Management of the plant collection at the Eastwoodhill Arboretum

Volume I

A thesis presented in partial
fulfilment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

in Horticultural Science at
Massey University.

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1996

Abstract

Eastwoodhill Arboretum at Ngatapa, near Gisborne, New Zealand, was developed by the late William Douglas Cook (1884-1967). Between 1920 and 1960, Cook planted an extensive range of exotic woody trees, shrubs and climbers throughout 65 hectares of the 130 hectare property. Considered by many to be an important collection in New Zealand, the Arboretum deteriorated during Cook's latter years due to diminishing time and resources for maintenance. An Act of Parliament in 1975 established the Eastwoodhill Trust Board and empowered them to 'maintain and develop the property as an arboretum'. Under the Board's direction, a clearing strategy was initiated to solve the problems of overcrowding and poor plant condition in the Arboretum and to establish a catalogue of the collection.

To meet their obligations under the Act, the Trust Board had to focus their management on the plant collection. The biological value of the Arboretum had to be sustained, particularly with respect to issues of conservation and biodiversity. The visual value of the Arboretum, an important factor for attracting public support, had deteriorated and required intervention. Moreover, as the landscape of the Arboretum was not a natural system and lacked self-regulating processes for renewal of important plants or plant groupings, systematic management was needed to sustain the collection within this human-made landscape. The Trust Board's efforts to address these issues were hampered by a lack of resources and appropriate data.

This research reports the results of an extensive landscape management study of the collection and develops and characterises the data and management processes needed for long term management of the biological value of the Arboretum. Although management frameworks and processes for landscape management have been reported in the literature, most operate at scales inappropriate for single sites and none focus upon the human-made landscape of an arboretum. Thus, while common characteristics of these processes (e.g. inventory, evaluation, development of goals and strategies) provided a basic framework, their application to an arboretum required development.

A complete and current inventory of the plant collection was made. The Arboretum was mapped at 1:200 using a grid square method, and a catalogue formed listing every plant in the collection. A second catalogue recorded the extensive range of accessions that had previously been in the collection but which no longer existed. In addition, about 1200 herbarium samples were made, two potential database formats developed for the data, and a record of management history formulated.

Although the inventory showed that the collection was extensive, its importance could only be established through an evaluation. As an extensive literature search failed to locate a suitable

process for evaluating a plant collection on a single site, a novel process was proposed that evaluated the site using two key concepts, significance and condition, and linked this evaluation to the goals of the Arboretum. Significance, a measure of the importance of a site according to selected landscape values, was determined using various indicators of diversity and rarity. Analysis revealed that Eastwoodhill was the most significant collection of its type in New Zealand, with 1666 species and 962 cultivars of trees, shrubs and climbers, of which 73% were of northern hemisphere origin and 41% of Asian origin. Eighty percent of species and cultivars in the collection were not readily available from commercial sources in New Zealand, and 102 species were on world conservation lists. These data were used to identify the most significant genera in the collection. The second concept, condition, measures health (in the broadest sense) of the site using such indicators as age, density, and maturity. Measurements of age and density showed that condition of the collection was below optimum. Moreover, plant death, particularly of short lived species, had changed the composition of the collection to the extent that about 53% of the plants collected by Cook no longer existed.

The evaluation process also revealed that while the collection had the potential to meet existing goals, condition was not ideal and unless it was improved significance could be lost. This interaction between significance and condition lead to the proposal of a new concept for 'landscape category' as a framework for describing the relationship between the two factors. Four categories, each requiring different management actions, were derived and discussed. The mission of the arboretum indicates which category is required, while the evaluation data show which category actually applies. To achieve the role of an arboretum in the long term Eastwoodhill needs to be a category one landscape (i.e. significant and in good condition), but is currently in category two (i.e. significant but with condition below par). This discrepancy between actual category and required category indicated the subsequent management action necessary to bring the Arboretum to category one status.

The second new concept arising from this research was developed as part of the processing stage of the evaluation. As Eastwoodhill is an arboretum, and biological value underpins its primary purpose, both biological significance and condition must be excellent. But vegetation also has aesthetic values, particularly visual qualities, and these play an essential role in many of the human values associated with arboreta. Landscape management paradigms were established to provide a framework for managing the balance between biological and visual value of a site. The paradigms describe a hierarchy for managing the interplay between biological and visual values, and can be configured for either value in the primary position. This concept provides a framework for integrating values and prioritising subsequent management actions. The evaluation data,

landscape category, and landscape management paradigms were used to propose management actions and priorities for those actions.

Three workshops were conducted during the course of this research to address a series of collection management issues. Conducted using a systematic management approach, the workshops involved a panel of experts using the data from inventory and evaluation to prepare three reports outlining plans and decisions for short and long term management of the plant collection. An important long term outcome was an assessment of the collection using botanical and aesthetic rating scales to determine the intrinsic importance of the genera in the collection. These data were used to identify the 'key' genera that would form the focus of collection development and to determine roles for the Arboretum. Detailed operational plans for three parks and two key genera within the Arboretum were also prepared during the workshops. Park plans covered objectives for the park, composition of the park, botanical and aesthetic importance of plants in the park, and future development strategies. Genus plans covered composition of that genus in the collection, status of key plants in the field, and future development policies. A key feature of park and genus plans was a system of rating scales used to determine plant status and prioritise management decisions. Development of park and genus plans led to a proposal for a method for vegetation management in human-made landscapes.

Overall synthesis of the management process led to a proposal for a model for management of a plant collection that could be applied to Eastwoodhill and other plant collections. Understanding of the underpinning principles allows the model to be readily adapted for application to other landscapes.

keywords: arboretum management, botanic garden management, landscape evaluation, landscape inventory, landscape management, plant collection, vegetation management.

Acknowledgements

I am very appreciative of the efforts of my supervisors in helping me complete this work. Dr David Chalmers was an enthusiastic participant in the workshops, and provided valuable editorial comment on early drafts of this thesis. In more recent times Dr Tony Jackman and Professor Errol Hewett made themselves available for consultation and I am grateful for their patient, thorough and timely edits of this work.

I wish to thank the Department of Plant Science and Massey University for the opportunity to undertake postgraduate study. I am particularly grateful to Professor Robert Anderson, Dean of Agricultural and Horticultural Sciences, for encouraging me to undertake the early visits to Eastwoodhill that led to this work being started.

The Eastwoodhill Trust Board and associates played a key role in this work. I thank them for making the Arboretum and its facilities available for this study, and for their willingness to support and participate in the workshops. The curator, Mr Clapperton, provided hospitality on many occasions and assisted with information and frequent discussions about the Arboretum.

This work would not have been possible without the funding support provided by the Massey University Agricultural Research Foundation, the C. Alma Baker Trust, the New Zealand Lottery Board, the Massey University Research Fund and the Faculty of Agricultural and Horticultural Sciences. I am grateful to these bodies for their support.

Studying the plant collection at Eastwoodhill required considerable field work and regular visits to Gisborne. I am very grateful to Stuart and Jackie Davis, for extending their hospitality to me on numerous occasions and allowing me to use their home as a base for my field work.

My family and friends have continued to give moral support to this endeavour. My parents, and my friends Pam Howell and Elizabeth Patching, deserve special mention for always being available with time to listen and give encouragement.

Finally, and most of all, my husband Bruce deserves the highest praise for his unlimited dedication and patience over many years. He gave energy, drive, and generosity of spirit that helped me complete this work and I am deeply grateful to him for his continued encouragement and contribution throughout this study.

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List of abbreviations

BGCI	Botanic Gardens Conservation International
CBA	Cost Benefit Analysis
dbh	Diameter at breast height
EIA	Environmental Impact Assessment
FRST	Foundation for Science, Research and Technology
GIS	Geographic information system
GPS	Global positioning system
IDS	International Dendrology Society
ITF	International Transfer Format
IUCN	International Union for the Conservation of Nature and Natural Resources
NCCPG	National Council for the Conservation of Plants and Gardens (Britain)
RNZIH	Royal New Zealand Institute of Horticulture

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Chapter 1

Introduction

Magnolia campbellii, Birch Hill Pond, August 1989

1.1 The Eastwoodhill Arboretum

The Eastwoodhill Arboretum is a 131 hectare property situated 35km inland from the city of Gisborne, on the East Coast of the North Island of New Zealand (Figures 1.1, 1.2, 1.3). The Arboretum was created by the late William Douglas Cook (1884-1967), and is now owned and administered by the Eastwoodhill Trust Board who operate the property under the mandate of the Eastwoodhill Trust Act (1975) and the Eastwoodhill Trust Amendment Act (1994). The Arboretum is "Lot 1, Deposited Plan 4294, situated in Blocks IX and X, Waikohu survey district, and being the balance of the land comprised in certificate of title No. 1A/687, Gisborne Land Registry" (Eastwoodhill Trust Act, 1975). Latitude is 38 degrees 33 minutes South, longitude 177 degrees 40 minutes East (Berry, 1982).

