7). The plates as published are decorative and informative, but the few surviving pulls taken by hand are truly beautiful in tone and texture.

With Buchanan's retirement his contribution of lithographed plates to the transactions ceased and the colonial museum was left with neither botanist nor artist. There was a gap of nine years before Thomas Kirk's "Forest Flora of New Zealand" was published by the Government Printer. Although he was never on Hector's staff, Kirk was closely associated with the colonial museum and had on several occasions been commissioned to make botanical surveys. His forest flora was illustrated by 142 lithographed plates (Figs. 8 & 9) prepared by five draughtsmen of varying skills, H. Boscawen, D. Blair, H. McKean, C. Graham and A. Hamilton. Their respective talents may be deduced from the signed plates.

By the late 1880s there was an urgent need for more illustrations of native plants, not only of the many new discoveries, but also of the plants commonly seen. Very few people owned or had access to the hand-coloured plates of J. D. Hooker's Flora Antarctica series. Kirk's recently-published "Forest Flora" provided only monochrome plates as did the transactions. Colour was much desired. The challenge was taken up by amateurs, the first, in 1888, was Mrs Charles Hetley whose "Native Flowers of New Zealand" was followed within a year by the Featon's "Art Album of the New Zealand Flora" of 1889. Both books used a new printing process, chromolithography. (Fig. 10). The colour plates, to modern eyes are rather crude, but the books had considerable popularity in their time and served well their intended purpose of bringing the native flora to the attention of a wider public.

The Featons and Georgina Hetley acknowledged the help they had received from Buchanan, Mrs Hetley in particular for she used two of his paintings and sought from him a letter of recommendation of her work to put before Sir Joseph Hooker. This and the correspondence between Sarah Ann Featon, who was the artist, and Buchanan shows that in retirement his opinions were

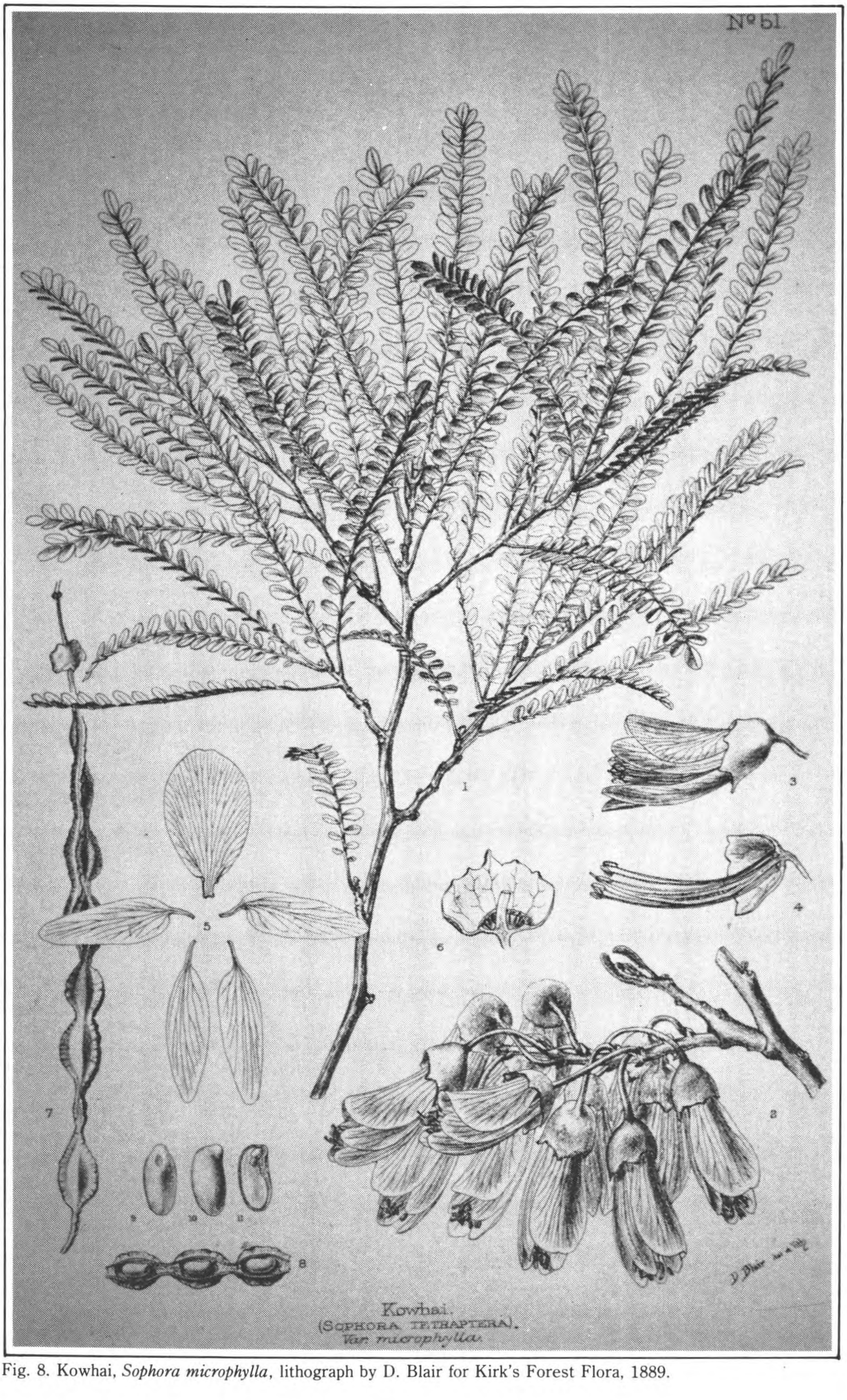

Fig. 8. Kowhai, *Sophora microphylla*, lithograph by D. Blair for Kirk's Forest Flora, 1889.

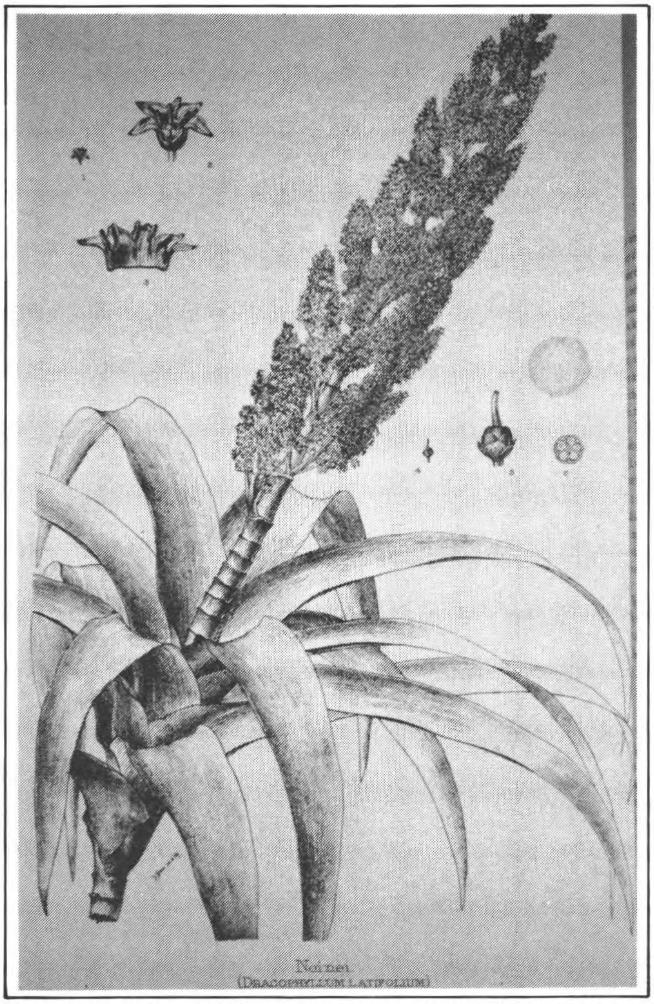

Fig 9. *Dracophyllum latifolium*, lithograph by D. Blair for Kirk's Forest Flora, 1889.

Fig. 10. *Ranunculus lyallii*, chromolithograph from a water colour by Georgina Hetley, for her Native Flowers of New Zealand, 1888.

still valued. The paintings of both ladies are much more pleasing than the reproductions would suggest. The 29 rather dull, monochrome plates of W. C. Field's "Ferns of New Zealand" published in 1890 may well have lost a great deal in reduction. Presumably, as there is no acknowledgement, they are the work of the Wanganui amateur botanist himself.

Although not a part of the mainstream of New Zealand botanical illustration it is diverting to record the brief visit of the famous English traveller, Miss Marianne North. By the time she came here in 1881 she had painted the flora of many remote parts of the world. Her cousin, J. D. Enys of Castle Hill Station on the road to Arthurs Pass, was her host. Enys, a keen amateur botanist, was in close association with Hector, Kirk and Cheeseman and Marianne herself a friend of J. D. Hooker. At the time of her visit she had already built and endowed a gallery for her paintings at Kew to which she later added those done in New Zealand. The most significant feature of her work, executed in oils, is that she saw the plants in a landscape or habitat and not as isolated botanical specimens.

Towards the end of the 1880s there were suggestions put forward for the revision of Hooker's outdated handbook of 1867. By 1890 a decision had been made to publish in New Zealand a completely new flora. Thomas Kirk, the foremost resident botanist was commissioned and in 1893 he formally undertook to complete the work within 33 months. At the same time a very ambitious project for its illustration was initiated by Sir James Hector. The trustees of the British museum were approached for permission to obtain proofs of the copper plates prepared from Parkinson's drawings over a century before and which, as part of the Banksian Bequest, were stored in the collections of the British museum (Natural History). 183 proofs, of New Zealand plants only, were requested and the receipt of these and other Banksian material was acknowledged by Kirk in September 1895.

What has not been generally known, even at the British museum is that not one, but six sets of New Zealand proofs were sent in 1895 and later, a further 6 sets of proofs of the plants from the other countries visited by the *Endeavour* on Cook's first voyage. Therefore by end of the century, through Hector's good offices, New Zealand had proofs of all the Banks and Solander copper engravings. In addition 4 sets of proofs of Forster's engravings were ordered and received. Even with this treasure at hand, an illustrated flora was not to be. Kirk died in March 1898 and, although his unfinished manuscript was published in 1899 as the "Students' Flora of New Zealand and outlying islands", the

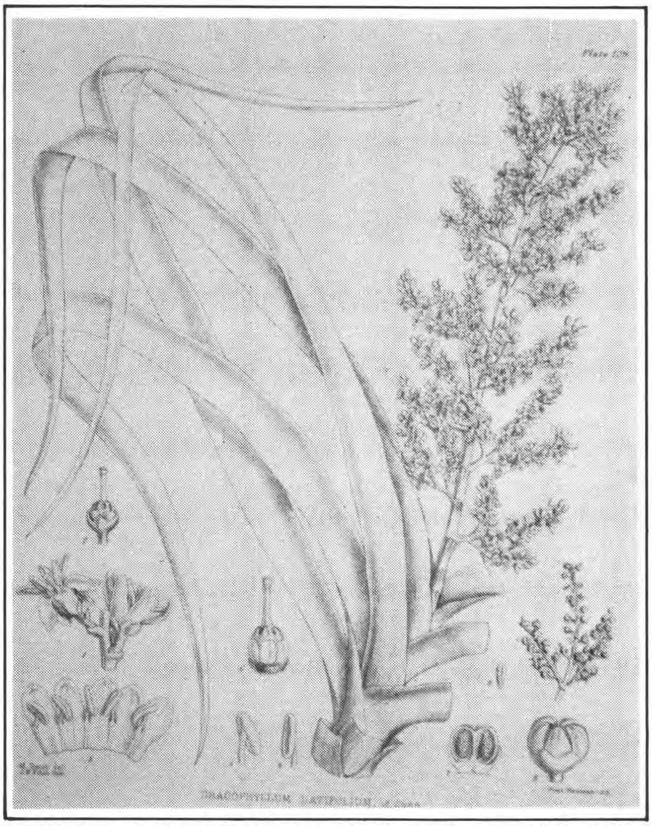

Fig. 11. ***Dracophyllum latifolium*** drawn by Matilda Smith and lithographed by John Nugent Fitch for T. F. Cheeseman's Illustrated Flora of New Zealand, 1914.

Fig 12. ***Ranunculus lyallii*** drawn by Matilda Smith and lithographed by J. N. Fitch, Cheeseman's Illustrated Flora of New Zealand, 1914.

intended companion volume of illustrations was somehow lost sight of. And so were the engravings. With the exception of the one set at the Auckland Institute and Museum, that Hector sent to T. F. Cheeseman in February 1899, they virtually disappeared for over twenty years.

After Kirk's death, Cheeseman had been asked to prepare a complete flora. His "Manual of the New Zealand Flora" was published in 1906; the proposed volumes of illustrations were to follow. Although Cheeseman had in his keeping the only complete and unmarked set of the New Zealand proofs of the Banks and Solander illustrations, he chose, for the very cogent reasons given in his preface to have new drawings prepared. This time it was Kew and not the British museum that was approached, and Matilda Smith, Kew's artist, received the commission from the New Zealand Government. Her lithographer was John Nugent Fitch. As Matilda Smith was J. D. Hooker's cousin and Fitch the nephew of Walter, the 50 year connection between the Hookers and New Zealand was maintained, for in 1914 just in time to avoid almost certain postponement by the Great War, the two volumes of the illustrations to Cheeseman's Flora were published. (Figs. 11, 12, 13)

This was to be the last real attempt to provide an official flora accompanied by drawings of the wide selection of native plants. But the botanical tree that has its roots in New Zealand soil is soon to blossom with the publication of the Banks' Florilegium in which the engravings of our plants will be printed in the colours so painstakingly laid down by Sydney Parkinson over two centuries ago.

Fig. 13. *Olearia chathamica* drawn by Matilda Smith and lithographed by J. N. Fitch, Cheeseman's Illustrated Flora of New Zealand, 1914.

Footnote: The important and beautifully illustrated botanical works resulting from the French voyages of exploration during the first half of the 19th century are not referred to as they merit a separate study.

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Editors Note: The lecture was illustrated with many superb slides, unfortunately space allows only a few to be reproduced here.

Citation for the Award of Associate of Honour A.H.R.I.H. (N.Z.) 1985

The title of Associate of Honour is conferred on a person who has rendered distinguished service to horticulture. The number of Associates of Honour shall not exceed sixty at any one time. Associates of Honour are entitled to use after their names the words 'Associate of Honour of the Royal New Zealand Institute of Horticulture, Inc.' or the distinguishing letters 'A.H.R.I.H.'.

Citation for A.H.R.I.H.

James S. Say

After serving in the armed forces during World War II Jim Say enrolled for a diploma course in horticulture at Lincoln College. He successfully completed the course and obtained a position with the Parks and Reserves Department of the Auckland City Council in 1948. He continued his studies in horticulture and obtained a National Diploma in Horticulture (New Zealand).

In 1953 he joined the Auckland staff of the Horticulture Division of the Department of Agriculture and later became the Upper North Island specialist in ornamentals. For a number of years he was actively involved with the commercial growers in the nursery and cut flower trade. He was a regular contributor to the department's publications, and articles he published on home gardening together with those by John Salinger and K. Marcussen were published in book form as 'Flower Gardening with the Journal of Agriculture' (Whitcombes & Tombs, 1962).

In Auckland he was a keen member of the Institute and an enthusiastic worker for the Auckland Horticultural Council and its many affiliated societies. It was with regret when we, in Auckland, heard of his appointment to the Technical Correspondence School in Lower Hutt as a tutor in horticulture in 1968.

He proved to be a most successful and respected member of the T.C.I. staff. His wide experience gained in the Department of Agriculture gave him a practical approach both to the students and to horticulture. He was responsible for writing many of the assignments when the new syllabus for the Diploma was gazetted in 1971. Throughout his career as a tutor he was intensively aware of the necessity of updating assignments and syllabi to meet the demands of modern horticulture. One of Mr Say's most recent contributions to horticulture was the re-writing of the draft description for the new Horticultural Sales Certificate. He willingly undertook this work after his retirement in 1982. Before he retired he published two books the first one, based on his own experience in establishing a garden in the difficult soils and climate of Wellington. 'Gardening in Difficult Soils' (Reed, 1977) and then with Neville Weal 'Developing a New Garden in New Zealand'. (Reed, 1981).

Mr J. Say has indeed 'rendered distinguished services to New Zealand in Horticulture'.

Rare Plant Conservation in Parks Departments

by P. B. Heenan

Extracts from a dissertation for the Diploma in Parks and Recreation (Lincoln College), submitted by P. B. Heenan in 1984

INTRODUCTION

Given the current world-wide interest in the conservation of threatened species I believe that, in New Zealand, Local Authority Parks and Recreation Departments (hereafter referred to as P.R.D.) have a conservation role to play. In particular this is so of those departments which have a botanic garden, a native plant reserve or a native plant domain under their jurisdiction.

In fact, P.R.Ds are well placed to undertake the cultivation and propagation of threatened plants. For instance, they have generally speaking, propagation facilities, growing on facilities and skilled horticultural staff. In addition they often have a wide range of habitats within the bounds of their city in which to cultivate a diverse range of plant species.

As yet, however, little systematic knowledge has been gathered on the work of New Zealand P.R.Ds in the conservation of threatened species, so that the material discussed in this dissertation is timely and also represents an original documentation of the present situation.

OBJECTIVES

At the time of writing there does not appear to be any well researched study on the conservation role of organisations like the P.R.Ds operated by the larger local authorities in this country. It is this topic then which is explored in the present dissertation, and is developed in terms of three principal objectives. These are —

i) to define the role of P.R.Ds in rare plant conservation,
ii) to identify factors which limit the contribution of P.R.Ds to a programme of rare plant conservation, and
iii) to identify which P.R.Ds are best equipped to make a positive contribution to rare plant conservation.

SURVEY METHODOLOGY

In 1982 Mr G. Paterson, Director of Parks and Recreation, Timaru City Council, distributed an open letter to P.R.Ds to gauge interest among them in plant conservation. To this author's knowledge Mr Paterson's effort is the only other attempt to collect information on rare plant conservation in P.R.Ds.

The thirteen departments identified by Mr Paterson and an additional one were surveyed by the present author in mid-1983. All questionnaires were despatched by 11 July 1983 and the last reply was received back on 4 September 1983. The questionnaire covered a number of different aspects of rare plant conservation among the P.R.Ds surveyed. These aspects included policy on this topic, constraints affecting conservation work, the development of collections, the distribution of plants and suitable propagation material, and the problem of replenishing wild populations. The survey also sought information on the cultivation of groups of plants and growing local or national rare species. Also two questions were designed so the respondent would be made aware of an international conservation agency and of books available on the subject.

In the South Island the cities surveyed were predominantly on the east coast. This means that two important areas for threatened plants have not been represented, these being the West Coast and Central Otago. A similar situation occurs in the North Island with the unrepresented areas being Northland, Gisborne/Napier and Central North Island.

These unrepresented areas exist because either there are cities with not enough facilities or staff to support a rare plant conservation scheme i.e. West Coast, South Island, or else there are very few rare species in the area that need protection i.e. Gisborne/Napier. The absence of survey information for these areas should be borne in mind in the course of discussion on material drawn from questionnaire returns of the other centres.

The Nature Conservation Council (N.C.C.) was advised of my intentions to conduct a survey as part of this dissertation on rare plant conservation in local authority P.R.Ds. They showed support and encouragement by requesting a copy of the completed dissertation. The P.R.Ds surveyed were deemed to have shown a genuine interest in the subject by comments made in the comments section and throughout the survey where they thought appropriate. Some departments enquired as to whether results would be published.

SURVEY ANALYSIS

Policy Statements

Seven of the fourteen departments surveyed had a policy for collecting and cultivating threatened plants. Of the departments without a policy, three indicated they would formulate a policy, while a further one said that they might do so. In addition, three said no policy would be formed.

From a conservation view point it might be seen as a good thing for as many departments as possible to have a favourable policy toward the cultivation of rare plants. However this does not necessarily mean that the conservation of threatened plants will be improved, for as commented by Mr L. Metcalf, Director, Invercargill Parks and Recreation Department, on his questionnaire.

> " . . . everybody is going to be anxious to appear to be doing the right thing whether they have a genuine interest or not . . . or hoping to be seen to be doing something when in fact they could not really care about rare and endangered species."

This statement identifies a situation which must be accepted for what it is worth, that is a gesture toward rather than a genuine commitment to the conservation of endangered plants. We must endeavour however, to look on the positive side of policy, that once it is written up it is then a step nearer to implementation.

There are several departments in New Zealand which have a written policy and are presently implementing it. The departments known to be doing so include Nelson, Dunedin, Christchurch, Timaru, New Plymouth and, in Wellington, the Otari Native Plant Museum. In addition, although Invercargill does not have a policy, its P.R.D. does cultivate rare plants and works with the Lands and Survey Department to maintain one plant site on Stewart Island, that of *Gunnera hamiltonii.*

Nevertheless, concern must be expressed as to the fate of policy implementation when staff at present actively engaged in conservation work leave the P.R.D. in which they are currently employed. This concern arises because often conservation represents a personal commitment by one person, as in those P.R.Ds where there is only one senior administrator with an interest in threatened plants, and who instigates and oversees the policy operation. This is the present situation in several cities, notably Timaru. In such cases as this, a key issue becomes the fate of the conservation effort when individual instigators, like Mr G. Paterson, Director of Timaru P.R.D., retire or move on. For example, will conservation activities cease and/or will the collection become redundant and neglected?

The point is that there is a need to shift responsibility for conservation work in P.R.Ds from individuals (like Mr G. Paterson, Timaru) to the institution itself. To this end, it is suggested that P.R.Ds known to have important collections of plants should be recognised by the co-ordinating body, the N.C.C. A watchful eye could then be kept on a given collection and its management.

In other words, I believe that there is a need for some collections to be given national recognition and status. If this move is not made at this time, then pressure for it will surely increase as collections grow in both size and quality in the future. Recognition of a collection of importance now, however, would ensure it was maintained as an important resource of the future.

Increasing Number and Size of Collections

It is evident from survey respondents that local authority Parks and Recreation Departments are unwilling to fund the collection of species not already in cultivation. Only Timaru P.R.D. was willing to pay for the collection of these species. This situation is understandable as P.R.Ds have other commitments to fulfil with public money.

As a method of obtaining plants all but one department saw exchange of propagation material with other departments as a way to increase their collection. This raises another problem, namely the distribution of costs incurred. Indeed, as Mr C. Gill, Hamilton City Council, commented, 'who will pay for such expenses as freight required to distribute stock'. On this point it could be argued that if a plant is worth saving, it is worth giving away, in which case the supplier might be expected to meet distribution costs. Neverthless, this is an unrealistic answer when Parks Departments have financial restraints and commitments to meet which may be considered to be more important to the needs of ratepayers.

One possible low-cost solution is that conferences which are held on a regular basis and attended by many departmental staff, could be used as a distribution point for threatened plants. This idea has several drawbacks however. One is that only people who feel committed to the propagation and distribution of rare plant material would bring them along. Another is that persons attending conferences often take this time as leave and may not return immediately to their work place. Even if such a scheme achieved only a small amount of plant distribution, this would serve the conservation effort.

Other institutions, such as the D.S.I.R. Botany Division and University Botany Departments and Grounds Maintenance Departments, also have collections of rare plants. These too should be made available for distribution. However, this process still needs people motivated sufficiently to undertake that task. To this end, regional co-ordinators could be used to facilitate the exchange of plants between regions and to distribute plants within regions. A regional co-ordinator could be affiliated to either the Royal New Zealand Institute of Horticulture (R.N.Z.I.H.) or the New Zealand Institute of Parks and Recreation Administration (N.Z.I.P.R.A.).

Many rare plants have only limited horticultural appeal, and so they would not be suitable for cultivation in an amenity horticulture situation. This is where the role of botanic gardens in threatened plant conservation is very important. It should be their duty to cultivate plants with limited horticultural potential. If they don't, who will?

Nevertheless, this proposition raises a point of very real concern, that is, that eleven of the departments stated they were prepared to collect propagation material from the wild to increase their collections. Although this is unlikely to happen, that such an attitude of mind is prevalent among P.R.D. administrators does not appear to be in the best interests of conservation. Because, even with the best of intentions, collecting on such a scale would surely see the demise of many natural plant populations and species. In this respect too, there is a need to ensure that P.R.Ds do not compete against each other to be the only place to hold such and such a rare plant. One way of helping to avoid this situation is to keep readily open the doors for plant exchange and P.R.D. administrations should make every effort to take up offers of plant material when they are made.

One possible means to this end has been suggested by Mr A. Jolliffe, Director, P.R.D., Nelson. He intends publishing a list of wanted propagation material to enable him to increase his plant collection. However, Mr Jolliffe's scheme will only work if the people holding plant stocks are prepared to distribute their plants. If people were to respond to such a list it might be a very effective method for distributing rare plants. A 'plants available for distribution' inventory or 'seed available' lists are other possibilities.

This information could be disseminated by using existing channels of communication. These include magazines such as N.Z.I.P.R.A. newsletter and R.N.Z.I.H. quarterly bulletin 'Horticulture in N.Z.' On a regional basis the newsletters of groups such as Native Forest Action Council and local plant groups such as Otago Alpine Garden Club and Canterbury Botanical Society, could be encouraged to publish lists. Members of these groups could also be used to grow rare species.

Publicising the names of rare plants which are either wanted or on offer to collections, is but one aspect of the conservation endeavour. Another is the form in which propagating material is best made available. In this regard, plants have the disadvantage of being bulky and heavy, as well as being costly to ship and perishable. Cuttings too are perishable, despite being lighter and cheaper to ship. Thus, because seeds are light in weight, of small size, and much less perishable than plants or cuttings, they appear to be the most satisfactory means of distribution.

In addition, questions of organisation and management are also included. To date the lack of rare plants in cultivation can be attributed to the unorganised, unplanned and haphazard way collections have been developed. If, in the future, collections are to be increased both effectively and efficiently, there needs to be much greater co-ordination and co-operation between P.R.Ds, so that exchange of plant material (cuttings, plants and seed) between P.R.Ds can occur readily.

The role of concerned members of the public in advancing the cause of rare plant conservation must not be under-estimated. Private persons who are skilled in plantsmanship and who like to grow rare plants should be encouraged to do so by being able to obtain cuttings, seeds and perhaps plants from P.R.Ds. However, this should be developed as a reciprocal relationship in that

P.R.Ds should seek to increase their collections by accepting donations by members of the public.

Commercial plant nurseries also have a part to play. Occasionally they offer rare plants for sale. For instance, one Auckland nursery listed 24 rare species in their 1982 plant catalogue and 35 in 1984. In other words, interested parties, including P.R.Ds should attempt to keep themselves informed about rare plants appearing in stock lists of commercial nurseries.

Regional Collections

With the wide range of habitats and propagation facilities available in P.R.Ds, there is a good resource base for the establishment of regional collections, at least in those parts of the country represented in the questionnaire survey. In fact, all P.R.Ds said that they would be prepared to be involved in the establishment of regional collections. However, this apparent enthusiasm should be viewed with caution for, as indicated previously, many P.R.Ds face constraints which restrict their ability to maintain such collections and to run them efficiently.

If departments were to be involved as catalysts in the development of regional collections, certain points would need to be clarified before a viable scheme could be implemented. These points are:

a) staff input requirements
b) financial input from national co-ordinating body
c) provision of adequate propagation facilities
d) the mechanics of co-operation with co-ordinating body
e) plant documentation. This would include relevant information on species being cultivated, number, age, origin and health
f) location of areas to cultivate plants in P.R.D.
g) provision of adequate after-planting maintenance e.g. pruning
h) regional specialisation (who grows what?)

As implied in a comment by Mr C. Gill, Hamilton City Council, the central question raised in point (h) is one of 'who will decide who grows and produces what?' One solution to this would be by P.R.Ds nominating which plant types they would prefer to cultivate. It is apparent that if this proposal was implemented, trees and shrubs would be the most commonly cultivated plants. In addition however, the responses indicate that the other groups, that is ferns, alpines and herbaceous plants, would all be adequately cultivated. Nevertheless, this might not be so in practise because each of these last three groupings of plants has special cultivation requirements. Moreover, they have generally a low amenity horticulture value, and so they are not frequently cultivated.

From the survey it is interesting to note that two of the main botanic gardens, Christchurch and Dunedin, both stated they would prefer to grow only rare plants of their own botanical region. While this is an understandable policy, they must be more than prepared to cultivate a wider range of rare plants if a rare plant conservation scheme is to be successful. On this point Mr M. Reece, Curator of Dunedin Botanic Garden comments

> Naturally propagation of plants from other regions would take place to ensure stable populations in the botanic gardens' own collections, but not on a scale that would provide for general dissemination of plants. Exceptions to this would occur where propagation material (especially seed) is freely available in a region other than where the plant is naturally found.

Concerning the dissemination of plants, nine departments would be prepared to distribute plants. Of the main gardens, Christchurch Botanic Garden and Otari Plant Museum preferred small numbers of many species, while Dunedin Botanic Garden preferred few species in large numbers.

Constraints on the Development of Regional Collections

Although P.R.D.s were unanimous in expressing support for the concept of regional collections, it has to be acknowledged that there are at present many constraints which limit the ability of such organisations to participate in such a scheme. The range and character of these constraints is captured in the following quotations extracted from the questionnaire responses:

> . . . there are limitations on the extent to which Parks Departments can be involved in special conservation projects. While a good measure of emphasis is placed on environmental calls, demands for more and more emphasis on recreational requirements of our communities can place limits on what can be achieved.
> (Mr A. Jellyman, Director, Parks and Recreation, New Plymouth.)

> . . . local authorities are very much restricted by the limitations of their rate-derived budget . . . and most Council Parks Departments will plead workload . . .
> (Mr C. Pharazyn, Landscape Architect, Upper Hutt.)

While these statements represent realistic personal assessments of local situations, the constraints of limited finances and resources, including equipment and staff, might be eased in part at least, by direct financial and other incentives (e.g. seconded staff, advisory assistance) provided by the national co-ordinating body. For this purpose, the latter would presumably require monetary support from central Government. However, even if such assistance was forthcoming, such a scheme would readily fall into neglect unless it was high on P.R.D. lists of priorities. The result being a waste of resources for all parties concerned.

The small size of some departments is also a limiting factor.

This is because although some departments have suitable resources (e.g. propagation facilities, staff) they are not sufficiently large or specialised to be used for an applied conservation project. The point was made by Mr Thompson, Superintendent of P.R.D., Ashburton, who commented, '. . . as we are a comparatively small Parks Department, our available resources are limited', and by Mr G. Hall, Director P.R.D., Oamaru, who observed 'our propagation facilities are limited.'

Other constraints affecting small departments are also evident. These include a general lack of staff interest and expertise. Perhaps a lack of staff interest could be overcome if staff members were given the reasons for and values obtained from rare plant conservation.

In more general terms, only four P.R.D.s gave a lack of propagation material as a constraint on the development of collections of endangered plants. However, the present writer believes that this constraint is more severe than the responses suggest. My experience over several years, in attempting to procure plant material and through observation of nursery plant lists and existing collections in botanic gardens and elsewhere, is the basis of an estimate that only thirty-one percent of plants listed in Given (1981) are actually in cultivation.

This low estimate indicates that, at least in the immediate future, the development of representative regional collections will be inhibited by a scarcity of suitable propagation material.

Concerning information on rare plants, three departments stated there was a lack of such information. As this problem was envisaged, I listed five books to indicate what is available on the subject. The most commonly read books were a) I.U.C.N. Red Data Book, b) The New Zealand Red Data Book and c) Rare and Endangered Plants of New Zealand by Dr Given. This was designed to encourage the respondents to do further readings on rare plants by familiarising themselves with books they previously had not heard of.

A further point is that there is also a need for one authoritive rare plant list to be published and to be updated regularly. At the present time there are several lists available all with varying numbers of species. One standard list, perhaps prepared under the auspices of the national co-ordinating body, could serve as a guideline for all agencies involved in conservation efforts.

Such a comprehensive list would also help eliminate the situation where departments wish to be seen to be participating in a threatened plants scheme, but by using a restrictive list (such as N.Z. Red Data Book which lists only 66 species) they limit the amount of conservation work they actually contribute. This point, and that made earlier to the effect that limited cultivation and lack of propagation material will severely inhibit conservation efforts, is supported by the fact that, as reported by the Nature Conservation Council (Newsletter 53, October 1983) for as many as twenty five of the sixty six species listed in the New Zealand Red Data Book there is no record of them being in cultivation.

The attitude and knowledge of local body politicians is another factor which can affect administrator's initiative in rare plant conservation. For example one P.R.D. director who responded to the questionnaire maintained that the main constraint he faced was a lack of interest in rare plants among councillors in his city.

This appears to be the crux of the matter in so far as it concerns local authority P.R.D.s. On the other hand if a director wishes to have an active policy on rare plant conservation, he will organise his resources and lobby local body politicians to achieve that end; on the other hand, if the director is not strongly motivated in favour of an active policy then it is most unlikely that such a development would occur.

Summary

The questionnaire survey revealed that several P.R.D.s do have a policy for collecting and cultivating rare plants. Even so, the existence of a policy should not be regarded as an end in itself. For conservation efforts to be successful, that policy needs to be actively implemented. Generally speaking, P.R.D.s are not prepared to finance the collection of species not in cultivation. They are willing to propagate and distribute stock, but this is unlikely to be done due to the cost of freight and the 'hassle' it involves. As an alternative, use could be made of conferences or individual staff travel opportunities to distribute plants. Moreover, institutions such as D.S.I.R. Botany Division and Universities, which have stocks of rare plants, should have these available for distribution. 'Wants' lists and 'plants available' lists could be circulated among interested parties. In this regard, seed appears to be the cheapest and most practical way of distributing propagation material.

The survey also found that all P.R.D.s are prepared to be involved in the establishment of regional collections. However, before such a scheme could proceed, several major questions to do with organisation management and resource use and availability need to be answered.

Finally, the development of conservation programmes among P.R.D.s faces a number of constraints. Important among these are insufficient finance, a lack of staff expertise and limited staff interest. Furthermore, what active conservation work is being undertaken could be strengthened by making available one standardized official comprehensive list giving details of known threatened species.

NEW ZEALAND OVERVIEW

Past and Present

The first botanic garden in New Zealand was established at Dunedin in 1863. This was followed by the development of botanic gardens at Christchurch, Timaru, Wellington, Auckland and Otari Native Plant Museum, also at Wellington.

The Christchurch Botanic Garden had the first substantial collection of New Zealand plants. This was established there by members of the Armstrong family in the later decades of the nineteenth century. (*Hebe armstrongii*, a very rare plant from Canterbury, commemorates their name).

Native plant collections in botanic gardens have been generally established in a haphazard manner, with little or no thought to the specific need to collect threatened plants. In other words, rare plants found in cultivation in such gardens, are almost invariably there only by coincidence. Moreover, such plants are usually those which have some horticultural appeal. A commonly found example is *Clianthus puniceus*. Other threatened plants considered to have only limited horticultural merit tend to be neglected, and thus not cultivated.

The most notable collection of indigenous flora is at Otari Native Plant Museum. This was the brainchild of Dr L. Cockayne, who is widely regarded as the 'father' of New Zealand botany. It was his foresight and enthusiasm which led to the establishment of this collection of New Zealand native plants. A number of rare plants are grown there. Moreover, Mr R. Mole, the present Curator, is a keen advocate of the need to cultivate and protect endangered New Zealand species.

Since the establishment of botanic gardens in New Zealand, there have been many changes of emphasis in the role of these gardens and their collections have seen corresponding ups and downs in the standard of maintenance and the physical health of the collections. These shifts reflect varying economic conditions and the variable attitudes and interests of the administration in charge of particular gardens. Today, generally speaking, research and plant conservation are hampered by a shortage of limited finance, limited expertise and facilities, and the demands of the public for more recreation and associated facilities in both parks and botanic gardens.

From the survey it is interesting to note that two of the main botanic gardens, Christchurch and Dunedin, both stated they would prefer to grow only rare plants of their own botanical region.

The Future Role of New Zealand's Botanic Gardens

As revealed by material discussed in the last section, botanic gardens in New Zealand have not yet recognised the important, if not crucial, conservation role they have to play by developing active programmes in the fields of propagation, research and education. In this regard, New Zealand is several decades behind developments in botanic gardens overseas, so clearly there is much to be learned from their experience, with appropriate adaptation to suit environmental conditions in this country.

New Zealand should be able to emulate what has, and is, happening overseas in rare plant conservation. Impediments exist, but they are by no means insurmountable, given goodwill and co-operation within and between P.R.D.s, a genuine interest in conservation and some rationalisation of resources to give greater prominence to rare plant conservation.

The main problems to be overcome before significant progress can be made include several which recall a number of points discussed in an earlier section.

Among the more important of these are the following:

1) lack of staff expertise in rare plant conservation
2) limited finances
3) a need to collect and introduce to cultivation those plants not in cultivation
4) to distribute more widely those plants that are only in limited cultivation.

In regard to their role in conservation, botanic gardens should not only cultivate threatened plants, they should also be involved in replenishing and maintaining wild populations in a stable situation. Maintaining threatened plants *in situ* must be the ultimate aim in rare plant conservation. The role of botanic gardens in such replenishment schemes, is to propagate and grow-on plants suitable for replanting in the wild. In this regard, Mr C. Gill, Hamilton Recreation and Welfare Department, notes three points that need careful consideration if conservation *in situ* is to succeed, namely -

a) What follow-up will be given in the field after plants have been placed *in situ*? i.e. Who will ensure that these plants are maintained until such a time as they are able to fend for themselves?
b) In order to protect new and artificially expanded habitats, will the controlling body seek further protection under the appropriate statutes of government?
c) What will be the policy in respect of plants on private land? Will land purchase or lease in perpetuity be an option for consideration?

Each of these points is valid, but the first appears to be the most immediate and urgent. In realilty there appears little point in encouraging the propagation of rare plants for replenishing wild populations *in situ* unless survival is assured in so far as it can be by effective after-planting protection and care.

Nevertheless, it is encouraging to find that so many P.R.D.s in New Zealand would be prepared to become involved in the replenishment programme. In fact, nine P.R.D.s indicated their willingness to be involved. This number included the major botanic gardens of Dunedin and Christchurch, as well as Otari Native Plant Museum in Wellington.

What can be done? (The N.C.C. Seminar, 1979)

At this stage in the development of rare plant conservation in New Zealand, there is a need for action, a need to move beyond consideration of intentions, possibilities and problems. To this end, the Nature Conservation Council held, in November 1979, a seminar on rare and endangered species and the role of botanic gardens in their conservation. In particular the role of botanic gardens was seen to encompass eight points, and because of their importance each of them is outlined below.

a) *Preservation.* This refers to the preservation of plants in a man-made 'natural' environment. This facility might be used to achieve any or all of the following five objectives, that is to grow more plants; to study them in order to understand their requirements; to document the process; to propagate endangered species; and finally, to disseminate rare plants to other botanic gardens and to re-introduce them into the wild.

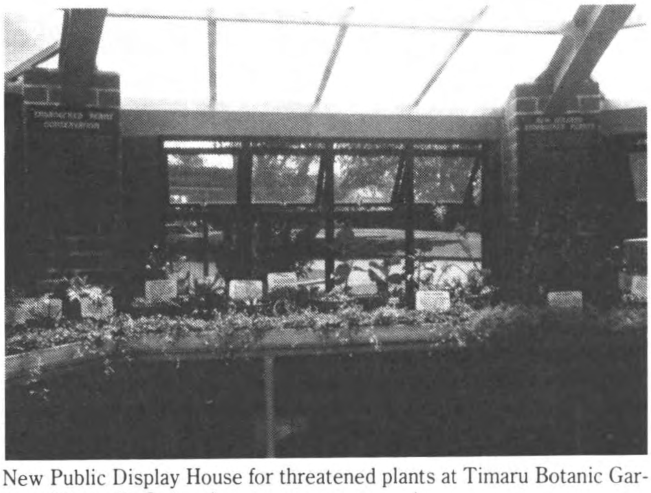
b) *Education.* The N.C.C. seminar recognised this aspect as a fundamental aim. Education would help to prevent collection in the wild and minimise other causes of depletion. The seminar concluded that the public have a right to be informed about rare plants, and for this purpose, botanic gardens should make use of instruction courses, lectures, garden walks and excursions.
c) *Propagation.* Individuals and amateur groups, with adequate skills and facilities, should be encouraged to propagate rare plants. Keen amateur gardeners can be a strong force in plant conservation, particularly if their efforts are well co-ordinated.
d) *Salvage.* Where sites are being developed for farming, public works construction and so on, efforts should be made to salvage threatened plants from them.
e) *Propagation gardens.* The N.C.C. seminar maintained that there was a need for a network of botanic gardens, some to be used for the propagation of plants which could be re-established in the wild.
f) *New botanic gardens.* In the interests of the conservation effort, there is a need to establish botanic gardens in areas where there are none. Suitable locations suggested were in North Auckland, Westland and Central Otago.
g) *Volunteer assistance.* Increased use should be made of voluntary groups, such as Friends of the Gardens and local botanical and garden societies, in the interests of rare plant conservation.
h) *Co-ordination.* Botanic gardens should be linked by both a national and international (through I.U.C.N.) network, to facilitate the exchange of information, plant material etc., on endangered species. Such co-ordination is considered essential if conservation efforts are to be successful.

CASE STUDIES

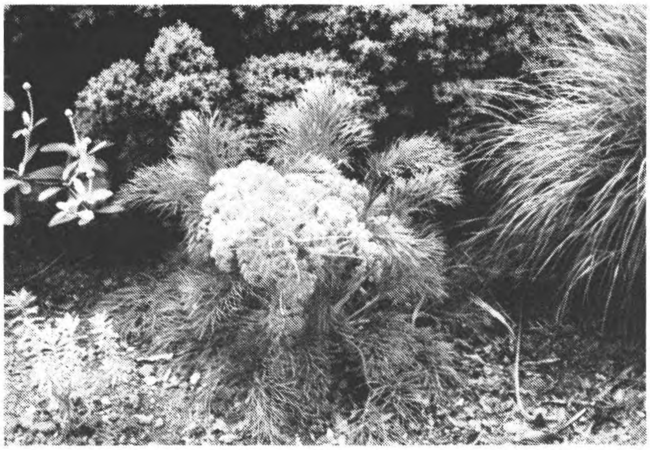
Timaru Botanic Garden

In December 1980 when Mr Graeme Paterson was appointed Director of Parks and Recreation for the Timaru City Council, he immediately set about providing facilities for the propagation and cultivation of threatened plants. The first acquisition was a small glasshouse to be used specifically for the propagation of endangered plants. There are also back-up misting and weaner facilities at the main nursery.

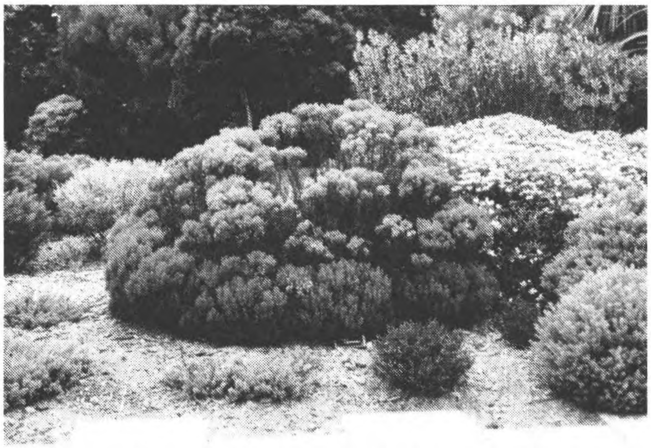
Timaru now has a collection of over seventy endangered species. A select few of these have been propagated and large numbers of these are held in stock. The next stage in the de-



New Public Display House for threatened plants at Timaru Botanic Garden. (Photo E. Cadzow).



Aciphylla dieffenbachii (right) and *Euphorbia glauca*. Two rare plants with excellent garden potential, at Dunedin Botanic Garden. (Photo P. Heenan).



Hebe cupressioides at Dunedin Botanic Garden. Although rare, this plant is widely cultivated. (Photo P. Heenan).

velopment of rare plant conservation work at Timaru took place in 1983 when new public display glasshouses were erected at the botanic garden. Incorporated into this complex is a display room which contains only endangered plants. The display room will house plants not only indigenous to New Zealand, but also from other parts of the world that could not otherwise tolerate the winter climate of Timaru, which is prone to low rainfall and frosts.

Contact has also been made with a local commercial tissue culture laboratory and already a programme is underway for the propagation of endangered ferns.

For the future, rare native plant displays are planned for a cultivated border which will be set against a bush area of native plants. This provides aspects covering 300° of the compass, and so will enable a wide range of species to be grown.

Mr Paterson argues that it is insufficient to exhibit endangered plants alone, that is as individuals with a name tag. The point is that plants are not pandas which can perform to bring attention to themselves. For this reason then, educational display boards will accompany the plant display. This facility will be complemented by an interpretative centre which is to be developed adjacent to the plantings, and will house modern museum-type displays and audio-visual presentations.

Because of the rarity value of endangered plants, a public display collection could be vulnerable to vandalism and thefts. To overcome this problem, extra stock will be held of all plants on display, making it possible to buy surplus plants from the botanic garden. This is to be a non-profit making, educative and public relations venture.

A draft proposal for a management plan for Timaru P.R.D., which includes the botanic garden, has been drawn up.

Dunedin Botanic Garden

As indicated earlier, the Dunedin Botanic Garden was the first such garden in New Zealand. The garden has seen many high and low points as far as the size and maintenance of plant collections are concerned. This is reflected in the *Hebe* species collection. As early as 1913 the collection comprised 122 species and cultivars with 14 of these being classified as rare. But by 1970 there were only 44 species and cultivars including 5 rare species. Fourteen years later, that is early 1984, the number of rare hebes being cultivated is 10.

The cultivated shrub and tree borders of the gardens have climaxed and re-development work is being undertaken. This will enable plant collections to be re-established and in the process it is hoped to give a stronger emphasis to New Zealand rare species.

Interpretative displays of endangered plants will be used in the newly-established visitor education centre, and in addition, the intention is to produce a series of pamphlets and self-guiding walks on matters of horticultural interest. A pamphlet or guided walk specifically on rare plants is envisaged.

Guided walks given by staff are also to be introduced in 1984/85. Again some emphasis will be given to rare plants. It is also planned to establish a Friends of the Garden group. This will provide new avenues, both for obtaining and disseminating rare plants, and should enable improved liaison with other botanical and horticultural groups, as well as with the public at large.

The Dunedin P.R.D. botanist, Miss A. E. Evans, liaises with numerous other agencies and institutions in pursuing several aspects of her work. This work includes the process of compiling a seed exchange list, identifying plants, routine taxonomic research, increasing the herbarium and providing information for the public. In doing so, Miss Evans devotes a certain amount of time to aspects of rare plant conservation.

Dunedin Botanic Garden, like that in Timaru, now regularly sees its collection of rare species increase through plant donations from the public, staff and purchases from nurseries.

The Case Studies in Perspective

The two case studies discussed previously are instructive in that they amplify a number of points made earlier in the dissertation. One is that the experience of Timaru provides a clear example of the role of the Director in stimulating interest in and the development of work in rare plant conservation.

A second observation is that despite the attitudinal and resource constraints which appear to inhibit the conservation effort in this country, existing resources can be effectively used to advance conservation work on recognised fronts.

As the Timaru case study, in particular, demonstrates, and less so Dunedin, there is much that can be quite readily accomplished in terms of propagation and, especially, public education. The most obvious deficiency, compared with overseas gardens, is in research.

SUMMARY AND CONCLUSION

The purpose of this final section is to summarise the principal findings of the study and, by way of the conclusion, to make a number of recommendations concerning the conservation of this country's rare plants. The summary is based on the three objectives listed in the first section.

Objective (i)

The first objective was to identify factors that limit the contribution of P.R.D.s to a programme of rare plant conservation. Each of the P.R.D.s was affected by a particular combination of inhibiting factors. These included limited finances, a low level of staff interest, lack of staff expertise, poor propagation facilities, little or no encouragement by city councillors, a lack of enthusiasm from senior P.R.D. administrators and inadequate supplies of propagation material. Many P.R.D.s were not prepared to finance the collection of species not in cultivation, and also raised was the question about who would pay for the distribution of plant material. Plants such as ferns and alpines usually require specialised habitats and would be difficult to cultivate in a typical P.R.D. garden environment where very little after-care could be given to them. However, by far the greatest problem is that P.R.D.s are, on the whole, already over-committed with functions which the public regard as being more important.

Objective (ii)

The second objective sought to define the role of P.R.D.s in rare plant conservation. Because of their organisational structure, and facilities, P.R.D.s appear to have a definite role to play in rare plant conservation. They have propagation facilities, skilled horticultural staff, growing-on areas and final planting areas in the various parks and reserves under their jurisdiction. However, given the limiting factors summarised previously, P.R.D.s should aim to cultivate those rare plants which are easy to cultivate, can be grown successfully in their area, and have some amenity horticultural value.

P.R.D.s with a botanic garden should complement this base level of conservation work. As well as growing species which fit the above description, they should aim to cultivate a selection of the more difficult to grow species, including those which have specific habitat requirements (e.g. alpines and ferns) and those which have a low amenity horticulture value but are unlikely to be cultivated other than in a botanic garden. In addition, where sufficient plant propagation material is available, it should be made available for distribution to other institutions interested in rare plant conservation, to horticultural groups, and to members of the public.

Objective (iii)

The purpose of this objective was to define those P.R.D.s which are best equipped to make a positive contribution to rare plant conservation. The first criteria used to identify these P.R.D.s was based on their individual policy statements. Ten P.R.D.s stated that they either had a policy for rare plant conservation or intended to develop one in the future. Other criteria to ascertain which of the ten P.R.D.s have a positive contribution to make were based on the internal attributes of each P.R.D. This information included restraints, local or New Zealand species, replenishing wild populations, establishing regional collections, co-operation with a co-ordinating body and staff input.

A final external criterion was the geographical location of P.R.D.s so that at least one is found in each major region of New Zealand, with a view to fostering the development of regional collections of rare plants. With these criteria in mind, a number of P.R.D.s covered in this study have been identified as having a positive contribution to make to rare plant conservation. They are Nelson, Christchurch, Timaru and Dunedin in the South Island, coupled with, in the North Island, Hamilton, New Plymouth and Wellington, to which should be added Auckland University. Ashburton and Oamaru are willing to participate in rare plant conservation, but are restricted by their limited resources. In any case, the location of Dunedin, Timaru and Christchurch in the same general region, means that the case of conservation in this part of New Zealand is well served.

Recommendations

By way of conclusion, the writer believes that the material discussed earlier in this study supports three major findings which are expressed here in the form of recommendations affecting the further development of rare plant conservation in New Zealand. These concern, firstly the establishment of regional collections of rare plants; secondly, the future role of local authority P.R.D.s in rare plant conservation; and thirdly, the establishment of a national collection of rare plants. Based on different combinations of these three administrative levels, and given that the Co-ordinating Body (i.e. the Nature Conservation Council) already exists, seven alternative development strategies which might be considered are as follows:

a) to utilize existing facilities only
b) to develop new facilities only
c) to utilize existing facilities and to develop new facilities
d) to establish a national collection
e) to establish a national collection and to utilize existing facilities
f) to establish a national collection and to develop new facilities
g) to establish a national collection, and utilize existing facilities, as well as develop new facilities.

The writer advocates that for the successful conservation of rare plants, the most desirable combination is that option or alternative which incorporates local authority, regional and national levels of action, viz option (g). This hierarchy would allow smaller local collections to be maintained while also fostering the development of regionally and nationally important collections. It would also mean that plant species are held in more than one collection. This would eliminate the unfortunate situation that could arise should a particular plant held in only one collection, die, either due to a management error or unforeseen circumstances.

The writer's recommendations follow.

Recommendation One

That regional collections of rare plant species be established in areas where there is currently no P.R.D. (or botanic garden).

The functions of these collections would be to

a) collect and cultivate nationally and regionally rare plants within the defined region.
b) undertake research into the cultivation and propagation requirements of rare plants.
c) present interpretative displays for public information and education.
d) liaise with and exchange plant material with other institutions and individuals involved in rare plant conservation.
e) undertake field work associated with wild populations of rare plants.

f) be involved with the management of wild populations of rare plants.
g) publish, document and distribute information on rare plants.
h) have plants available to the public for sale.
i) cultivate species from other regions of New Zealand and species from overseas, if they can be grown successfully in a given region.

Justification of Recommendation One

The specific purpose of regional collections of rare plants is to successfully cultivate them. By having all policies, objectives and functions of the regional collection geared towards rare plant conservation only, there would be no work priority conflicts as occur in P.R.D.s. Moreover, employees involved in the development of regional collections would be trained and engaged specifically for this work, rather than be a 'jack of all trades' as almost invariably they are in P.R.D.s. In addition, work facilities and equipment would be specially geared for rare plant conservation, and equally important, time could be spent providing the optimum propagation and cultivation conditions without being distracted by other tasks and competing priorities.

The establishment of regional collections in areas where there are currently no botanic gardens or P.R.D.s capable of conserving rare plants, would ensure that the flora of these areas was well represented. Such areas include Central Otago, Westland and North Auckland.

Recommendation Two

That P.R.D.s (including existing botanic gardens) be used as secondary or "back up" agencies for conserving rare plants.

The functions of P.R.D.s would be to

a) cultivate plants with which they are provided or which they desire to grow.
b) undertake, as they wish, propagation and cultivation research into rare species.
c) liaise with other agencies involved in rare plant conservation.
d) distribute rare species to other conservation agencies, members of the public and horticultural groups, should they have adequate plant material.

Justification of Recommendation Two

Those P.R.D.s identified by this dissertation as having a contribution to make to rare plant conservation, would complement the work of regional collections. Such a network of P.R.D.s would assist the systematic preservation of a wide range of species at risk, especially those which have only general propagation and cultivation requirements.

If P.R.D.s wished to contribute to such a scheme their only obligation would be to cultivate the plant species of their own choice or which they were provided with from either the regional or national collections. P.R.D.s would not be obliged to do research into propagation and cultivation requirements, or to be involved in management of wild populations etc. This would minimize the limitations imposed on rare plant conservation by general purpose propagation facilities, non-specialist staff skills and interest, by the ambivalent attitudes of senior administrators, and the problems of financial and work priority. However, if P.R.D.s desired to contribute more resources to a conservation scheme, they would be encouraged to do so.

Recommendation Three

That a national collection of rare and endangered plant species should be established.

The functions of such a national collection would be several, including

a) the establishment of a comprehensive collection of nationally rare plants at Otari Native Plant Museum, Wellington, the collection not being substantially duplicated elsewhere (i.e. among regional collections or in P.R.D.s)
b) giving assistance, advice and guidance to those involved in developing regional and P.R.D. collections
c) undertaking research into the propagation and cultivation requirements of rare plants and to co-ordinate research with other plant conservation agencies
d) the publication and documentation of research results
e) preparing interpretative and educational displays for public viewing in different parts of New Zealand
f) acting as a parent body to which regional collections and P.R.D.s can be affiliated.

Justification for Recommendation Three

A national collection gives recognition to the importance of such for its research, scientific, historical and national heritage values. Also, the status inferred by being a national collection would create and foster greater public awareness and interest in rare plant conservation. In addition, it would help to ensure a high standard of care, curation and maintenance of the collection so gazetted. This would serve to keep a collection intact in perpetuity and adequately preserved at a desired, acceptable high standard.

If, in the future, a bleak economic situation forced a reduction of funds to the proposed regional collections, the consequences would be disastrous for the quality of the collection. It would undoubtedly become run down and dilapidated. However, having a national collection housing the most important respresentatives of New Zealand's rare and endangered flora would still allow, in this situation the cultivation and curation of these plants to a high standard.

This writer advocates that in New Zealand the Otari Native Plant Museum, Wellington, be developed as a national collection for rare and endangered indigenous plants. Otari is nationally and internationally renowned for its premier collection of New Zealand's flora, and, in addition, it already cultivates a number of rare plant species. The curator of Otari, Mr R. Mole, comments in the questionnaire, 'The entire operations at Otari are to grow only New Zealand plants . . . as many as possible from the New Zealand botanical region.' With this stated purpose, Otari is well suited to being developed as New Zealand's national collection of rare plants. Moreover, Otari has horticultural and gardening staff skilled in the propagation and cultivation of New Zealand's indigenous flora. These staff would be able to undertake research on the propagation and cultivation requirements of rare plants and to provide advice, assistance and guidance to other agencies involved in rare plant conservation.

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The Effect of N and K on the Rooting of Leaf Cuttings Grown in Liquid Media

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ABSTRACT

A study was carried out to measure the effect of two macronutrients (nitrogen and potassium) on root and shoot initiation of *Peperomia caperata, Saintpaulia ionantha* and *Streptocarpus holstii*. Leaf cuttings were grown in liquid media in containers. The major effects were as follows:

(a) Medium or high levels of N are likely to inhibit root growth in certain species of herbaceous plants. Nil or low levels of N produced the best root growth for the plant species used in this study.
(b) The effect of N on root emergence and initiation may be transitory and if cuttings are left in the medium for a long period of time relatively high levels of N may improve overall cutting growth.
(c)The inclusion of K in the rooting medium improves subsequent cutting growth and appears to reduce the severe effect that high N has on resultant cutting growth.
(d) Liquid media appear to have more potential for research work particularly in relation to the speed in which cuttings appear to have responded and further work with this medium may provide commercially viable options.

INTRODUCTION

A study was carried out to measure the effect of nutrient applications to cuttings looking at the effect this had on both ARF* and ASF**. This is an area which seems to have had little research in recent years and has been overshadowed by research into the effects of synthetic growth regulators on cuttings.

Plant species chosen were those with a known ability to generate both roots and shoots from a single leaf only. Speed of root initiation was also considered an important factor and so only species that produced ARF and ASF relatively quickly were considered.

An experiment was set up to study the effect of N and K on the leaf cuttings of *Saintpaulia ionantha, Streptocarpus holstii* and *Peperomia caperata.* Earlier trials using *Peperomia obtusifolia, Peperomia caperata* and *Saintpaulia ionantha* had indicated no response to added levels of P in the cutting media. *Peperomia obtusifolia* was not used for this trial because it was found to be widely variable in the amount of time required to initiate both roots and shoots.

METHODS AND MATERIALS

Cutting preparation

Cuttings of *Saintpaulia ionantha, Peperomia caperata* and *Streptocarpus holstii* were prepared from uniform stock plants purchased from a local nursery and repotted into a standard potting mix at Lincoln College and grown on to adequate size.

*ARF — Adventitious root formation,
**ASF — Adventitious shoot formation.

Cuttings taken from all species contained both lamina and petiole and efforts were taken to ensure an even size distribution of leaves amongst all treatments. Cuttings were all dropped into a shallow tray of warm water until ready to set.

A liquid medium was used in preference to a typical propagating mix so that root growth could be readily observed and measured. All cuttings were set with the petiole inserted through a hole in polystyrene discs which had been prepared earlier. The polystyrene disc was then floated with the petioles dangling in their respective liquid solutions in individual plastic beakers (Plate 1 and 2).

Experimental design

The experimental design was a 3 x 3 factorial in randomised blocks. Each treatment was replicated by four blocks with each replicate represented by four cuttings.

Plastic containers holding 300 mls of solution were used for each replicate of four cuttings of *Peperomia caperata* and

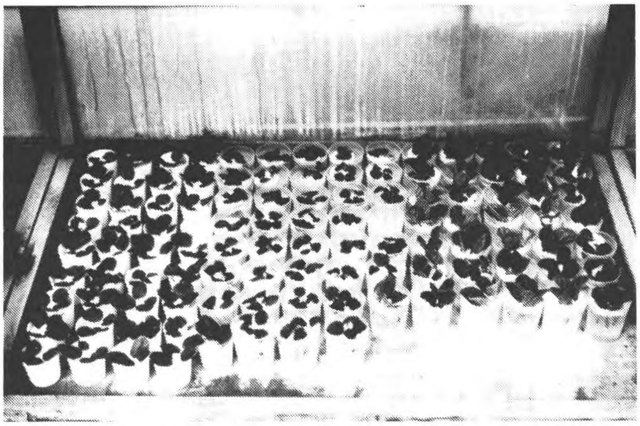

Plate 1: Cuttings set with petioles inserted through holes in polystyrene discs and floated on the liquid medium.

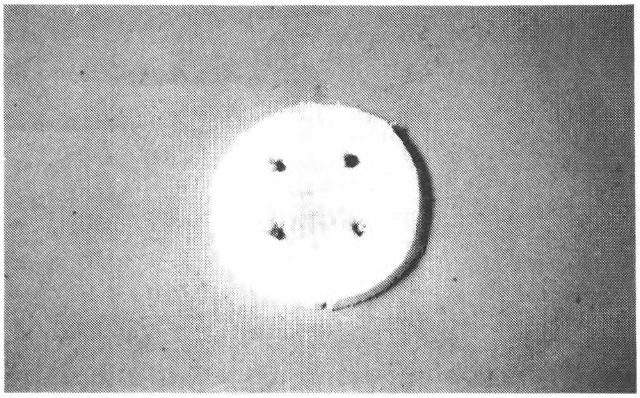

Plate 2: Polystyrene disc.

Saintpaulia ionantha whilst smaller containers holding 150 mls of solution were used for *Streptocarpus holstii;* in this way the group of 4 cuttings in a container was aggregated to represent a single replicate.

Polystyrene discs were cut from 6 mm thick sheets of polystyrene with a diameter of 40 mm. Four holes were punched equidistant to allow the petioles to be passed through.

Environment

Cuttings were grown on a hot bed in a thermostatically controlled fan ventilated glasshouse with a minimum temperature of 15°C. The cuttings were kept moist by means of an automatic mist system controlled by an electronic leaf. High humidity conditions were maintained by means of a polythene tent enclosure. The maximum temperature with cooling fans is 4 to 5°C above the outside ambient. The base temperature of the hotbed was 21°C.

Measurement of Chemicals

Ref. 'Analar Stds' 1977 publ. Analar Stds Ltd G. Britain.

N 0, 50, 100 ppm
P all treatments 25 ppm
K 0, 50, 100 ppm
pH all treatments 6.0

P

Using $NaH_2PO_4\ 2H_20$ (Mol.Wt 156.01) Sodium dihydrogen orthophosphate

Require 25 ppm = 25 mgm/litre Atomic wt P = 30.97

$(\%P = \frac{30.97}{156.01} \times \frac{100}{1} = 19.8513\%P)$

∴ 25 mgm P contained in $\frac{156.01}{30.97} \times \frac{25}{1000} = 0.1259g$

∴ Add 0.1259g $NaH_2PO_4\ 2H_2O$ per litre of water (= 25ppm P)

N

Using NH_4NO_3 (Mol. Wt 80.04)

Atomic weight N = 14 (2 x 14 = 28)

$(\%N = \frac{28}{80.04} \times \frac{100}{1} = 34.9825\%N)$

∴ 50 mgm N contained in $\frac{80.04}{28} \times \frac{50}{1000} = 0.1429g$

∴ for N = 50 ppm add 0.1429g NH_4NO_3 per litre of water

∴ for N = 100 ppm add 0.2858g NH_4NO_3 per litre of water

K

Using K_2SO_4 (Mol. Wt 174.25)

Atomic wt K = 39.098 (2 x 39.098 = 78.196)

$(\%K = \frac{78.196}{174.25} \times \frac{100}{1} = 44.8757\%K)$

∴ 50 mgm K contained in $\frac{174.25}{78.196} \times \frac{50}{1000} = 0.1114g$

∴ for K = 50 ppm add 0.1114g K_2SO_4 per litre of water.

∴ for K = 100 ppm add 0.2228g K_2SO_4 per litre of water.

1. Make up 27 litres add 3.3993 g $NaH_2PO_4\ 2H_2O$

Treatments	N		K	
1	N_0		K_0	———
2	N_0		K_1	add 0.3342g K_2SO_4 / 3 litres
3	N_0		K_2	0.6684g K_2SO_4 / 3 litres
4	N_1	0.4287g NH_4NO_3	K_0	———
5	N_1	0.4287g NH_4NO_3	K_1	0.3342g K_2SO_4 / 3 litres
6	N_1	0.4287g NH_4NO_3	K_2	0.6684g K_2SO_4 / 3 litres
7	N_2	0.8574g NH_4NO_3	K_0	———
8	N_2	0.8574g NH_4NO_3	K_1	0.3342g K_2SO_4 / 3 litres
9	N_2	0.8574g NH_4NO_3	K_2	0.6684g K_2SO_4 / 3 litres

Dates

Cuttings were set on November 2nd. The first assessment of root numbers that had emerged was made on November 16th and again on November 22nd when a visual rating score system was used to assess root quality.

Root measurements were taken on November 30th along with fresh weights, root length and visual grade scores. Adventitious shoots were also counted.

Aeration

Air was blown into containers once per day, using a bicycle pump with a rubber extension.

Root Scores

Cuttings were scored on a visual basis on the quality of root produced; Nov. 16th and Nov. 22nd. 3 = excellent, 2 = average, 1 = poor or no roots.

November 30th 5 = excellent, 4 very good, 3 average, 2 poor, 1 no roots.

All discs containing cuttings were removed from and placed in front of containers so an overall assessment of roots could be made first. Another person with no knowledge of the experiment also graded the root systems and an average of the 2 ratings was taken before analysis of the results.

Root Measurements

Root length data was measured on the 'Comair Root Length Scanner'.

Processing the Results

The results were processed with the aid of Lincoln College computing facilities using the programme 'Genstat'.

Results

STREPTOCARPUS HOLSTII

Potassium failed to have a significant influence either individually or with N in any of the data analysed for this species and therefore only N treatments are shown in Table 1. N had failed to show any significance on shoot growth at the time of harvesting.

Table 1 — Effects of N on root emergence and root growth of *Streptocarpus holstii* cuttings.

	Root Emergence (mean number of cuttings per rep. showing roots)		Visual Root Score		Root Fresh Wt. g per rep.	Root Length (metres)
	14 days	20 days	20 days	28 days	28 days	28 days
N 0	3.75**	3.83**	2.61**	14.00***	1.22***	6.90***
(ppm) 50	3.17	3.33	2.27	12.50	1.06	4.87
100	2.67	2.83	2.08	9.50	0.57	3.12
Linear Significance	***	***	***	—	***	***
LSD (5%)	0.69	0.59	0.33	1.56	0.34	1.78
C.V. (%)	26	21	17	16	43	43

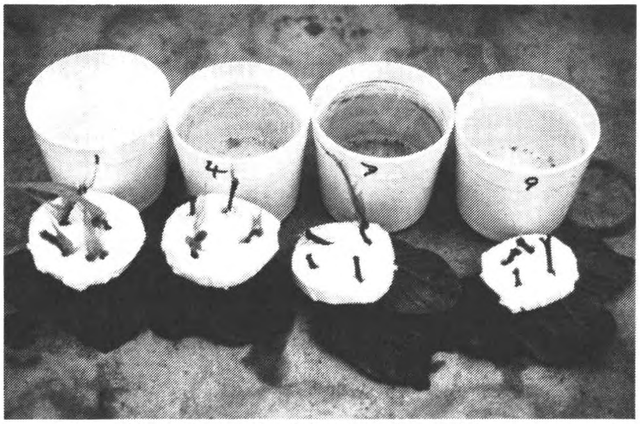

Plate 3: The effect of increasing N levels (left to right) on root growth of *Streptocarpus holstii* was to reduce root growth.

The effect of N on this species on root initiation and growth over a 28 day period was detrimental. Root emergence in this species was apparent in 9 days in nil N treatments. Two weeks from setting the cuttings, over 50% of the cuttings had produced roots over a wide range of treatments.

Effect of N on the root growth of Streptocarpus holstii

Nitrogen clearly had an inhibitory effect on root emergence at both 14 and 20 days. As the level of N was increased the number of cuttings per replicate that produced roots dropped. N at 100 ppm appeared particularly inhibitory.

Visual root grade scores showed strong linear trends with increasingly poor root systems again apparent at the highest rate of N added to the medium. In many ways this could be expected when cuttings with N in the medium had delayed emergence at the start. The large differences between root scores shown on table 1 is due to a change in the rating system but the trend is still the same. (See M & M Root scores section).

Root fresh weights measured after 28 days showed similar results confirming the inhibitory effect N had on root emergence and subsequent root growth. Control (Nil N) had an average fresh weight of more than twice that of N at the high level.

The root length data as measured by the Comair root length scanner confirmed earlier results. High and medium levels of N had an inhibitory effect on root growth at this point in time either through the slower start due to later root emergence or through a slower growth rate. Nil N had a yield in metres of more than twice that of N at the high level (see plate 3).

The CV's for the data from this experiment were generally low and most data showed strong linear trends with N reducing yield.

SAINTPAULIA IONANTHA

Results for both N and K were significant for this species and are included in Table 2.

The effect of N on root emergence at day 14 and on visual root score at day 20 was not statistically significant and in both cases there was no significant difference between treatment means. Potassium had no significant effect on root fresh weight although again K at 50 ppm produced the greatest weight.

The effect of N on root production of Saintpaulia ionantha

The influence of N on root production of *Saintpaulia ionantha* cuttings was less inhibitory than on *Streptocarpus holstii*. Root weight measurements showed no difference between nil N and 50 ppm N although nil N had a significantly heavier fresh weight average. High N was once again shown to be inhibitory.

The visual root score after 28 days mirrors the results given by the fresh weights of the roots and nil N and N at 50 ppm were clearly better than 100 ppm N although the differences were not in the same magnitude as they were for *Streptocarpus holstii*.

Root length again showed nil N to have been the best treatment in yield terms but also showed 50 ppm N to be an inferior treatment with 100 ppm N again having a strong inhibiting effect on root length.

The first roots were observed over a range of treatments in *Saintpaulia ionantha* from 10 days after setting. After 13 days over 50% of all cuttings were seen to have initiated roots.

The effect of N on shoot production

Nitrogen had a strong influence on shoot production with a clear optimum at 50 ppm N, however at 100 ppm N shoot production was inhibited to below that obtained at nil N. This was a highly significant quadratic response.

The effect of K on root emergence and size of Saintpaulia ionantha

Potassium at 50 ppm produced the best results for all data sets. Root emergence after 14 days was enhanced by levels of K at both 50 and 100 ppm.

Visual root grade scores after 20 and 28 days both show no significant difference between 50 and 100 ppm K but a clear advantage over nil K. This again may be due to the value of faster initial emergence as occurred with the N response of *Streptocarpus holstii*.

Root length measurements favour 50 ppm K much more so than 100 ppm K and is clearly much better than cuttings grown at nil K levels.

The effect of K on shoot growth

A rate of 50 ppm K is again seen as the optimum level for shoot production. Shoot numbers at nil K were depressed compared to either treatment with K included in the solution. Shoot number data was more variable (high CV's) than for other observations.

PEPEROMIA CAPERATA

This species took the longest of the three species to produce roots. Roots were not noticed until 15 days after setting the cuttings in the solution. After that root initiation was very quick and very uniform over all the treatments.

Potassium was not statistically significant for the data on root emergence at day 20 nor for the number of shoots at the base of the petiole counted on day 28.

The effect of N on root emergence and production of Peperomia caperata

The results given for the data sets of this species show some variability but overall show high N to be inhibitory (Table 3).

There was no difference in root emergence between nil and 50 ppm N but 100 ppm N was inhibitory. This result was similar to the other two species studied.

Visual root ratings after 20 days showed no significant difference between nil N and 50 ppm N while high N was clearly inhibitory. However after 28 days low N was clearly the best mean root scores while there was no difference between nil N and high N.

Table 2 — Effects of N and K on root and shoot emergence of *Saintpaulia ionantha* leaf cuttings

	Root emergence — day 14 mean no. of cuttings per rep. showing roots	Root fresh weight g per rep. after 28 days	Visual Root Score after 20 days	Visual Root Score after 28 days	Root Length (metres) after 28 days	Shoot no at petiole base after 28 days
N 0	2.92 NS	0.64***	2.73 NS	15.00*	2.04***	4.92***
(ppm) 50	3.33	0.61	2.85	14.75	1.60	8.00
100	3.08	0.44	2.73	13.67	1.00	2.92
Linear Significance	—	***	—	**	***	—
Quadratic Significance	—	—	—	—	—	***
K 0	2.67#	0.51 NS	2.60*	13.58**	1.28*	2.75**
(ppm) 50	3.50	0.63	2.88	15.08	1.81	7.50
100	3.17	0.55	2.83	14.75	1.55	5.58
Linear Significance	—	—	*	*	—	—
Quadratic Significance	—	#	—	*	*	*
Significant Interactions	—	—	—	—	—	—
LSD (5%)	0.69	0.12	0.228	0.91	0.38	2.85
C.V. (%)	27	25	10	8	29	65

Table 3 — Effects of N and K on root and shoot emergence of *Peperomia caperata* leaf cuttings

	Root emergence — day 20 mean no. of cuttings per rep. showing roots	Visual Root Scores after 20 days	Visual Root Scores after 28 days	No. of shoots at petiole base after 28 days
N 0	3.92***	2.65***	14.83**	14.92***
(ppm) 50	3.92	2.58	15.75	16.83
100	2.92	2.13	14.67	12.08
Linear Significance	***	***	—	***
Quadratic Significance	**	—	***	***
K 0	3.42 NS	2.06***	14.08***	14.33 NS
(ppm) 50	3.67	2.71	15.50	14.42
100	3.67	2.58	15.67	15.08
Linear Significance	—	***	***	—
Quadratic Significance	—	***	*	—
Significant Interactions	—	—	NK*	—
LSD (5%)	0.11	0.3	0.68	1.31
C.V. (%)	16	15	5	11

Effects of N on shoot number

The highest shoot number was found with cuttings growing in solutions containing 50 ppm N. High N, as with *Saintpaulia ionantha*, was again inhibitory and nil N was better than high N. The same effects of N on shoot growth of *Saintpaulia ionantha* were repeated in *Peperomia caperata*.

Effects of K on visual root scores

No significant difference between 50 and 100 ppm K was noted in the results but both were clearly better than nil K which, as with *Saintpaulia ionantha*, was seen to inhibit root production. There was low variability in this experiment with all C.V.s below 17%. Significant linear and quadratic trends were noted.

Interactions between N and K

The highest root score (Table 4) occurred at 100 ppm K and 50 ppm N while poor results occurred with nil K and either nil N or 100 ppm N.