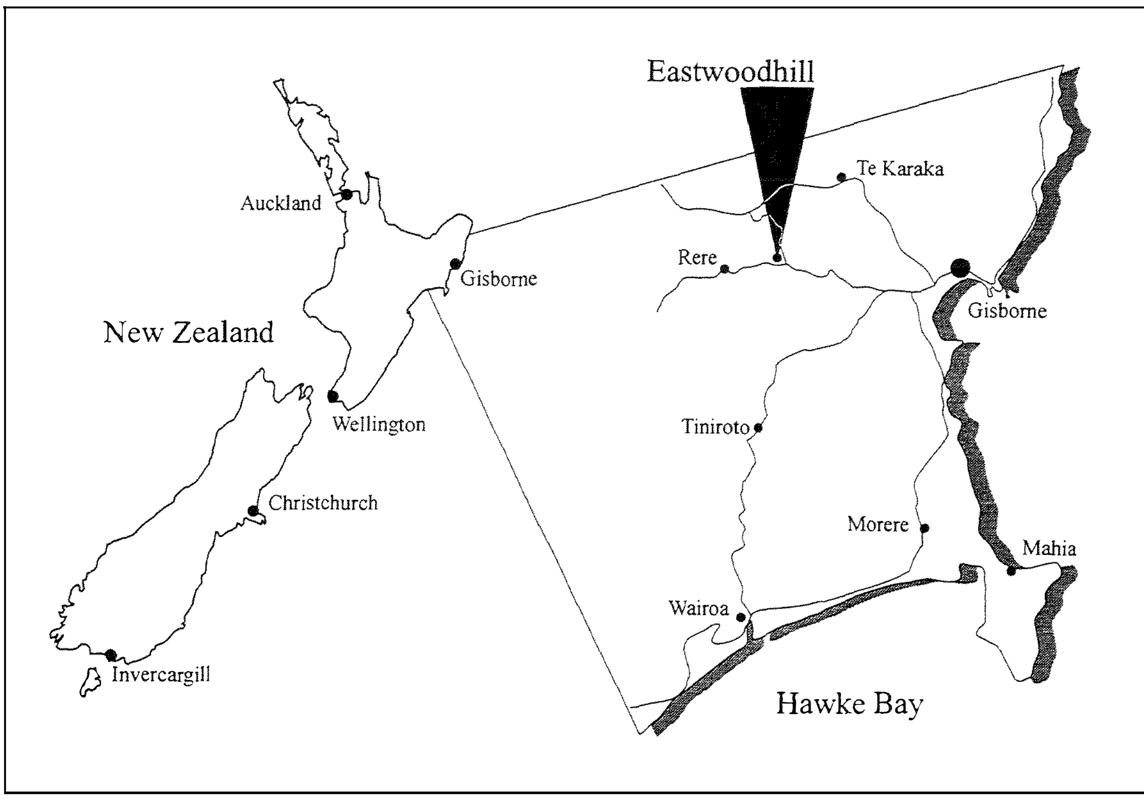


Figure 1.1 Location of Eastwoodhill Arboretum

The district is an agricultural area with a predominance of sheep, beef and deer farming although some horticultural production (e.g. fruit and vegetable production) exists. The climate of the area is temperate to subtropical with about 2200 hours of sunshine and an annual range of mean temperature of 7-20 °C for elevations below 500m (Hessell, 1980). Comparison of average annual minimum temperatures puts the Gisborne area between zones nine and ten of the American system (Anon., 1990; New Zealand Meteorological Service, 1983). The winter minimum at Gisborne Airport can reach minus 3.5 °C, but Eastwoodhill is at a higher elevation and Douglas Cook reported that minus 8-12 °C could occur (Cook, 1949). Ground frosts are likely on 40 days per year at Gisborne Airport (New Zealand Meteorological Service, 1983). Eastwoodhill receives about 1200mm of rainfall, mostly in winter and with periods of low rainfall common from October to February (Cook, 1949; Hessell, 1980). The property is situated on rolling to steep hill country with poorly drained pumice, ash and clay based soils (Rijkse and McLeod, 1993). Eastwoodhill varies between 70m above sea level at the valley floor, 160m above sea level at the house, and 220m above sea level at the highest point. The climate is cool enough for most *Prunus* and *Malus*, while the summers generally have sufficient heat for some subtropical *Michelia*, but are too warm for many *Abies* and *Picea* (Cook, 1949).

The property is divided into two broad sections (Figure 1.4): the Arboretum of 65 hectares which contains mature plantings, and the remaining 65 hectares which, until recently, was farmed and did not contain any significant planting. In the last five years shelter and soil stabilisation plantings have been made in the latter area, in preparation for eventual arboretum planting.

The Arboretum section of the property is divided into named parks (Figure 1.5). The land is predominantly flat through Pear Park, Corner Park, and the Circus, but develops into steep hills and valleys in Cabin Park, Douglas Park, Orchard Hill, and Glen Douglas. A complex network of tracks overlays each park, generally following the contour of the landform. There is a series of human-made ponds in Glen Douglas, Douglas Park and the Circus, which are connected by seasonal streams in the valley floors.

The Arboretum contains about 2600 species and cultivars of northern hemisphere trees, shrubs and climbers, with *Acer, Prunus, Magnolia, Malus, Pinus,* and *Quercus* the predominant genera. In total there are about 6000 individual plants in the Arboretum.

1.1.1 Douglas Cook and the creation of the Eastwoodhill Arboretum

The current composition and arrangement of the Arboretum reflects its history of development. The Arboretum was the life's work of its creator, William Douglas Cook, who came to the Gisborne district in 1910 to take up 250 hectares (600 acres) of farm land from the Ngatapa subdivision. Although Douglas Cook started out as a farmer, his ambition was to plant trees: "I had always loved beauty round me and in less than six months had quite a garden surrounding my one room shack. Plantations were put in and an acre of mixed orchard. A cow paddock was enclosed, and in my secret heart I hoped that some day all of that paddock would be a garden and shrubbery. I dared not tell a soul of my hope as it seemed in those days of struggle almost stupid to cherish such an ambitious hope as there must have been quite six acres" (Cook, 1948). Flowers, orchards and woodlots were planted in 1910 (Clapperton, 1992).

Figure 1.2 Eastwoodhill Arboretum in summer, February 1990.

Figure 1.3 Eastwoodhill Arboretum in autumn, March 1989.

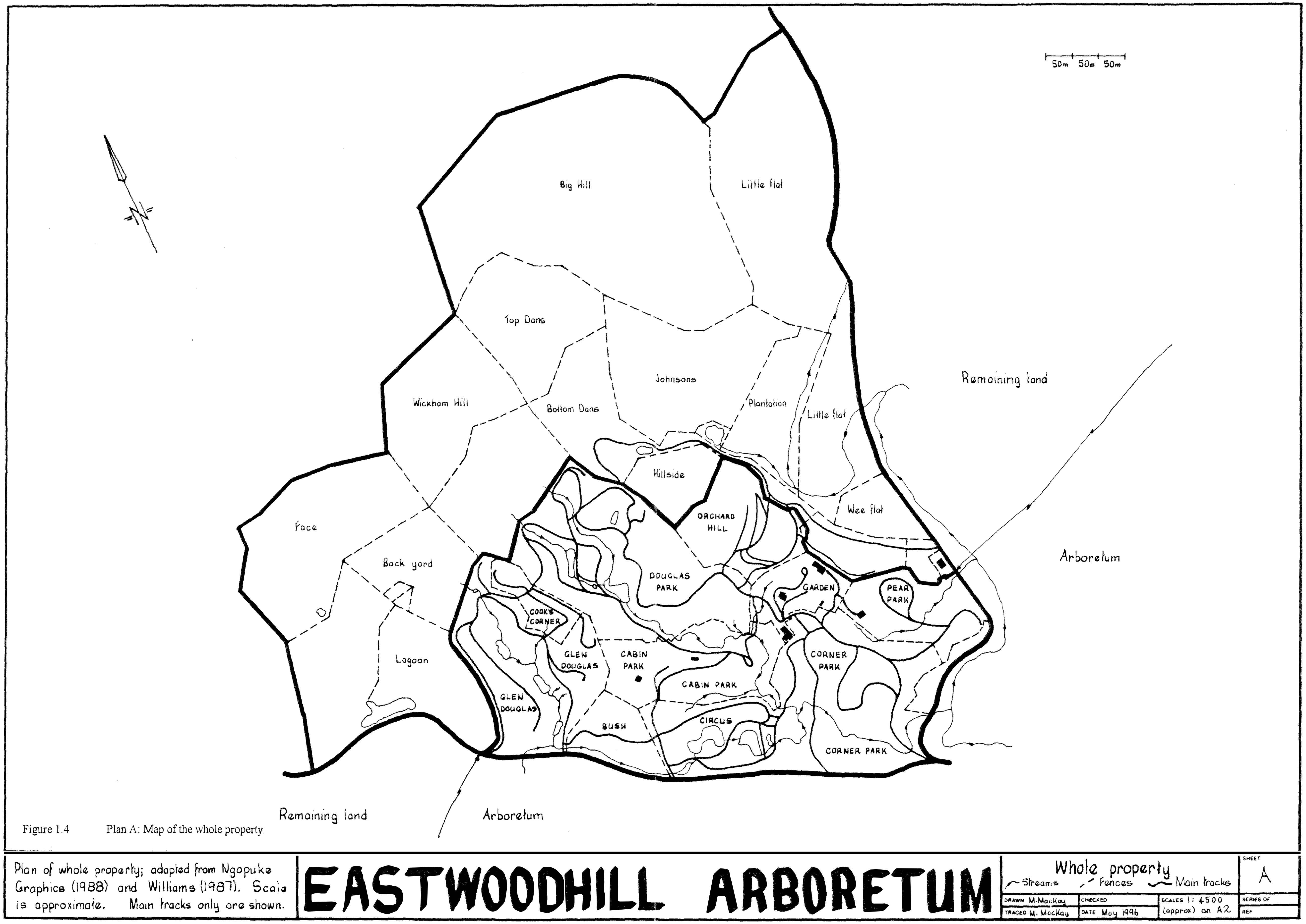


Figure 1.4 Plan A: Map of the whole property.

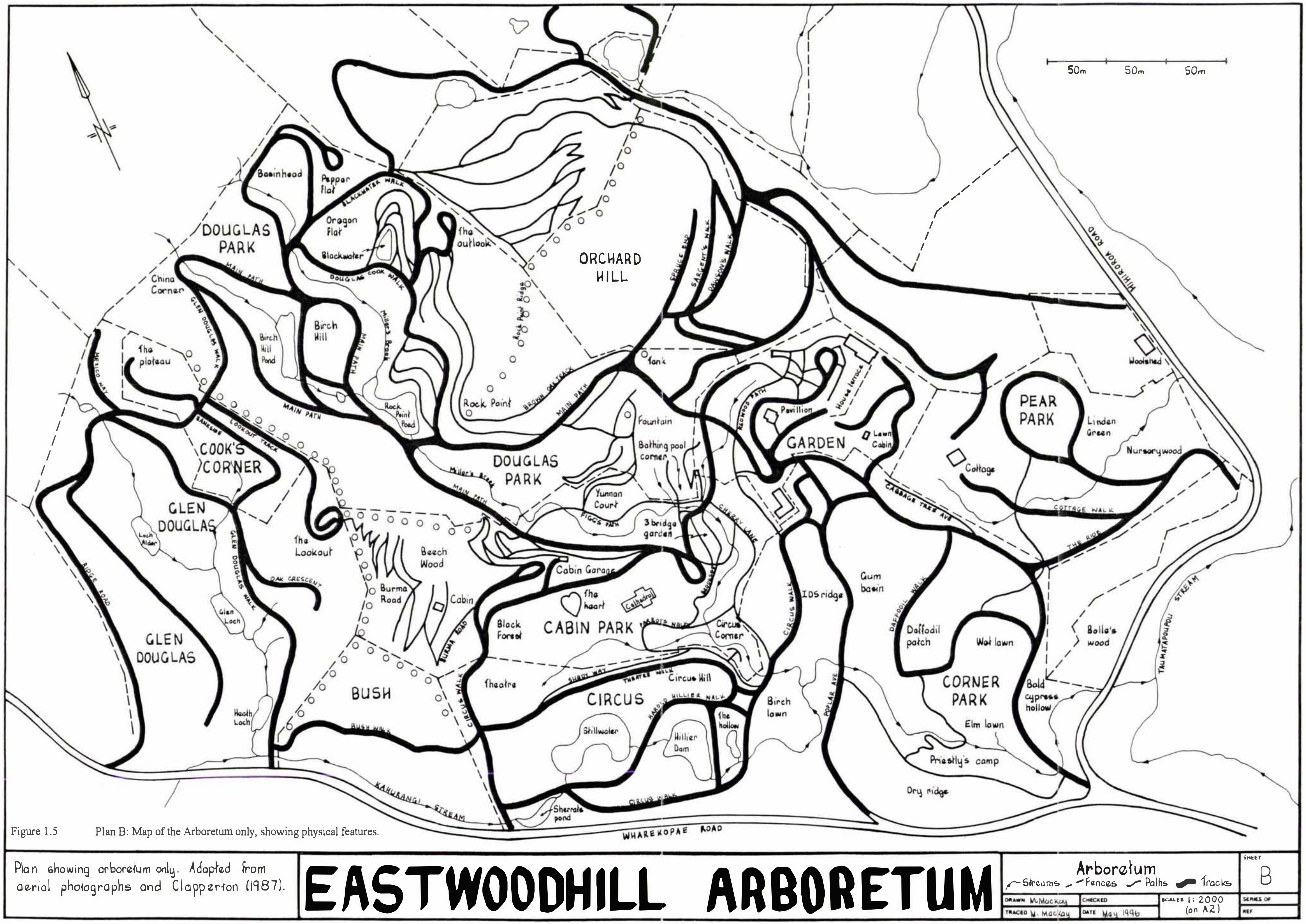


Figure 1.5 Plan B: Map of the Arboretum only, showing physical features.

In 1914 Cook was sent to war in France, but was injured and sent to England to recuperate. His stay in English country homes fuelled his ambition for parks and planting: "During the war I stayed in several beautiful country homes in Britain and this left me with a growing desire to create something worthwhile in New Zealand" (Cook, 1948). "I loved the country scene in England and its beautiful parks and wondered how far I could get in the creation of a park in one lifetime. I determined to make a start" (Cook, 1949).

The first arboretum plantings were made in 1918 and were mostly large growing species (e.g. *Pinus radiata* and *Eucalyptus spp.*) planted as woodlots and shelter plantings, with *Platanus orientalis, Acer platanoides*, and *Ulmus spp.* along road boundaries and as specimens (Cook, 1949). The main entrance drive, Poplar Avenue, was planted in 1918, followed in 1920 by a large planting of trees and shrubs for the Gardens (Figures 1.6, 1.7), and then an expansion of the gardens in 1926 (Clapperton, 1992; Cook, 1949). Cook began 'serious' planting of the parks from about 1927 onwards and he intended to collect a wide range of material. "Eastwoodhill is very young yet but it has made a good start and my ambition is to grow every worthwhile tree and shrub which will grow in our conditions" (Cook, 1949). He started planting Corner Park in 1927 (Figure 1.8), the Black Forest, Burma Road and Beech Forest sections of Cabin Park in 1934/35, and the Millar's Brook section of Cabin Park (including Bathing Pool Corner) in 1937, and Circus Corner in 1938 (Clapperton, 1992; Cook, 1948, 1949, 1950a). After the second world war he planted part of Douglas Park in 1945 (Figure 1.9, 1.10, 1.11), Pear Park from 1950, and Orchard Hill in the mid 1950s (Clapperton, 1992; Cook, 1949, 1963). Finally, the Circus was planted in 1959 (Figure 1.12), Glen Douglas in 1960 (Figure 1.13), and the later parts of Douglas Park (Blackwater and Basinhead) in 1961 (Cook, 1963).

Douglas Cook wanted to create an Arboretum of exotic material and was not particularly interested in New Zealand plants (Cook, 1949). "We grow quite a number of native trees, but they do not thrive and I am much more interested in those from other lands" (Cook, 1949). He particularly wanted to grow rhododendrons (Cook, 1949) but came to realise that they were not suited to the region (Cook, 1950b) mainly due to summer droughts. "Rhododendrons do not do well, and, were it not for my love for them, I would have abandoned them long ago" (Cook, undated c). At the same time he collected a wide range of exotic plants. "Very large numbers of *Acer* are doing well here and also a great many species and varieties of *Aesculus, Betula, Fagus, Fraxinus, Buddleia, Euonymus, Juniperus, Larix, Nothofagus*, and many other genera" (Cook, 1949). "*Acer* and *Quercus* are always increasing. Rhododendrons, azaleas, camellias I couldn't count" (Cook, undated d).