Table 4 — Interaction of N and P on the visual root score grade of *Peperomia caperata* leaf cuttings.

		Potassium (K) 0 ppm	50 ppm	100 ppm
	0 ppm	13.25	16.00	15.25
Nitrogen	50 ppm	15.75	15.00	16.50
(N)	100 ppm	13.25	15.50	15.25

L.S.D. .05 = 1.18

General Discussion

The general nitrogen response indicated that nitrogen was inhibitory to root production but that at low levels, in some instances, it did favour shoot production. This seemed to be greater the more time allowed from setting the cuttings to harvesting. Consequently if the cuttings were allowed twice the amount of time, this factor may have emerged more clearly in the results.

High levels of nitrogen for all species clearly inhibited root production. Consequently with early harvesting of the cuttings (without root emergence) shoot production was delayed or inhibited in the time allowed for these experiments.

Another experiment to look at the effect of high levels of nitrogen over a longer period of time allowing root development to occur may show a far greater number of shoots produced per cutting than low nitrogen.

In an earlier trial the growth of *Peperomia obtusifolia* was left in the media for a period of 243 days and appeared to overcome earlier inhibitory effects of high levels of N by producing thicker and longer shoots. At high N levels both adventitious roots and shoots emerged from the petiole just below the lamina and above the level of the medium as well as from below. There was also prolific branching of the roots with high N levels. This did not occur at low N levels or control.

Doak (1940) found the addition of several N compounds, both organic and inorganic had a beneficial effect on root response of rhododendron cuttings. Good and Tukey (1967) found N was required during root elongation for chrysanthemums but not for root initiation. Van Overbeek *et al.* (1946) found that leafless hibiscus cuttings, when treated with ammonia sulphate in combination with sucrose, were stimulated markedly in initiating roots providing they were also treated with auxin.

In this experiment all species responded poorly to high N levels, however the incorporation of K at low and high levels did appear to improve the cuttings' tolerance to N.

Harris and Hart (1964) working with leaf squares of *Peperomia sandersii* found that there was no promotion of either rooting or budding as a result of supplying leaf squares with inorganic nutrient solution instead of water. They found this did not hold however if the stock plants from which the leaves were taken were grown in a nutrient deficient medium.

Deen (1973) observed that over a wide range of material tested that the incorporation of Osmocote in the cutting medium benefited many species by increasing side shoot growth. Wott and Tukey (1967) found nutrient mist increased the number of lateral shoots over a range of species after transplanting. McGuire and Bunce (1970) using slow release fertilizers in the medium also found species were producing more side shoots than cuttings growing in untreated mediums.

Algae

Algae was noted in liquid mediums containing 50 ppm and 100 ppm N on the thirteenth day after setting the cuttings. Algal levels increased in these solutions until the time of harvesting and could easily be distinguished from those with no N. Although the algae was present it had no apparent deleterious effects on the cuttings apart from the green slime covering those parts of the cutting in the water. Because the trials were of a short duration, (only 28 days) this did not cause any great problems. However if the species were slow to produce roots then N in the liquid medium may become a problem. McGuire and Bunce (1970) using a solid medium found no problem with algal growth when Osmocote was incorporated into the cutting medium in a trial on *Peperomia obtusifolia*. They found this overcame algae problems that had occurred when using nutrient mist. Wott and Tukey (1967) used frequent applications of algacides, especially during the short days of winter to control algae when using nutrient mist. Sorenson and Coorts (1968) cite the main green algae as *Stichococcus* spp. or *Chlamydomonas* spp., whilst blue green algae are often *Oscillatoria* spp., *Phormidium* spp. or *Arthrospira* spp.

Potassium

The effect of potassium generally was to enhance root weight and length of roots produced as well as the visual root grade scores particularly at 50 ppm K. This also occurred at the high rate of 100 ppm K where the actual weights, visual root scores and length were often better than 0 ppm K. Similar results were obtained with the production of shoots. It is possible that the response to K during this experiment is a response to K lost through leaching under mist during propagation. Sharpe (1955) found K to be the element most easily leached, although this did vary depending upon the species concerned.

Peaches for instance lost more K than the leaves of grapes or blueberries. Good and Tukey (1967) found softwood and herbaceous cuttings such as chrysanthemums do not lose appreciable amounts of mineral nutrients under mist as the nutrients in the cuttings are more easily translocated to the young actively growing regions. Tisdale and Nelson (1975) state that K is a highly mobile element within the plant, while Wott and Tukey (1967) found *Pachysandra terminalis* had three times the amount of K by growing under nutrient mist than water mist.

Further trials could be carried out with the cuttings on base heat but without any form of misting to determine if leaching has a significant effect on the loss of K from the cutting, and this may determine if the addition of K to the media is worthwhile.

Root and Shoot Emergence

Streptocarpus holstii was the fastest of the four species used in this study to produce roots. It was also the fastest to produce shoots although they were isolated and not as a result of any treatment effect. A number of variables may be responsible for this effect but the most likely, as suggested by Marston (1958), is the effect leaf age has on the number and production of shoots. Harris and Hart (1964), also found leaf age affected the time from root initiation to production of shoots of *Peperomia sandersii* with young leaves which were not fully expanded taking longer to produce shoots after forming roots than fully expanded leaves. Other variables could however include temperature, leaf size and the point on the plant from where the petiole was detached. (Plate 4).

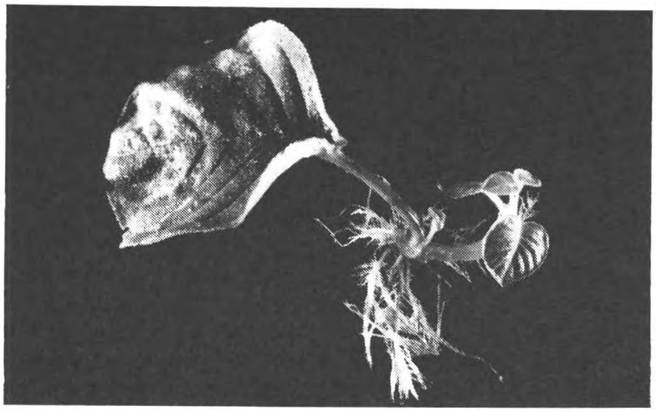

Plate 4: The emergence of shoots from a leaf cutting of *Streptocarpus holstii*.

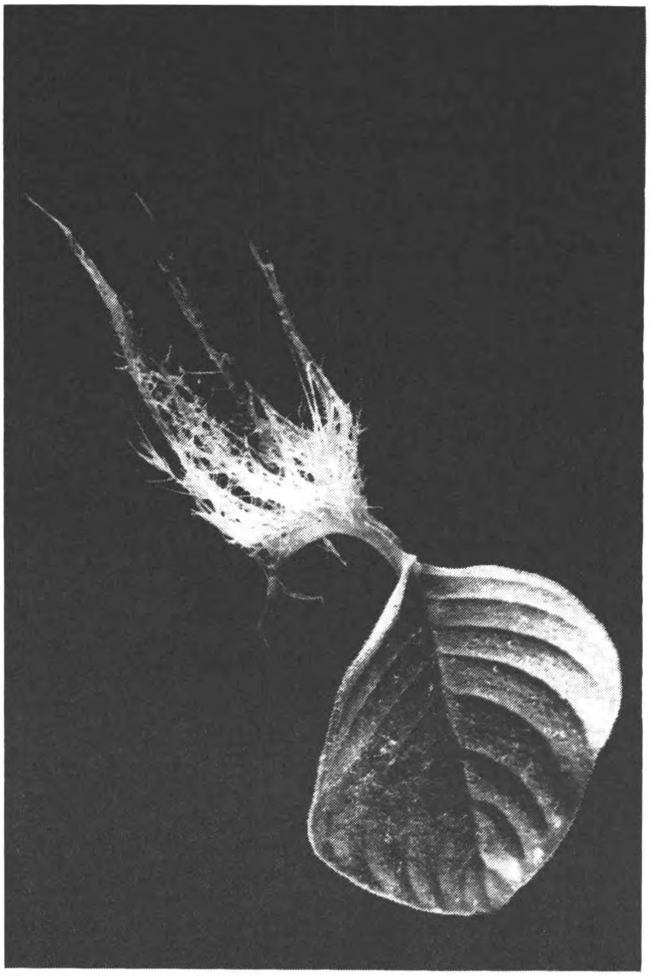

Plate 5: Roots emerging from the upper side of the petiole of *Streptocarpus holstii.*

Root emergence occurred on the upper side of the petiole in almost all cases on *Streptocarpus holstii* (Plate 5), although high N treatments appeared to cause a slightly discoloured callus like lump at the base of the petiole where few roots emerged. The root systems of *Peperomia caperata* and *Saintpaulia ionantha* emerged directly from the base of the cutting. *Peperomia caperata* appeared to produce three or four thick main roots at an oblique angle of about 40° from the petiole and these then proceeded to branch and go down into the medium. *Saintpaulia ionantha* produced roots which appeared to grow vertically downward from the petiole and were much finer and greater in number than those of *Streptocarpus holstii.* Naylor and Johnson (1937) state root tips of *Saintpaulia ionantha* follow the line of least resistance in their outward growth, sometimes giving the false appearance of originating from the callus developed at the cut surface. Marston (1958) states complete regeneration has taken place when the developing shoot has formed its own root system.

Shoots on *Peperomia caperata* appeared within just a few days of root initiation as was the case for *Saintpaulia ionantha.* Naylor and Johnson (1937) reported shoots form on *Saintpaulia ionantha* several weeks after roots form. Harris and Hart (1964), found shoot initiation of *Peperomia sandersii* was 7-10 days after root formation except if the leaf was young, shoot production was then delayed. The shoots of *Peperomia caperata* were seen to originate from the very base of the petiole inside the perimeter of the petiole from where the roots had emerged. (Plate 6). The shoots of *Saintpaulia ionantha* were seen at the outer periphery of the petiole base while the roots emerged directly from the cutting base (Plate 7). Naylor and Johnson (1937), agreed with this,

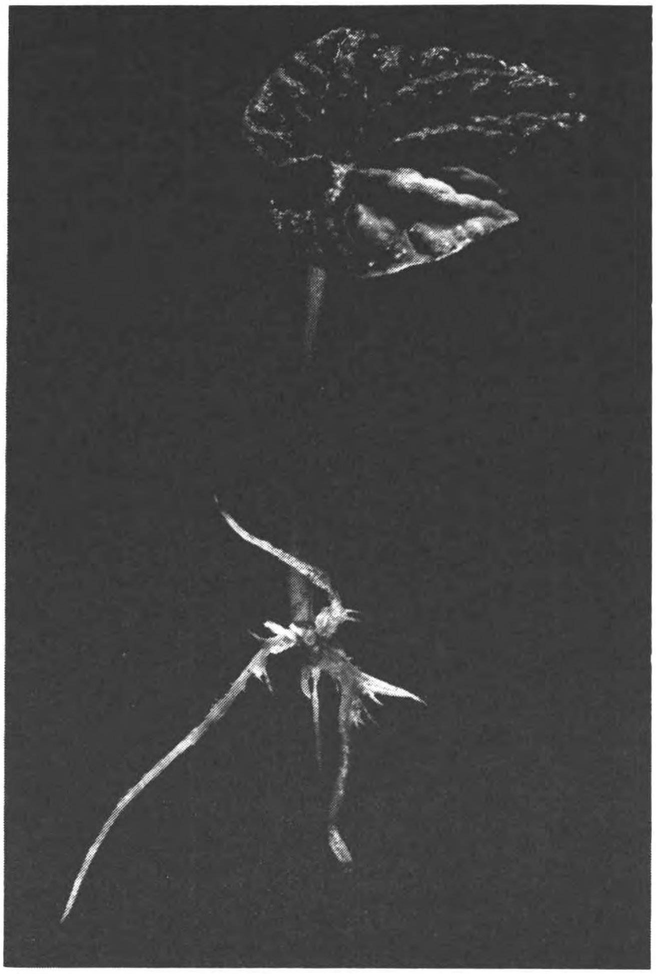

Plate 6: Shoot emergence occurring directly from the petiole base with *Peperomia caperata.*

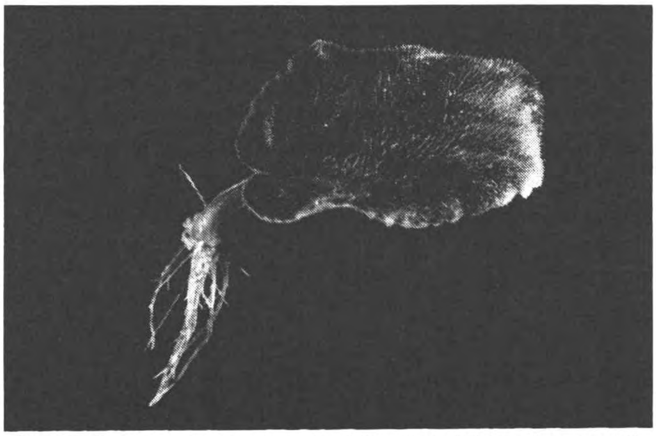

Plate 7: Shoot emergence occurring from around the periphery of the petiole base with *Saintpaulia ionantha.*

stating shoots grew out at any place along the circumference of the petiole within one or two millimetres of the cut end. The new shoots originate in epidermal cells. Meristematic activity may start in any epidermal cells near the wounded surface but generally cells on the upper side of the petiole show activity first. This was also evident on the cuttings grown at Lincoln. Varying numbers of shoots were clearly evident at the bases of cuttings in this study. Naylor and Johnson (1937), found vegetative reproduction in *Saintpaulia ionantha* exhibits a striking similarity to that of *Begonia rex.* In this plant shoots arise from epidermal cells and roots originate from parenchymatous cells in the neighbourhood of the xylem/phloem boundaries of the vascular bundle.

Aeration of the Medium

Cuttings grown in solution require oxygen for root growth. Hartman and Kester (1983) cite willow cuttings being able to produce roots with as little as 1 ppm oxygen content in the medium while English ivies require a minimum of 10 ppm. Carnations and chrysanthemums produced better root systems with increasing amounts of oxygen from 0 to 21%.

Saintpaulia ionantha demonstrated how very strongly survival oriented a single leaf can be in this trial (Plate 7). In one replicate a leaf brought its root system to the top of the liquid medium where oxygen would be more freely available by reorientating the base of the petiole.

Petiole rot in Peperomia caperata

Problems with *Peperomia caperata* were experienced in the experiment. For no apparent reason the petiole of isolated leaf cuttings from a replicate would rot off near the base of the lamina.

Efforts were made to diagnose the cause of the problem by the M.A.F. diagnostic station in Lincoln College but were unable to isolate any pathogenic fungi. Possible explanations for the problem may be related to leaf age or other cultural factors. In *Phaseolus vulgaris* there is a distinct senescence zone at the base of the lamina called the pulvinus which enlarges due to enhanced synthesis of RNA and protein along with other changes which eventually lead to separation (Osborne, 1973). A similar situation may exist with *Peperomia caperata.*

Practical Implications

The practical implications of this project are firstly that advantages are possible by using nutrients in the cutting medium, however this requires a precise knowledge of the species. It is also important to consider the application of nutrients to the medium, nutrient mist causes problems with algae growth blocking misting nozzles and growing over the foliage of cuttings. Osmocote incorporated into the medium apparently does not cause algae problems of the same magnitude.

As well as a knowledge of the species' response to nutrients it is essential that the propagator is also aware of other variables that affect the response of the cutting. Variables such as the effect of daylength, temperature and the response of cuttings to growth regulators.

This study also highlighted the need to explore various techniques of propagation and look at not only the chemical properties of the rooting medium but also at the physical properties. Liquid mediums providing support can be arranged for the cutting to stay upright and given sufficient aeration to supply oxygen to the emerging roots appear to have many advantages. These advantages include: observations of when root initiation and shoot initiation occur is a simple matter of lifting the cuttings from the medium and visually checking them, there are no problems in washing media from the roots of cuttings and running the risk of losing bits of the root system or incorporating other foreign material into fresh or dry weights, and finally a major advantage would appear to be in the time cuttings take to respond. Faster root growth by roots not impeded by solid physical barriers leads to faster shoot growth as well. Disadvantages were principally in the extra equipment and time needed to set up the system.

By using techniques such as liquid solutions more detailed observations on root emergence may lead to better information relating to critical timing of N applications to enhance root length after root initiation. Nutrient uptake by cuttings is a complicated field of study and one which clearly is worthy of more research.

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Trends in the Nursery Industry

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The major trend is the widening gap between the thoroughly professional modern nurseries, and those which are least successful.

The most successful nurseries are well managed. They are in constant communication with their customers and potential buyers. They assess the market accurately, and have the skill and facilities to provide healthy well-grown plants of standard size and quality, in the required varieties, when and where they are wanted. They are also alert to developments in the various sections of horticulture, in New Zealand and overseas, which might provide opportunities for sale of planting material. They keep in touch with advances in plant propagation and production techniques, and make use of appropriate research. They have keen, competent staff.

They have display areas of native plants, to attract buyers and to provide propagation material.

The basic costs of establishing and running a nursery are such that plants which are produced but not sold; sold at or below the true cost of production; or "sold" but not paid for, represent a negative cash flow which can eventually lead to failure.

Sound business and financial management is as important as the technical skills in propagation, plant production and marketing.

There has been a revolution in the offices of some nurseries. Computers have simplified the keeping of records, planning, stock-control, invoicing etc. They have also imposed a discipline, requiring a close scrutiny of every aspect of nursery production. Those who kept accurate records in the past are most able to program their computers for the future. They use them to advantage.

The status of the industry in New Zealand has improved dramatically with the realisation that export earnings though small at present, are increasing by 50% or more per year, and that there are good prospects of continuing development.

Confidence in the future of the export nursery and cut flower industries is reflected in the increase in investment of funds by both the public and private sector; and by the increase in research on ornamentals. Both are needed.

Research at DSIR, MAF, Universities, Nursery Research Centre (N.R.C.), and on the nurseries themselves is helping to solve urgent problems.

Research is being conducted in management and pest and disease control; plant nutrition; container mixes; propagation; micro-propagation (tissue culture); environmental control; flower initiation and dwarfing techniques for pot plants.

The development of tissue culture techniques, originally for orchids, and now for an increasing range of plants, has been dramatic in New Zealand. There are several laboratories offering micro-propagation services.

Great strides are being made in propagating woody plants by this technique. New Zealand was the first country to produce *Telopea* in this way.

The major advantage of tissue culture is that one plant can be multiplied rapidly to very large numbers, in comparison with traditional methods of propagation. Because thousands are replicated, the selection of the mother plant is of utmost importance. It must be as near perfect as possible, of its type and for its ultimate use, be it cutflower production, pot plant or bedding plant. The criteria for selection needs far more consideration than some growers are prepared to give. Inferior types must be discarded and replaced by the best available. The main problem of producing plants from tissue culture is the transfer of plants from the sterile conditions of the test tube or flask to the normal environment. Heavy plant losses can occur at times during this stage.

High health daphnes and nandina have been produced as a combined research project of DSIR and NRC. Propagation of the mother plants is monitored and controlled. High health daphnes and nandina are available at garden centres in New Zealand and are in very strong demand for export.

Nurseries are selecting, propagating and promoting (in New Zealand and overseas) many more of the ornamental plants which have been bred in New Zealand. Lilies, zantedeschia, nerines are in strong demand. New Zealand plant breeders are at last receiving the recognition they deserve. They have produced internationally acclaimed varieties of many other plants, including dahlias, narcissi, camellia, phormium, cymbidium, protea, leucadendron and roses. A few nursery men are themselves plant breeders.

The demand for planting material by the various sections of the rapidly developing horticultural industry in New Zealand is great and delays are occurring in some areas. Selections are being made from both imported and locally bred varieties. Subtropical fruit and cutflowers predominate at present, though many of these are propagated on the fruit or flower-growing properties rather than on traditional nurseries.

The increasing cost of transport of plants in New Zealand has resulted in a different pattern of distribution, which in turn affects the supply and demand for plants in each centre. It can make the production of specific plants in one locality more profitable when former suppliers are no longer competing there.

Mail order costs are so high that some nurseries have discounted this service.

However, the number of *specialist* nurseries, throughout the country have developed their mail order business, after carefully designing and costing cartons, delivery costs, catalogues and other promotional items.

Greenhouse design continues to improve, but few nurseries have the environmentally controlled structures which are standard for commercial growers in harsher climates. Making do with less sophisticated greenhouses and equipment places a greater strain on the grower, who has to be ever vigilant to protect his plants from the effects of constantly changing patterns of temperature, light and humidity.

It is extremely hard to produce large quantities of plants to specification of size, quality and delivery date, if the growing conditions are not controlled.

Plant propagators are innovative, and keen always to learn methods of increasing the percentage and speed of rooting. The use of fogging units maintains humidity without the use of excess water, and is a distinct advance on older misting units.

The ideal container mix for propagation and growing on, is still not perfected and experiments continue.

Garden centres in Auckland reflect the general trends in the nursery industry.

There are fewer ornamental and fruit trees, especially of those which are budded or grafted. Prices have escalated. Demand has dropped. Is it not time to offer small young trees alongside a few larger more mature specimens?

There are more annuals and perennials sold in flower in containers. The demand is for instant colour, especially in small gardens. Displays of annuals and herbaceous perennials at the Auckland Regional Botanic Gardens has stimulated interest and demand.

Small neat shrubs, in flower or with colourful foliage are preferred.

The 'bargain bin' presents a clear picture of expensive failures in production, ordering, garden centre care and/or promotion. One can learn a lot from it. Plants are left unsold for many reasons: There are well-grown plants ordered in excess of demand. Common, easily produced plants which were in strong demand ten years ago, but not now. A few choice plants, unfamiliar to the general public, and not promoted. Plants which sold well in flower, but not afterwards. Plants with unreadable labels, or with no labels. Plants which have deteriorated due to overcrowding lack of water in the garden centre. Plants which were badly grown on the nursery, stunted or drawn, mis-shapen, or diseased.

The nursery industry produces plants which directly or indirectly earn overseas funds. Plants are exported. Fruit, flowers and vegetables are exported. Plants in the gardens and parks of New Zealand are part of the attraction of this country. They leave a lovely and lasting impression on our overseas visitors.

The Hamilton Gardens Concept

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Hamilton Gardens are still almost unknown outside the Waikato Region but that situation will change over the coming years. As development of an unusual concept and an outstanding site proceeds. The Gardens (a 58 hectare park) are being developed by the Hamilton City Council with support from the Waikato Technical Institute, local firms and various community groups.

THE SITE

The site itself is magnificent.

Most Hamiltonians remember the area a few years ago as an undeveloped wilderness in the centre of which was the city tip. In those days you found yourself in an isolated world of litter, mud, blackberry, seagulls and unpleasant smells.

Fortunately the Councillors and Senior Parks staff at that time had the vision to see the area's potential.

The Park stretches along the river, providing both outstanding views and the opportunity for a centre for scenic boat trips. The ground form creates a range of micro-climates which, together with Hamilton's mild climate, should accommodate a wide variety of plant material.

Being located next to the main southern entrance into the city, the Gardens should also make an ideal tourist stop.

The proposed centre of the site is surrounded by high banks that once enclosed all that rubbish, mud and blackberry. Now cleared and grassed, the site can be seen at a transitory stage before those same high banks enclose lush green gardens set along the scenic riverbank and around Turtle Lake. The surrounding banks already block out most of the views and distracting noise of the surrounding city.

THE CONCEPT

Recent Park Development Plans in Hamilton appear to turn standard answers back to front. For example in the proposals for Hilldale Zoo redevelopment the humans will be the ones in cages. At Hamilton Gardens too, the usual objectives for a Botanical Garden have been turned upside down, so that aspects such as taxonomic plant collections are very secondary functions.

Apart from the fact that the Auckland Regional Authority Botanic Gardens are just over an hours drive away there was a desire to get away from the concept of a 'Museum of Living Plants' and to aim for a wider range of interests as possible. The Gardens still have a horticultural theme but the concept attempts to go a lot further than the usual series of plant collections, amoeba shaped flower beds and shrub borders.

The Park is already dissected by steep banks, existing land uses and areas of rubbish fill. In the end, a concept evolved which capitalised on these barriers by dividing the proposed concept into a series of sectors. Each sector has a particular theme which in turn is related to the overall horticultural theme for the Park. Examples of these themes are: Food production in the home garden, the display of ecological principles, plant propagation and horticultural shows. Some sector themes are more conventional such as Roses, Meadow Gardens and Water Gardens.

Other sectors lie within a central secure area that can be locked up at night and hence there can be attractions that could not normally be displayed in a public park.

There is not space in this article to explain all of the sector themes, even the ones with intriguing names such as 'The Governors Garden', 'The Mother Earth Sector' and 'The Green Egg Garden'.

However two very important elements of the Gardens currently being concentrated on are worth expanding on. These are the Horticultural Education Centre and the extensive community involvement in the project.

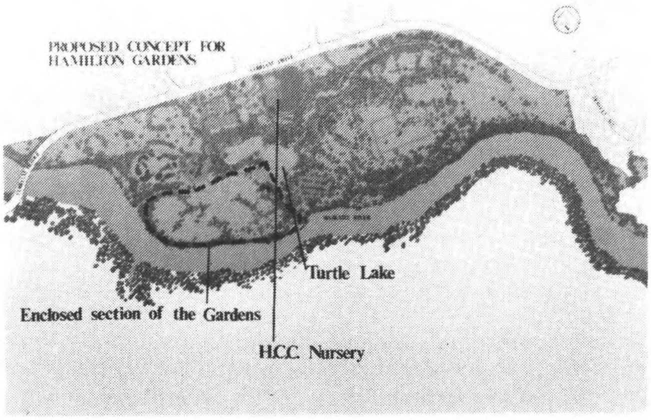
THE HORTICULTURAL EDUCATION CENTRE

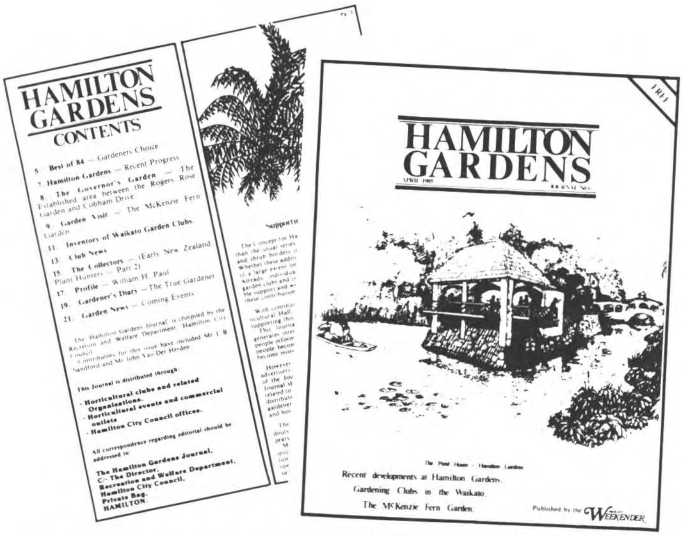
Last March, the Education Department achieved a remarkable feat when they opened a Horticultural Education Centre at the Gardens within one year of a decision to proceed being made.

This centre is actually the Horticultural Section of the Waikato Technical Institute which has expanded in recent years to cater for the rapidly growing Horticultural Industry in the Waikato. The head of the Centre is Mr Ian Gear, who is an Executive Member of the R.N.Z.I.H. and local N.D.H. Students have already benefited from the facilities.

The big advantage over the section's old town site is that the many practical components of the various courses can be demonstrated on site. Propagation and nursery management can be demonstrated in the existing Council Nursery at the Gardens, and

Hamilton Gardens looking east down Cobham Drive. The existing Hamilton City Council Nursery and Turtle Lake can be seen in the centre of the picture. The netballers have recently been relocated on another park.





The Hamilton Gardens Journal keeps the public up to date with work in the gardens.

the Gardens themselves provide a facility for subjects ranging from plant identification to plant husbandry. Current developments will provide for orchard, berry fruit and vegetable demonstration displays as well as specialist collections and further aspects of amenity horticulture.

These specialist displays were all proposed for home gardeners and school children anyway but the development of the W.T.I. school has accelerated the programming, made certain elements more viable and added another dimension to the Garden's concept.

COMMUNITY INVOLVEMENT

Right from the start, we wished to get away from the old concept of Municipal Gardens just being a collection of beds, with no heart, where visitor involvement was just passive and where once the park was developed there was little happening and little element of change apart from seasonal change. Up until now, that vigour has been provided by development projects but various other programmes are now being phased in.

For example a 'Hamilton Gardens Journal' has been produced bi-annually for the past three years which keeps amateur horticulturalists in the region in touch with what is happening. The Journal is funded through advertising and distributed free of charge.

Since June 1984 practical demonstrations have been held at the Gardens every month which are open to the general public. Usually two or three subjects are demonstrated each month covering a wide range of subjects related to the home gardener. The demonstrations are given by local experts and organised by the Hamilton City Council, the Royal NZ Institute of Horticulture and the Waikato Technical Institute. Most have been well attended even in the most atrocious weather conditions. At some point we hope to make such demonstrations more frequent, perhaps every two weeks.

Local firms and Garden Clubs have also been very involved in the Garden's development itself. Structures such as gazebos, pergolas, a river jetty and an information kiosk, have been funded through this source and specialist garden clubs have become involved in the development of specialist Gardens within the Park. For example; the Rose Society, the Camellia Society, the Cactus Society, the Herb Society and the Soil Association.

Gardening appears to be a particularly popular pastime in the Hamilton Region and the area is well served by about three dozen Garden Clubs. Many of these clubs have now got together to form a Building Trust for Hamilton Gardens. The proposed building complex will accommodate horticultural club meetings, lectures and indoor demonstrations, specialist Horticultural Library, an information centre, facilities for Horticultural shows, perhaps even national shows, facilities for trade displays and selected compatible hobbies groups such as 'Spinners and Weavers.'

Fundraising for a target of about $1/2 million is proposed for 1986.

Up until three years ago, development at Hamilton Gardens had concentrated in and around the Rose Gardens and the Display Houses. Since the Hamilton City Council approved the new comprehensive Development Concept for the Gardens in 1983, substantial progress has been made. If this continues and if supporters of Hamilton Gardens achieve most of their aspirations, the Waikato region will have a unique centre for both professional horticulture, and the Home Gardener.

Trees and the Urban Landscape: A Landscape Architect's Viewpoint

A paper presented at a one day seminar, "Trees As An Urban Resource", Department of Extension Studies, University of Canterbury, New Zealand, 29th April 1985, by M. A. P. Robinson, Lecturer in Landscape Architecture, Lincoln College.

A primary concern of landscape architects is the image of place, created as people move through landscapes, large or small, rural or urban.

Landscapes are composed of a physical framework moulded by people's use of the land. Most landscapes are to some extent moulded by people's actions and the most satisfactory relationships, both in a visual and functional way, appear when there is a sympathetic and harmonious merging of natural and cultural patterns and processes. The complementary scale and spatial qualities of the landscape are important in reinforcing the character people experience in these landscapes.

The intensity of cultural influence is most immediately expressed in urban landscapes. Urban cities and towns are frequently those where the relationship between the underlying natural landscape and the cultural development is as equally appropriate and sympathetic as in valued rural landscapes. Whilst this may result in a strongly cultural and artificial landscape suited to the requirements of city living, these towns' layout and focus relate to the principal landscape features, and the qualities of the natural setting are reflected. This relationship with the patterns and qualities of the underlying landscape ties the city to the land even though "nature" as an item may not necessarily be dominant. Less successful cities ignore the patterns of the landscape and are superimposed on the land. "Nature" as an item may then be introduced, but it does so often as a superficial ornament, like a pot plant in a tower block.

We experience cities by movement through the spaces, or voids, created by buildings or other forms such as massed planting. These spaces are central to our image of a city, and not only enable us to view the natural and cultural elements of a city, but have a quality of their own which can enhance our experience. Whilst these spaces may be designated as highway, shopping mall or town square they are intimately interrelated as we experience them as a continuous sequence. They cannot be seen as separate to the development of the built form either, which is the major creator of the open space network.

A resource is a means of supplying a want, according to the Concise Oxford Dictionary. Why do landscape architects want trees as an urban resource? Trees are important in strengthening the patterns of the underlying landscape and in enhancing the relationship of the cultural landscape to its setting. They can do this by reinforcing the spatial qualities of a river, for example, defining the linear space. In a similar way they can integrate this important landscape feature to other linear corridors by reinforcing the open space designated for movement, both vehicular and pedestrian. In areas specifically designated as 'open space', whether a town square or a reserve, they can be used as a mass or form to create spaces of quality. In this way trees not only assist in reinforcing the setting of a city in its landscape, but create spaces which enhance the quality of experience of visitors to, or inhabitants of, a city.

In some circumstances, trees are totally inappropriate as is clearly indicated in some rural landscapes. They would not strengthen but weaken character, and would dilute the quality of space by confusion. This principle is equally important in some urban spaces. However, enclosure becomes particularly important in many urban areas not only because space is at a premium but because of human comfort. In many circumstances spatial enclosure of quality is obtained by the built form alone and trees would be an intrusion. But where this is not the case, for whatever reason, trees become specifically relevant as an alternative form to create coherent spatial qualities. Trees can have architectural proportions and determine a vertical scale, except where taller buildings or landform dominate, where they can complement this. They can relate buildings to one another, and to the land's contours. They can provide a 'roof' to space by overhanging canopies.

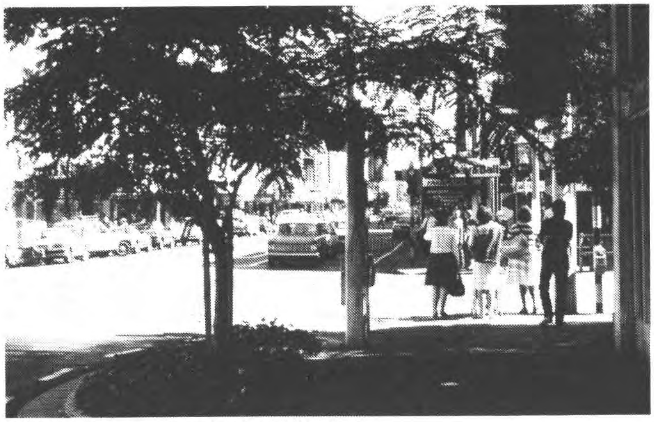
Functionally, trees in artificial ecosystems help purify the air, provide shelter from cold winds and dust, smoke and noise. They provide shade from glare and heat. They have ecological benefits for birds and insects. They could be directly productive for humans. The case for the tree is strong. Yet for many of these functional benefits trees must be grouped and not planted as specimens, as they are naturally adapted to forest environments. Urban settings create stress for trees which increases with the age of planting, so initial massed planting of very young stock to be thinned as it grows, is frequently the most successful way of rapidly establishing healthy specimens. Stress is also induced by the alteration of a mature tree's immediate environment, such as new roads or buildings, exposing new winds or affecting roots. Too often the fact trees are living is overlooked, and so they are subjected to pressures they cannot recover from. Trees, of course, also take time to mature and cannot provide instant results. For this reason conservation of specific specimens alongside a positive policy of new planting is essential. Christchurch has a legacy of planting from the past but there has not been similar concern for future generations on a broad scale for some time. The city relies heavily on this older framework in its public space, and beyond this, its garden city image is heavily reliant on private planting. Apparently the case against the tree is also strong.

If people are to benefit from trees, both visually and functionally, they must be considered as an integrated framework and given high priority in the planning of the overall physical environment. They cannot be added in later, or slotted in corners. They cannot be seen as an extra. A landscape architect's success when using trees as part of a landscape framework in an overall plan, or as an integral part of a site design, is directly related to attitudes held, not only by the general public, but by the professions who also have an interest in spaces within a city. Whilst landscape architects have their "centre" in the quality of space, and use trees as a tool in enhancing this, too often other professions have apparently conflicting attitudes.

Architects design the form which is paramount in creating space. Their perspective generally radiates out from the built form into the space, and does not always produce a satisfactory relationship with the wider spatial network. Trees are frequently used to complement the building, but are often dotted about in an irrational manner. In other cases opportunities are lost for important new tree planting. An equal partnership which acknowledges the expertise and objectives of both landscape architect and architect is essential in siting buildings and relating trees to them.

The Avon Christchurch Integration of the natural and cultural landscape.

Vancouver, Canada. High quality landscape treatment as an integral part of the city scene.



Christchurch: trees and micro climates.

The planner designs the functional working and organisation of zones, circulation and forms. Whilst their objective is co-ordinating conflicting demands, this is often achieved by segregation. The oddly termed 'public open space' becomes another compartment to be slotted in and too often results in 'left over' space, distinct from all the other public open spaces of a town, primarily the corridors of roads, rail and river. These spaces must be co-ordinated by the inclusion of a landscape plan as a basis for

Vancouver, Canada. High quality landscape treatment as an integral part of the city scene.

multi-disciplinary discussions, and the place of trees in that network given priority.

The road engineer deals with the principal movement spaces, and their objective is to facilitate smooth circulation. This, however, presupposes this is the primary function of those spaces, and all other factors are secondary. This may not always be true, and choices should consciously be taken and multiuse and compromise investigated. Equal importance should be placed on the character and quality of these spaces often created by private trees or needing a large scale input of public planting.

Engineers are responsible for the smooth and efficient operation of the servicing of a city, whether it be drainage or provision of services. Yet to suggest that this must take place at the cost of the image of the city, by canalisation of rivers, or prevention of tree planting, for example, is to have made a sweeping and fundamental decision. It is hard to believe that the consequences of this hierarchy of importance have been fully considered. Once again, if attitudes of true professional respect existed, the design of space in a town could accommodate numerous functional requirements to everyone's benefit.

The Parks Department deals with the designated 'public open space'. Here the equally odd term 'amenity value' becomes important and at last specific value is placed on nature and quality of experience. Yet too often the horticulturist is concerned with specific plants, and their ornamental qualities, distinct from the space itself. If trees are used they become specimens, and the whole lot is frequently fenced in, or cut off from the rest of the city, restricting the full range of outdoor experiences in these places.

Too often the urban landscape is seen as a Toy Town, where one begins with an empty board and things are placed on it. This not only ignores the underlying landscape and the benefits it has to offer a city, but leads to an unco-ordinated and fragmented filling up of space. This results in much unsatisfactory left over space without a quality of its own, although it may have a specific functional use. These areas need to be organised and integrated in a functional way. Trees can successfully be used to create both discrete and complex spaces of value, and an environment more appropriate to human use.

When spaces exist which have a quality of their own, this quality should be strengthened and enhanced by the use of trees, reinforcing the experience of that space. Yet too often trees are misused and the infill mentality continues, cluttering up the area with unrelated objects as if irrationally dropped down by helicopter. When trees are used in this way it is inappropriate and the functional use of the area will emphasise this. Rather than defining space and inducing people to benefit from, for example, a pedestrian mall, people will avoid the obstructions and abuse the trees. When such trees mature the confusion will increase and the problems trees can present multiply, rather than strongly defining and enhancing a concept.

Space in a city is, of course, very important, as it is the medium we all use every day. Trees form an integral and positive part of it when used in a functional and rational way. Yet in the organisation of the management of a city we have no department which coordinates this space. It is parcelled out and becomes a part of the consideration of many departments, but in none of them is it the central concern. How ironic, when it is the co-ordination and integration of spatial experience which dictates much of the image of a place. It is the landscape architect's role to attempt to co-ordinate spatial experience and enhance its quality, frequently with the use of trees. Why is there not a Department of Landscape Architecture in our councils? This omission is graphically seen in the quality of many areas of Christchurch. The lack of such a department is partly to blame for the problems experienced in Victoria Square. Rather than it being viewed as an integral part of a network in the city with a quality of its own, every profession with a say in use of space wants their viewpoint to take pride of place in that decision making process. Who represents the spatial qualities of Victoria Square? (Christchurch). Who represents the relationship of this node on the river to the linear corridor of the river? Who places the character of the space alongside the other large open spaces of the city? It becomes the overlap of many people's concerns and is never brought together as a whole — a scrum without a referee. The landscape architect must be the referee, the one who ultimately balances the many considerations, co-ordinates the many uses and designs a solution which gives dignity to the space. Trees have an important role to play in this specific space because of its lack of architectural definition, the central focus of the river, linking it to that green network throughout the city, and its relationship to the harshness of Cathedral Square. Trees must give this area its spatial quality, its focus on the river, and its character so that it becomes an important node within the overall city. Other uses can certainly be integrated within these primary objectives, and should be used to enhance these qualities, not dilute them.

Victoria Square is a perfect example of the varied attitudes to space and trees by different professions. It is presently subdivided in ground plan by roads. The left over pieces are filled with ornaments, whether unrelated objects or horticultural displays. The buildings are varied and can dilute the quality of the space itself. The river is not visible and is an isolated factor. The trees are scattered through the area, increasing its place-lessness. It is used by people primarily as a bus stop, yet it has such potential. The river is tremendously important and the treatment adjacent the Law Courts enhances this. It has historical association and continuity can be created, not by refusing to relocate individual items, but by understanding the area's varied use as a place over time. It can be an important central node in the city and trees can enrich people's experience and functional use of the land by enhancing its spatial qualities and reinforcing its landscape and cultural features. There is an opportunity to develop all that is urbane about Christchurch's urban centre, but it requires an understanding of spatial quality and a stop to professional parochial thinking.

The Revegetation of Tiritiri Matangi Island: The Creation of an Open Sanctuary

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INTRODUCTION

Three and a half km off the end of the Whangaparaoa Peninsula, in the Hauraki Gulf, lies Tiritiri Matangi, an island of some 220 ha (Fig. 1). Until recently the island was largely ignored both by potential visitors and the reserves system, its only claim to fame being the lighthouse. In late 1979, myself and John Craig of the Zoology Department put forward proposals to the Hauraki Gulf Maritime Park Board (HGMPB), to revegetate the island and to liberate rare and threatened wildlife. There was then a period of wide consultation by the park board with interest groups both community based and from the scientific establishment. Once the principles involved had been agreed, there remained the problem of finance. Perhaps fortuitously the World Wildlife Fund had been looking for an Auckland project and this coincided with a visit in early 1982 by Sir Peter Scott (international chairman of the World Wildlife Fund council). The outcome was that the World Wildlife Fund adopted the project and sought donations to assist during the setting up phase, to supplement the funding available to the park board. In October 1982 the HGMPB published the Tiritiri Matangi Island Working Plan. This plan established a scheme which was to transform both the management of the island and the island itself. In essence the island was to be converted from its highly modified condition, resulting from centuries of human occupation, back to a state approaching a presumed more natural condition. The long term goals being to provide habitat for rare and endangered wildlife and to allow open access so that the public could more easily view them, hence the concept of an 'open sanctuary'.

I. THE ISLAND
HISTORY OF HUMAN ACTIVITY ON THE ISLAND

Tiritiri Matangi was occupied from an early period by the Kawerau tribe, the remains of their settlement being found throughout the island. These include well preserved pa sites, burial grounds, terraces, pits and middens, all of which suggest a long period of stable occupancy. For example there is evidence of settled cultivation, such as the presence of 'Maori onion' *Allium vineale* and soils that give the impression of having been deeply cultivated. However, by the 1830s, Maori occupancy of the island appears to have ended, possibly as a result of Hongi Hika's southward advance. Some members of the Kawerau returned to the island from 1837 to 1856, although during this period (1841) members of another tribe sold the island to the Crown. From the mid-1850s, European settlers started to use the island for grazing. European occupancy 'officially' began in the mid-1860s with the granting of a grazing licence (which eventually covered 202 ha) and the decision to build a lighthouse on the island. The lighthouse began operation in 1865.

It is unclear how much of the island was under grass when European occupancy began, but it was perhaps less than 50%. By 1908, grazing licence records suggest that 'quite one third (outside reserve) is in bush, ti-tree and fern', at least 40 ha had been sown in the years preceding this date. The usual mixtures of pasture grasses were used, e.g. cocksfoot *Dactylis glomerata*, ryegrass *(Lolium perenne)* and Yorkshire fog *(Holcus lanatus)*, although there are also areas of *Paspalum* and species of *Bromus*. These were sown in areas cleared by fire or used to oversow the areas of native Danthonia grasslands. In the following years, the proportion of the island under pasture was gradually increased, until 1940 when 92% was pasture, 2% in bracken and scrub, and 6% in coastal forest. After this period grazing intensity declined and the pastures were gradually invaded by bracken and shrubs.

The number and kinds of livestock on the island varied throughout this period. During last century sheep, pigs, goats and rabbits were all abundant at various times. When the Hobbs family took over the lease in 1901, the island was farmed more systematically. Rabbits and 'wild pigs' were eradicated within a few years, although goats (and cats) were present until the 1960s. At its peak stocking in the first half of this century, there were up to 500 sheep and 50 cattle. In 1971 the grazing lease was not renewed and the bulk of the island was incorporated into the Hauraki Gulf Maritime Park. In 1980, the 206 ha of scenic reserve was designated a scientific reserve. The remaining 16 ha of lighthouse reserve was finally incorporated into the park in 1985.

The present-day appearance of the island reflects its past human usage and occupancy. The predominant features are the abandoned pastures, covering the ridge crests and the patches of

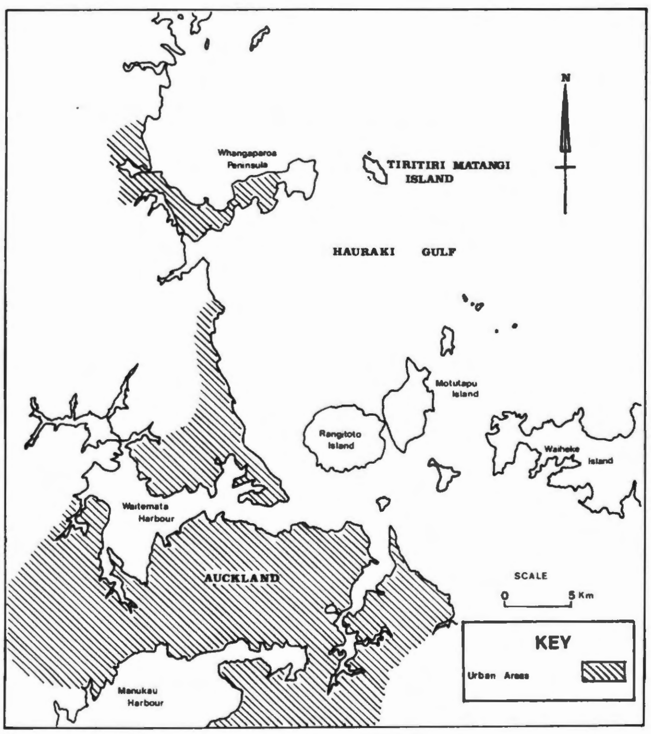

Figure 1. Locality map.

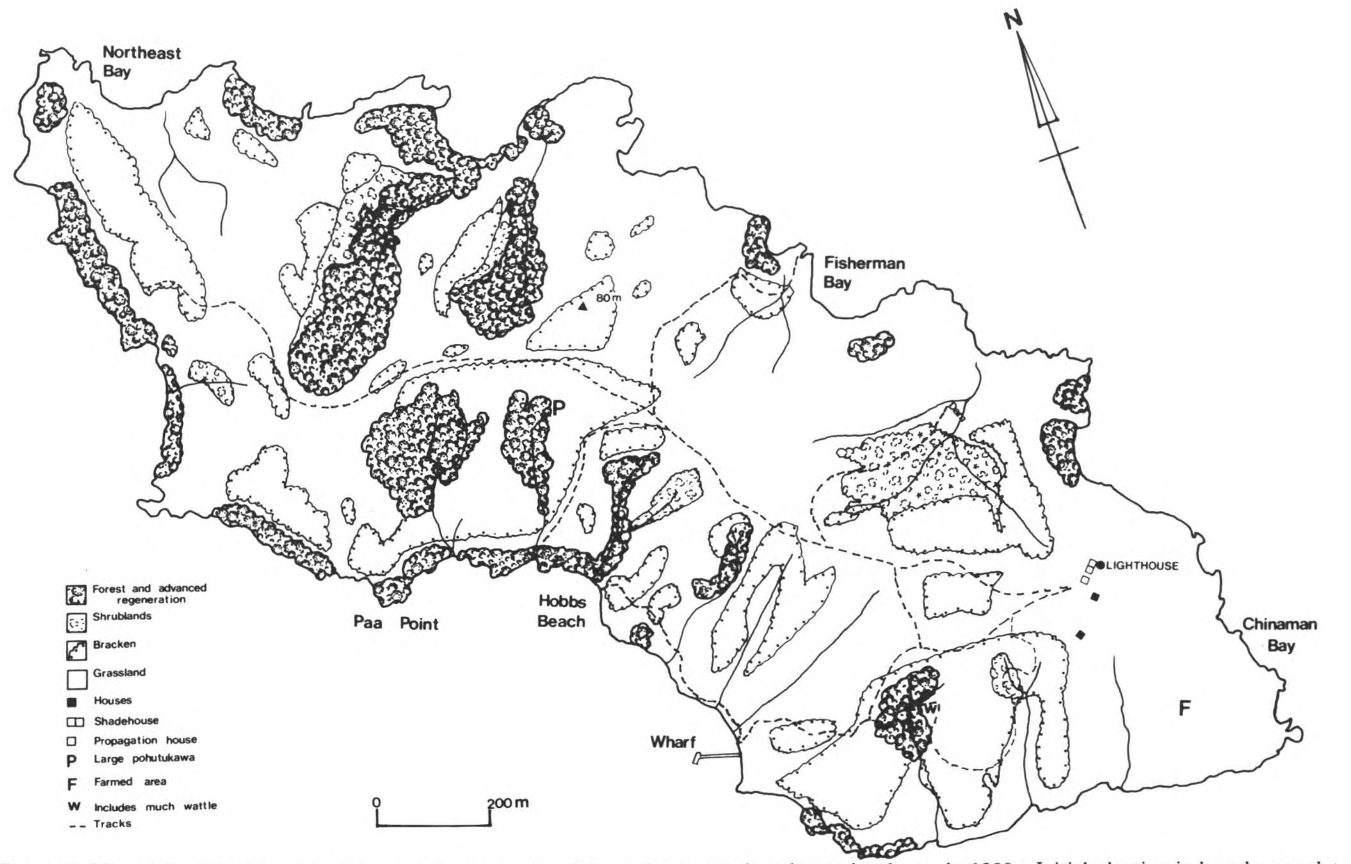

Figure 2. Map of the island to show the approximate extent of the major vegetation classes by the early 1980s. Initial planting is largely complete between Hobbs Beach and the wharf, the lighthouse and Fishermans Bay, together with the intervening areas.

coastal forest in the gullies (varying in size from a few hectares to a few square metres). There is still an actively managed farm associated with the lighthouse.

CLIMATE AND TOPOGRAPHY

The island has a gentle topography with broad ridges sloping away from the main longitudinal ridge (of between 60 and 80m altitude), these ridges mostly end in steep cliffs. The high point of the island (91m) is dominated by the lighthouse. The climate is mild, with temperatures ranging from a mean monthly minimum of 9.2C in July to a mean monthly maximum of 22.6C in February. It has a moderate rainfall of 1,100mm, but as this tends to be concentrated in the autumn and winter periods, summer droughts can be a problem. Consequently, very few of the small streams on the island run all the year. Despite the otherwise moderate climate, the location of the island at the transition between the inner and outer Gulf, means that it experiences the full force of north-easterly cyclonic storms.

The soils of the island are a yellow-brown earth, derived from the upper strata Waitemata series silty-sandstones and siltstones. These soils are free-draining and of high natural fertility, but tend to dry out and crack during summer droughts.

FAUNA AND FLORA

The fauna and flora of Tiritiri Matangi are very interesting despite the long term human occupancy and the drastically reduced areas of native habitat (Fig. 2). Some species have persisted which are now absent from the nearby mainland and in microcosm give an idea of what the neighbouring coastal regions were once like. A detailed description of the flora is provided by Esler (1979).

It is assumed that as with all the other islands in the Hauraki Gulf, Tiritiri Matangi originally would have been almost completely forested. At the cessation of grazing the main areas of forest were restricted to a few valleys and the more inaccessible parts of the cliffs. The forests were completely eaten out by stock grazing and the canopy trees were starting to show signs of senescence. If grazing had continued for many more years it is quite likely that the forests would have been completely destroyed, since there was no regeneration to replace the older trees. Thus the incorporation of the island into the Hauraki Gulf Maritime Park was timely. However, it is only now, 14 years later, that we are observing successful seedling establishment. The combined effects of soil compaction and absence of a litter layer to the soil, prevented almost anything from establishing. The canopy trees responded much more quickly, in particular kohekohe *(Dysoxylum spectabile)*, which produced many epicormic shoots, which are in some instances, starting to replace the old canopy trunks.

The present day forests are fairly typical of the northern offshore islands and Northland coast. On the exposed cliffs and ridge tops, pohutukawa *(Metrosideros excelsa)* predominates, with on the cliffs, occasional tawapou *(Planchonella costata)* and karo *(Pittosporum crassifolium)*. Large pohutukawa often occupy the

Figure 3. One of the forest remnants, showing the huge pohutukawa at the head of the valley; kohekohe and cabbage trees line the valley bottom and lower slopes, with taraire on the upper slopes.

heads of the valleys (the pohutukawa with the largest spread in New Zealand is on the island — 52m), the more sheltered areas having a canopy of kohekohe in the valley bottoms and taraire *(Beilschmiedia tarairi)* on the upper slopes (Fig. 3). Scattered through the canopy are mahoe *(Melicytus ramiflorus)*, whau *(Entelia arborescens)*, cabbage trees *(Cordyline australis)*, pigeon wood *(Hedycarya arborea)*, ponga *(Cyathea dealbata)* and mamaku *(Cyathea medullaris)*. All the larger areas of forest are fringed by manuka *(Leptospermum scoparium)* and/or kanuka *(Kunzea ericoides)*, a number of valleys also having extensive areas under these two shrub species. It is common to find mapou *(Myrsine australis)* growing in these latter communities. A number of other tree species are also found, but just as a few or single individuals, e.g. puriri *(Vitex lucens)*, mangeao *(Litsea calicaris)*, totara *(Podocarpus totara)*, rewarewa *(Knightia excelsa)*, hinau *(Elaeocarpus dentatus)*, turepo *(Paratrophis microphylla)* and broad-leaf tawa (tawaroa, *Beilschmiedia tawaroa*).

The abandoned pastures that make up the bulk of the vegetation cover are rapidly changing. On the moister south facing slopes, bracken *(Pteridium aquilinum)* has rapidly invaded many of the old pastures, but its advance into the drier areas is much slower. In these areas, where the pasture grasses persist, native grasses are becoming prominent, e.g. *Rytidosperma racemosum*, and in particular *Microlena stipoides*. Invasion of these pastures by native shrub species had been almost non-existent (West 1980) and it was this that stimulated the possibility of the revegetation project.

Some of the animals on the island are of considerable interest and have been subject to detailed research by John Craig and his students. Kiore (the Polynesian rat — *Rattus exulans*) are present in large numbers, particularly in the abandoned pastures. Tui *(Prosthemadera novaeseelandiae)* and bellbird *(Anthornis melanura)* both maintain good populations in the forest; the bellbird being particularly notable as they are essentially extinct on the Auckland/Northland mainland. The grasslands and bracken support pukeko *(Porphyrio porphyrio)* and spotless crake *(Porzana tabuensis)*. Red-crowned parakeet *(Cyanoramphus novaeseelandiae)* were released on the island in 1976 and soon became well established throughout all the forested areas. A number of other species regularly visit the island and may breed there, e.g. pigeon *(Hemiphaga novaeseelandiae)*, kaka *(Nestor meridionalis serpentrionalis)*, harrier *(Circus approximans)*, and morepork *(Ninox novaeseelandiae)*. A wide range of marine birds nest on the island or regularly visit it.

The studies on various of these species and their habitats, together with the success of the unplanned red-crowned parakeet release, was the other stimulus for the open sanctuary concept. The complete absence of introduced predators such as the ship rat *(Rattus rattus)*, the Norway rat *(Rattus norvegicus)*, mice, possum *(Trichosorus vulpecula)*, cats or mustelids was the other factor that would make the introduction of rare species possible.

II. THE REVEGETATION PROJECT INTRODUCTION

The basis of the project was that scientific investigation had shown that natural regeneration and invasion of the pastures by forest, was only occurring very slowly. Effective recolonisation of the abandoned pastures would take many decades due to the very dense grass and bracken growth. In the meantime the island presented a major fire risk and that to let nature take its course could pose considerable problems. At the same time there was increasing public pressure on the other special islands of the Gulf such as the Poor Knights, Hen and Chickens, and Little Barrier island. Much of this pressure stemming from the desire of people to see rare species of animal in a natural environment.

Tiritiri Matangi had of course been highly modified, but despite this it still offered habitat that supported native fauna. Thus it was felt that further intervention in the modified areas, could be justified on the basis of trying to re-create suitable habitat for native fauna. These fauna could then be more readily viewed by the public and would to some extent satisfy the desire to see such species.

Thus the project was born. Our original concept was to try and short-cut the natural regeneration processes, by planting the 'climax' forest species directly. Under natural regeneration it was likely that the pastures would either be firstly invaded by bracken or manuka. In the case of bracken, it forms a very dense, tall (2.5 — 3m) canopy and will occupy the site for several decades. Eventually, the bracken loses 'vigour' and shrub species such as mahoe, cabbage tree and *Coprosma* spp. are able to invade. Under such conditions pohutukawa, will come to dominate the site together with its other associates of kohekohe and taraire. In the case of manuka succession, the same shrub species will occur often with mapou, the development to this stage taking perhaps half the time of the bracken sequence. Kanuka may become dominant, but this is fairly rapidly followed by pohutukawa, kohekohe and taraire. We decided that as both major successional pathways progressed towards a pohutukawa dominated forest that this species should be the major species planted. From some of our studies we knew that pohutukawa seedlings are very resistant to dessication and can survive for several months without being watered. The essential point about the programme being that it had to be low cost and low maintenance. Once the plants were planted there was not going to be any releasing or watering.

SPECIES PROPAGATION

As the intention is to 're-create' a forest with a similar species composition to the existing remnants, the other main species to be used are readily available. The basic planting strategy is to use pohutukawa as the main species, particularly on the exposed ridges and slopes, with taraire and kohekohe as the other principal canopy species. The latter would be planted either in the more sheltered locations or inter-planted with the pohutukawa, once some shelter has been created. These two species form the canopy in many places, except that our research has shown their seedlings only establish under shaded conditions. Thus more care has to be taken with the selection of suitable sites at this stage in the project. In some respects consideration has had to be given to delaying the large scale production of these species because of their more precise requirements. A range of other species are also being grown, to encompass the variety of canopy species found, i.e. tawaroa, tawapou, karaka, cabbage tree, karo, rewarewa, kanuka and puriri. These species have a variety of requirements their tolerance of exposure being the overriding factor controlling their placement. Shrub species are of course not forgotten and a wide range of these are being grown. However, the selection of these species is as much determined by bird requirements as more strictly botanical criteria. Included here are *Coprosma* spp, mahoe, five finger *(Pseudopanax arboreus), P. lessonii,* whau, hangehange *(Geniostoma rupestre)*, flax *(Phormium tenax)*, and heketara *(Olearia rani)*. Careful consideration was given to the 'importation' of species absent from the island, but which might have been expected to have been present, if it were not for human activity. In general 'importation' is avoided in order to maintain the genetic purity of the island, each 'introduced' species being considered on its merits and may only come from a nearby source. To date only a few species have been 'introduced' these include kowhai *(Sophora microphylla), Alseuosmia* spp and *Rhabdothamnus solandri*, all of which are considered essential food sources for birds. Additionally, puriri seed has had to be 'imported' because the only tree on the island produces seed of very low viability; puriri being a particularly important nectar source.

THE NURSERY

From the outset it was decided that all propagation is to be carried out on the island to reduce the risk of introducing diseases, minimise transport costs and to grow the plants under conditions that they would be exposed to. The basic facilities required were a propagation house/workshop/office, a glasshouse for seed raising, a shade house, standing out area for hardening off and soil mix bins. All of these having been built on site from materials shipped out.

The shade house is two thirds covered with 30% shade cloth under which the pohutukawa grow (Fig. 4); the remainder is 50% shade for the more sensitive species. The standing out area has three zones of shading 70% for taraire, tawaroa and kohekohe, 30% for pohutukawa and 50% for everything else. This area is provided with moveable shade to aid hardening off, although kohekohe, taraire, tawaroa, tawapou and kawakawa (*Macropiper excelsum*) always require shade.

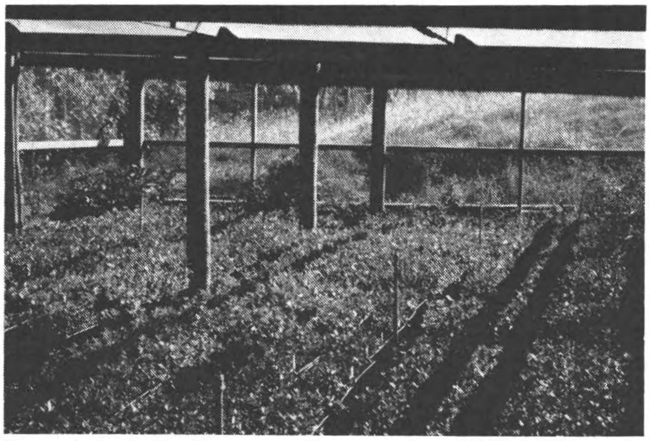

Figure 4. A view inside the shadehouse to show mainly pohutukawa in their root trainers.

The numbers of plants to be produced were based on estimates of how many plants it would be possible to plant, using volunteer labour, the number of likely boat trips during the planting season (bearing in mind likely cancellations due to bad weather) and the numbers of passengers the hire boats can carry. We estimated that approximately 30,000 plants could be handled in this way per year (a total of 200,000 plants being finally required). From this figure the specifications of the facilities were determined. The other constraint being that the whole programme was to be run initially by two full time staff, with a likely reduction to one, once the project was underway.

The plants are mostly grown in root trainers using a commercial peat-pumice seed raising mix (with 'Osmacote' and 'Terazole'). A bark-pumice mix was experimented with, but it was found that the bark would tend to separate from the roots when the plants were removed from the trainers for planting. The advantages of growing plants in root trainers are considerable. The space occupied is very compact, eg four plants can be grown in the space occupied by a 'book' 19 x 4.5 cm (x 12 cm deep). The amount of soil required is far less than for other methods and it promotes the development of a good root system. The 'books' are supported on wire frames that take ten books. This means that it is very easy to handle large quantities of plants and to easily transport them to sometimes difficult locations. The size and light weight of the plants in these containers also means that almost anyone can carry and plant a surprisingly large number, which became an important consideration for the volunteer groups involved. For most species the Tinus RT-40 size are used, although for some of the larger species RT-45s are better. Not all species are suitable for growing in root trainers, eg taraire, whau and puriri, their roots requiring a larger volume of soil than is provided in root trainers. In these cases the plants are grown in polythene planter bags.

The drawback of root trainers is that because of their low soil volume, a guaranteed water supply is essential. Up until this time roof supply and a small quantity of bore water were all that were available. This became one of the major worries of the programme and it was necessary to completely upgrade the water supply. A new dam has been built in the valley below the lighthouse and additional water storage capacity is now available at the nursery. This comprises 40,000 litres storage which needs to be refilled every two or three days from the dam 85m below. The watering regime essentially being on demand, which usually means every 2-3 days.

A routine pest and diseases spray programme is followed with spraying every fortnight, a Benlate/Lanate mix alternating with other mixes such as Orthene/Ronilan or Ridomil. Relatively few pest and disease problems have been encountered after the early learning period, when damping off and scale insects were troublesome. One disease problem that is still under investigation is an infection of kohekohe, which to date is still unresolved. A high level of hygiene is carefully maintained both through on-site controls and restrictions on the movements of plants and materials to and from the island.

Most plants are only in the nursery for one year, during which time they have put on sufficient growth to allow planting out (e.g.

Fig. 5), although it is possible that tawaroa will need two years. Initially we had expected that many of the plants would need two years in the nursery, but the excellent growing conditions and in particular the good root growth promoted by the trainers has shortened this time. Undoubtedly this has helped with plant hygiene as it means there is little carry over of material between years and that a thorough clean up is possible each year.

PRODUCTION AND PLANTING

In 1984, 28,900 plants were produced and in 1985, 36,300. The bulk of these were pohutukawa the rest being a mixture of tree and shrub species (Table 1). Inevitably the numbers will vary from year to year because of the variability of seed production and growing conditions; although there is never any shortage of pohutukawa seed.

Table 1. Approximate numbers of plants propagated on the project to date.

Species	**1984**	**1985**
Pohutukawa	16000	22200
Kohekohe	2000	1500
Manuka	2280	—
Taraire	1570	615
Coprosma spp	1500	1200
Karo	—	4560
Tawapou	150	1300
Mahoe	410	1000
Kawakawa	—	1360
Pseudopanax spp	160	900
Rhabdothamnus	150	480
Cabbage tree	40	600
Karaka	660	—
Kowhai	500	40
Rewarewa	—	500
Whau	210	130
Flax	374	—
Heketara	40	240
Alseuosmia spp	—	180
Hangehange	80	—
Pigeon wood	—	80
Tawaroa	60	—
Puriri	—	56

Planting trips to Tiritiri Matangi have become quite a feature in Auckland during the winter. A very wide range of groups have volunteered their services. These include schools, forest and bird branches, tramping clubs, alpine sports clubs, scouts, service clubs, etc. Over-60s clubs have been particularly helpful with pricking out and help around the nursery. The numbers on any trip may vary considerably ranging from 15 up to 400, although the usual number is between 50 and 100. Irrespective of the size of party, the usual number of trees planted is between 1,000 and 1,400 per trip, with a record of 2,000. In 1984, 43 planting trips were made and by late 1985, 35 trips.

If the area to be planted is in grass then no site preparation is needed, but if the area is under bracken, then it is mown one or two weeks prior to planting. A trial to establish the need for site preparation had shown that other methods such as grubbing or weedkiller had no benefits, and that no preparation or simply mowing were all that were necessary. In either case the trees or shrubs are planted straight into the ground, a teaspoon of 'Osmacote' being placed in the bottom of each hole; a spacing of approximately 2 m is used. The plant is gently firmed into the ground and grass or bracken pushed back over any bare earth to inhibit weed growth (there are a large number of buried, viable weed seeds in the soil). This is all the 'care' the plants receive. Watering is not possible and 'releasing' not seriously considered. It has been found that the plants survive well, with mortality ranging between 20-50%; the lower part of the range being more typical. The project has perhaps been fortunate with the weather; winter conditions have been mild, even by Auckland's standards and summer rainfall has been more than adequate. The decision not to consider releasing plants has, for an unexpected reason, been shown to have been correct. There have been some strong gales since planting began and a few plants around the nursery were 'released'. These plants were violently whirled around in the 70-80 knot winds and uprooted. Nearby plants that had not been 'released' just bent over with the surrounding grass and survived the storm. One occasional source of mortality is pukeko damage; in some areas pukekos have uprooted quite large numbers of plants, probably out of curiosity. However, overall they are only of minor significance. A more serious problem in some areas, particularly near the lighthouse, is honeysuckle (*Lonicera japonica*). This very aggressive weed has recently spread over some hillslopes and urgent action is necessary to control it. Various control measures are under consideration and it is prov-

Figure 5. Ray Walter with some of the one year old whau ready for planting.

ing difficult to find an effective control, that will not at the same time damage the natural systems.

The pattern of planting on the island has been to tackle the more sheltered, moister south-west facing slopes first. Most of these have now been planted and the exposed north-eastern flanks of the island are starting to be afforested. Not all the island is going to be revegetated, the north western end, beyond the major areas of forest, is to be left to naturally regenerate, as is one of the slopes where ongoing research into regeneration is concentrated. This will ensure that a diversity of habitats is maintained and hence a greater diversity of animal life can be supported. The other consideration is the preservation of archaeological sites. It is well known that tree roots destroy archaeological sites and thus special care is being taken to avoid planting up areas of archaeological interest.

WILDLIFE RELEASES

Saddlebacks (*Philesturnus carunculatus*) were released on the island in February 1984 and have flourished. Twenty-four birds were released of which the majority have survived and 18 months later they have almost doubled their numbers. The great success of the saddleback release augers well for the future. The other species that it is hoped will be considered for release include: stitchbird (*Notiomystus cincta*), particularly when winter nectar supplies are augmented; little spotted kiwi (*Apteryx owenii*) once the area of forest increases, similarly for whitehead (*Mohoua albicilla*). Shoreline species might include shore plover (*Thinornis novaeseelandiae*) and tuatara (*Sphenodon punctatus*). However, the island must remain free of introduced predators.

THE FUTURE

The revegetation programme will continue for a number of years yet, with pohutukawa planting gradually being scaled down in favour of species to be inter-planted. It might be expected that within 5-10 years the planting programme will be completed. A proper track system is being developed so that visitors can easily traverse the island and view its wildlife, but also so that they can be guided around potentially sensitive areas. In the longer term other aspects of the island will be developed and interpreted. Specifically the archaeological and historical features will become integrated into the project to thus provide an illustration of the continuum of human occupancy and the inter-relationship with the natural environment.

ACKNOWLEDGEMENTS

Special mention must be made of the HGMPB staff on the island — Ray Walter and Mike Cole. They have converted the working plan into practical action and have then developed the scheme further and with great efficiency into the outstanding success it has become. I would also like to thank Ray Walter for the helpful discussions whilst preparing this article. The success of the project is also, of course, due to the full support of the HGMPB, the enthusiasm of its staff and chief ranger, Rex Mossman and the management committee of the island. The conversion of our original ideas into an appropriate management plan format is due to Bob Drey, a planning officer with Lands and Survey. Much of the horticultural advice and in particular the idea of using root trainers, which in many respects made the propagation so efficient, are due to Herwi Scheltus, Director of the Taupo Nursery of Lands and Survey.

My thanks are also due to Anne Murie who prepared the diagrams.

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Cherimoya — Sub-Tropical Fruit with Potential

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The past 10 years have seen very little progress in determining the potential of cherimoyas in New Zealand. But there are signs of increased interest. Hopefully, cherimoya plantings will increase and provide much-needed information on its culture.

We know about the performance of the cherimoya in New Zealand and what factors we should consider in evaluating the cherimoya under our conditions. My main interest is in commercial production as I think the cherimoya could become an important sub-tropical fruit crop in New Zealand.

I have tasted many cherimoyas from various sources as part of my work on cultivar evaluation. This experience has certainly strengthened my faith in the future of the cherimoya as a potential commercial fruit. In fact I think that the often quoted description of the cherimoya by Mark Twain as "deliciousness itself" is not an over-statement.

Many tropical fruits, for instance, are cloyingly sweet. Although the soluble solids level of a cherimoya fruit may be very high (20% or more), it has sufficient acidity to give a good sugar/acid balance. This is one of the major factors in its agreeable flavour. I am sure that in the cherimoya we have a fruit that has instant appeal to most people once they have tasted a fruit of good quality at the right stage of maturity. There is a potentially large market for a consistently pleasant-flavoured, medium-sized, fruit of low seed number and good keeping quality.

In New Zealand there is the added advantage that fruit are available from August to November, a time when there is little fresh fruit on the local market. Cherimoyas are mostly eaten fresh, chilled, cut into slices like a watermelon, or peeled, the seeds removed and eaten in dessert dishes with ice cream and fruit salad.

The cherimoya is native in the highlands of Ecuador and Peru. It is only one of the members of the family *Annonaceae* which bear edible fruit, but in contrast to other species that are from low-altitude tropical climates, the cherimoya comes from a warm temperature zone, being most common at 1500 to 2000 metres above sea level. This is the same climatic zone in which the tamarillo is native, and the conditions required by the cherimoya, such as freedom from frost, the temperature regime, and protection from wind, are very similar to those required for tamarillo culture. It is, therefore, the species most suited to our conditions.

The culture of the cherimoya in the Andes is undoubtedly ancient as the fruit is well known to the people of pre-Incan civilizations. Undoubtedly the South American Indian peoples have been responsible for major improvements in the plant as a crop by virtue of a long period of selection for yield and fruit quality. The cherimoya is a popular dessert fruit in Ecuador and Peru to this day and is available in major cities for five or six months of the year. Although the fruit is popular and there have been big improvements brought about by steady selection, cherimoya culture is still relatively primitive in the Andes region, the fruit being mainly produced from seedling trees in small mixed orchards growing a variety of fruit crops. Even in recent times there has been very little effort put into careful selection, vegetative propagation, and culture of the cherimoya in its region of origin.

From its habitat in South America the cherimoya was spread northward to the highlands of Central America and Mexico; later, it was introduced to the Mediterranean and southern South America where it is being grown on an increasing scale commercially. The main producing areas are southern Spain and Chile, with a lower scale of production in Argentina, South Africa, Madeira, the Canary Islands and southern California.

Cherimoya growing is still a small industry on a world basis and even in Spain and Chile, which each have about 500 hectares under cherimoya production, the culture is fairly primitive, with erratic fruit production.

Seedling cherimoyas have been grown to a limited extent in coastal areas of northern New Zealand for many years and were listed in Auckland nursery catalogues in the 1930s. Such trees are variable, however, and often produced poor-flavoured, seedy fruit. The first introduction of named cultivars was probably that of Mr P. R. Kent of Tauranga, who imported several cultivars from Armstrong Nurseries of California in the early 1950s. These included the well-known Californian selections Chaffey, Ott and Deliciosa.

In the early 1970s the DSIR increased its effort into subtropical fruit research and this included some work on the cherimoya. By that time we already knew that the cherimoya could be grown and would produce good quality fruit on our warmest coastal sites suitable for tamarillo production. However, little information was available on the yield of fruit attainable and hence the economics of cherimoya culture.

The greatest need was for the introduction and evaluation of a

Cherimoya cultivars under evaluation at DSIR research station, Pukekohe.