He was very serious about his work and was not interested in the casual visitor or those who did not know something about trees: "It is not a one-day walk for anyone who is interested to see this place now, and I fear I get little pleasure from showing people round who are not. There are many who come here to view and then go away and air their ignorance - but I am pleased to show true gardeners round or people who appreciate beauty and can sense the restfulness of the place" (Cook, 1948).

Douglas Cook brought about 5000 different species and cultivars of trees and shrubs to Eastwoodhill, although the number of individual plants was much larger as many species were purchased several times. Many plants were imported from well known British nurseries such as Hilliers, Veitchs and Slococks, with other material being obtained from New Zealand nurseries such as Duncan and Davies in New Plymouth and Harrisons in Palmerston North. "I first got everything the New Zealand catalogues had to offer, then searched England for new material. I read Bean's three volumes from cover to cover and noted everything that sounded interesting - and got them" (Cook, undated c).

Douglas Cook hoped that one day his Arboretum would become a public park, but worried that he would be unable to complete the job himself. "I am becoming crippled with arthritis and need someone young here to take on my job and get to understand my aim. Someone with energy and some money, with all his life ahead of him and who does not make money his aim. Someone who can give, as I have given, to create something beautiful, some place restful, in a world full of trouble and full of hates and greed" (Cook, 1948). He continued planting until about 1960. He wrote several times of having worked for the good of the nation: "Our work all goes to make New Zealand more beautiful and future New Zealanders happier. I'm not working for myself - I'm working for my country and its people whom I love" (Cook, 1963).

After spending his lifetime fulfilling his ambition, by the early 1960s Douglas Cook was almost penniless. Reflecting upon his efforts in 1963 he wrote: "I've suffered all the setbacks any man could. Poor food, living alone, depression through lack of money and at times through ill health through worry. I've never squandered money but I've always been in debt. I always felt I had lots of security if not money and the family motto being "Forward". I've always gone forward - I'd never let it down. If to be poor is to prove oneself a failure then I've failed but I've left a heritage behind me for future generations of New Zealanders to enjoy" (Cook, 1963).

In his latter years Douglas Cook became anxious that his Arboretum should be preserved. He proposed that the government take it as a national Arboretum, but it refused (Cook, 1964a). He then negotiated for several years with the Royal New Zealand Institute of Horticulture (RNZIH),

Figure 1.6 Photograph of the Gardens, October 1989.

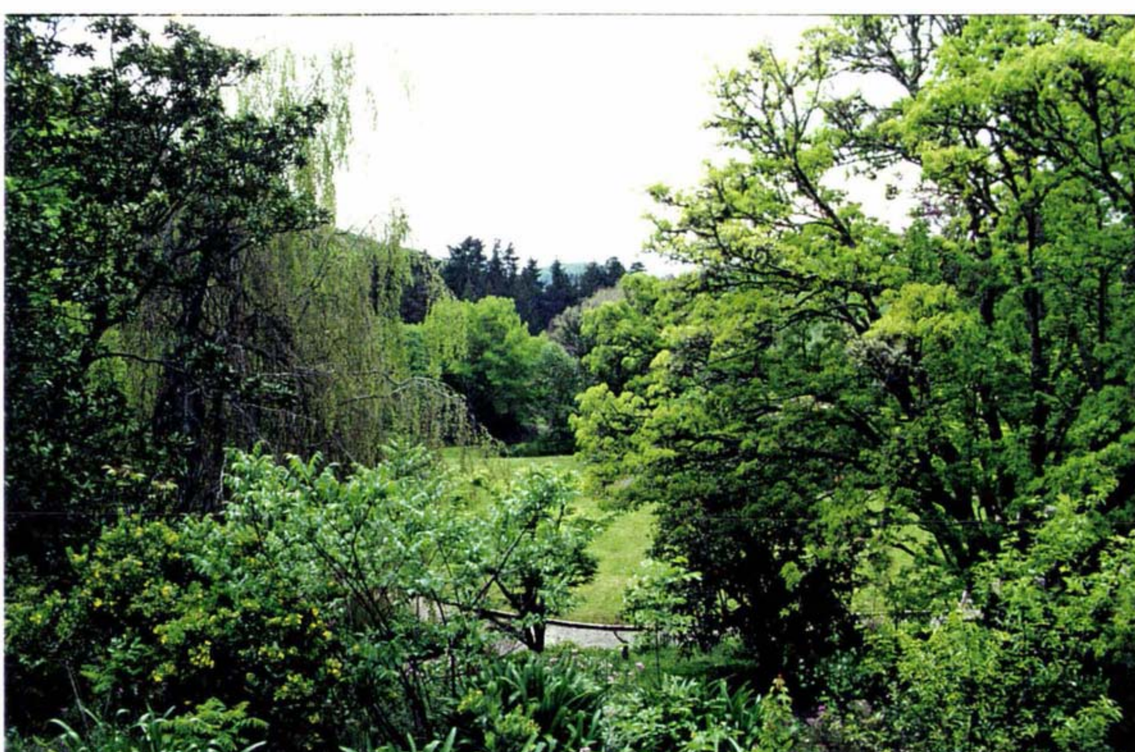


Figure 1.7 Photograph of the Gardens, October 1989.

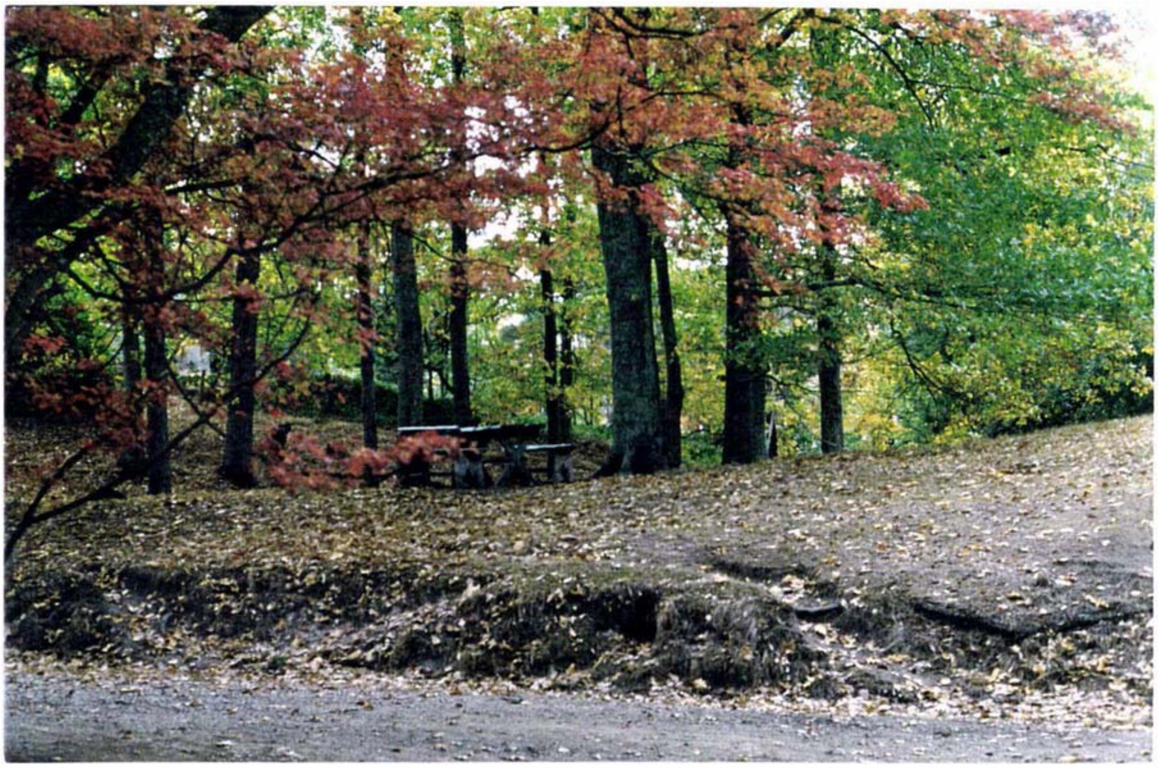


Figure 1.8 Photograph of a section of Corner Park, autumn 1989.

Figure 1.9 Photograph of the Fountain section of Douglas Park, April 1993.

Figure 1.10 Photograph of Rock Point Pond in Douglas Park, April 1993.

Figure 1.11 Photograph of Birch Hill Pond in Douglas Park, March 1990.

Figure 1.12 Photograph of the Circus, looking over Hillier Dam, March 1990.

Figure 1.13 Photograph of Glen Douglas, April 1993.

but again was unsuccessful (Cook, 1964a, 1964b). Finally, in 1965, the Arboretum was purchased by local businessman Mr H.B. Williams.

1.1.2 Formation of the Trust Board

After Cook's death in 1967, Mr Williams initiated new discussions with both the RNZIH and the Forest Service who both supported preserving the Arboretum but could not offer any financial assistance. A merger with Pukeiti Rhododendron Trust and a Crown conservation area were also considered but neither went ahead. In 1970 it was proposed that Eastwoodhill be established as a trust and, after considerable work, a Private Members Bill was put to Parliament. In 1975 the Eastwoodhill Trust Act (1975) was passed and the Eastwoodhill Trust Board formed. In 1994 the Act was amended with changes being made to the composition of the Trust Board and its advisors (Eastwoodhill Trust Amendment Act, 1994).

The Trust Board has six members (Eastwoodhill Trust Amendment Act, 1994). One member represents each of the Poverty Bay Farm Forestry Association, the Poverty Bay Horticultural Society, the Friends of Eastwoodhill Association, the Gisborne District Council, the family of Mr H.B.Williams, and a resident of the Gisborne or Wairoa districts. The function of the Trust Board is as follows:

(i) "The primary function of the Board shall be to maintain and develop Eastwoodhill as an arboretum".

(ii) "So far as it is consistent with its primary function the Board shall use its best endeavours to make Eastwoodhill available to the public for its education and recreation" (Eastwoodhill Trust Act, 1975).

When the Trust Board was formed in 1975, the Arboretum was already recognised as containing an important collection. Many experts inspected the Arboretum and reported it to be a valuable resource and unique in New Zealand (Goodwin, 1964; Jackson, 1964; Jew, 1972; Salinger, 1971; Sykes, 1964, 1972; Weston, 1971; Yeates, 1964). Eastwoodhill was considered one of the most important scientific collections in the southern hemisphere (Salinger, 1971; Sykes, 1972; Weston, 1971). Many species were rare, otherwise unknown in New Zealand, of unknown potential or impossible to obtain again (Jew, 1972; Sykes, 1972; Yeates, 1964).

Nevertheless, the collection was in poor condition because time and reduced maintenance had led to a deterioration of the plantings (Jew, 1972; Skipworth, 1976). Jew (1972) felt that the potential of the collection had been affected by "the apparent lack of planning and clearly defined objectives throughout its development stages." Both Jew (1972) and Weston (1971) recommended that scientific value of the collection could not be properly determined without thorough analysis.

From 1975 until about 1985 the Trust Board concentrated their resources on having the overgrown and crowded Arboretum cleared. The parks were choked with dead trees, weed species, volunteer plants, and old shelter belts which had to be cleared. Over half a million super feet (13,500 cubic metres) of timber was removed during this period (Williams, 1987). Progress on site clearing and vastly improved appearance were consistently reported in Trust Board records. At the same time improvements were made to property infrastructure including fencing, tracks, equipment, housing, water supply, workshops, visitor facilities, noticeboards, and plant labelling (Board Minutes 1975-1988).

Although the Trust Board concentrated on the clearing strategy over the period 1975-85, there were also some activities relating to planning. Even before the Trust Board was formed, Mr Williams sought expert advice on development and management of the Arboretum (Thorp, 1971a). The need for planning was subsequently supported by local and outside authorities (Advisory Committee, 1979, 1980, 1981, 1982, 1983; Berry, 1978; Way, 1978). Significant progress was made with development of a catalogue of the collection in 1976, which was updated twice (Berry, 1976, 1980, 1982). Lists of possible accessions and plants requiring urgent propagation were also developed (Berry, 1979, 1981). In the summer of 1978/79 the Trust Board initiated a mapping project which was conducted by two university students as summer project, but unfortunately it was not completed. Planting and/or planning committees were formed in 1980 (Board minutes, 25.11.80), 1985 (Board minutes, 12.3.85), and 1987 (Board minutes, 14.1.87). While each developed a plan, which were largely carried out, none developed a comprehensive long term plan for the collection.

In 1987 a management plan was published which dealt with four aspects of the Arboretum: funding; administration and management; use of the Arboretum; and resource protection and development (Williams, 1987). The plan was a major advance for the time, as it was the first comprehensive consideration of the Arboretum. Unfortunately, the plan was not as useful as it might have been for collection management as it did not include either inventory or evaluation and could only comment on collection planning at a general level. Although a series of worthwhile ideas was proposed, none could be developed or substantiated without more data. As a consequence, no plan for the collection could be formed.

By this stage, the Trust Board had reached a position where important base documentation had been developed, but this had not been extended into a planning or design framework for the collection. A catalogue had been developed, but the collection was not mapped and there were no herbarium or archival records. The collection had not been evaluated with any scientific process. This inhibited development of long term plans and specific strategies such as accessions plan, planting plan, collection layout plan, removals plan, replacement plan or maintenance plan. Similarly, there was no documentation for any future design framework for the visual and spatial arrangement of the collection. Although Douglas Cook apparently developed themes in some parts of the Arboretum, many of the patterns had been lost or blurred by the overcrowding and subsequent clearing work. The question of restoration of Douglas Cook's arrangements, or development of any new patterns had yet to be addressed. The weak overall planning framework was unfortunate but it must be appreciated that there were four important reasons for the situation: a marked financial constraint; a lack of landscape management expertise amongst the managers; the level of deterioration that necessitated ten years of clearing; and an insufficient labour force.

1.1.3 This research

This research considers the plant collection at the Eastwoodhill Arboretum and the management framework for that collection. To set the scene, four broad sets of ideas are developed in this introduction. First, a general introduction to landscapes and the forces that act upon them will give an understanding of landscapes and show where an arboretum fits into the broad range of landscape types. Second, an overview of botanic gardens and their roles and functions will illustrate parameters that apply when managing an arboretum. Third, an overview of landscape management principles will indicate the processes that should be used when managing a landscape. Fourth, Eastwoodhill Arboretum will be considered, with an outline of the problem that was addressed in this research, and then the framework of the solution. As a result of a series of investigations and management workshops, a collection management model is proposed. This model could be used to formulate a planning framework for the Arboretum, and manage the perpetuation and development of Douglas Cook's collection.

1.2 Landscapes

'Landscape' can be interpreted in many ways: as land, scenery, nature, the space for human living, a repository for human history, or as the segment of environment that supports living things (Dowling, 1991; Fabos, 1979a; Fabos and McGregor, 1979; Jackman, 1980; Laurie, 1986, p 10; Russell, 1989; Swaffield, 1990). Swanwick (1989) identified 'landscape' and 'nature' as subsets of environment. Landscapes may be of the country or the city, with cultural or natural features. As landscapes involve land, one of the basic commodities of the world, the use and conservation of landscapes is an important political and social issue (Laurie, 1986).

1.2.1 Components of landscapes and the landscape continuum

The natural or physical components of landscapes are landform (geomorphology and soils), water and vegetation. The human components of landscapes are people and their artefacts. Landscapes are the product of interactions between natural components and processes, and human components and activities (Jackman, 1980, 1986; Wilson, 1985; Zonneveld and Forman, 1990).

The aforementioned components can produce a range of landscapes such as a national park, a production forest, a botanic garden, a shopping mall, a town square, or a designed garden. In spite of the variety, it is possible to derive a landscape continuum (Figure 1.14) which ranges from natural undisturbed landscape to human-made landscape. At the 'natural' end there is high ecological influence and low human influence. At the 'human' end there is low ecological influence and high human influence. This concept was derived from views expressed by Fairbrother (1974), Gilbert (1989), Hitchmough (1994, p 5), Jackman (1980), Melnick (1981), Miller (1988), Westoff (1983) and Zonneveld and Forman (1990).

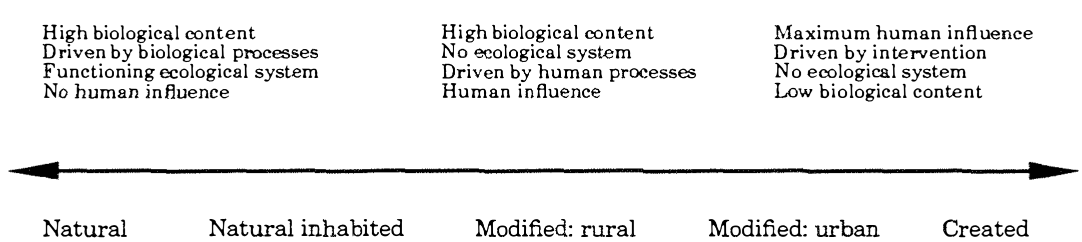


Figure 1.14 The landscape continuum

Natural (undisturbed and uninhabited) landscape is formed by natural processes which may result in different natural systems such as forests, wetlands, and deserts (Jackman, 1980; Westoff, 1983). The composition and succession of natural landscapes are directed by nature and they are self-sustaining with natural cycles of growth, development and decay. Theoretically, these landscapes are unaffected by human interference but in practice they are threatened by various factors, many originating well beyond the boundaries of the area. Global factors such as pollution, acid rain, global warming, and ozone depletion may be involved and have widespread detrimental effects. Local factors such as drainage, exotic pests, and nitrification may also affect an area. Therefore, natural landscapes may need active management input for protection, elimination of threat, and positive support to ensure that ecological processes can continue (Hitchmough, 1994, p 6).