Local selections
PK 1
PK 12
PK 23
PK 29
PK 30
PK 31
PK 33
PK 36
Early
Jenny
Smoothy
Ballinger
Burtons
Burtons Favourite
Chamberlin
Court
Drummond
Reretai
Wilsons

From California
Bays
Chaffey
Deliciosa
Spanish
White

From Hawaii
Del Campo
McPherson

From Chile
Bronceada
Old Bronceada
Bronce Canaria
Canaria
Concha Lisa
Pina

From Peru
ASCA
Guayacayan
P 43
P 52

From Ecuador
E 8

From Australia
Kempsey
Mosman
African Pride) Atemoyas
Pinks Mamoth)

From Canary Islands
Cruz Del Rayo
Jete
La Campa

From Madeira
Madeira

Table 1. Cherimoya cultivars under evaluation at DSIR research station Pukekohe.

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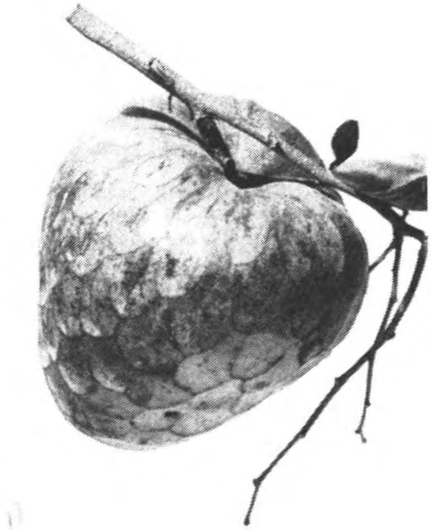

Cherimoya tree and fruit . . . potential for New Zealand orchardists.

wider range of genetic material and a programme of introduction was initiated. The evaluation of this material is mainly based at the DSIR research station at Pukekohe, where we now have more than 409 cultivars under observation (Table 1). All of the trees are young, four years of age or less. Some of these cultivars are included in co-operative trials with growers, mainly in the Kaitaia and Kerikeri areas.

In addition we are developing a co-operative variety trial at the MAF Horticultural Research Station at Kerikeri, and a trial at Kaitaia under the New Fruit Crops Scheme. A few additional cultivars (not listed in Table 1) have been introduced by growers — for instance, Mr D. J. W. Endt of Oratia has further cultivars from Chile and Ecuador and Mr L. Grey of Gisborne has cultivars from California.

At Pukekohe we are also growing a population of more than 300 seedling cherimoyas, mainly of South American origin, from which we hope to select additional commercial cultivars.

COMMERCIAL PRODUCTION

There is still no real commercial production of cherimoyas in New Zealand. There are a few small plantings and odd trees from Gisborne to the Far North but there has been almost no effort to grow them on a truly commercial basis. We know sufficient about cultivars such as Chaffey and Reretai to realise that we now need further small experimental plantings to work out cultural techniques. One problem has been the difficulty of obtaining grafted plants, but these are now becoming more readily available. However, anyone contemplating planting cherimoyas does need to understand that such an investment must be regarded as an experiment, not to be relied upon as a source of income. It must also be remembered that small-scale experiments are more likely to be successful than large ones, especially when resources are limited.

FUTURE PROSPECTS

I think the prospects for the development of the cherimoya as a commercial crop in New Zealand are good if we can obtain consistent yields of good quality fruit. This goal should be attainable if we apply to the cherimoya those techniques of good husbandry that we have learnt from growing other fruit crops. The growing of cherimoyas on a commercial basis is still in its infancy worldwide, but in New Zealand we can take advantage of what has been learnt elsewhere and also use our knowledge of growing other fruit crops to put cherimoya growing on a proper commercial footing.

FRUIT YIELD

Information from Spain (Cervantes Gomez 1983) shows that yields of 15 to 20 tonnes a hectare are possible from mature trees (15 years and older) at relatively wide spacings (8x8m). In New Zealand, trees normally produce their first fruit three years after planting, and we should be able to obtain a yield of 10 tonnes a hectare as early as eight years, by close planting and careful training and pruning. Such yields are comparable with those obtained from some other subtropical fruits such as avocados.

POLLINATION

One of the most important factors affecting fruit yield is pollination (Hopping 1982). The cherimoya has a compound flower (syncarpium) made up of many individual carpels, with several whorls of anthers at its base. When the petals first begin to separate the stigmas are receptive while the anthers have not dehisced. Anthesis (pollen shedding) does not occur until the petals are open wide, by which time the stigmas are often dry and not receptive. This is the general pattern and the reason why flowers are generally not self-pollinating, and is particularly true of dry climates. Where the humidity is higher the stigmas do not dry out so rapidly and there is greater opportunity for pollination.

Nevertheless, partial pollination may occur, leading to the production of small or mis-shapen fruits. In a dry climate, hand pollination is essential in order to obtain a crop at all, and this method is practised commercially in California and Chile. Our climate favours natural pollination but we must look at the practicality of hand pollination, which becomes more realistic with the control of tree size.

There are of course variations in the degree of self-compatibility of various cultivars and part of the cultivar evaluation programme involves selection for consistent yields of well-shaped fruit. Another possible way of obtaining good yields is from the use of hormones. Mr Wade Cornell has carried out a number of trials with low concentrations of gibberellic acid that look promising, and further experimentation seems warranted.

There is little evidence that insects play an important role in pollination, but we should closely observe cherimoya flowers and watch for pollinating insects. Flowers are thought to be adequately wind pollinated at temperatures of 16° to 20°C and relative humidities of 50 to 90 percent.

VARIETY EVALUATION

We need to step up work on variety evaluation and continue to introduce any promising cultivars. Also we must obtain a wider genetic base with further introductions from the cherimoya's area of origin. This should include a greater number of field trials to allow more rapid evaluation. The attributes we are looking for are:

1. Consistent heavy yields of medium-sized (approx ½kg) fruit.
2. Fruit of regular shape with a relatively smooth skin.
3. Fruit flesh sweet, juicy, and of pleasant flavour.
4. Absence of grittiness and/or browning near the fruit skin.
5. Fruit of good keeping quality.

There is room for fruit having a range of shapes, skin patterns and flavours. Most of the cultivars under trial in New Zealand have not been fully evaluated. However, the cultivars Chaffey and Reretai can be recommended. Both crop regularly, producing yields of good quality fruit comparable with those obtained overseas.

PRUNING AND TRAINING

One very important way to improve the productivity of the cherimoya is to contain tree size. This allows closer planting and, in particular, it improves yields in the early years of an orchard's life. New plantings in Spain are 5 x 5 to 6 x 6m, with later thinning, and plantings of 5 x 4m are reported from Chile. Tree shape seems to be important in controlling tree vigour and productivity, and a vase shape is preferred for both cherimoyas in Spain and the related atemoyas in Queensland. To develop this structure, young trees need to be headed back to about 50cm above ground level, as the natural habit is usually to a central-leader tree.

Another important aspect of tree training is protection of fruit. Even without frost damage, exposed cherimoya fruits may darken and even split due to exposure. It is important that fruit be protected by foliage during the winter, which is difficult to achieve on young central-leader trees.

The training of cherimoyas on trellis structures, both fan and V-shaped, should be tried as a way of keeping tree size small, protecting fruit and making hand-pollination possible. Shade-cloth structures could have a place where there is a frost hazard or where excessive temperatures are a problem and I have recently seen an interesting shade-house structure over cherimoyas in the Gisborne area.

If left unpruned, cherimoyas grow into a tangled mass. Some thinning and shortening of branches is necessary to maintain productivity. Cherimoyas flower on both the current season's and older wood and we need to know much more about the effect of pruning on yield, and which flowers produce the best quality fruit. Excessive pruning of cherimoyas should be avoided as it only encourages vigorous vegetative growth.

FERTILISER

We need to relate leaf analysis of cherimoyas to productivity so that we can encourage regular, heavy, bearing and contain tree size. A balance of elements is needed: excessive nitrogen, for instance, causes vigorous vegetative growth at the expense of yield and may lead to an imbalance with other elements. Young plants need to be well fed to obtain good early establishment but once plants have been two or three years in the field then the rate of fertiliser should be reduced, to encourage fruitfulness.

HARVESTING, STORAGE AND SHIPPING

Much remains to be learnt about when to harvest cherimoya fruit so that they have a reasonable shelf life. One important criterion for the selection of cultivars is that fruit can be harvested mature, have a satisfactory period from harvest to ripening and still have a good flavour. There is little experience of this in New Zealand, but we know that cherimoyas are successfully transported to European markets from Spain and Madeira and also from the highlands of Peru to coastal cities. Similarly, the atemoya (custard apple) is sent from Queensland to Sydney and Melbourne. Some research has been done on storage of cherimoyas which shows that fruit can be held at 10°C for approximately 5 days.

PESTS AND DISEASES

So far there has been little trouble with insect pests on cherimoyas, although thrips and leaf-roller cause some damage.

The main disease problem of cherimoyas is the fungus, *Botrytis*, which can cause severe die-back of shoots in autumn and winter. Periodic protective sprays are needed from autumn to early spring.

CONCLUSION

There are good indications that the cherimoya could become a popular local dessert fruit. To achieve this, further experimental plantings are needed to enable more rapid evaluation of cultivars and the development of appropriate cultural techniques. Provided we can obtain good yields of high quality fruit the development of export markets should also be possible.

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Functions of the Soil

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Introductory paper for European Environmental Bureau conference on Soil Protection in the European Community, BRUSSELS, 12th-14th November, 1984.

If we are to protect the soils upon which, up to now, we have depended for our existence, it would be as well that we appreciate the fully integrated complexity of the ecosystems that we use for this purpose.

The functions of soils are those which they have acquired through time as plants and animals have evolved to exploit their potential for living space, physical support and sustenance. For plants they are the rooting medium to which they have had to become adapted.

As there are many different soils — some wet, some dry; some acid, some alkaline; some nutrient rich and some impoverished — so, specialised groups of plants have evolved to extend the range of habitats exploited. In the short time available I shall summarise how the nature of the plant/soil inter-relationships that have evolved in the moist climates of Europe now condition their response to Man's interference.

Plant requirements of soil may be summarised as in Figure 1. The items underlined — anchorage, water and nutrient supply — are likely to be best achieved by deep, exploitive rooting. Aeration is a matter of maintaining the right balance between water and air in the living space; that means a right balance between large, free-draining pores for the rapid infiltration of rainfall, and also for drainage, aeration and easy root penetration; and small pores for water retention and nutrient uptake. This is normally satisfactory where the large pore content exceeds thirty percent of the total pore space (Stewart and Adams, 1968) and is achieved in the majority of our soils only when the fundamental particles are organised into water stable granules, as illustrated diagrammatically in Figure 2.

Because plants, when fully active, can only acquire water and nutrients at an adequate rate from a distance no more than a few millimetres from the growing tips of their root systems, they have to ramify continuously through a large volume of soil to acquire what they need. Therefore, in evolutionary terms, biological success will depend on the efficiency with which the effort expended on rooting is matched to the reward in water and nutrients.

It has been demonstrated fairly recently (Drew, 1975) that root branching is a direct response to the presence of soluble forms of nitrogen and phosphorus. This explains why, in Nature, we find root density very much conditioned by the distribution of organic matter for, in Nature, it is from decaying organic matter that a great deal of the available nitrogen and phosphorus is derived. If the organic debris accumulates on the surface we have what, in soil terms, is described as the "Mor" condition. Here, rooting is concentrated at the surface whereas, with organic debris deeply incorporated, that is, the "Mull" condition, roots are distributed throughout the soil.

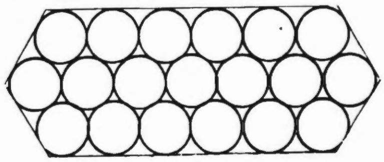
Figure 1

PLANT REQUIREMENTS OF SOIL

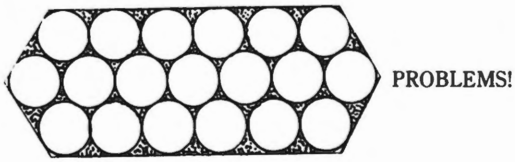
<u>ANCHORAGE</u>	Those underlined are all satisfied in crop plants when the soil is organised to encourage deep, exploitive rooting.
<u>WATER</u>	
AIR	Water and air compete — 70:30 balance ideal.
<u>NUTRIENTS</u>	

Figure 2

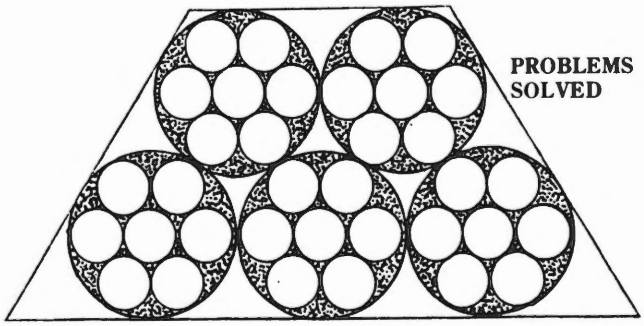
SINGLE PARTICLE, CLOSE PACKING
LARGE PARTICLES — LARGE PORES
SMALL PARTICLES — SMALL PORES



MIXED PARTICLE, CLOSE PACKING
PARTICLES INTER-PACK — **SMALL PORES** THROUGHOUT



MIXED PARTICLE, OPEN PACKING
DUAL PORE SYSTEM — **LARGE PORES** BETWEEN GRANULES
SMALL PORES WITHIN



In agriculture we have the possibility that the nitrogen and phosphorus in granular fertilisers may perform the same function as does organic matter in Nature, but there are vital differences; the range of nutrients available around a decaying nucleus of organic matter is likely to be far better balanced than that around a fertiliser granule, and it is very likely that where there is organic matter there will also be a reserve of water.

As to the primary roots, they seem unaffected in their behaviour by the nitrogen and phosphorus environment and are thereby well adapted to exploring the soil in depth but, for this they must be able to extend into a well-aerated soil.

Figure 3
PLANT ADAPTATION TO THE SOIL DEVELOPMENT DICHOTOMY
CONDITIONED BY THE PRESENCE OR ABSENCE OF BURROWING EARTHWORMS

Lime
Organic Matter
Human Hazards

+ ···················· EARTHWORMS ···················· —

+	—
SOILS	SOILS
Organic matter incorporated.	Organic matter unincorporated.
Mineral soil aggregated.	Mineral soil compact.
("Mull" condition, typical of Brown Earth Soils)	("Mor" condition, typical of Podsol Soils)
Freely drained and well aerated if site drainage satisfactory.	Drainage impeded and aeration poor unless mineral soil very sandy.
PLANTS	PLANTS
Deep rooted.	Surface rooted.
Ill-adapted for: — Drought. Waterlogging.	Well-adapted to cope with: — Periodic drought. Temporary waterlogging.
Nutrition mediated through free-living bacteria in rhizosphere.	Many conditioned to "special" feeding mechanisms mediated by symbiotic relationships with fungi.
Intolerant of: — Drought. Waterlogging. Acidity leading to problems of aluminium and iron toxicity.	Intolerant of: — Earthworms Disturbance Alkalinity leading to problem of low availability of iron.

Typically CALCICOLE ················ VEGETATION ·············· Typically CALCIFUGE

Thus, to encourage the depth and density of rooting required for thorough soil exploitation, we must aim in our management to maintain efficient site drainage and keep the soil open, and well-endowed throughout with an adequate mixture of organic matter.

The problem is to achieve these objectives in a medium that starts essentially mineral in character, particularly in loam textured soils. Loams are our commonest soils and, in them, the wide range of particle sizes present are very liable to interpack so that the nature of the pore space is then determined by the packing of the smaller particles (Stewart *et al*, 1980).

My own research has shown, contrary to the accepted wisdom amongst most agriculturalists (Strutt, 1970), that it is not the grass root that is primarily responsible for the water stable soil granulation so necessary for the conditioning of loams. Though grass is a good source of the fresh organic matter required for water stabilisation, the vital organising role is played by burrowing earthworms (Stewart *et al*, 1980; Stewart and Salih, 1981). They injest both organic matter and mineral matter, blending them intimately with calcium, introduced from a gland in their gut, and finally, they mould this mixture into the casts that break down to form the water stable granules we find, most typically, within, and on top of, a fertile soil under long-term grass.

However, even in nature, there are large areas, commonly associated with acid-tolerant, heath and coniferous vegetation, from which burrowing earthworms are, for the most part, absent. The soils, in consequence, are very different from those typical of worm-worked pasture.

Thus, it is not surprising to find that we appear to have had two main lines of evolutionary adaptation in our natural vegetation. These two lines are conditioned by the divergent trends in soil development that are initiated by the presence or absence of burrowing earthworms. The main characteristics of this dichotomy are summarised in Figure 3. It is within this context that I believe we can best rationalise our practical experience of plant/soil interactions.

The evolutionary conditioning of the two main lines of plant adaptation postulated is probably best explored first down the earthworm deficient side of the dichotomy.

The lime hating, calcifuge flora, in evolving to exploit the Mor soil condition, has had to hold on to chance variations that have better fitted plants to cope with:-

1. The regular alternation of the dual stresses of water deficiency and water excess that are inevitable on a compact loam soil in a moist climate.
2. The inevitability of primary rooting and secondary root branching being restricted to the surface accumulation of organic debris resulting from the absence of organic incorporation by earthworms.

For plants having to cope regularly with drought, brought on, incidentally, both by summer heat and winter freeze, there is an obvious benefit in the xeromorphic adaptations characteristic of calcifuge plants. However, the mechanism evolved for dealing with the periodic waterlogging that also is bound to occur around the roots in the shallow, organic surface, has not been so obvious. The plant physiologists are now revealing that, for typical calcifuge plants, this involves a simple biochemical shunt to the temporary accumulation of relatively harmless malic acid instead of the potentially harmful ethanol, which is typically the internal end-product of environmentally induced anaerobic respiration in less specialised plants (Crawford, 1967 and 1976).

But that is not all. Many of the calcifuge plants, which are to be associated with the Mor soil condition, have now come to depend, for their nutrition, on a mutually beneficial symbiosis with the fungi that prosper in the absence of any grazing pressure from an earthworm population.

And, because of the high concentration of iron and aluminium likely to be found in solution at the very acid pH's that are typical of Mor soils, it is not surprising to find there are mechanisms to limit the mobility and activity of these elements within calcifuge plants for, in high concentration, they can be toxic (Grime and Hodgson, 1969).

Now, all these adaptations to features of a soil environment typical of Mor, the relatively acid, earthworm deficient soil, are excellent in their place, but can become a liability when Nature or Man insensitively attempts to place them in the wrong environment, that is, switch them across the evolutionary lines postulated. For example, a conifer, with its dependence on a mycorrhizal association for its nutrition, is not at an advantage in a Mull soil as the presence of grazing earthworms continuously threatens to eliminate the fungal hyphae. A mechanism evolved to limit the utilization of absorbed iron and aluminium is not likely to help a plant acquire an adequate supply of dissolved iron, where a pH above 6.0 is likely to ensure that iron is in short supply anyway.

Most of our agricultural crops have evolved in harness with soils whose major characteristics have been determined by the activities of burrowing earthworms. Such soils are never strongly acid, have a relatively open, free-draining structure, uniformly enriched with earthworm incorporated organic matter, and are deeply exploited by roots. These are the "Mull" soils, typically colonized by lime loving, calcicole plants. These plants are buffered against the twin threats of periodic waterlogging and periodic drought by the free draining nature of their substrate, and their deep rooting, but are ill-adapted to cope with either the waterlogging or the drought when placed in a Mor soil. Similarly, because they have evolved in a rooting environment that is insufficiently acid to carry any threat from soluble iron or aluminium, they have likewise evolved no special defences against toxic excess.

There are probably other aspects of this plant/soil relationship yet to be exposed and fully rationalised. One question that particularly interests me arises from the fact that nutrition, in a worm-churned, Mull soil, appears to be a matter of pre-digestion by free living bacteria inhabiting the rhizosphere, whereas, that typical of calcifuge plants involves the love/hate relationship that seems to be embodied in the close physical association of fungus and root stabilised in the mycorrhizal mechanism. How then do calcicole plants react when earthworm activity is temporarily interrupted, allowing fungi greater freedom for action? Is that what explains why we have found the cereal root fungus disease, *Ophiobolus graminis* (Take-All) dominating only where earthworms have been experimentally excluded (Al-Bakri, 1984)?

It would not be surprising to find that Man, interfering piecemeal in these evolved, closely integrated ecosystems, is liable to run into difficulties.

Anything that threatens the well-being of the earthworm population diverts a Mull soil in the direction of Mor, starting trends in soil development progressively more unfavourable to the original calcicole vegetation.

In Nature, absence of burrowing earthworms is associated with arid climates, acidity, unpalatable or insufficient organic matter supply, or suffocation following soil disturbance. However, Man can achieve this also. For example, Man, planting an unrelieved blanket of coniferous trees, whose litter is notoriously unpalatable to worms, will decimate the earthworm population and divert land use for the foreseeable future solely to the production of calcifuge plants. By contrast, mixed planting, with the significant inclusion of trees and ground flora whose litter is palatable to burrowing earthworms, for example, birch, ash or cherry, could help preserve a useful re-inoculum source of earthworms, allowing greater flexibility of choice in land use in the future. So long as a significant earthworm population remains, albeit in only moderate numbers, we retain the possibility of rapid recovery to the full Mull state, simply by liming, careful choice of vegetation and careful grazing management. Once the earthworm population has been entirely lost, the soil will inevitably degrade to the Mor state, and flexibility will be lost. The treatments required to attempt recovery are far too expensive to be applied to land that, in the first place, had difficulty justifying even the cost of regular applications of lime. And even better quality, agricultural land has been found to take many years of expensive and specialised management to recover, once structurally degraded and impoverished of worms, during the disturbance and storage involved in the opencast mining of gravel, coal and metal ores (Balchin, 1981; Stewart and Scullion, 1984).

A new problem, which we are only now beginning to appreciate, is that earthworms are highly chemo-sensitive and are adversely affected by a wide range of agro-chemicals: some of the now commonly used herbicides, fungicides and pesticides will cause death (Wright, 1977; Edwards and Lofty, 1977; McEwen and Stephenson, 1979), and readily soluble forms of concentrated nitrogen fertilisers, and even highly soluble forms of lime, will discourage earthworms from ingesting the soil until dispersed by dilution (Stewart, 1979; Stewart *et al*, 1980; Stewart and Salih, 1981).

Further, a pre-occupation with fertility through fertilisers, can lead to a failure to return organic residues in sufficient quantity as stubble, manure or compost, and this limitation in food supply may lead to a reduction in earthworm numbers, with consequent limitation on benefit.

Is it surprising, therefore, that some of our farmers complain of an escalating dependence on the agro-chemical industry to sustain production? It is quite possible that their problems originate in the need to coddle crops struggling to prosper in soils no longer functioning as Nature intended.

We may have the ability to achieve, with the aid of agrochemicals and modern equipment, ever increasing production targets, even on inferior land, or without fully exploiting the natural potential of the soil, but more and more we should be asking, "Does it make environmental or even economic sense?" What we can do may be technologically clever but does it really meet our social requirements? Pehaps it would be well if we decided to review all our land-use activities again in the light of the fact that plant/soil inter-relationships would appear to have evolved in Nature to function as a whole, and in harness.

Boosting production by high inputs of readily soluble fertilisers can reduce the surface activity of burrowing earthworms, harm surface structure, discourage deep rooting and encourage diseases and pests. Limitations of yield, that may appear in dry seasons, and the increased incidence of pests and diseases, may encourage yet larger fertiliser applications and more regular applications of pest and disease controlling sprays. If this then threatens the survival, or even just the efficiency, of the earthworm population, we veer in the direction of trying to grow calcicole crops in a Mor soil. No wonder there are difficulties, and no wonder we see our farmers becoming more and more dependent on the products of the agro-chemical industry. In this scenario the agro-industrialists prosper whilst the small farmers suffer, and because the earthworm is threatened, so is the well-being of our soils.

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Guayule — The New Zealand Experience

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INTRODUCTION

Interest in the growing of *Parthenium argentatum* or Guayule in New Zealand began early in 1981 when the Managing Director of Skellerup Industries Limited, Mr P. J. Skellerup, contacted the author and asked for information about this Mexican desert plant. A literature search was initiated and in a short time sufficient information was available to allow a four-year research project to be set up.

The objectives of the research were to determine whether Guayule would thrive in the climate of Canterbury (South Island) and if successful, to compare dry-matter yields with figures achieved overseas. (Guayule is a source of rubber).

New Zealand, like most countries, imports its natural rubber from Malaysia. Skellerup Industries specialises in the manufacture and sale of a wide range of rubber products and in 1984 imported 1714 metric tonnes of natural rubber at a cost of NZ$3,131,000. Import substitution would be an ultimate objective if New Zealand production costs could be kept within range of the imported material.

In response to an inquiry to the Department of Food and Agriculture, Guayule Development Project, Campbell, California, a quantity of seed was gratefully received from Dr Mark Lubinski, Assistant Project Leader, Guayule Development Project, Department of Food and Agriculture in California, U.S.A.

Propagation

Two grams each of the following cultivars was received — A48118, N-56511, N-576 and 11591. Also 100 grams of bulk seed, stated to be variable and possibly containing some crosses with *Parthenium incanum* or 'Mariola'.

Germination tests on the 'bulk' seed using sodium hypochlorite to break seed coat dormancy were carried out. Nine treatments of two petrie dishes each were put in an incubator at 22°C. Germination varied between 16% and 36%.

The tests closely followed the recommendations given in the Report on the Feasibility of Commercial Development of Guayule in California, 1982.

Subsequent incubator tests were carried out on the four cultivars and the germination percentage within 12 days noted as follows:

Variety	% Germination
N-576	42
N-565-11	72
11591	70
A48118	82
Bulk	24

In order to determine an appropriate seed sowing medium, experimentation with several mixes was carried out. These trials were placed in a propagating house using bottom heat (22-26°C) under intermittent overhead mist. Because there was no significant difference between the different seed mixes and the standard potting mix, which was also trialed, the latter was used for the main sowing. This comprised the following:

Sphagnum peat	40%
Sieved *Pinus radiata* bark	40%
Sand	20%
	g/m³
+ Osmocote N,P,K, 18, 5, 9	2000
Dolomite	4000
Agric Lime	4000
Micromax	1000

When the seedlings were approximately 10 mm high, they were transplanted out into 'Plixipot Trays' No. 100 (96 seedlings/tray). Then they were placed in a growing-on house 18-26°C with supplementary lighting under Mercury vapour lamps (6.00 am-9.00 am, 3.00 pm-6.00 pm). Sowing date was 19 August 1983 (Feburary, Northern Hemisphere), and the transplanting was carried out 14 days later. Growing on took place in an airy, unshaded, unheated glasshouse for four weeks, after which the plants were transferred to an outside growing area.

Three thousand, eight hundred plants were potted into black plastic bags, P.B. 3/4, holding 450 m.l. of soil. M. Spurway, Nursery Foreman, Lincoln College, undertook the propagation work.

Planting

A level 1300 m² site partially sheltered by Lombardy poplar wind-breaks was cultivated by rotary hoe to a depth of 20 cm. After an initial weed seed germination was allowed to occur, the site was rotary hoed again and then rolled, using a cambridge roller.

The soil is classified as a Wakanui silt loam, sand 32%, silt 38%, clay 30%. Wakanui soil is an "ochrept" in the U.S. soil taxonomy. A soil test was as follows:

pH	6.9
Ca	14
Mg	22
K	11
P	18

Planting was carried out between 30 November and 14 December, 1983 in rows one metre apart and the distance between plants, 40 cm. For the first two weeks after planting, overhead irrigation was applied, but since then to the present time (October 1985), no further irrigation has been given.

Throughout the summer of 1983-84 there was steady, even growth, particularly with the varietals. The 'bulk' hybrid seedlings varied considerably in their growth size and habit. Flowering commenced in January 1984. Weed control throughout has been maintained by hand and rotary hoeing. Little weed germination occurred during the dry summer period, but there was a flush of weed growth when early winter rains occurred.

Plant Measurement

In May 1984 wet weight, dry weight and plant measurements were carried out by a Ph.D. student, M. Hameed at Lincoln College.

Difference in growth parameters between five Guayule cultivars grown in Canterbury, New Zealand conditions.
Data is represented in the mean of five replicates.

Cultivar	Plant height (cm)	Plant width (cm)	Root depth (cm)	Total fresh wt. (g)	Total dry wt. (g)	Water-tissue content (g)
11591	30.2	25	26.3	180.6	72.53	108.07
N.576	35	26.7	25.4	164.6	65.17	99.43
A.48118	32.8	23	25.6	146.32	62.09	84.23
N.565.11	31	18.4	23.8	114.8	49.46	65.34
Bulk	23.8	17.8	27	81.8	42.4	39.4

Cultivar No. 11591 at this stage produced the highest dry matter yield of the varietals under test. The highest rubber yield recorded by Davis Rubis was for the cultivar No. 11591 at the University of Arizona (Baird, 1981).

Climatic Considerations

During the first winter following establishment in the open ground, periodic observations were made. There was a gradual decline in plant vigour through the months of May through August. Foliage became curled and somewhat drooped.

There were 59 days of ground frost during this period and total precipitation was 251.8 mm (9.9"). On 22 May a ground frost of −9.6°C (16.9°F or 15.1° of frost) was recorded. All plants survived with the exception of approximately 20% of the 'bulk' mixed seedlings.

From mid September onwards, new spring growth slowly appeared and steady growth continued throughout the summer. No fertiliser or irrigation has been given to the plot since establishment.

Meteorological Observations, Lincoln College
12th Month - Summary 9.00 am

	Highest max. temp. °C	Lowest grass min. °C	Days of frost (Ground)	Rainfall mm	Hours of Sunshine
1983					
Nov.	25.5	−3.1	4	21.2	172.9
Dec.	28.2	0.5	0	86.5	210.0
1984					
Jan.	28.3	−1.5	1	86.2	238.5
Feb.	28.5	−0.8	0	54.6	186.2
Mar.	28.3	−0.7	0	101.4	123.8
Apr.	24.7	−5.4	9	16.5	175.5
May	19.6	−9.6	18	43.3	129.1
June	19.9	−8.4	17	12.6	124.0
July	17.4	−8.0	12	81.2	83.6
Aug.	18.9	−8.1	12	14.7	152.2
Sept.	22.4	−6.0	10	32.6	146.4
Oct.	26.2	−4.5	9	32.5	215.5

Because a primary concern for the successful growing of Guayule in many parts of New Zealand is the low limit temperature tolerance of the plant, particular attention has to be paid to winter temperature and its effects. The 1985 winter at Lincoln College has been relatively mild and up to the end of September, no adverse effects have been observed.

Meteorological Observations, Lincoln College
April — Sept. 1985. Summary 9.00 am

	Highest max. temp. °C	Lowest grass min. °C	Days of frost (Ground)	Rainfall mm	Hours of Sunshine
Apr.	27.6	−4.7	7	6.6	186.5
May	23.8	−4.5	13	31.8	116.5
June	18.3	−5.0	21	21.0	109.6
July	18.4	−7.1	16	44.7	99.9
Aug.	19.6	−7.4	15	43.3	164.0
Sept.	21.6	−3.6	14	26.0	208.7

April was the driest April on record with the lowest recorded rainfall in 105 years (6.6 mm) and 28 deficit days of zero soil moisture. The dry weather continued until 12 May and a definite slowing of growth on the Guayule was obvious.

Plant distress, due to 72 days on which ground frosts occurred during the period, was less severe than in the winter period of 1984 when 68 ground frosts occurred.

Fig. 1. Guayule, 18 months after planting, under frost at Lincoln College, Canterbury, 1985.

Considerations for the Future

Although Guayule has survived satisfactorily for two winters at Lincoln College, in July 1982 a −11.3°C temperature was recorded. Therefore, cultivars with improved frost tolerance must be developed for Canterbury, New Zealand conditions.

Increased rubber yield per hectare by the breeding of improved cultivars is obviously a target of vital importance.

The production practice of total canopy cover of land requires to be developed rather than the row system, which we have used at Lincoln College. A satisfactory selective weed control chemical will be of immense value in the field production of Guayule.

Seedling production using vacuum precision sowing machinery directly into individual compartments will facilitate the mass production of stock and reduce handling time. Propagation by cuttings directly into separate containers is a possibility, but much research will be required to confirm the potential or otherwise of this technique.

After a number of trials using several types of cuttings and different rooting media at various times of the year, limited success was obtained with 4-6 cm cuttings immersed in water for 10 minutes at a temperature of 43.3°C (110°F) before inserting in perlite. The cuttings took 10 weeks to root using a bottom temperature of 22°C under intermittent mist. They were basal dipped in a powder containing 0.8% beta-Indolylbutyric acid.

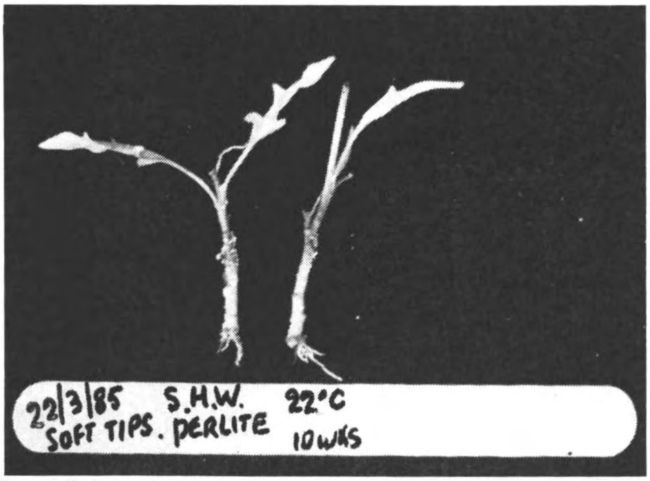

Fig. 2. Softwood cuttings of Guayule rooted in 10 weeks.

A Commercial Projection

Assuming a yield of 1344 kg/ha of rubber after three years' growth, Skellerup Industries Ltd., would require the production from 1488 ha to meet its consumption of 2000 tonnes in one year. Therefore, approximately 4500 ha would need to be in continuous production to sustain its annual requirements. Currently, the cost of Malaysian crude rubber is $1.25/kilo (N.Z.). Thus the gross return from 1344 kg/ha would represent $1680 (N.Z.) or $974 (U.S.). Production and marketing costs have not been calculated.

The viability of Guayule production in New Zealand will depend on the rubber yield, the economics of production and processing compared to the landed cost of imported Malaysian crude.

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The Vegetative Propagation and Development of Sophora Microphylla Ait.

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INTRODUCTION

The genus Sophora belongs to the family Papilionaceae and consists of about 30 species of temperate and subtropical trees and shrubs (Allan 1961) of wide distribution. Three species are represented in New Zealand, *S. tetraptera, S. prostrata* and *S. microphylla. S. tetraptera* J. Mill is a small to medium sized tree up to 10 m tall found from sea level to 450 m. The leaflets are large (3cm long) and the flowers, which appear in October and November are large and pale yellow with wings longer than the standard. This species does not have a juvenile form and usually flowers in four to five years from seed. *S. prostrata* Buchan. is a low-land bush of approximately 0.5-2.0 m tall. It forms a low hummock with densely intertangled divaricated orange-brown rigid branches and bears small (25 mm) orange/yellow flowers. *S. microphylla* Ait. is a small tree up to 10 m tall found from sea level to 700 m. It is the most variable and hardy of the three species. *S. microphylla* usually exhibits a juvenile non-flowering phase which has been reported to last up to 17 years when grown from seed. The juvenile plant forms a dense tangled bush with small leaves and is similar in habit to *S. prostrata.* The flowers are generally large and bright yellow with wings the same length as the standard which is distinctly notched at the tip. The flowering time is variable with some plants being in full flower in June or July while others are as late as November. Two varieties within *S. microphylla* are recognised. *S. microphylla* var. *longicarinata* is a tree up to 5 m tall with 10-20 cm long leaves each having 20-40 pairs of leaflets. *S. microphylla* var. *fulvida* is a small tree (up to 3 m tall) with 8-10 cm long leaves bearing up to 50 pairs of small leaflets. Both varieties grow true from seed and do not exhibit the juvenile form.

S. microphylla shows greater potential than *S. tetraptera* for the selection of superior forms suitable for use as specimen trees, tub and pot plants due to its wide diversity of form and flowering times, the brightly coloured flowers and the greater degree of hardiness. A collection of ecotypes of Sophora from around New Zealand (and one *S. microphylla* from Chile) was obtained from the Botany Division of the Department of Scientific and Industrial Research and established at Levin by the late Mr G. N. J. Goldie. One type of *S. microphylla,* grown from seed collected from Stephens Island, exhibited particularly early flowering (May) and a dwarf habit (1.5m tall after five years). Further seed was collected from Stephens Island and the subsequent trees planted in the seedling grove at Levin. This collection shows a high degree of variability in form, habit and foliage colour. Selections of superior forms from the grove began in 1982.

Three early selections from the ecotype grove now named "Earlygold", "Goldie's Mantle" and "Goldilocks" have been released to the nursery industry. The cultivar "Earlygold" has been registered for Plant Variety Rights in New Zealand. This cultivar and its seed grown progeny are being used as the basis for further breeding programmes including inter and intra-specific crosses and the use of gamma irradiation.

The first requirement of a selection programme is the development of a method of vegetative propagation. Goldie (1976) showed that several grafting methods as well as cuttings could be used to propagate *S. microphylla*. The cutting propagation method described proved to be difficult to implement on a commercial scale and a low percentage strike rate was reported. The cutting propagation has been further investigated using propagating conditions similar to those likely to be found in commercial operations. Flowering and control of plant form in containers has also been studied.