In the second part of the continuum are natural landscapes that are used or inhabited such as a beach, a national park, or a mountain with a ski field. These landscapes are similar to the previous category but with the added pressures of human use and/or habitation (e.g. trampling, plant removal, and introduction of pests). The natural system may not be able to perpetuate itself without protection, assistance or intervention. For example, McCaskill (1983) outlined the planting and weeding strategies needed to sustain Riccarton Bush in the city of Christchurch. These landscapes show the conflict between human use and biological needs; the natural aspect of the landscape attracts people yet that naturalness may be threatened by use. Management of these landscapes addresses three aspects: management of the biological system, management of the pressures imposed by human use, and management of the people within that landscape.

Modified landscapes in rural areas are next on the continuum. These landscapes have a high content of living things, but are not actually natural as the biological components are ordered by human activities (Jackman, 1980; Russell, 1989). Landscapes such as countryside, urban fringe, country parks, and agricultural land may appear to be natural, but are created by people to serve various purposes (Miller, 1988). Indeed, many people identify landscape as natural if it has a high vegetation content (Lamb and Purcell, 1990; Ulrich, 1986). These landscapes are not biologically stable and need constant management interventions to keep them in the desired state (Miller, 1988; Owen, 1991; Sales, 1988). If cultural practices such as weeding, trimming and fertilising were stopped, the landscape would revert to some other form and no longer achieve its original purpose. Furthermore, it is unlikely to revert to the natural ecology of the region as the indigenous components may have been removed and foreign components introduced. Management of these landscapes must involve intervention; natural ecological processes have been suppressed and have a lesser role.

Finally, at the human extreme of the landscape continuum are created urban landscapes such as home gardens, city parks, and street tree populations. These human-made artificial landscapes are made of disjunctive natural components (Dawson, 1991) which lack the interdependence characteristic of natural systems (Hall, 1981). The criteria of the manager or designer are imposed on the site resulting in a landscape that is (i) not 'normal' for the site and, (ii) composed of plants that would not normally be found together. Many (particularly inner city landscapes) are created on sites that are polluted, with poor soil, and restricted space available for root and top growth. Such landscapes are biologically unstable and require continuous intervention to maintain the created regime, and to stop any previous regime from reimposing itself (Hall, 1981; Owen, 1991). Nevertheless, these are an important landscape category. Dawson (1991), for example, reported that there was ten times more garden area than nature reserve in Britain.

Correctly identifying the position of a particular landscape on the continuum is an important task for landscape managers, as the changes along the continuum determine the frequency and type of management that is needed. Thus some managers will be primarily ecologists, others will be ecologist/managers, and some will manage created systems under human control. Each must understand the landscape, the factors that influence it, and the processes needed to manage that landscape.

1.2.2 Factors that shape landscapes

Natural and human processes are the major factors which shape landscapes (Jackman, 1986; Laurie, 1986, p 110). Swaffield (1990) also identified aesthetic and functional perspectives as essential for landscape design as they underpin the spatial relationships and human responses that must be understood by the designer. These perspectives do not relate to this research as it does not focus on the landscape design aspects of Eastwoodhill.

1.2.2.1 Natural processes

Natural processes combine to influence the living system. These are divided into (i) abiotic processes such as geological processes (tectonics and weathering), landform, climate and water processes, and (ii) biotic processes such as soil, vegetation processes and fauna (Jackman, 1986; Motloch, 1991). Some abiotic factors, such as the climate of a region or geological events, are large scale and cannot be influenced by the manager. Landform, water and soil conditions can sometimes be managed at site scale by operations such as earthworks, irrigation and drainage. Abiotic processes are described in detail by Motloch (1991) and will not be discussed further here.

This research focuses upon biotic processes, particularly the vegetation component of landscapes. Vegetation in natural landscapes is part of the ecosystem which is characterised by features such as interdependence, homeostasis, succession and self regulation (Hall, 1981; Hitchmough, 1994; Rowntree, 1988). There is a huge body of literature (e.g. Archibold (1995), Burrows (1990), Ellenberg (1986), Peterken (1981), Rieley and Page (1990)) which describes the features and functioning of vegetation in natural environments. Conversely, although the benefits of vegetation in human-made landscapes are well described (Bernatzky, 1978; Grey and Deneke, 1978; Miller, 1988), there is limited understanding of functioning of human-made plant associations in these environments (Rogers and Rowntree, 1988; Ware, 1994). For example, do these plant associations behave like ecosystems; do they follow patterns of succession and adaption; and how does the human-made environment influence plant response to environmental factors? Some scientists believe that ecological principles, such as diversity and succession, can be applied to vegetation in human-made landscapes (Nilon, 1991; Ware, 1994; Welch, 1994; Widrlechner, 1994), but this is a recent trend and there is relatively little work which considers the management of human-made vegetation associations (Hitchmough, 1994, p 83).

A key feature of vegetation processes in landscapes is the long time frame. Some vegetation, particularly trees, can take many years to reach maturity, and may then live for up to a thousand years or more. It may take years to realise the desired outcome of a plan; management decisions may have little impact until vegetation matures (Cobham, 1986; Laurie, 1986, p 9; Robinson, 1985). This time lag can be a problem, particularly when visual values are involved as most people prefer mature vegetation. For example, removal of over-mature trees on streets or in historic gardens is often controversial because visual value is reduced while new trees grow to the same size as those that were removed (Munson, 1993). The long time frame inherent in vegetation processes should be reflected in the management approach, indeed, an overall planning cycle of 200 years or more is recommended by many landscape managers (Banks, 1988; Hitchmough, 1994, p 269; Lobel, 1983; Moggridge, 1983; Workman, 1974). The overall cycle can be broken down into shorter intervals as required.

Change is another feature inherent in biological systems. Landscapes continually change as biological processes influence components of the system (Egerton-Smith, 1987; Hackett, 1980; Holliday, 1987; Jackman, 1986; Laurie, 1986, p 10; Miller, 1988; Motloch, 1991, p 47). This distinguishes landscapes from many other management scenarios (architecture, clothing design, furniture design) in which the product remains relatively fixed. For example, a new house, once completed, does not change shape and size each year, change colour three times per year, grow or decline according to the local climate, or disappear below ground in the winter. Although change is a normal feature of landscapes, it must often be managed according to human criteria. For example, restoration of the landscape at Blenheim Palace in Britain involved managing change with visual criteria for a design effect. Groups of trees were required of particular species and numbers, in particular locations, and of specified maturity (Cobham 1985).

1.2.2.2 Human processes

People have a fundamental influence upon landscapes as there is a continuous and complex interaction between people and their environment (Altman and Wohlwill, 1983; Ittelson et al., 1974; Laurie, 1986, p 175; Parry-Jones, 1990; Uzzell and Lewand, 1990). Landscapes influence people and, at the same time, people constantly select and manipulate their surroundings (Gordon, 1991; Laurie, 1986, p 175; Relf, 1992b; Taylor, 1990). There are three categories of interaction between people and landscape: physical, physiological and psychological (Laurie, 1986). The first two categories are concerned with functional use such as shapes and sizes, and provision of a comfort zone such as suitable temperature and clean air. The psychological interaction is more difficult to quantify, yet it is fundamental to understanding landscapes. It is important to realise that changes in the physical environment have consequences other than the obvious change in visual appearance (Uzzell and Lewand, 1990), therefore an understanding of plant-people interactions is essential. Management decisions should be related to the preferences and responses of landscape users, through an understanding of human needs, perceptions and behaviours that relate to landscapes (Laurie, 1986, p 175; Motloch, 1991; Uzzell and Lewand, 1990).

(i) Landscapes influence people

People receive a range of positive benefits from interacting with plants and landscapes (Kaplan, R. 1992, 1993; Kaplan, S. 1992; Relf, 1992b; Ulrich and Parsons, 1992). These benefits include improved healing in patients, improved behaviour of prisoners, improved work satisfaction, stress reduction, improved self-esteem, and improved community health in poor areas (Dwyer et al., 1992; Kaplan, S. 1992; Lewis, 1992; Relf, 1992b; Ulrich, 1986; Ulrich and Parsons, 1992). Plants and landscapes have positive influences on people's emotional state by reducing anxiety and increasing relaxation (Swanwick, 1989; Ulrich, 1979, 1986; Ulrich and Parsons, 1992). Many people actively seek interactions with nature through activities such as gardening, flower arranging, hobbies, nature related activities, and outdoor recreation (Francis, 1987; Kaplan, R. 1992). Nevertheless, people may not consciously identify any need for a relationship with plants, or be aware of any benefit (Kaplan, S. 1992; Ulrich and Parsons, 1992). Indeed, Ulrich and Parsons (1992) reported that, regardless of whether people were aware of it or looked at it, stress was reduced by the presence of a landscape scene containing plants.

Why do people benefit from an interaction with plants and landscapes? Psychologists believe that plants and landscapes have a restorative value which helps people recover from mental fatigue (Kaplan, 1983, 1993; Kaplan, S. 1992). 'Being away' in a different setting gives a feeling of escape (Kaplan, S. 1992). Nature provides a large scope for different experiences (Kaplan, S. 1992). Fascination reduces stress by engaging involuntary attention and not requiring direct concentration (Kaplan, R. 1992; Kaplan, S. 1992; Parry-Jones, 1990; Ulrich and Parsons, 1992).

The features of landscapes that cause positive response can be identified by testing the responses of sample populations. In general a positive response is stimulated by vegetation (particularly trees), well maintained grass, paths, water, and an absence of crowds (Dwyer et al., 1989; Getz et al., 1982; Herzog, 1987; Kalmbach and Kielbaso, 1979; Mudrak, 1982; Schroeder 1982, 1989, 1990; Ulrich, 1986). Conversely, poor maintenance, too many human-made objects, litter, and large areas empty of any features are usually disliked (Schroeder, 1982). Closer examination of the response shows that certain characteristics and configurations are important (Herzog, 1984, 1987; Ulrich, 1983, 1986). These observations have been used as the basis for models for landscape preference (Altman and Wohlwill, 1983; Jackman, 1986; Swanwick, 1989), although there is considerable debate about the theoretical framework underlying the models (Gimblett et al., 1985; Ulrich, 1986; Uzzell, 1991). The models are discussed in detail in Chapter 3.

(ii) People influence landscape

People influence and manipulate landscapes according to their perceptions, attitudes and beliefs. Even though interactions with plants and landscapes are beneficial, people display a range of differing attitudes towards them. Meinig (1979) and Laurie (1986) outlined various attitudes towards nature and landscapes which range from exploitative to stewardship. Indeed, the human relationship with nature is a paradox; on one hand it provides shelter and refuge, on the other hand it is used and exploited (Westoff, 1983). Swanwick (1989) suggested that little was known about the influences upon people's attitudes to nature, and that the connections between attitudes and behaviour were not well understood.

The behaviour of individuals, and society at large, shapes the landscape of that society. A study of landscape history illustrates a continuous interaction between art, culture, religion, politics, and landscapes with different patterns apparent in different cultures and historic periods. For example, in the Dark Ages nature was considered hostile, therefore people lived a comparatively reclusive lifestyle. In contrast, Louis XIV of France wanted to master nature and show his domination over it with grand gardens imposed on the natural form. There is a large amount of literature on this topic, such as Hoskins (1988) and Jellicoe and Jellicoe (1975), which will not be considered here as it is not directly relevant to this research.

1.2.3 Landscape values and their management

Landscapes and the plants they contain are part of the 'natural capital' of a country, providing a variety of benefits to the community (Folke and Kaberger, 1992; Groombridge, 1992; McNeely, 1988). These benefits are discussed in detail in Chapter 3 and will only be summarised here. Plants and plant communities support life on earth by generating clean air and water, regulating climate, protecting soil, storing biomass, and storing and cycling nutrients (DeGroot, 1987; McNeely, 1988). Plants also improve environments by modifying temperature, air movement, light and shade, noise, and reducing erosion and pollution (Bernatzky, 1978; Miller, 1988; Smardon, 1988). In New Zealand, the life support and environmental improvement functions are emphasised in the Resource Management Act which focuses upon 'sustaining the potential of natural and physical resources' and 'safeguarding the life supporting capacity of air, water, soil and ecosystems' (Resource Management Act, 1991, section 5).

Plants and landscapes also provide a range of human benefits. Some of these are direct benefits such as food, clothing and shelter (DeGroot, 1987; Janick, 1992; Raven, 1989; WWF and IUCN, 1989). There is also a range of indirect human benefits which relate to various human uses of the landscape such as health, cultural, social, historic, aesthetic and recreational benefits. Health benefits have already been referred to in section 1.2.2.2. A variety of social and cultural interactions also occur between people and their environment. For example, trees are considered an asset to the community and are an important factor in determining where people live, and satisfaction with their neighbourhood (Dwyer et al., 1991, 1992; Getz et al., 1982; Gold, 1986; Relf et al., 1992; Schroeder and Appelt, 1985; Schroeder, 1989; Sommer et al., 1990). Aesthetic benefits of plants and landscapes come to the fore when their architectural and visual qualities are used to create spaces, screen unsightly views, form green spaces and design areas (Cobham, 1990; Robinson, 1985; Smardon, 1988).

Although plants and landscapes provide substantial benefits, they are threatened by several factors. World conservation authorities predict that one quarter of plant species will be extinct by 2050, making a smaller plant resource in the future (Bramwell et al., 1987; Groombridge, 1992; WWF and IUCN, 1989). Furthermore, although plants are renewable resources, this is only possible if they are managed before extinction occurs (Tisdell, 1983). In addition, predicted immense population increases will place greater demands upon plants and landscapes (Andreev, 1989; DeGroot, 1987; Laurie, 1986). Changes in technology have made rapid consumption possible (e.g. forests can be felled faster with modern machinery than with handsaws) (Andreev, 1989; Westoff, 1983). In fact, people and their activities can be a considerable threat to the environment, with humans doing irreversible harm by exploiting, damaging, depleting, or destroying species and ecosystems (Grey-Wilson, et al., 1987; Jackman, 1986; Lucas and Synge, 1981; Peet et al., 1983; Tisdell, 1983).

The landscape manager's role is to uphold the values of a landscape and minimise any threats to those values. This is a complex task because landscapes have multiple values (Kirby, 1986; Peterken, 1981), some conflicting, and establishing a hierarchy and a balance between them can be difficult. Managing the balance is complicated by differing views on that balance, which is related to people and their attitudes; unfortunately many people have negative or exploitative attitudes towards the environment (Ittelson et al., 1974; Meinig, 1979; Motloch, 1991).

Managing values is further complicated by an uneasy relationship between landscape values and economics. Conventional economics focus upon market-price but many landscape values are indirect ones, based upon a functioning ecosystem and which seldom have a market price (McNeely, 1988). Many of these indirect values are very difficult to measure and often disregarded in economic analyses (Church, 1990; Cobham, 1990; Hampicke, 1994; Jackman, 1986; Laurie, 1986, p 102; McNeely, 1988). Furthermore, conventional economic analyses generally examine short term time frames, which is at odds with the long time frame inherent in biological systems (DeGroot, 1987). Thus economic analyses can be weighted against the environment (Folke and Kaberger, 1992; Jackman and Treeby, 1984; McNeely and Miller, 1983). Landscapes and economics are a complex topic which is discussed further in Chapter 3.

The opportunity to enjoy landscape values in the future depends upon availability of a suitable stock of 'natural capital'. Therefore, even though economics and attitudes make the task difficult, effective management of plants, ecosystems and landscapes is prerequisite to any future development (Church, 1990; McNeely, 1988; Swaminanthan, 1989; WWF and IUCN, 1989). Landscape managers should contribute to the quality of environment and management of species, ecosystems and landscapes by using excellent management practice. They should try to overcome the disadvantages imposed by the economic system and develop better methods to collect, assess and apply information in management (Church, 1990; Jackman, 1986; Trudgill, 1990).

1.2.4 Goals of landscape management

The overall mission of landscape management is to achieve optimum value from the landscape. There will be two broad approaches: (i) development (if necessary) of the landscape and then management to ensure its continued existence, and (ii) management of the human uses of the landscape, e.g. recreation. The latter are not possible without the former, e.g. people cannot enjoy recreation in a park unless the park existed in the first place. There are five broad goals that might be used to achieve the overall mission: preservation, protection, improvement (enhancement), provision for human use, and development of sustainable landscapes (Fabos, 1979b; Fabos and McGregor, 1979; Penning-Rowsell, 1975; Resource Management Act, 1991; Sidaway, 1990). None of these goals is independent and all are related to the notion of sustainable management, but for the purpose of this discussion they will be considered separately.