PROPAGATION

Experiment 1: Time of taking cuttings

Method: Cuttings 15 cm long were taken from field grown stock plants of "Earlygold", "Goldie's Mantle" and "Goldilocks" at three or four week intervals from May 1982 to June 1984. The cuttings were stripped of their lower leaves, given a single wound, dipped in IBA talc (Seradix 3) and inserted 3 cm into a 50:50 "Fibremix" bark: pumice medium in trays. The cuttings and tray were then drenched with a 1.5 g/l solution of "Benlate" before being placed under mist with 20°C bottom heat at the cutting base. The number of dead, callused or rooted cuttings were counted after six weeks. Those cuttings that were callused but not rooted after six weeks generally rooted after 8-10 weeks. The trial design was a randomised block with five replications.

Results: The results for "Earlygold", "Goldie's Mantle" and "Goldilocks" are presented in fig. 1; A, B, C respectively. Approximately 100% rooting could be achieved using this system when cuttings were taken during June, July or August. Cuttings should be semi-hard and this is dependent on weather conditions. The drop in rooting percentage during the second season was probably

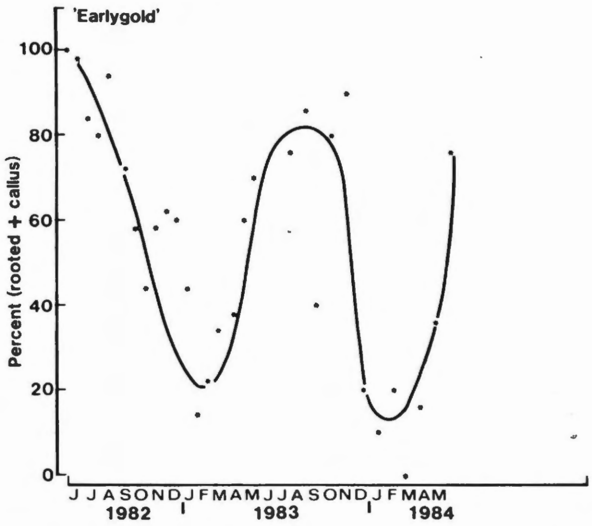

Fig. 1A: Percent rooted + callus cuttings of *S. microphylla* cv. "Earlygold" versus time of taking cuttings.

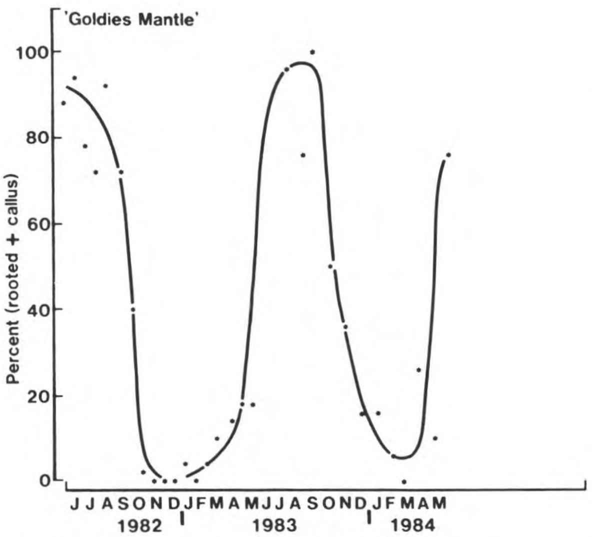

Fig. 1B: Percent rooted + callus cuttings of *S. microphylla* cv. "Goldies Mantle" versus time of taking cuttings.

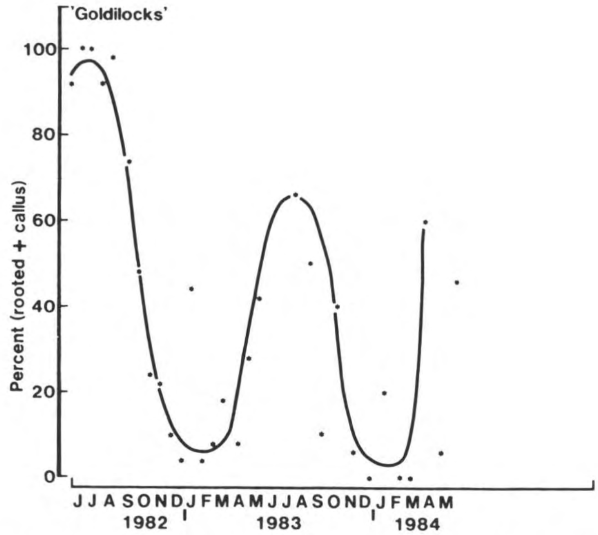

Fig. 1C: Percent rooted + callus cuttings of *S. microphylla* cv. "Goldilocks" versus time of taking cuttings.

due to a lack of suitable cutting material. This effect was particularly noticeable in "Goldilocks".

The results for the three cultivars were averaged at each propagation time and graphed against monthly weather data. While rooting appeared to be poorly correlated with day length (Fig. 2). It appeared to be well correlated with dry bulb temperature (Fig. 3) and the monthly total number of sunshire hours, but not with the monthly total radiation (Fig. 4) or open pan evaporation (Fig. 5). Investigations are continuing with the aim of predicting periods of high propagatability.

Experiment 2: Fertilised propagation mixes
Method: Cuttings of *S. microphylla* cultivar "Earlygold" were prepared as described previously and placed in 50:50 "Fibremix" bark:pumice media containing 0, 0.5 and 1.0 times the following fertiliser regime:

	kg/m^3
Osmocote 3-4 month (14:6.1:11.6)	4.5
Dolomite lime	5.0
Superphosphate	1.0
Calcium ammonium nitrate	0.2
Fritted trace elements	0.4

Trial design was a randomised block with five replications.

Results: No significant increases in the rooting or initial survival was found using fertilised propagation mixes.

Experiment 3: Fungicides and cutting sterilisation
Method: S. microphylla cv. "Earlygold" cuttings prepared as de-

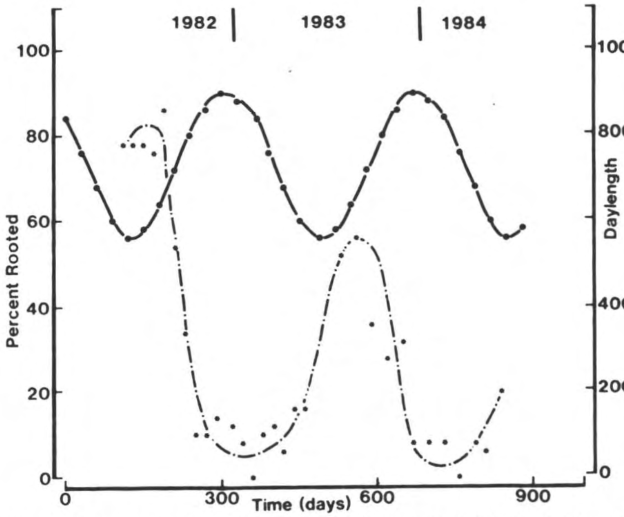

Fig. 2: Percentage of *S. microphylla* cuttings rooted and the day length at Levin versus time
• day length * percent rooted

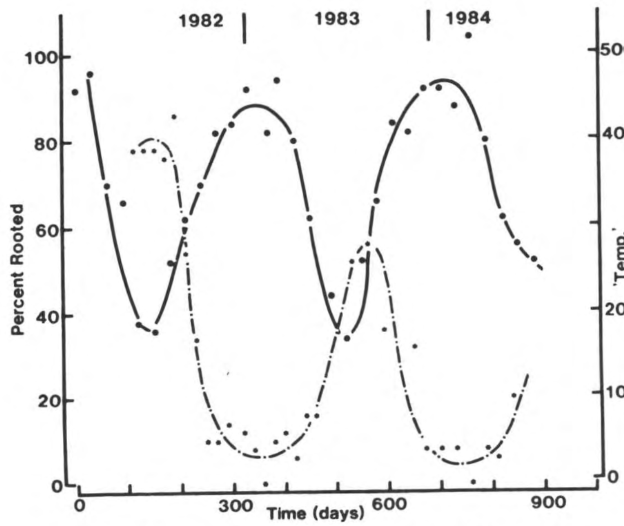

Fig. 3: Percentage of *S. microphylla* cuttings rooted and the dry bulb temperature (monthly totals of the day bulb temperature reading at 9.00 a.m. every morning) versus time
• dry bulb temperature * percent rooted

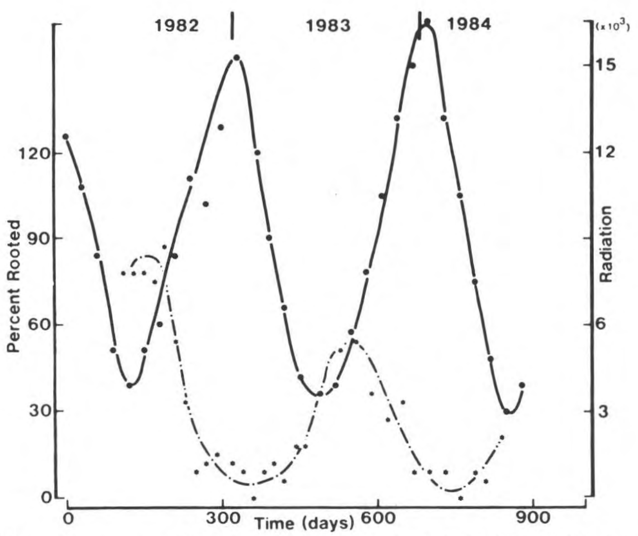

Fig. 4: Percentage of *S. microphylla* cuttings rooted and the monthly total radiation levels (Langleys) versus time
• radiation totals * percent rooted

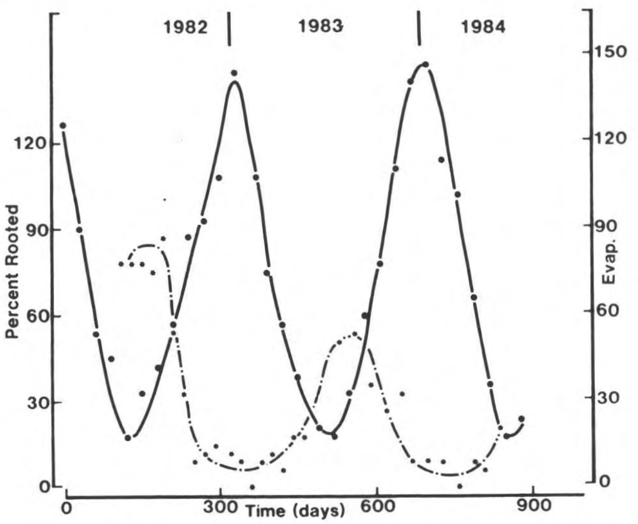

Fig. 5: Percentage of *S. microphylla* cuttings rooted and the monthly total open pan evaporation (x 0.1 mm) versus time
• open pan evaporation * percent rooted

scribed previously were subjected to factorial combinations of the following pre and post-sticking treatments:

Pre-treatments	Post-treatments	
control	control	repeated applications every seven days
50% ethanol dip, 5 sec	Benlate 1g/l	
0.3% sodium hypochlorite dip, 30 min	Ridomil	
0.6% sodium hypochlorite dip, 30 min	Thiram	
	Sumisclex	

Trial design was a 4 x 5 factorial with five cuttings per plot.

Results: Significantly better survival of plants was achieved using no pre-sticking treatments followed by Ridomil, Thiram or Sumisclex than the control of Benlate treatments. If 0.3% pre-sticking treatment was used only Ridomil post-treatment was better than the control or Benlate treatments.

Flowering in Pots

Successfully rooted cuttings of *S. microphylla* will flower in the following season on very small plants (10-12 cm) making attractive small pot plants. Cuttings taken from floriflorus cultivars such as "Goldilocks" make very attractive tub plants. To be a successful pot plant, the "shelf-life" of a flowering plant must be reasonably long and the plant must withstand conditions experienced in the home. Similarly, the plant form must be attractive. To evaluate the usefulness of *S. microphylla* cultivars in this regard, trials using plant growth regulators to control plant form, and the "shelf-life" of flowering plants were conducted.

Experiment 4: Shelf-life of potted S. microphylla

Method: Potted plants of *S. microphylla* cv. "Goldilocks" were placed in a shelf-life room at 20°C and 70-80% RH with fluorescent lighting. Floral development was assessed using a rating system for flower bud development from tight bud to fully open flower and abscission.

Results: Plants with very tight flower buds developed normally and gave a display life of approximately two weeks. Floral development appeared to be normal with seed pods beginning to develop. The foliage withstood the conditions well and new shoots had commenced elongating. The display period was limited by floral abscission but larger plants with more flowers should extend this.

Experiment 5: The use of plant growth regulators to control plant form

Method: Three rates of "Alar" (2550, 5100 and 7650 ppm a.i.), Maleic hydrazide (60, 120 and 240 ppm a.i.), Ethrel (1440, 2880 and 4320 ppm a.i.), "Cycocel" (2250, 4400 and 6750 ppm a.i.) and Glyphosate ("Roundup") (360, 1080 and 1800 ppm a.i.) plus a control (water) were sprayed on to three week old *S. microphylla* seedlings three times at intervals of three weeks. The height of each plant was measured initially, prior to each treatment application and three weeks after the completion of the treatments. Trial design was a randomised block with four replications.

Results: "Alar", "Ethrel", Maleic hydrazide and Glyphosate significantly reduced the growth of *S. microphylla* seedlings compared to the control or "Cycocel". However, phytotoxicity was observed at the two higher rates of Glyphosate and tissue damage, distortion or leaf drop occurred when "Ethrel" or Maleic hydrazide was used. "Alar" was an effective plant growth regulator on *S. microphylla*.

CONCLUSIONS

S. microphylla cuttings of cultivars "Earlygold", "Goldie's Mantle" and "Goldilocks" can be successfully propagated by cuttings in a semi-hard state in late winter corresponding to the months June, July and August at Levin. Better survival of cuttings could be achieved using Ridomil, Thiram and Sumisclex sprays than with Benlate. *S. microphylla* plants in containers make attractive flowering pot plants and respond to applications of "Alar". The development of *S. microphylla* is continuing with the aim of further improving the propagation and in controlling flowering in containers.

Reprinted from Volume 34 of the Proceedings of the International Plant Propagators Society.

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Garden History Section

The R.N.Z.I.H. has since 1932 shown an interest in New Zealand's horticultural history through publication of articles in the Bulletin and Journal as well as through the Banks Lecture. In recent years there has been a feeling amongst many members that a group should be set up within the Institute to co-ordinate activities in this area. At the A.G.M. of the Institute in May of this year it was agreed that the R.N.Z.I.H. Garden History Group be formed.

It was also decided that a Garden History Section be included in the Journal. This will include articles on all aspects of garden history in New Zealand. In the future it is hoped to include a list of people currently carrying out research in this field and also to publish a bibliography of articles from horticultural Journals over the past few years on Garden History in New Zealand.

Some Garden History Impressions

J. Adam
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Fig. 1. Government House, Auckland. Reproduced from 'The Illustrated London News' July-Dec. 1864, Vol. 45. (Auckland Public Library Photograph Collection).

Gardening as we have been told by Helen Leach in her excellent book *1,000 Years of Gardening in New Zealand* has a long distinctive history in this country. Both Maori and European having actively participated.

At the last Annual General Meeting of the Royal N.Z. Institute of Horticulture at New Plymouth, the subject of garden history was briefly raised by several members. The Institute has always had members who had a strong interest in the history of horticulture and botany.

Mr A. W. Anderson for example wrote many papers that can be found in the early editions of the *New Zealand Gardener* and Institute publications. Mr Anderson presented the annual Banks lecture in 1959 which was initiated back in the 1920s close to the founding of the then New Zealand Institute of Horticulture. Sixty

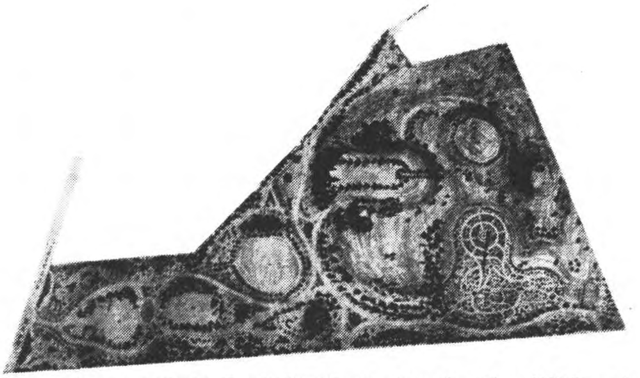

Fig. 2. The original plan for the laying out of the One Tree Hill Domain, Epsom. Reproduced from 'N.Z. Graphic', 20th July, 1901, page 118. (Auckland Public Library Photograph Collection).

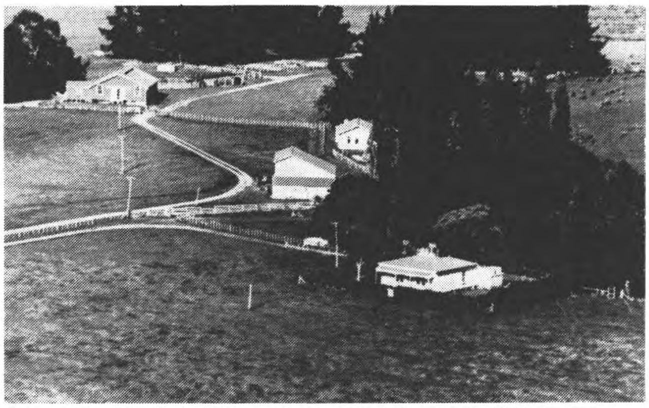

Fig. 3. Farmhouse and bush, Matahiwi, Wairarapa C.1960.

Fig. 4. Sir Duncan Cameron's house, St Keven's, afterwards the 18th Regiment's Mess house. Now the site of St Keven's Arcade, Karangahape Road (Danbury album, Auckland Institute and Museum).

years of our Institute were celebrated in 1983 at the University of Auckland, the same location where the seventh conference in 1929 was held! It was the University Centennial in 1983 that acted as a catalyst for me to research the University's garden history, including the historic gardens of Old Government House acquired by the University in the late 1960s (figure 1).

It has become evident from my research that there has been little interest shown in those people who managed the public and private gardens and pleasure grounds of the nineteenth century. In the Auckland Province the actions of gardeners and architects who designed public land including cemeteries have been overlooked or been under rated when, for example, a city or borough have published their history. Much of this design work, was carried out in part, as a result of public competitions.

The elaborate One Tree Hill Domain plan (see figure 2) is an example of a public park designed probably as the result of a public competition. Auckland's Domain, Albert Park and Western Park were laid out with assistance from competitions.

What are some of the recent themes that are appearing from research into garden history?

The recent book by Thelma Strongman; *The Gardens of Canterbury, A History,* describes in the opening chapters the gardens of a number of large stations. Mount Peel, Homebush, Rockwood and Orari Gorge all retained and incorporated the native bush near their homes into the garden. This action of protecting the indigenous flora, for whatever reason can be seen to have been applied elsewhere in New Zealand. The Brooklands park in New Plymouth, once a grand estate, comes to mind.

It has extensive areas of native bush extending around part of the formal gardens which contain large deciduous and coniferous exotic trees, some extending along part of the old estate's boundaries to perhaps shelter the bush?

As a child in the Wairarapa, I have vivid memories of my parents' old rented farm house which had an extensive area of bush that was fenced off from the surrounding grazed pasture. The bush grew right up to the rear of my mother's flower garden. Several mixed broad-leaf native trees including Lemonwood *Pittosporum eugenoides,* grew throughout the flower garden. I remember a large Macrocarpa *Cupressus macrocarpa* and a very large cabbage tree *Cordyline australis,* grew at the front of the house. The house was enclosed on three sides by a clipped lawsoniana hedge, *Chamaecyparis lawsoniana* (see figure 3).

Why was this bush saved from the axe? Was it more than just to provide shelter from the strong westerly winds in the district?

Over the Rimutakas in Petone, near Lower Hutt, my ancestors were responsible for the gifting of the Percy's Reserve. Indigenous flora is an important feature of this reserve with formal gardens, a lake and bush walls, that I believe existed most of this century if not earlier.

The retention of native bush in a garden setting by the early settlers deserves some serious research. These examples I be-

Fig. 5. 'Clovernook' Newmarket, Auckland. Source H. Winkelmann, photo 1905, (Auckland Institute and Museum).

Fig. 6. Auckland Domain View in Gardens C. 1906. Some appendix to the Journal of the House of Representatives C.10 1906. (Reproduced with permission of Auckland Institute and Museum).

lieve show threads of a distinct New Zealand garden character — that is one of the many surprises of recent garden history research for me.

Across the Tasman there is the Australian Garden History Society with further garden history societies in Britain, founded in 1965 while in Ireland, the Irish Plant Society was formed in 1981.

The Australian Society was formed in 1980 with the view to bringing together all those people with an interest in the various aspects of garden history, horticulture, landscape design, architecture and related subjects. Its primary concern was to promote an interest in and research into historic gardens. It was also concerned, through a study of garden history, with the promotion of proper standards of design and maintenance that would be relative to the needs of the present day. It is concerned with the conservation of those valuable plants in danger of being lost to cultivation. It aims at "garden making" in its wide historic literary, artistic and scientific context.

So far there has been no attempt to gather together those interested in the study of and practical application of garden history in its widest definition in New Zealand.

Plans are under way for the Dunedin Conference of the R.N.Z.I.H. to discuss garden history. One of the priorities of those gathering there should be the promotion of an interest in and research of the nation's gardens.

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Australian Garden History Society Membership form.

Landscapes and Gardeners in Early New Zealand

S. Challenger*
Okuti Valley, R.D. 2, Little River, Canterbury

The early history of New Zealand's introduced plants, and of contemporary attitudes towards their functional and design use has received very limited study. At least two aspects of the story are of interest. One, the direct narrative of the emergence of the new landscape; the other, the influence of Britain upon attitudes and methods in its offspring colony. My studies, by reason of residence, have been very largely limited to Canterbury. This province is also one of the more suitable areas for such work. Its unenclosed spaces, with their original paucity of large vegetative cover and exposure to strong winds, made rapid modification of the environment a prime necessity after settlement. Its nursery trade established quickly, and plant stock had to satisfy practical as well as visual criteria.

Early sources of plant material

Many pioneers brought plants and seeds with them, or made their own importations. But significant spread in plant material requires a nursery trade. Although Akaroa, on the Banks Peninsula, was established in 1840, 10 years ahead of the first English settlement, its nurseries do not appear to have been particularly active in aiding Canterbury's development. Initially, Canterbury nursery stock was imported from outside the province in quite large quantities. Within New Zealand, stock came from Nelson, where nurseries were established in the 1840s, and from Wellington and Auckland. Outside New Zealand, Sydney, Hobart and Launceston were major ports from which nursery stock was supplied. This trade was extensive, and even after the establishment of a substantial nursery trade in Canterbury itself, imported supplies still continued, through agents, auctions, and direct sales.

The needs

The emphasis on all these importations was upon fruit. Some included ornamentals, but only a few were concerned with hedging or shelter plants, the prime need on the open Canterbury plains. These key needs were pointed out as early as 1851. A letter to John Godley from a correspondent in Wellington, and sent by Godley to the *Lyttelton Times* (15.3.1851) spelt out the scope quite clearly. Godley's correspondent stated

> It seems to me that two objects are worthy of . . . special care. 1. the growth of wood suitable for fuel; and 2. of plants suitable for hedges.

The opportunity for the nurseryman was considerable, and William Wilson, the most significant of the pioneer Canterbury nurserymen, seized it fully.

William Wilson (1819-1897)[1]

Wilson was apprenticed to the nursery trade as a boy of 14. Here, he was well trained, and subsequently gained good experience; he was also an astute businessman. Wilson arrived in Canterbury in August 1850, 4 months ahead of the 'first four ships.' He then travelled to Nelson and Auckland, gaining experience, making contacts, and obtaining stock, before returning to Christchurch in July 1851. By early September he had leased for his nursery the 23 acres proposed for the original site of the Botanical Gardens. Wilson obviously chose this site with care, for not only was it more fertile than the land which eventually became the present-day Botanic Garden, but it was also immediately adjacent to 'The Bricks', the wharf on the Avon at which the goods of the pioneers were landed (see Fig. 1). It was an automatic centre of congregation and activity in the fledgling city.

Here, Wilson concentrated on hedging and shelter trees as his major woody-plant stock. His very first advertisement for the nursery (*Lyttelton Times,* 13.9.1851) offered 'a quantity of Furze seed and Acacia, or "Green Wattle", suitable for fencing and shelter.' His second advertisement (*Lyttelton Times,* 20.9.1851) gave the source of the Acacia . . . . 'the seeds were collected by W.W. in the neighbourhood of Auckland a few months ago and may be relied on as good and sound.'

This emphasis on shelter, timber and hedging, which was the result of a conscious appraisal of the need by Wilson, continued throughout the duration of his nurseries. By May 1852 his stock included 50,000 gorse and 10,000 thorns — presumably all raised from seed obtained in Auckland or Nelson, and sown immediately after Wilson started his nursery. By May 1855 his stock of hedging plants alone was 200,000 thorns, privets, gorse and sweet briars — a remarkably high figure for the current population of 4,500 as well as an able job of nursery production. The 'ditch, bank and hedge' system of enclosure then used, which preceded the use of wire, required from 5,000 to 6,500 plants per kilometre, according to contemporary accounts, and must have been a prodigous consumer of nursery stock. Little wonder that Wilson seldom seems to have had less than 100,000 hedging plants on hand; sometimes he had up to 1,000,000 as in May 1867. Wilson frequently offered gorse seed in bulk for direct sowing, up to half a ton being available in some years; 2 tons was offered in September 1874.

Besides hedging plants Wilson also offered shelter trees, and his advertisements always included Lombardy and Black Italian poplars *(Populus nigra italica* and *P. x serotina).* These were frequently offered as large plants, from 1.5 to 3.5m in height. Commencing in 1854 Wilson made a specialty of *Robinia pseudoacacia,* and had a stock of 50,000 on offer in 1858. He first offered Blue gum plants *(Eucalyptus globulus)* in 1857. His stock of 'English trees' — i.e. oak, beech, elm, horse chestnut etc. — took time to reach viable proportions, however, due to problems in seed importation. William Swale, who worked for Wilson before setting up his own nursery, gave a useful account of this aspect of Wilson's work in the *Gardener's Chronicle* (1.1.1859).

> The stock of forest trees is meagre . . . no Spanish or Horse chestnuts in the province . . . the beech and elm have not made their appearance yet, nor the English oak . . . the scarcity of forest trees is very much felt. The Pinaster, the only imported coniferous plant in the province, looks here dreadfully shrivelled up and starved . . . During the last seven years great

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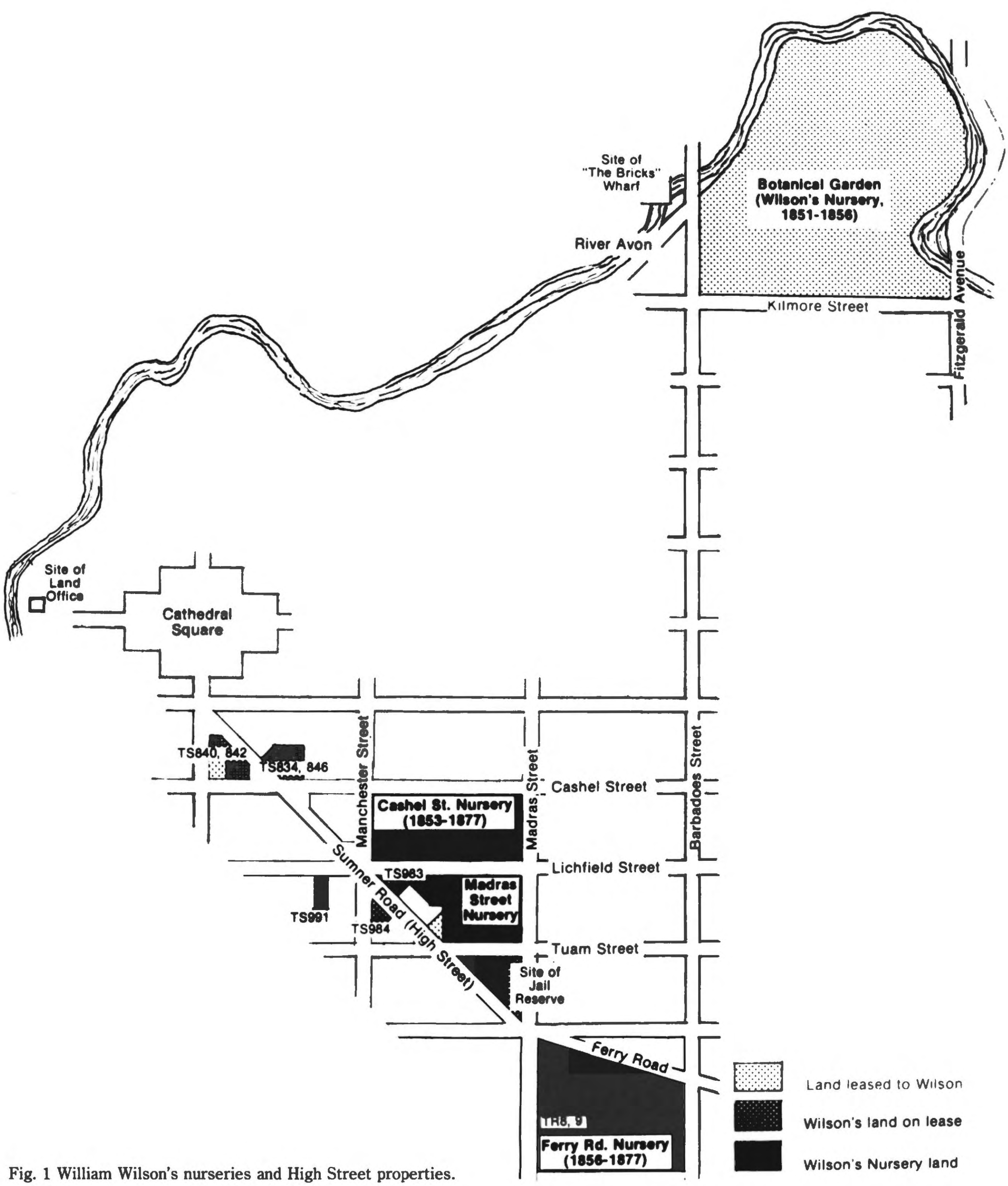

Fig. 1 William Wilson's nurseries and High Street properties.

efforts have been made to introduce forest trees into this province, but without good success, the long sea voyage generally destroying their germinating and vegetative properties. The seeds on arrival appear good, but the growing points on examination generally turn out to be black.

Later in the same article Swale discusses improvements in shipping technique initiated by Wilson, which lead to the successful introduction of an importation in May 1858, and comments:

> This may be mainly attributed to their having been packed in sound airtight casks, and the interstices between the canvas bags being filled in with dry chaff.

From this time onwards an increased stock range may be traced; for example, an article on 'Arboriculture' in the *Lyttelton Times* (3.6.1863) states:

> Amongst the British forest trees available in the Colony may be enumerated the oak, ash, elm, beech, birch, hornbeam, lime, plane, sycamore, Horse chestnut, Spanish chestnut, walnut, pinaster, Spanish fir, elder, the Weeping and Bedford willows, the Lombardy, Black, Italian and other poplars, the yew and holly.

The introduction of conifers, the present-day dominant shelter on the Canterbury Plains, did not commence until around this period. Certainly seed of larch, Scots fir and spruce was offered by Wilson on 13 September 1851. But this was apparently only selling stock on hand, for Swale's comment on conifers generally, and *Pinus pinaster* specifically (written August 1858, and published January 1859) has just been noted. However, between then and 1873 (the date of publication of Wilson's only catalogue located so far), the position had changed dramatically. In this catalogue Wilson offered 75 species and varieties of conifers, and they appear to have attained a position of unassailable dominance. This fact is shown even more effectively by the collation of stock quantities which Wilson advertised as being on hand, prior to his closing-down sale in August 1876:

William Wilson's Nursery Stock, May 1876

Conifers	
Abies canadensis	10,000
Abies Douglasii	50,000
Abies Excelsa	50,000
Abies Menziesii	51,000
Abies Nigra	5,000
Cupressus funebris	30,000
Cupressus lusitanica	5,000
Cupressus macrocarpa	50,000
Cupressus sempervirens	5,000
Cupressus torulosa	30,000
English Larch	50,000
Pinus austriaca	50,000
Pinus halipensis	50,000
Pinus insignis	100,000
Pinus maritima	100,000
Pinus muricata	100,000
Pinus pinaster	50,000
Pinus ponderosa	4,000
Pinus sylvestris	100,000
Wellingtonia gigantea	5,000
English Yew	2,000
	927,000
Deciduous Hardwoods	
Ash	50,000
English birch	20,000
English elm	10,000
Horse chestnut	2,000
English lime	5,000
English oak	200,000
Poplar varieties	10,000
Sweet chestnut	5,000
Sycamore	100,000
Walnut	5,000
	407,000
Hedging	
Holly	100,000
Evergreen privet	5,000
Thorn quicks	500,000
	605,000

The massive dominance of conifer stock over that of deciduous hardwoods is undoubtedly due to the greater ease of establishing and growing conifers under Canterbury conditions. Two other groups of plants not included in the listing above are fruits — 11,000, and miscellaneous ornamentals, including 300 varieties of roses — 40,000, bringing the grand total of Wilson's stock to 1,990,000 plants. This latter information, on ornamentals, is of particular interest, for today it is the major stock-in-trade of the average nurseryman; here it comprised only 2% of Wilson's total stock.

Businessman v. Plantsman?

Whether Wilson was atypical in this matter is not now capable of precise evaluation; however, there appears to be every evidence that he was. Wilson would appear to be a businessman in attitude, rather than a plantsman; he saw a need and he supplied it. His contemporaries, William Swale and William Hislop, were plantsmen and readily admitted it. Swale, for example, tells us, in an article about his nursery in 1865:

> In this garden quantity will not be taken into consideration at all, but variety and newly-introduced trees, shrubs, evergreens and conifers will always meet with a fair trial. An accumulation of plants in Canterbury which have enriched the plains induces the owner to commence arranging them into shape, so that their value may be truly and faithfully appreciated having regard to the advance of knowledge in the science of botany and horticulture.[2]

Hislop's record as a businessman is a somewhat erratic one;[2] certainly his advertisement in the very first issue of *The Press* (25.5.1861) offered 'upwards of 1 million hedge plants — quicks, acacias, gorse and broom.' But his real love, as with Swale, appears to be the 'plantsman's plant' — rarities, raised in limited quantity, rather than the bulk supply market, which Wilson's nursery programme concentrated on. An advertisement by Hislop, in the *Southern Provinces Almanac* for 1861, for example, makes the significant comment:

> At considerable outlay, many plants of merit have been added to the nursery stocks, the prices of which will be reduced as speedily as possible, according to their facilities of propagation.

Perhaps the best evidence on this matter, of whether Wilson's 'business' attitude to nursery stock was a normal one, comes from analysing David Hay's catalogues. Direct evidence of this type is difficult to locate.[3] The highest quality evidence, obviously, would be nursery stock lists, which give both species and quantity; but next to this comes the nursery catalogue. The data given in this paper so far, with the exception of that based on Wilson's catalogue in 1873, has come from lower-grade evidence, obtained by collating newspaper and almanac advertisements. This information is certainly incomplete in its range of species, even though quantity statements, where made, are probably quite useful.

David Hay established the Montpelier Nurseries at Hobson Bay, Auckland, in 1858, and fortunately, what appears to be his first five catalogues, for 1860 (?), 1863, 1865, 1867, and 1872, are preserved in the Grey Collection in the Auckland Public Library.

Hay appears to have been to the North Island what Wilson was to the South — a significant and knowledgeable introducer and multiplier of nursery stock, considering both range and scale of production. But his range of stock was infinitely wider than that of Wilson, as the following table shows:

Number of species and varieties catalogued by Hay and Wilson

	Hay					Wilson
	1860 (?)	1863	1865	1867	1872	1873
Conifers	72	51	81	81	124	75
Deciduous trees	17	17	18	21	33	34
Ornamental shrubs and climbers	303	226	271	259	439	82
Total	392	294	370	361	596	191

Hay's stock is more in accord with that of the present-day nurseryman, for between 75% and 80% are of the non-utilitarian type. Wilson had a larger range of deciduous trees earlier than Hay, but Hay's stock of conifers was not only wider, but developed at an earlier date.

One further comment on the matter of conifers is worth making. The commercial availability of *Pinus radiata (= P. insignis)* at an early date has been seldom noted. In fact, Wilson's 1873 catalogue contains a eulogy on the

> very beautiful Californian, *Pinus insignis,* of beautiful light green colour and highly ornamental character, which gives promise to be one of our most useful shelter and ornamental trees.

He claimed to have a stock of 500,000 plants, and offered it at 40/- to 100/- per 100, dependent upon age and quality. Whether he knew the tree well, however, is doubtful, for in a court case of 1877 *(Lyttelton Times,* 18.7.1877) Wilson stated that 'he had never seen any *Pinus insignis* timber, nor anyone in Canterbury. It had not been here long enough'. But Hay listed it in every one of the catalogues noted above, with a price progressively reducing from 7/6 to 3/- per plant.

It appears evident from this data that Wilson was primarily a supplier in bulk to meet specific needs, and who saw the basic need in Canterbury as being wind shelter and timber, not ornamental values. The contemporary description of his nursery by Swale *(Gardener's Chronicle,* 28.2.1858) shows clearly that Wilson practiced what he preached; Swale goes so far as to say that

> the example being set (by Wilson) to the inhabitants to provide shelter for themselves place him in the position of a public benefactor to the province.

Nursery locations

Whilst Wilson was undoubtedly the major supplier of nursery stock in Canterbury during the majority of this period in business, he did have a wide range of competitors, and the distribution map of Canterbury nurserymen (1851-1880) (Fig. 2) shows this clearly. The distribution pattern which this analysis shows originates in two major factors. First — proximity to major traffic routes; and second — the suitability of soils. The proximity to traffic routes obviously gives customer convenience, and potentially increases clientelle. In Wilson's case, however, his massive accumulation of land along Sumner Road (present-day High Street) (see Fig. 1) was as much forward-looking for land dealing purposes, as for customer accessibility. The Cashel Street nursery area, for example, purchased for £345 in 1856 was eventually sold in 1877 for £24,557. The only two nurserymen who

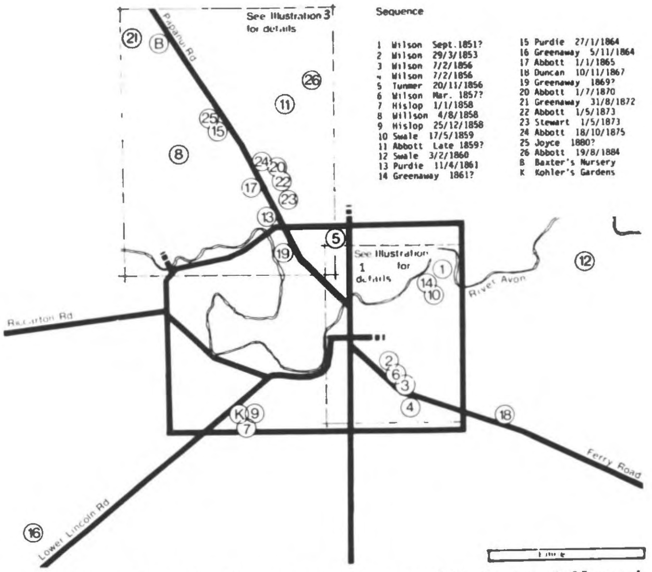

Fig. 2 Geographical distribution and sequence of Christchurch Nurseries, 1851-1880.

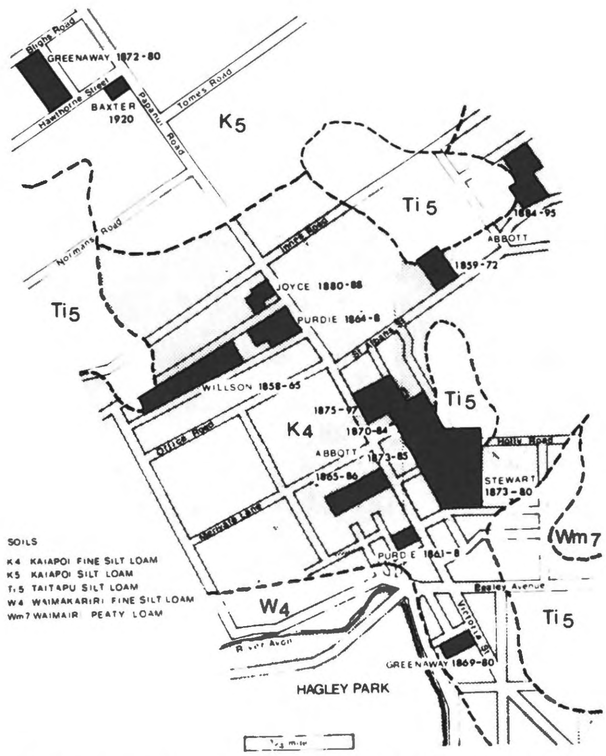

Fig. 3 Papanui Road Nurseries, 1858-1925; distribution and soil types.

disregarded the significance of traffic routes — Greenaway (Site 14) and Swale (Sites 10 and 12) — both had shop outlets, and Greenaway had a further outlet in his landscape planting work.

The fertile and — once broken-in — good working soils of Papanui Road, coupled with the placement of Christchurch's major northern outlet, created a most significant concentration of nurseries in the mid-to-late 1800s. (see Fig. 3).

The Private Landscape

Papanui Road was also a locus for some of the major Christchurch estates of the period. The farming and business fraternity of Canterbury believed in the Victorian ethic of self-help, were well-endowed with material goods, and commonly possessed large town houses with estates to match. It is here that we see the emergence of the private landscape, aided by gardening staffs under their head gardeners. Some of these estates are shown on Fig. 4, including those of J. Studholme, C. W. Turner, J. T. Matson, R. H. Rhodes, and J. Triggs, whilst just round the corner in Springfield Road was G. Gould. John Dutton, gardener to R. H. Rhodes in 1866, stated later that 'there were at least 30 gardeners busy making the early gardens of Christchurch'. These included John Joyce, later gardener to R. H. Rhodes and J. Studholme; Alexander Davidson, gardener to G. Gould from 1867-87, and who succeeded Gould's earlier gardener, J. F. Armstrong, when he became Provincial Gardener, in charge of the Botanic Gardens (then Government Domain) in 1867; William Hislop, gardener to Mrs Deans; John McGillivray, gardener to Watts Russell at Ilam; and Richard Dulieu, gardener to W. G. Brittan.

Most of these men came to New Zealand as trained gardeners. John Joyce, for example, stated

> I was born in 1850 on the Kilbree Estate, County Cork, owned by a gentleman named Wallace Adams. Here my father had served as gardener for more than forty years . . . I spent five years learning the gardening profession under my father, and then left to study under another gardener on the Kilboy Estate . . . I rose to a good position, and then came the opportunity of going to New Zealand.[4].

Joyce was associated with the Rhodes family for many years, being Head Gardener at 'Elmwood' (shown alongside Heaton Street in Fig. 4); he was also responsible for the layouts at 'Otahuna' and 'Meadowbank', other Rhodes family properties. At 'Elmwood', however, Joyce was responsible for an estate used intermittently as a Governor-General's residence. Although plans of the precise layout have not been discovered — the estate is now largely covered by Elmwood Park — contemporary accounts (1898), when the estate was at its zenith, provide factual information on its contents. The area exceeded 20 hectares, of which 1.5 were front lawn, and 1.2 kitchen garden; the drive was .5km in length. Miscellaneous contents included a lake, fernery ('probably the largest and best in New Zealand'), a conservatory 'of noble dimensions', and a tennis court. The adjacent orchard 'through which grass winding walks have been formed, (which) are pleasant retreats from the games, affording the resting players an opportunity to indulge in the luscious fruits which are to be had throughout the season' was obviously a visual feature as well as a functional one. The whole was interwoven amongst large trees: *Wellingtonia* 30m tall, *Libocedrus decurrens* 18m tall, *Cedrus atlantica, Picea excelsa, Abies nordmanniana* 'perhaps the finest in the colony,' 'a fine line of English elms from which the estate takes its name' . . . and so on. Even when due allowance is made for the rather obsequious reporting, it is evident that 'Elmwood' was a most substantial and influential estate.[5]

The degree to which New Zealand, through such important examples, was influenced by the British attitudes and thinking which helped to form them is far from being worked out. But people like Joyce most certainly influenced New Zealand. His practice as a landscape gardener, between 1880 and 1888, and subsequent to 1900, was quite extensive, extending from Dunedin to Blenheim. Joyce was one of a limited number whose prime interest was in layout, rather than raising nursery plants. Nevertheless, what today would be termed the 'philosophy of design', was still in the embryonic stage, and obviously lost much in the transference to the Southern Hemisphere. Joyce has described[6] several gardens, but the purpose of design, other than ostentation, is difficult to identify. Most cases involve rigid boundary belts — for segregation as much as for shelter — and the development of long carriageways as the major design elements. For example, Joyce's own work for John Studholme, in Merivale Lane, involved

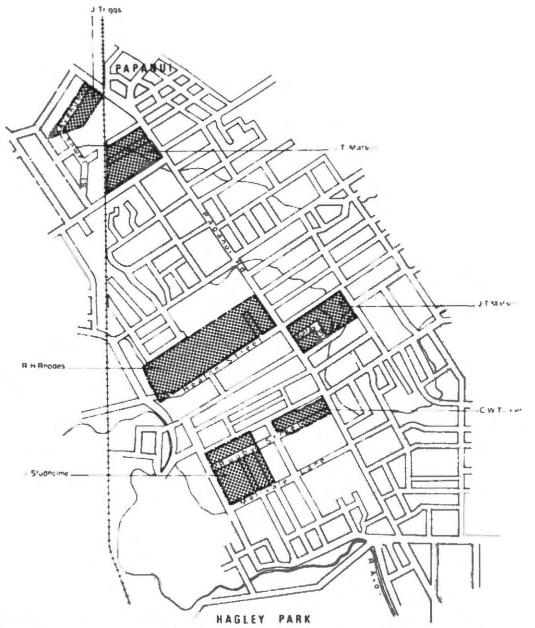

Fig. 4 Estates in Papanui Road, Christchurch, in the 1870-90 period. (The present-day street layout is shown to enable location).

> laying down lawn and shrubberies, also a belt of English trees planted around the boundaries, and a long carriage drive leading from Merivale Lane to the house. This was an ideal gentleman's residence many years ago.

J. T. Matson's estate, at 'Springfield' in lower Papanui Road

> was a very fine estate, planted with a fine plantation of trees, forming a belt all around it, with a very fine avenue leading up to the house, which stood away back a long way from the road, surrounded by beautiful gardens and plantations. There was ample paddock room (25 acres) for horses and cattle . . . ostriches used to parade the lawn fronting on to Papanui Road.

A description of J. Drummond Macpherson's Canterbury estate, given in the *Gardener's Chronicle* (1.7.1865) shows an even more elaborate style:

> This seat is beautifully situated about six miles from Christchurch. The park consists of 75 acres, in which is planted an avenue of trees; the park is planted with trees here and there, which gives a picturesque appearance. The mansion is built in the centre of the park. The garden occupies 5 acres, 3¾ being pleasure grounds; the remainder is devoted to the cultivation of fruit and vegetables. The flower garden is laid out with taste

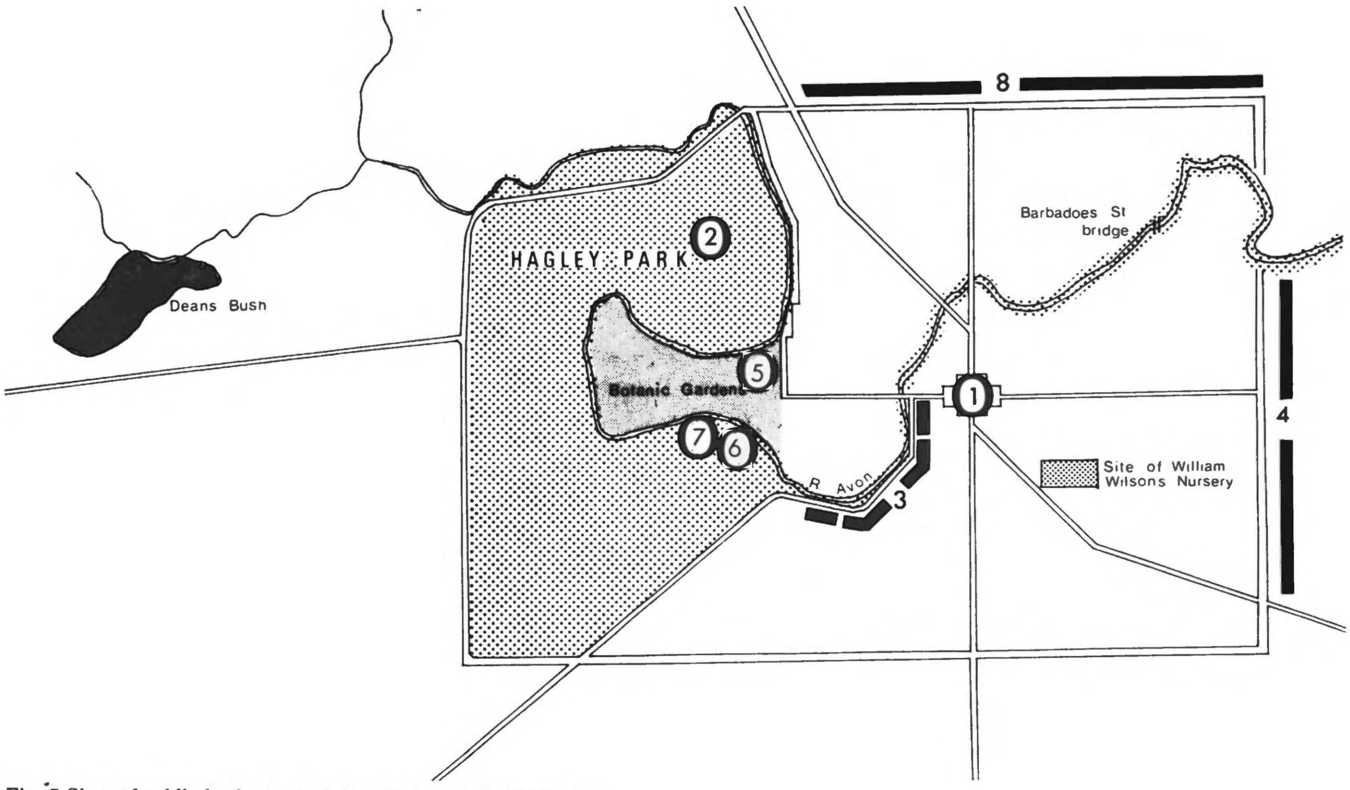

Fig. 5 Sites of public landscape activity, Christchurch, 1860-1867.

> and judgement, and is rich in flowering and ornamental trees and shrubs. There are also many specimens of the Coniferous tribe . . .

(and 13 lines of botanical names follow).

There is no doubt that the major emphasis was the typically Victorian one of plant variety; almost all garden descriptions are very short on the purposes of design, but exceedingly lengthy in their plant content. The nurseries encouraged — or were encouraged by such trends. Some nurseries, such as Duncan and Son, Exotic Nurseries, Ferry Road, Christchurch, had surprisingly wide collections of greenhouse plants as early as 1870, showing that garden contents quickly advanced beyond the essentially utilitarian. But the stove and conservatory must have been somewhat incongrous introductions into a relatively raw landscape. Nevertheless, in his catalogue of 1870, Duncan offered 82 species and varieties of stove and greenhouse plants, whilst the Show Schedules of the Christchurch Horticultural Society between 1878 and 1881 included classes for Pitcher plants, Dracaenas, Aroideae, Orchidaceae, 'the best six Amaryllids in flower (at least four varieties)', and for 'four genera of Irritable plants.' This degree of horticultural sophistication would be impossible to parallel today, over a hundred years later.

The Public Landscape

The proposals for public landscape in Canterbury were made early. Edward Jollie's initial layout of Christchurch, dated March 1850, shows a Botanical Garden, Latimer and Cranmer Squares, Market Place, Hagley Park, and public space along both banks of the Avon. And this was after Captain Thomas, Chief Surveyor for the Canterbury Association, had pruned from Jollie's plan other landscape proposals which he termed 'gingerbread'. The control of this early public landscape was in the hands of the Provincial Council. But it took a decade from the Provincial Council's formation in 1853 for effective action to be taken in developing these reserved spaces. Hagley Park was leased for grazing for many years, and the public squares were only developed at the initiative of the cricket clubs who levelled and grassed them. Indeed, a correspondent to the *Lyttelton Times,* in August 1861, enquired

> What provisions are being made in the layout of our territory here, for the out-door amusements of our people in generations to come? . . . Large spaces or parks are required, not usually for athletic or simple amusements but that the people may have the opportunity to show themselves and be seen.

However, the Provincial Council had commenced to vote finances for the public landscape in 1858, when £200 was voted for planting in Hagley Park, and £250 for planting and fencing in Cathedral Square. The first finances for staff were made available in November 1859, and this, presumably, is when Enoch Barker, the first Provincial Gardener, was appointed. At first he was required to be merely another nurseryman, although it is difficult to understand why, in view of the availability of nursery stock. Perhaps the Provincial Council foresaw the increases necessary in the vote for planting — £300 for Hagley Park in 1860, £250 for public plantations in 1861, £500 for Hagley Park and £688 for public plantations in Canterbury, both in 1862, and £843 for public plantations in 1863.

Enoch Barker was reputed to have been trained at Chatsworth, the famous gardens of which Sir Joseph Paxton was in charge from

1826 to 1858. He could have gained a landscape appreciation under Paxton, whose Birkenhead Park was inspiration from Olmsted's Central Park in New York and visited by Olmsted on at least two occasions. But I have yet neither proved nor disproved this potential association between Barker and Paxton.

Between 1860 and 1867 a series of landscape activities occurred in Christchurch, shown in Fig. 5.

1. Planting the Government Gardens, Cathedral Square, c. 1860.
2. Planting Hagley Park, 1862, and probably earlier.
3. The development of Oxford Terrace in 1862.
4. The initial planting of Fitzgerald Avenue Town Belt, 1863.
5. The initial development of the Botanic Garden in 1864.
6. Planting the Acclimatisation Society's grounds in 1864.
7. Planting the Horticultural Society's grounds, adjacent, in 1865.
8. Planting the Bealey Avenue Town Belt in 1867.

In addition to these public landscape activities, the first privately-owned public pleasure gardens in Canterbury, the Vauxhall Gardens in Lincoln Road, was open between January 1862 and September 1867. So the landscape scene was certainly alive at this time.

The major participants in these activities were the Provincial Council and, after 1862, the Christchurch Municipal Council, with the active involvement of the professional horticulturists Wilson, Hislop and Barker, and the amateurs, George Gould, Vice-President of the Christchurch Horticultural Society, and John Hall — later Sir John Hall, Premier of New Zealand. Hall's contribution to both horticulture and landscape in Canterbury has not been investigated at all, and is a fertile field for study.

Although the Government Gardens in Cathedral Square were developed by 1862, it was Oxford Terrace, the west bank of the River Avon, which was the first of Edward Jollie's landscapes to be developed. It is also of interest to me, as a professional landscape architect, since it stimulated the first landscape report for Canterbury, in 1862. The report still exists in the city archives, so that we can see the design 'logic' which underpinned the work. The sub-committee report, signed by Wilson, Hall and Gould, proposed Lombardy poplars within 18 inches of the roadside — later amended to 24 inches; a central grouping of trees — sycamore, Blue gum, laburnum, and Pinaster pines, arranged in that order, and repeated 93 times; and a river edge planting of Weeping willow. To quote their report:

> By this arrangement the first line of upright poplar next to the footpath will form a handsome uniform avenue. The second . . . judiciously and systematically blended will afford an interesting variety of foliage throughout the year, whilst the pendant branches of the weeping willows gracefully overhanging the margin of the stream will afford an interesting and pleasing diversity.

Edward Jollie had originally planned that the town should be bounded by the streets, St. Asaph, Barbadoes and Salisbury, and that outside this would be a temporary area, containing, Town Reserve. The present-day remnants of the Town Reserves are the three wide 'town belts' — Moorhouse, Fitzgerald and Bealey Avenues. The southern part of Fitzgerald Avenue was planted in 1863, and Bealey Avenue in 1867.

The most interesting of these from our point of view are undoubtedly the planting of 'East Belt' — Fitzgerald Avenue. At first welcomed as a symbol of the developing city, it later became the centre of bitter acrimony. Basically, the cause for this change of attitude had a landscape reason — inadequate awareness of the implications of the precise proposal, coupled with inadequate detailing of the method.

We start with the City Council passing a Notice of Motion, on February 16, 1863. Proposed by George Gould, and seconded by William Wilson, it stated:

> That in laying out the street around the Town Belt a roadway be reserved in the centre of 72 feet wide, leaving footpaths on each side 30 feet wide so as to allow a reserve of 10 feet on each side of the street out of the footpath for the purpose of planting an avenue of trees on each side of the street, as per rough sketch annexed.

Planting was carried out in the winter of 1863, and the first complaints started to roll in in early August, when the work was well in hand. Between then and the end of September there were no less than 20 letters and editorial comments in the *Lyttelton Times* alone. Almost all the objections were based on two factors:

> 1. The inability of property owners to get to their properties without going down the footpath all the way from the nearest road junction. The fencing, necessary because of free-wandering stock, had been installed continuous, the whole length of a city block; no breaks were made for direct access from the road to each property, for it would have required extra railings at each break to inhibit stock entry into the plantings.
> 2. Lack of concern over the relationship between road levels, and those of the adjacent property, so that water could be ponded inside the properties where the road level was higher.

Although there were other considerations, it is basically on these two factors that the whole grand concept of wide and gracious avenues around the city foundered.

By June 1865 Mr Andrews, foreman of the City Council, was reporting that

> a great number of the young trees in the plantations of the Town Belt have been greatly injured, and in many cases totally destroyed, by the goats and calves which find easy ingress into the plantations

so presumably fences were being removed to make direct access to properties feasible, as well as other direct acts showing antagonism. Nothing further was done until May 1867 when, for planting Bealey Avenue, a pattern of dual carriageways was recommended, with trees in the centre, rather than the original avenue concept proposed for Fitzgerald Avenue. This central planting is the pattern throughout the tree belts today — a less visually emphatic result and the product of a pragmatic solution to an ill-thought out problem.

The other significant designs which emerged during this period are, of course, those relating to the Botanic Garden and Hagley Park, and I have tried to trace their evolving designs. At one stage I thought I saw basic resemblances to the English Landscape Garden style, as would befit Enoch Barker, reputedly trained at a place at which Capability Brown had worked. But I regret it is much more prosaic; as W. W. Dartnall's map of Christchurch for 1868 clearly shows, Barker's concept in Hagley Park was only one of external tree belts, parallel to the roads. The perimeter belts of today were almost wholely in existence by 1868, except for a small portion in the north east corner at present occupied by *Pinus pinaster.* Careful analysis of the Domain Board records shows that the various clumps, which today create the present-day superficial resemblance to the 'Landscape' style, were placed by relatively arbitrary decisions by the Domain Board, who assumed responsibility for the day to day planting.

The pattern of the present day Botanic Garden, with its lack of correlation between circulation and spatial organisation appears to have arisen in a similar arbitrary manner. Domain Board records and contemporary newspaper information leads me to believe that the sequence was as follows:

1. In 1864 the west end was fenced off. It was subsequently used for animal pens by the Acclimatisation Society.
2. The east end was fenced off, approximately through the present-day Pine Mound, to contain the space now called the 'Armstrong Lawn.'
3. Also in 1864, Barker commenced the development of the River Walk, around the loop of the River Avon. He appears to have done so because of the poor soils in the body of the Domain, and the labour of amelioration involved. A strip, half a half-chain wide (i.e. approximately 5 metres) was dug parallel to the river. By planting this strip, and emphasising the one landscape feature, the river, Barker was able to obtain maximum impact for his efforts. Certainly, this appears to be so by a contemporary account:

> We believe that the reclamation of this ground has been one of the first attempts at landscape gardening in the Colony. The river has been included in the plan, and forms a very striking feature in it.[7]

4. In the interim, the Domain was being used as a source for gravel, so that when, by 1866, the Archery Lawn was eventually laid down in grass, it was natural that it should be fenced off for protection, and access routes developed along the edges.
5. Planting along the sides of these spaces then 'firmed up' these arbitrary divisions. The sense of enclosure they created can be sensed to this very day.
6. When finally the Acclimatisation Society was evicted from the western end, Armstrong, in Barker's place as Government Gardener, developed that space as a Pinetum, a unit on its own.

It thus appears to me that there never has been a design concept, just a series of *ad hoc* decisions, pragmatic solutions of day to day problems. Such unity as the Botanic Garden does possess is due to the river, and Barker's capitalisation upon it, again in a somewhat pragmatic way. The subsequent changes, which built upon the slowly 'fossilising' remains of wire fences, re-used animal pens, and protected lawns, are I suppose, a simplistic form of 'genius loci', but one in which the quality of the ancestral forms were given dimensions rather larger than life, and certainly endowed with values for retention which they did not possess.

This study is rather like the tip of an iceberg; that to be uncovered vastly exceeds that which has been discovered. I have discovered no Capability Brown's of New Zealand, and little by way of designers, unless it be the surveyors. Perhaps the very emphasis upon gardeners and on gardening which the study has so far demonstrated may have been a source of the narrow-based attitude to the greater landscape, from which we are only just beginning to emerge.

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A paper presented at
THE HISTORY OF SCIENCE IN NEW ZEALAND Conference Wellington, Saturday 12 February to Monday 14 February 1983.
Sponsored by the Alexander Turnbull Library and the Royal Society of New Zealand.

An Early Introduction of Tangelos into New Zealand

P. Hammer

The Tangelos grown on our former property North of Paraparaumu were young growths of scions off trees growing in Southern California; rooted in Spagnum Moss and sent by air mail with Certificates of Health in early 1955. They were a 'swap' or deal for a Cymbidium Orchid plant whose flowers were needed for a hybridisation programme, and as no trees were allowed Mr Hammer decided that rooted growths would be the next best thing. Negotiations were through the Sydney Nurseries of the grower. The growths were cleared by Customs & Ministry of Agriculture; in those days there were not the tight restrictions on imported plants as long as a Certificate of Health was with them.

However, we put them in semi-quarantine in our glasshouse separating them into several containers. (Fig. 1). In the spring of 1955 they were put into our Kilbirnie garden to 'harden-off' staying there till next spring — losing their hard earned leaves in late autumn 1956. Fortunately, they were hardy but we realised we would have to plant them in their permanent positions sooner than we expected.

We had prepared the ground at Paraparaumu North by ploughing in untreated sawdust, general manures and/or fertilisers plus all the trace elements we could obtain using these in minute quantities diluted in water, distributed over the entire ground by watering can and later sprayed. Then the ground was disced and harrowed several times, checked for a reasonable level and sloping towards the sun. We positioned the sites, dug 2 ft circles and fertilised again with small quantity of 1/3 Superphosphate, 1/3 Potash and 1/3 Sulphate of Ammonia. The 'tangelos' were planted; the summer was hot so we sheltered them with concrete blocks and handwatered each and every one of them. They prospered and in their second year after planting were growing well (Figs. 2 and 3). Each year their demands for fertilisers and trace elements grew, as did the bulbs we had growing between the long rows to recoup costs of fertilisers and other expenses.

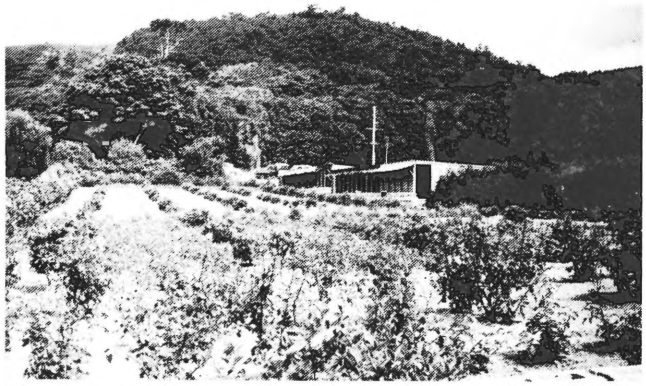
We kept all the ground hoed and free of weeds. Christmas 1960, we decided to prune off the lower branches to get air around the trunks — they were nearly 7 ft high by then. We left the weeds, clover etc., to grow to provide cover for roots. This growth was mown frequently and left as a mulch and regularly fertilised.

About 1962, the first flowers were noted, the minute fruit about September of that year, only small but a 'start.'

By then, the Levin Research Station of the Ministry of Agriculture were more than interested — we had to register as an orchard, we had more than 25 trees with a possible commercial undertaking. In 1966, the fruits were larger; they were sprayed with a Systemic spray with a BASF 'sticker' for adherance. The Ministry's officers tagged some trees with red cloth, which meant we could not pick any of these fruit. Odd fruit were taken to Levin for checks on sugar and acid content also for spray residue. The other trees were also subjected to these tests, 'red cloths' and all at regular intervals. Fruit was too small, however, but could be 'juiced'. It was very pronounced in flavour, colour good, skins gradually reduced in thickness, so by late 1967 we could give away reasonably sized fruits.

The fruit was not marketed as in April 1968, Mr Hammer suffered a severe stroke and on his Doctor's advice we sold the property.

Young tangelo growths in the Hammer's glasshouse.



Tangelo trees showing some of the 475 rose bushes planted between them and the passionfruit area. Roses were 'First Love.'

100 foot shed on the left. Tangelo trees with 18,000 iris bulbs and anemones between rows.

We have never returned there to see the trees' progress. Mr Hammer died October 1975, and I have since been told that some of the tangelo trees may still be on the boundary of the property and producing fruit.

Research Section

The 1985 Journal sees the addition of a Research Section which will include reports from the horticulture departments at Massey and Lincoln, as well as abstracts of recently presented New Zealand theses and dissertations of interest to horticulturists. It is also hoped to publish abstracts of papers presented at the Annual Conference of the New Zealand Society for Horticultural Science. (N.Z.S.H.S.).

Notes from the Department of Horticulture, Landscape and Parks Lincoln College

The Institute has kindly asked us to make an annual contribution to the Annual Journal. Normally we shall provide a review of some of the research currently underway, trying to select that which will be of most interest to members. This year, however, we shall mention those of the staff who are involved in horticultural work and describe the types of research that are conducted.

Professor Richard Rowe is the Head of Department and one of his main interests is the post-harvest physiology of fruit: currently he is working with a post-graduate, *Tejinder Singh,* looking at specific aspects of storage of peaches and nectarines. Results from this research will assist in the export of these fruit to Australia and elsewhere. He is interested in the way roots work and has had a series of graduate students trying to unravel the mysteries of these organs. Together with Technician, *John Eiseman,* he is evaluating suitable stone fruit cultivars for Canterbury.

Dr David Jackson is Reader in Horticulture and has, over the past ten years, taken special interest in grapes. This crop has been introduced to Canterbury where they are now growing commercially. He is extending his interest from wine grapes to dessert grapes and grapes for juice, assisted by *Graeme Steans* and *John Eiseman.* He has been involved, with technician *Gilbert Wells,* in investigating the potential of the European intensive apple systems with M9 for Canterbury, and they are also looking at other methods such as the Ebro and the Lincoln Canopy.

Mr Graham Thiele is Senior Lecturer in Management and also takes a course in horticultural crop management which develops a systems approach to crop study using his wide understanding of horticulture. He is a keen advocate of the whole property approach to management and the systems approach to crop research. Although his research interests in the 1970s concentrated on berryfruit he has extended his crop monitoring approach to tree fruits and vines, with homogeneous grower groups in a number of districts. Development of computer programmes and usage by growers is another area of his work.

Mr Bob Crowder is Senior Lecturer in vegetable production. He has investigated the field production of vegetable crops such as tomatoes and onions in Canterbury. He now specialises in the development of biological husbandry techniques and had an area of 2 hectares devoted to research based on ecologically-sound practices for five years. This work has created a considerable amount of interest and it is the largest area of its type in New Zealand.

Dr Michael Thomas, Senior Lecturer in nursery production, supervises the nursery area at Lincoln College assisted by *Merv Spurway.* His main research interest is the nutrition of container-grown plants and several aspects of plant propagation.

Mr J. O. Taylor is Senior Lecturer in local authority parks. His specific amenity horticultural interest is in Arboriculture and Turf Culture. He has a research interest in the production of Guayule, a small shrub which produces a rubber latex which can replace the normal sources of rubber. His preliminary results suggests it will crop well in New Zealand.

Dr Rupert Tipples is a Senior Lecturer in management specialising in industrial relations, labour management and the history of the horticultural industry in New Zealand. Previously he has investigated the course and career choices of horticultural students and trainees. At present he is working on a biography of Alfred William Buxton, New Zealand Nurseryman and Landscape Gardener 1872-1950, a study of the Canterbury Gardeners Union 1901-1942, and the history of the Canterbury Fruitgrowers Federation.

Richard Stevens, a Senior Lecturer in management is principally interested in horticultural crop economics from both a teaching and research perspective. Specific research programmes and interests include work planning, the simulation of horticultural systems and the use of applications software for assessing crop resource requirements and financial performance.

Mr Michael Morley-Bunker is a lecturer in general horticulture and fruit production who specialises in the subtropicals. His special interest is in the development of pepino cropping and the use of phenological observations for husbandry practice. Phenology is the observation and recording of biological periodic events such as flowering. These are useful for prediction of plant behaviour and for the scheduling of husbandry tasks.

Mr Dennis Farr is a lecturer in cut flowers and protected cropping. He has worked on the assessing of cloches for several vegetable and flower crops and is interested in developing post-harvest treatments for prolonging the life of cut flowers.

We haven't reported on the work of those staff members who specialise in landscape architecture, national parks or community recreation since their work is possibly of less interest to readers of this horticultural magazine.

In future issues we shall feature some of the research being conducted by members of this department and when appropriate results from student work will be recorded.

Abstracts of Dissertations Presented in Partial Fulfilment of the Requirements for the Diploma in Horticultural Science at Massey University

STUDIES ON DICARBOXIMIDE-RESISTANCE OF *BOTRYTIS CINEREA (PERS.)* ON OUTDOOR GRAPES

Kerry-Lee Munro

Thirty-two isolates of *Botrytis cinerea* collected from outdoor grapes in New Zealand were tested for resistance to the dicarboximide fungicides. There was a general pattern in which isolates grew least well on procymidone medium, better on the iprodione one and best on the vinclozolin agar. Isolates were also tested for resistance to benomyl, a benzimidazole fungicide. Three isolates were resistant to dicarboximides and benomyl, two had low-level resistance to dicarboximides and one had resistance to benomyl only. A 'tufted' growth habit was noticed in some isolates on some fungicide agars. It was concluded that this 'tufting' was related to the translocation of fungicide through the agar medium. Isolates were also tested for osmotic sensitivity on malt agar and Oxoid Malt Extract Agar amended with a series of concentrations of NaC1. Malt agar amended with 1-4% NaC1 was found to be the most useful medium for determining osmotic sensitivity. In total, four of the five dicarboximide-resistant isolates were found to bs osmotically sensitive. The one remaining dicarboximide resistant isolate was found to be osmotically insensitive and the evidence suggests that both these characteristics could be controlled multigenically. If so, such isolates could pose a serious threat in the field.

A STUDY OF SELECTED FACTORS THAT INFLUENCE COMMERCIAL PLANT TISSUE CULTURE LABORATORIES

David John James

A comprehensive literature review was undertaken on the subject of plant tissue culture in relation to commercial production. Special emphasis was placed on the initiation and maintenance of aseptic cultures, and the influence of environment on *in vitro* growth.

A study was undertaken to examine the effect that media volume and container size had upon the *in vitro* growth of two plants, a *Zantedeschia sp.* and *Ficus lyrata*.

Four commercially available clear plastic containers were used, of volumes 66.6, 169.5, 289.2 and 1076.0 cm^3, and heights 12.8, 29.6, 51.0 and 128.8 mm respectively. Three media levels of 15, 30 and 60 ml were used in the three larger containers while 15 and 30 ml of media were used in the smallest container due to size. The results of these eleven treatments were collected at two week intervals over a 14 week period.

It was found for both plants that increasing the media volume had a positive effect on both the fresh weight and dry weight accumulation. Increasing the size of the container had a negative effect on fresh weight accumulation but no significant effect on dry weight accumulation.

The commercial significance of these findings is that to optimise growth, media volume should be maximised while container size should be minimised but without physically restricting growth.

ASIAN PEARS A LITERARY REVIEW

Julie Laurenson

Modern literature of Asian pears has been reviewed. Information discussed is from research performed in Japan and the University of California, California. Establishment of this crop in New Zealand is discussed based on current practices in Japan and California.

STUDIES ON THE EFFECTS OF CHILLING, GA_3 AND PP_{333} ON BREAKING BUD DORMANCY, SHOOT GROWTH AND FLORAL DEVELOPMENT OF KIWIFRUIT (ACTINIDIA CHINENSIS)

Pasumarty Venkata Satyanarayana

Experiments were carried out to investigate the chilling requirements for kiwifruit buds to overcome dormancy, and to determine the effects of chilling, GA_3 and PP_{333} on breaking dormancy, shoot growth and floral development of the kiwifruit cuttings.

Kiwifruit cuttings were collected from two pistillate cultivars (Abbott & Hayward) at approximately monthly intervals throughout the winter. The cuttings were subjected to 3 temperature regimes and 4 growth regulator treatments. In addition to recorded levels of field chilling, the cuttings received 1000 hours chilling in the laboratory through daily fluctuating temperature (16 hours in 6°C; 8 hours in 16°C) or 6°C continuous low temperature, whilst controls were maintained at 23°C in the laboratory. Some cuttings were treated with 50 ppm GA_3 or 50 ppm PP_{333} or both these compounds.

Kiwifruit buds developed their deepest dormancy during May, and rapid and high bud burst was then stimulated by chilling. Dormancy was broken by the second week of July. It appeared bud dormancy was broken by 510 hours field chilling, but 900 hours chilling caused faster bud burst. The cuttings which received additional chilling performed better than non-chilled control cuttings. The 6-16°C temperature regime was more effective than continuous chilling at 6°C in breaking bud rest on a weighted chilling hour basis. Hayward buds were shown to have a higher chilling requirement than those of Abbott. The cuttings treated with 50 ppm GA_3 delayed bud break when buds were dormant, but on non-dormant buds it hastened bud break. In contrast, PP_{333} hastened bud break when buds were in the dormant stage. The flower bud development was good only when shoots were harvested after mid-July.

SOME FACTORS AFFECTING ROOT DISEASE OF PASSIONFRUIT

Simon V. Young

Root diseases were found to be a major problem in the New Zealand passionfruit industry. No manageable cause of the disease was identified in management practices. The fungus ***Fusarium sambucinum*** was isolated from diseased tissue and thought to be a major pathogen of consequence.

Particular soil physical properties could not be linked to disease incidence. Soil pH though, tended to be low in all of the passionfruit soils.

A suppressive effect was noted in all the passionfruit soils although some inhibited pathogen growth more than others. The nature of the pathogen appeared to have some bearing on disease as well as the nature of the soil.

The addition of straw, and straw and nitrogen amendments were examined in relation to their effect on disease. Disease incidence was greater in the straw and nitrogen soils. This was attributed partly to the development of more susceptible fine feeder roots and partly to the amendments' effect on inoculum density. Disease incidence was directly related to inoculum density.

Total microbial population, including that of the pathogen, ***F. sambucinum,*** was increased substantially by the passionfruit root exudates. The inoculum density of the pathogen was also found to be influenced by the nitrate form of nitrogen used.

It was concluded that two factors affecting root disease incidence in passionfruit were the root exudates and the form of nitrogen applied.

A REVIEW OF SOME ASPECTS OF GREENHOUSE COVERING MATERIALS IN NEW ZEALAND

John Douglas Beauclerk Maurice

This dissertation reviews many of the aspects relating to greenhouse covering materials in New Zealand.

The first chapter discusses the importance of solar radiation for plant growth and development relating this to the greenhouse environment and the 'warm air trap' that is induced. Sources of heat loss from this environment and the influence of condensation on radiation transmission qualities of the cladding are discussed.

Chapter 2 reviews the different types of covering materials available for greenhouses. These are grouped into three main areas: glass, rigid and film plastics. Product formulations and the use of special additives are investigated.

Chapter 3 compares the qualities and properties of the alternative claddings available. This chapter covers six major areas:

i) transmission qualities — in terms of radiation and thermal re-radiations

ii) structural effects on the greenhouse on claddings, e.g. roof slope, architectural form, heat transfer and the occurrence of 'hot spots'

iii) weatherability of the different covering formulations

iv) physical properties such as impact strength, flammability and gas exchange

v) yield comparisons — related to environmental, temperature, humidity and CO^2 modifications

vi) economic considerations using straightforward cost comparisons and discounted cash flow analysis.

VIRUS AND VIRUSLIKE DISEASES OF STRAWBERRY

Narandra P. Patel

Random samples of strawberry plants, from fruiting and propagation beds which were indexed by graft transmission, revealed the presence of several latent strawberry viruses. A small group of aphid-borne viruses were implicated as being responsible, based upon the resultant symptomology induced on infected indicator plants. This is further supported by the clumping patterns of latent virus infections around existing older infections.

Interations between strains of a single virus and strains of different viruses were frequently encountered. The expression of field symptoms often signifies an interaction between strawberry viruses that are otherwise latent. This is accompanied by varying degrees of growth and yield reductions.

An electron microscopic examination of strawberry affected by a yellows-type disease has indicated that mycoplasma-like organisms are likely to be responsible. An abundance of these organisms were found exclusively in the phloem components of vascular tissues. Different forms of MLO were observed, the most abundant being the mature oval forms.

The findings in this study are complemented by a current review of virus and virus-like diseases of strawberry.

Abstracts of Theses Presented in Partial Fulfilment of the Requirements for the National Diploma in Horticulture (N.Z.)

AN ASSESSMENT OF THE ROLE OF A GARDEN CENTRE IN THE 1980s

N. J. Arbury

COMPARATIVE METHODS OF ESTABLISHING LETTUCE, DWARF TOMATOES, AND CUCURBITS WITH PARTICULAR REFERENCE TO SOIL BLOCK TRANSPLANTS

M. H. Rhodes

GARDENING WITH NATIVE TREES & SHRUBS IN THE NORTH

J. K. Gavin

In this thesis I have endeavoured to outline the cultivation requirements of a wide range of New Zealand native plants, which I have found to be worthwhile under conditions experienced in Northland and Auckland.

This thesis is divided into ten chapters including the Introduction and Conclusion.

The first chapters are concerned with soil and climatic conditions in the region and how adverse situations may be improved or overcome. Following these are two sections describing good garden preparation, planting techniques and caring for established plants.

Chapters six and seven are designed to help the home gardener select plants which will be most suited to their requirements and to their site conditions. Detailed descriptions of individual native plants, with which I am familiar, are included with information on their habitat and requirements. Lists of plants for special places are given along with a guide to selecting and purchasing plants.

Descriptions and control methods for pests and diseases common to native plants are covered before a final chapter describing the setting up of two new gardens which included a number of indigenous plant species.

As a home gardener and a worker in a local garden centre I have come to realise the difficult growing conditions in the Northland and Auckland regions and what a terrific asset many of the New Zealand small trees and shrubs are. In this thesis I have attempted to dispel common misconceptions, such as drabness and slow growth of these plants whilst showing their value in establishing gardens under harsh conditions and in providing aesthetically pleasing form, flower or foliage colour.

FACTORS INFLUENCING TREE YIELDS OF MACADAMIAS WITH SPECIAL REGARD TO NUTRITION AND NUT SET

G. Swinburn

Although Macadamias were introduced into New Zealand in 1932 they have only been considered as a commercial crop in the last few years.

The main world production of Macadamias comes from Hawaii and Australia but New Zealand has had to establish its own industry based on different varieties. These varieties suit our cooler climate, heavier soils and rainfall patterns and appear to produce good crops in the northern half of the North Island. The post harvest handling and processing must be developed to suit these varieties.

The successful growing of the tree (and crop) involves a study of the factors controlling yield and determining ways of manipulating those factors to produce an economic crop and thus a potentially viable industry.

The main components of growth and yield of Macadamias in the orchard are food, water and reproduction, therefore manipulation and encouragement of nutrition, irrigation, pollination and nut set by the grower, can determine the success of the crop. The effect of this management on final yield is limited, however, by the overriding, less controllable, climatic elements.

NUTRITION

Provided nutrition is adequate, yield is most affected by the varieties grown, temperature, water and light. The role of nutrition in Macadamias is to encourage the storage of carbohydrates in to the nut kernel in desirable proportions of sugars and oils. The vegetative cycle, influenced by nitrogen, must be managed to complement the carbohydrate cycle (nut development). Timing of nitrogen application has a direct effect on flower initiation, flowering itself, nut drop, oil development and of course flushing.

IRRIGATION

Water is also an integral part of vegetative growth and carbohydrate storage. Rainfall in New Zealand is adequate but not ideal in timing, as there are critical periods in the growth cycle where a good supply of water is required; for example during flower initiation and oil development. Irrigation can be installed to provide water at these stages but is not essential in most areas of New Zealand.

FLOWERING/POLLINATION

Macadamias are similar to many other subtropical/tropical crops in that they produce enormous numbers of flowers but only a small percentage are finally set. Manipulation of nutrition and water is the prime management tool in determining this final nut set. Temperatures also play an important role in this process as well as flower initiation. Macadamias have been found to produce heavier crops in orchards with cross pollination facilities i.e.: interplanted with a number of different varieties.

Finally Climate, the most difficult variable to manage. This factor appears to be very important in the production of so many crops in various parts of the world. The basic nutrient requirements of a family/genus do not vary so much e.g.: most Proteacea dislike high Phosphates, but the success of species of that family/genus depend so much on local temperatures, rainfall wind, frosts etc. The major climatic factors in Macadamia culture are mean temperatures, heat accumulation, rainfall distribution and the prevalence of destructive winds. The Macadamia Industry in New Zealand, however, is based primarily on the selection of varieties to suit our overall climate, then secondly selecting more suitable climates to increase our yields.

A STUDY OF THE PRODUCTION OF HIGH VALUE CAULIFLOWER CROPS ON A YEAR ROUND BASIS IN CHRISTCHURCH

G. H. Wells

The thesis has three chapters. The first, the introduction, contains a literature review, and describes commercial practices in Christchurch used to produce high value crops of cauliflower, *Brassica oleracea* var *botrytis*, on a year round basis. The development of modern cultivars through selection and hybridization to produce a diverse range of phenotypes is described, and the suitability of particular cultivars for seasonal production is discussed.

The income realised from a commercial crop is due to both the yield and quality of the curd; the white edible portion. The major factors influencing yield are; plant density, nutrient availability, the effect of pests and disease, and the time of curd formation. The conditions that can occur in a curd to down-grade it are described; namely discolouration, riciness and woolliness, bracting, hollow-stem and over-mature.

Policies for year-round production are described by considering, (i) the targetting of the mean harvest date, and (ii) factors affecting the spread of harvest within a single cultivar.

Chapter two describes four experiments, using a presumed appropriate range of cultivars, that were grown by the author at the Horticultural Research Area, at Lincoln College. Crops were harvested during early summer from a protected sowing in late winter; and harvested in late summer, early winter and spring from sowings made in an outdoor seedbed. Curds were cut when assessed mature, trimmed of all leaves, weighed, their diameters measured, then graded according to the incidence and severity of the faults that can occur.

Generally, the recently-selected open-pollinated cultivars and the hybrids produced crops of a higher yield and better curd quality than the older established cultivars.

'Selection 174', 'Hormade' and 'Supersnow 3½ month Hybrid' were the best cultivars for cutting in December and February. 'Supersnow 5½ month Hybrid' produced an exceptionally high yield in August when compared to either 'Ruapehu' or 'Perfected Deepheart'. A range of Walcheren-winter cultivars were used for harvest in October. 'Armado April'. 'Armado Tardo' and 'Markanta' were significantly superior to 'No 4'. The effect of reducing the leaf area for the December transplanted crop was investigated. The results using 'Selection 174' and 'Snowball X' tend to favour the practice as it produced a more uniform crop, and a higher percentage of plants produced a curd of a marketable size and quality.

In the final chapter the results from the experiments are discussed along with aspects of crop establishment and the effect that the weather had on both yield and quality of curds harvested. The study concludes that it should be possible to produce all year round by using the appropriate cultivar. November is the one month when a harvest is not easily attainable.

The range of cultivars available to the grower is being constantly updated. It is suggested that growers should continuously assess performance of cultivars on their own property.

N.B. All theses listed above are deposited in the Lincoln College Library and are available through the N.Z. Libraries' Interloan Service.

Abstracts of papers presented at the Annual Conference of the New Zealand Society for Horticultural Science, held at Lincoln College, September 1985

POT TYPE AFFECTS GROWTH AND YIELD OF GLASSHOUSE RAISED ASPARAGUS SEEDLINGS

A. S. Nikoloff, Peter G. Falloon,
Crop Research Division, DSIR, Lincoln

Four commercial pot types were evaluated for their effect on growth and yield of seedlings before and after transplanting. Seedlings raised in FH508 paper pots produced more shoots and taller fern than any other type at transplanting and differences in plant growth at transplanting affected subsequent growth and yield. (Ferdinand Rootrainers and Paperpots gave the highest yields).

Difference in yield was significant in the 1983 season, but there was no difference in yield in the 1984 season.

Survival was not affected by pot type.

AN OPTIMUM PLOT SIZE FOR ASPARAGUS CULTIVAR TRIALS

T. P. Palmer, A. S. Nikoloff, P. Ensor,
Crop Research Division, DSIR, Lincoln

An asparagus variety trial with 30 new varieties under evaluation, was divided into subplots of four plants. Each subplot was harvested and recorded individually for a harvest season of 6 weeks.

The total yield from subplots was grouped to give continuous pseudo-plots of 4, 8, 12, 16 and 20 plant length.

A split-plot analysis was carried out with varieties as the main treatment. The standard error of the mean was calculated for each plot length and expressed as a percentage of the mean.

It is concluded that a plot length of 20 plants with 4 replications would be the most efficient design, for variety evaluation but that if land was limited smaller plot sizes of 12 or 16 plants could be used.

THE VALUE OF IRRIGATION MANAGEMENT TO CENTRAL OTAGO ORCHARDISTS

G. L. Hutchinson, T. G. Rudge,
Ministry of Agriculture and Fisheries, Alexandra

The expansion of the horticultural industry in Central Otago has lead to development of land with light soils. The traditional irrigation practice of large water applications at long intervals limits yield and quality. Water management is the biggest constraint to stonefruit yields on these soils. This paper assesses the benefits of irrigation management, the costs involved and the return to the grower.

PRACTICAL GUIDELINES FOR WATER SCHEDULING AND FERTILISER APPLICATION IN HORTICULTURE

M. R. Christeller, National Irrigation Adviser,
New Zealand Fruitgrowers Federation

Although the new techniques of drip and microsprinkler irrigation have been accepted as the most effective and economical methods of irrigating our horticultural crops, little research and extension work has been provided to our growers in the form of guidelines for operating fundamentally different irrigation systems. Because only a small proportion of the orchard soil is wetted, the maintenance of both moisture and nutrient levels in these wetted zones requires very frequent application of water and fertiliser and practical means for growers to monitor the status of both these inputs.

Whereas meteorological data have been promoted for water scheduling in many regions of New Zealand, the use of tensiometers appears to provide a more practical solution for growers. This paper discusses the interpretation of tensiometer readings for correct determination of irrigation frequency and depth of wetting.

Fertigation techniques have still not gained wide acceptance in New Zealand as part of a micro irrigation fertiliser programme. In addition the current soil testing procedures used to determine fertiliser requirements have limited relevance for monitoring the application of fertilisers through the irrigation system.

The need for fertigation, acceptable methods of soil sampling and the interpretation of analytical results are discussed in this paper.

PERMEABILITY AND ANATOMICAL CHANGES ASSOCIATED WITH SECONDARY GROWTH OF ACTINIDIA DELICIOSA (KIWIFRUIT) ROOTS

C. W. Lemon, J. A. Considine, Crop Improvement and Plant Genetics Research Unit; Department of Botany, University of Auckland

The developmental changes in structure and histochemistry of kiwifruit roots have been examined with particular emphasis being given to suberised tissues. These studies have demonstrated that in the mature primary root both the endodermis and epidermis are suberised. Secondary growth is characterised by the formation of a periderm in the outer cortex and by continual growth of the endodermis in the mature secondary root the pericycle endodermis and remaining cortical cells form an outer cork 4-5 layers thick.

The development and structure of the root is unusual in that cortical collapse does not accompany secondary development and the integrity of the endodermis is maintained even in roots up to 12 mm diameter.

The significance of these characteristics in determining root permeability is being investigated.

REGULATION OF SHOOT MORPHOLOGY AND WAX SECRETION IN JUVENILE ADVENTITIOUS SHOOTS OF PINUS RADIATA

Christina Webb[1], Jenny Aitken-Christie[2], Kathryn Horgan[2], John Considine[1], [1] Botany Department, University of Auckland; [2] Forest Research Institute, Rotorua

A problem frequently arising in the tissue culture of many plant species is that of 'vitrification', or 'translucency' of shoots. Such shoots typically display a waterlogged, glassy appearance, and may also show distorted growth.

In the micropropagation of adventitious shoots from embryo cotyledons of *Pinus radiata*, both 'translucent' and normal, or 'waxy' shoots arise. In addition, a third phenotype has been recognised; the 'wet' shoot. This phenotype is normal in appearance, but has a wet surface, and the needles tend to adhere. Both 'wet' and 'translucent' shoots are undesirable in culture, since survival on planting out into seed trays is low due to susceptibility to infection and dehydration.

In this paper we will describe both the fine structure and development of each shoot phenotype, and the effect of particular conditions of culture such as light intensity and medium composition on incidence of the disorder.

GROWING PEACH TREES ON MOUNDED BEDS

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The growth of peach trees when planted on flat beds and on mounded beds was compared on a Wakanui silt loam at Lincoln College. Trees were planted in one row in 1981 at 1.5 m spacing, trained to a centre-leader and trickle-irrigated. Flat areas had 0.2 m of topsoil above the clay subsoil and there was 0.4 m of topsoil in the centre of the 3 m wide mounded beds. Measurements in 1984 showed tree root mass and depth to be greater under mounded beds than underneath flat areas. Trees on mounded beds grew faster; their trunk diameters in 1984 were 16% more than trees grown on the flat. Foliage on trees on mounded beds appeared denser and was retained about four weeks longer into the autumn. Winter pruning in 1984 removed significantly more branches from trees grown on mounded beds. No significant difference between treatments was observed in the time of leaf emergence and flowering.

Fruit from trees grown on mounded beds were smaller, but the yield of picked fruit from these trees was 12% greater than the yield from trees on the flat in both 1984 and 1985. Windfall fruit yield from trees on mounds was 22% less than that from trees on the flat in 1984, perhaps indicating a slower ripening of fruit on trees on mounded beds.

Although dry winters did not allow waterlogging to occur and advantages to mounding are small in this experiment, we believe that growers using overhead sprinkler frost protection would benefit from mounded beds and that the range of soils suitable for stone-fruit production can be increased with this technique.

FUNGICIDE — RESISTANT STRAINS OF BOTRYTIS CINEREA IN NEW ZEALAND VINEYARDS

E. P. Laracy, R. E. Beever, Plant Diseases Division, DSIR, Private Bag, Auckland

The incidence of fungicide-resistant strains of *Botrytis cinerea* was surveyed in the four main grape-growing areas — Auckland, Gisborne, Hawke's Bay and Marlborough. Over 60 vineyards were visited close to harvest in March and April 1985 and 20-30 infected berries sampled on each. Isolates were recovered from each berry and tested for resistance by transferring spore suspensions to medium amended with carbendazim (to test for benzimidazole resistance) or with vinclozolin (to test for dicarboximide resistance).

Strains resistant to the benzimidazoles were present in most vineyards even though useage of these fungicides has been negligible for some years. Strains resistant to the dicarboximides were also found on most vineyards, as were strains showing dual resistance to both fungicide groups. Dicarboximide fungicides (iprodione, procymidone or vinclozolin) had been used at least three times on most vineyards visited. The possible loss of efficacy of the dicarboximide fungicides due to resistance will be discussed.

PRELIMINARY STUDIES ON THE EFFECT ON RADIATION AND 'ETHREL' ON BUTTERCUP SQUASH

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After radiating seed (dose 500 rads) and then treating seedlings, which were grown in the field at a 2m x 2m spacing, at the 2 and 4 leaf stage with 300ppm ethrel, fruitset was concentrated on consecutive nodes close to the main stem. Maturity time was similar in treated and untreated plants, possibly because flower opening was delayed in treated plants, and a similar number of slightly smaller fruit matured on treated plants. Vegetative growth was reduced in treated plants, the total length of main and secondary branches being only about half that of untreated plants.

Manipulation of growth and flowering by radiation and ethrel in trailing cultivars of buttercup squash is likely to give advantages in harvesting and marketing the crop. More concentrated fruitset will make the crop easier to harvest. The possiblity of more even maturity will give fruit with better storage characteristics.

INTENSIVE APPLE TREES ON M9 ROOTSTOCK

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Granny Smith, Royal Gala and Cox's Orange apples were planted in 1977 using two growing systems: intensive, with 1905 trees per hectare (1. x 3.5m) on M9 rootstock; and semi-intensive, 635 trees per hectare (3.5 x 4.5m) on MM106 rootstock. The former were trained as spindlebushes, the latter as centre leaders.

The intensive system has consistently produced more fruit. This season (1984/85) it averaged 101 tonnes per hectare of marketable apples, the semi-intensive averaged 74 tonnes per hectare.

The accumulated yield (t/ha) from seven consecutive harvests was: intensive x Granny Smith, 352, semi-intensive x Granny Smith, 204; intensive x Royal Gala, 287; semi-intensive x Royal Gala, 137; intensive x Cox's Orange, 212; semi-intensive x Cox's Orange, 138. The semi-intensive system, averaged over the three cultivars, has accumulated only 56% of the yield from the intensive. No significant differences due to the growing system have been found in either percentage fancy grade or the occurrence of disorders in the fruit after cool storage. The apples grown on the intensive system matured 7-10 days earlier than those from the semi-intensive system.

SOME PHYSIOLOGICAL EFFECTS OF BROMACIL ON ASPARAGUS

Godwin Balasingam, Plant Physiology Division, DSIR, Palmerston North

A clone of Mary Washington 500W was propagated using tissue culture methods. Uniform 18-month-old plants were placed in 1.2L non-draining pots containing coarse sand and grown under controlled environmental conditions. The plants were exposed to a single application of various doses of the herbicide bromacil. Measurements of fluorescence emission from shoot tips as well as shoot growth, shoot death and root fresh weight indicated that bromacil was readily absorbed by the roots and translocated acropetally causing severe initial damage to the photosynthetic apparatus. The plants were found to be susceptible to herbicide damage even at the lowest dose tested of 0.1 mg/pot. The severity and rate of injury increased with increasing bromacil dose. The sequence of injury symptoms observed were: yellowing of cladophylls followed by bleaching and necrosis. The symptons were initially manifested at the cladophyll tips and extended basipetally.

FLORENCE FENNEL — A POSSIBLE NEW CROP FOR THE WAIKATO

J. M. Follett and J. A. Douglas, Ministry of Agriculture and Fisheries, Ruakura

Florence Fennel (*Foeniculum vulgare* var *dulce*) was evaluated at Rukuhia Horticultural Research Area using seven cultivars: Zefa Tardo, Zefa-fino, Perfection, Mantova-solar, Domino and two unselected lines, one from Italy and the other from New Zealand. The cultivars were sown in mid-October and late November and December 1983.

At the first sowing, Zefa Tardo and Zefa-fino produced the highest marketable yield with 27.4 and 10.7 tonnes/ha, respectively. Although the second sowing produced the greatest number of plants, it also had the least number of marketable bulbs due to a high proportion of plants bolting. Again, Zefa Tardo and Zefa-fino had the highest marketable yield, with 11.2 and 10.6 tonnes/ha, respectively. Plant survival was not high for the third sowing. However, all cultivars except the New Zealand line and Montova-solar produced relatively good marketable yields. For the third sowing, Domino and the Italian line produced the highest marketable yield, with 33.1 and 32.0 tonnes/ha, respectively.

Marketable yields were considered below the maximum potential because of poor seed germinating conditions and the tendency for many plants to bolt. Bolting was reduced in the last sowing, and it possibly would be further reduced by more systematic harvesting.

The main export market is identified as Australia; however, for the crop to meet quarantine requirements it needs to be grown in a carrot rust fly-free area or fumigated with methyl bromide.

Pilot trials indicated no adverse reaction to methyl bromide fumigation.

INTER-RELATIONSHIPS OF FRUIT WEIGHT, SEED NUMBER AND SEED WEIGHT IN KIWIFRUIT

N. B. Pyke and P. A. Alspach,
DSIR, Riwaka Research Station (DHP)

The relationship between kiwifruit weight and each of 50-seed weight, total seed weight and seed number is examined. The relationship was generally poor for 50-seed weight. The total seed weight usually provided the highest correlation co-efficient although this was often also remarkably better as a curve than a straight line with both total seed weight and seed number, but particularly the latter. Agronomic management sometimes altered the shape of the fruit weight to seed number curve and some possible explanations are discussed.

A SURVEY OF KIWIFRUIT ROOT DISTRIBUTION IN A RANGE OF NEW ZEALAND SOILS

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Palmerston North

Kiwifruit root systems were surveyed in nine orchards in 1984/85. Orchards ranged in age from four to 50 years old.

Data obtained can be modelled in various ways, including determining root density (mm root/cm3 soil) distribution and the volumes of soil occupied by roots. Results show that roots generally occupy the whole area under a mature (10 + years) canopy down to a depth of 0.7— 4+ m, depending on soil type. Root density is often low within the total occupied volume.

No clear evidence that irrigation affects root distribution was found.

THE INFLUENCE OF PRE AND POST BUD BREAK TEMPERATURES ON FLOWERING IN KIWIFRUIT

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DSIR, Palmerston North

Five-year old vines of kiwifruit (*Actinidia chinensis* Planch.), growing in containers, were placed in controlled environment rooms from approx. 40 days prior to field bud-break until flowering. Prior to bud-break the plants were grown under day/night temperature regimes of 13/3°C and 17/7°C and after bud break at either 17/7°C or 21/11°C; responses to all four growth stages x temperature combinations were examined using four plants of the female cv. Hayward and three plants of the male c.v. Matua in each combination.

Bud-break occurred after approx. 40 days at 17/7°C and at 13/3°C was delayed by a further 12 or 17 days for Matua and Hayward, respectively. The interval from bud-break to flowering was 50 days at 21/11°C for both cultivars and at 17/7°C was approx. 70 and 80 days, respectively, for Matua and Hayward (i.e. each 1°C decrease in mean daily temperature increased the total time to flowering by 10-12 days).

The proportion of bud-break was highest under the cooler temperature regimes but bud-break occurred over a very prolonged period. Conversely, the proportion of fruitful shoots was highest under the warmest temperature regime and was dependent on the entire pre and post bud-break temperature sequence.

INCREASING KIWIFRUIT FLOWERING AND EXPORT YIELD

A. M. Cliffe, M. S. Venning, Farmers Fertiliser Ltd, Auckland

A randomised block trial was laid down in December 1980 to investigate the effects of a single petalfall foliar application of daminozide on female kiwifruit vines. It continued over the next three years with treatments reapplied to the same vines each season. At each harvest the crop was graded to export standards. In 1982-83 a detailed evaluation of bud and flower numbers was carried out.

In the first year of the trial, daminozide treated fruit was significantly larger than untreated fruit.

The following season daminozide increased return bloom. Vines treated previously at 1500 ppm and 2000 ppm carried 56% and 66% respectively more fruit than control vines. This trend continued in each of the two successive years with yield increases over untreated of 54% and 51% (82-83) and 29% and 28% (83-84) respectively for each rate. Over years 2, 3 and 4 of the trial, the average export packout was 16.1 trays per untreated vine and 25.1 trays for each daminozide treated vine.

Daminozide treated vines carried more buds per metre of cane. A higher percentage of these produced fruitful laterals and each lateral carried more flowers.

ASSESSING FROST RISK IN STONEFRUIT IN NEW ZEALAND

H. C. Smith and A. T. G. McArthur,
Agricultural Research Consultant and Lincoln College

This paper uses meteorological and flowering data to assess crop losses from peaches and nectarines using simulation. This procedure provides the framework for making decisions about frost protection expenditure, diversification with varieties, and the development of insurance schemes to reduce the risk of frost losses.

SUMMER PLANTING OF STRAWBERRIES IN AUCKLAND

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Department of Horticulture, Lincoln

Tioga strawberry plants were dug on 15 May, 30 May, 16 June, 15 July and 29 July, 1981 and cold-stored at −2.2°C until planting on the 15 December 1981, 15 January, 15 February, 15 March and 15 April 1982. There were three harvest periods; January to June 1982, October, November 1982 and January, February 1983. The second harvest period was the most significant. Plants from the first digging date were too immature for long-term storage and produced significantly less fruit than the later digging dates. The first planting date produced the highest mean yield. The later the planting date, the lower the mean yield. A delay in planting increased the percentage of marketable grade fruit.

NEW ZEALAND FRUIT BREEDING

T. P. Palmer, Landale, Christchurch

Horticultural production, fruit production and especially kiwifruit production have been promoted as important export earners for New Zealand. New Zealand producers have no particular soil or climatic advantages over other Southern Hemisphere producers, and are further from most major markets. Advantages of expertise are being eroded by Northern Hemisphere Agri-business operating in South America.

New Zealand producers will retain markets only by producing higher quality produce than competitors. Basic to this is first access to superior cultivars.

New Zealand fruit breeding effort is inadequate to meet the industry need. Resources should be mustered and deployed more effectively. The present breeding establishment seems unable to respond to the challenge. Reforms are suggested.

STORAGE AND HANDLING TRIALS WITH FEIJOAS

T.V. Thorp and J. D. Klein, DSIR, Auckland

Feijoa *(Feijoa sellowiana)* fruit stored at 0°C for 3 to 8 weeks developed chilling injury (CI), which increased in severity during 7-10 days shelf-life. External CI appeared as sunken spots at the stem end, while internal CI manifested as browning of the vascular elements. Fruit stored at 4°C had much less CI. 'Triumph' feijoas stored in polybags at 0° or 4°C showed more internal browning and rots than control fruit. Dipping fruit in 2.5% $CaCl_2$ prior to 8 weeks storage at 0°C did not prevent internal browning or rots during the 1984 season. 'Gemini' and 'Apollo' fruit dipped in 50°C water for 5 minutes had severe scald after 3 weeks stroage at 0°C, but not at 4°C. 'Apollo' and 'Triumph' held 3-4 weeks at 0°C or 4°C showed no scald after a 2-2.5 minute dip in 50°C water. Triumph' held at 38°C in high humidity for 24 hours showed severe external scald even prior to placement in storage. Fruit bruised by dropping 40cm to a hard surface showed no external damage until 7 days after treatment; internal browning was evident within 24 hours. Fungal rots developed at point of impact during 4-6 weeks storage. In all three varieties, % soluble solids and % titratable acidity (expressed as citric acid) decreased 10-20% and 30-60% respectively during 10 days shelf-life at 20°C after storage, regardless of prestorage treatment.

IRRIGATION TIMING: A MANAGEMENT TOOL FOR AUTUMN CROPPING RASPBERRIES

David Jordan, Ruakura Soil and Plant Research Station, MAF, Hamilton; Phil Rhodes, Templeton Research Station, MAF, Canterbury

The effect of irrigation on autumn cropping raspberry plant establishment and first season production was investigated at Rukuhia Horticultural Research Area, Hamilton (1983-84) and Templeton Research Station (1984-85). Plants were irrigated under four strategies: (1) Irrigated throughout season, (2) Irrigation up to first fruit set only (early January), (3) Irrigated from first fruit set only, (4) Not irrigated.

At Rukuhia, mid-season yields were about 20% higher from 'Heritage' plants irrigated throughout or up to first fruit set than plants not irrigated or irrigated from first fruit set. However, late season yields were about 40% greater when plants were not irrigated or irrigated from first fruit set. Also, late season berry size was greater than that on plants irrigated throughout or up to first fruit set. Total yield was similar for all treatments. These responses occurred in a season with few days of water deficit.

Early results at Templeton showed early season irrigation improved 'Heritage' yields but tended to depress 'Southland' yields. 'Heritage' performed best when irrigated throughout or up to first fruit set. 'Southland' plants irrigated from first set had 2-3 fold higher yields than the other treatments. Many days of water deficit caused visible stress in non-irrigated plants.

Strategic irrigation application has the potential to be a management tool for autumn raspberry production. This will be discussed.

GREENHOUSE PRODUCTION OF BOUVARDIA

Kate I. Caldwell, Conway Ll. Powell, Pukekohe Horticultural Research Station, MAF

Bouvardia is a perennial cut-flower crop in the family Rubiaceae, endemic to Central and Southern America, which is now being evaluated at Pukekohe for its export potential. Rooted cuttings of three cultivars (red, pink and white) were raised under mist and transplanted into a glasshouse into 1.0m wide beds at 21 plants/m² being picked by the end of this first flush (9.4.85). Similarly, harvesting of the pink and white cultivars began at 15.2.85 with 54 and 39 stems/m² being produced in the first flush. Supplementary light is being used over winter to ensure that flower stem length and quality is maintained in this short day plant. Post harvest studies indicate that Bouvardia flower stems may have up to a two week vase life if they are harvested in tight bud and treated before and after transport with suitable preservatives.

NITRATE REDUCTASE — A KEY ENZYME AFFECTING WINE GRAPE QUALITY?

R. S. Smart, S. M. Smith and G. S. Smith, Ruakura Soil and Plant Research Station, Hamilton

Studies in New Zealand and elsewhere have shown that shade of grapevine canopies leads to increased fruit K levels and pH, an undesirable compositional change. Studies at Te Kauwhata and Ruakura have investigated the effects of cultivar, light quantity and quality, training systems and time of day on nitrate reductase activity (NRA) and its association with fruit composition. Shade light within canopies reduced NRA, with which was associated higher K levels in the leaves and fruit. There was little diurnal variation in NRA measured before harvest, but east-facing canopy sides had slightly higher values of NRA than west-facing. Glasshouse studies showed a difference in NRA between cultivars, and that neutral shade delayed the ripening of Cabernet Sauvignon fruit and reduced NRA. These effects were particularly overcome by increasing the ratio of red to far red light.

LATITUDE-CORRECTED DEGREE DAYS (LDD)

D. I. Jackson, Department of Horticulture, Landscape and Parks, Lincoln College

Climatic data from 39 European and New World wine districts were related to the grapes shown in each. These districts were chosen as cool climates of Regions I and II which had gained or are gaining reputations for quality. It was shown that Degree Days or the Mean Temperature of the warmest month (MTWM) was inadequate for separating districts in Region 1 and a new concept was derived. This is called Latitude-Corrected Degree Days (LDD): LDD = MTWM x (y0-latitude). It is very effective in distinguishing the ripening capacity of cool-climate areas. Groups are designated as sub-groups of Region 1. Gewurztraminer, Muller Thurgau, Pinot gris, Pinot blanc, Chardonnay are examples of Group A which has LDD below 190. Between 190 + 270 grapes in Group B are normally grown, significant cultivars being Pinot noir and Riesling. In Group C, 270-380, Cabernet Sauvignon, Sauvignon blanc, Semillon are among the important grapes found. Above 380 Grenache, Cinsaut, Palomino and other warm climate grapes are used and this LDD overlaps Regions II-V. One significant discrepancy was shown to include eight districts where grapes grown were of a lower group than LDD suggested could be ripened. It was discovered that these were all districts with rainfall over 800 mm p.a. It is suggested that such rain, especially in the autumn, can be expected to lower the group to the one below the LDD predicted. Cold winter temperatures in continental areas have a similar effect.

A Checklist for the Cultivar Names of Hebe

One of the lesser known activities of the RNZIH is its role as the International Registration Authority for the following genera of native plants — *Leptospermum, Hebe, Phormium, Pittosporum* and *Coprosma*. In this capacity the Royal New Zealand Institute of Horticulture was appointed by the International Commission for the Nomenclature for cultivated plants, which has its headquarters at the Hague in the Netherlands.

The compilation of a check list of cultivar names is an exacting and time consuming project and especially so for that of *Hebe*, which has taken more than fourteen years. In general, cultivar names are not nearly as well documented as botanical names, much of the information being in the form of sketchy descriptions in nursery catalogues. A further complication is the fact that most of the cultivars have originated overseas with the consequence that required information has, at times, been very difficult to obtain.

The Check List of *Hebe* Cultivar Names has been prepared for publication in the New Zealand Journal of Botany, where it should appear next year. It contains an index of some 500 cultivar names, with synonyms cross-indexed to the currently accepted name. Not unexpectedly, when work of this nature is undertaken, there are a few surprises, as the sample page from the manuscript demonstrates.

The aim of such a check list is to document all known cultivar names in the genus, and to promote uniformity, accuracy and fixity in the naming of all *Hebe* cultivars now in cultivation.

Editors Note: The Checklist of *Hebe* cultivars has been compiled over the past 14 years by Mr Lawrie Metcalf, a National Executive member of the RNZIH and Director of Parks and Recreation, Invercargill City Council. The RNZIH is indebted to Mr Metcalf for his care and dedication in producing The Checklist.

'Evansii' Courtright in Trees & Shrubs for Western Gardens. 1979, 50. H. 'Rubra' Hort. The leaves are a blend of dark green and reddish-purple, about two inches long. Flowers are three inches and reddish-purple. Blooms in summer. Could have originated at Evans and Reeves Nursery in southern California.

'Eveline' *The Garden* 23.12.1893. *Veronica Gautlettii* Gauntlett *nurs. cat.* 910,183. 'rose lilac'. In Gauntlett's catalogue it is described as enormous spikes 6 inches long, of the richest salmon-pink; handsome foliage. Both 'Eveline' and 'Gauntlettii" have been grown side by side and there are no noticeable differences between the two cultivars, therefore the epithet 'Eveline' must take precedence. In New Zealand this cultivar has variously been known as 'Payne's Pink', 'Pink Payne', 'Rainer's Beauty' and *H. speciosa* 'Pink'. Probably originated at Cawdonia Nursery, Guernsey, in the Channel Islands sometime during the latter half of the last century.

'Evelyn' Hort. *Veronica* 'Evelyn' Bean in Trees and Shrubs Hardy in the Brit. Isles 7th ed. 3, 1951,477. Flowers rich carmine. In general characters and appearance very similar to 'Eveline', but appears to differ in its larger leaves and racemes.

'Eversley Seedling' Bean in Trees & Shrubs Hardy in the Brt. Isles 8th ed. 1973, 349. described as having erect narrow red-brown edged leaves, erect brown stems and short spikes of mauvey-blue flowers. Seldom out of bloom. Some authorities consider that this may be the . . . .