Preservation goals relate to the continued existence of landscape resources. These are justified by the economic notion of option value, which is the value gained from the continued existence of a resource rather than its depletion or extinction (Groombridge, 1992; McNeely, 1988). Preservation goals are commonly applied to rare, sensitive, or significant plants and landscapes (Zonneveld and Forman, 1990). Examples of preservation can be found throughout the landscape continuum and include preserving national parks (Laurie, 1986, p 69; McNeely and Miller, 1983), native vegetation, species and ecosystems (Davis, 1987; Larkcom, 1986; McCaskill, 1983; Noss and Cooperrider, 1994; Raven, 1989), historic landscape conservation (Cobham, 1985; Goulty, 1993), open spaces in cities (Morgan, 1989), and garden plant conservation (Brickell and Sharman, 1986). Landscape restoration is an important part of preservation. Decline and deterioration is reported for natural landscape (Cass, 1990), parks (Beckett and Dempster, 1989; Rogers, 1983; Teggin, 1988), historic landscapes (Jones, 1981; Pattison, 1989), and urban areas (Bourque, 1985). Fortunately many of these landscapes are being rescued and restoration plans are frequently reported (Beckett and Dempster, 1989; Jones 1981; Weinmayr 1981). Organisations such as the British National Trust (Sales 1988), the Australian National Trust (Marquis-Kyle et al., 1992) and the QEII Trust in New Zealand (Evans, 1985) work to preserve significant landscapes. Botanic Gardens Conservation International (BGCI) and the British National Council for the Conservation of Plants and Gardens (NCCPG) work to preserve important plants (NCCPG, 1994; WWF and IUCN, 1989).

The second (and related) goal is protection which usually arises in response to human inflicted pressures. Protection is necessary to stop damage or exploitation of landscapes. Examples of protection include notable tree schemes (Flook, 1994; Morgan, 1989), and protected areas of natural and city landscape (McNeely and Miller, 1983; Ravine, 1995; Wittkugel, 1988). In New Zealand the Protected Natural Areas programme (Owen, 1984; Ravine, 1995), and the QEII Trust (Evans, 1985) have been important in landscape protection. Preservation and protection goals are often needed as legislation and planning processes are sometimes incapable of protecting important plants and landscapes (Coleman, 1993; DeKlemm, 1985; McNeely and Miller, 1983; Willis and Garrod, 1993), or stopping damage from excessive recreational use or poorly controlled development (Cass, 1990; Russell, 1989; Salmon, 1990; Stutz, 1989; Taylor, 1990). The notions of preservation and protection are the focus of the World Conservation Strategy, with two of the main aims being to maintain essential ecological processes and life support, and preserve genetic diversity (Selman, 1985b).

Improvement, also known as enhancement under the Resource Management Act (Resource Management Act, 1991) is the third goal. Improvement through landscape design is a highly visible and well known form of landscape improvement. This goal may also be achieved in other ways including creation of new greenspace (Jones, 1989; Morgan, 1989), planting of new urban forest (Caballero, 1986; Cobham, 1990, p 184), rehabilitating derelict or polluted land (Cobham, 1990; Fabos, 1979b; Jones, 1989; Selman, 1985a; Usherwood, 1991), restoration of habitat (Stutz, 1989), planting to improve city climate (Cordell, 1979; Shafer and Moeller, 1979), development of better maintenance programming (Burton and Matthews, 1989), and improving woodland quality through better management methods (Selman, 1985a).

In New Zealand the broad notions of preservation, protection and improvement of the landscape are embodied in the Resource Management Act (1991). The purpose of the Act is to promote sustainable management of natural and physical resources (Resource Management Act, 1991). The Act changed the emphasis from repairing damage to ensuring damage does not occur, and replaced a number of outdated laws which could not always protect important landscapes and their values (Dowling, 1991; Salmon, 1990). The main aims are to sustain natural and physical resources, safeguard life support capacity of ecosystems, and avoid or mitigate adverse effects on the environment (Resource Management Act, 1991). Natural resources are defined as land, water, air, soil, minerals, energy, all plants and animals (native and exotic), and all structures (Resource Management Act, 1991 Part I). This definition clearly has important implications for landscape management as it includes all the components of landscapes. The Act puts great emphasis on protection, specifically referring to protection of outstanding natural features, landscapes, significant indigenous vegetation, and significant habitat of indigenous flora as matters of national importance (Resource Management Act, 1991, section 6). Section seven requires 'persons exercising powers' under the Act to pay particular attention to intrinsic values of ecosystems, the quality of environments, heritage values of sites, amenity values of an area, and any 'finite characteristics of natural and physical resources' (Resource Management Act, 1991, section 2). Jackman believed that, although the Act appears to encompass human-made landscapes, in reality cultural and heritage landscapes are not well catered for in the interpretations used to operate the Act (T.Jackman, personal communication, August 1996). Cultural and heritage matters could possibly be accommodated under the Historic Places Act or the Conservation Act, but Jackman concluded that the necessary linkages were very poor and those landscapes were poorly covered by legislation in New Zealand (T.Jackman, personal communication, December 1995).

In broad terms, legislation such as the Resource Management Act influences human use of the landscape by controlling which activities may take place on a particular site. Within that context the landscape manager may pursue the fourth goal, provision for human uses such as recreation. Recreation is recognised as necessary for good health (Ulrich and Parsons, 1992) and landscapes have both direct and indirect roles. Some activities such as gardening and tourism use landscapes directly, while other activities such as cross-country running and hunting are indirect uses and the landscape is simply a venue (Jones, 1989). According to Cloke (1989) success as a recreation site is predicted by quality of the landscape, highlighting the link between landscape management practice and recreation use. That link is also illustrated in conflict between human and biological values; uncontrolled recreation use of landscape may cause damage, ruining the very features that attracted people in the first place (Blatchford, 1990; Larkcom, 1986; Laurie, 1986, p 72).

All of the previous goals can be drawn together under the issue of sustainable landscapes. Preservation and protection contribute to continued existence of a landscape, improvement raises the quality of poorer sites, and properly managed human use controls the impacts upon a landscape. Sustainability, however, operates at a higher level than the interaction between the aforementioned four goals, being very large scale (planetary) and over a very long time frame (Zonneveld and Forman, 1990). Zonneveld and Forman (1990) emphasised the notion that change and adaptability are inherent in sustainable systems, and that many changes (climatic, social, economic, biological and technological) must be managed over many time scales. They emphasised that, although a whole system may remain in a steady-state, components will change in cycles of expansion and contraction. Thus a comprehensive and in-depth understanding is needed of the functioning of plants and landscapes, and the relationships between those and all human activities that influence (directly or indirectly) the landscape.

Swaffield (1990) criticised the landscape profession in New Zealand, suggesting that practitioners claimed to support sustainability, but little was done in practice and most operated in a short term time frame and emphasised economic outcomes. Several commentators believe an integrated approach is essential, particularly one which synthesises an in-depth understanding of landscapes and their different values, and develops the new ideas, information and management practices that are needed to achieve sustainable landscapes (Andreev, 1989; Gordon, 1991; Haigh, 1988; Jackman, 1986; Jackman and Treeby, 1984; O'Connor and Swaffield, 1987; Swaffield, 1990).

In developing and pursuing goals for a particular landscape, the interrelationships between goals should be recognised, as should the interactions between goals and landscape values. Pursuit of a particular set of goals will have certain outcomes in terms of the values of a site. A sectorial approach concentrates on one factor at the expense of others (Kirby, 1986), e.g. emphasising the visual features of an arboretum at the expense of the biological features. An holistic approach recognises that values interact and the question of balance must be considered in developing and achieving goals (Kirby, 1986). This approach recognises all factors and manages them in tandem, even though one might be in a superior position (Kirby, 1986). The appreciation of the interaction between values, and the consequent relationship between that and pursuit of a particular set of goals is a key management skill. Neither the interaction nor the need to manage the balance seems to be well recognised in the literature (with the exception of Cobham (1990), Jackman (1986), and Kirby (1986)). Indeed various authors have commented on the emphasis on visual factors at the expense of others (Holliday, 1990; Lamb and Purcell, 1990; Russell, 1989; Swanwick, 1989). Jackman believed this was also true in New Zealand, where the complexity of managing a wide range of landscape values had not been grasped (Jackman, 1986; Jackman and Treeby, 1984).

1.2.5 Scope, scale and the role of the manager

The landscape is managed at several scales, although the landscape manager usually operates at site scale. At the broadest scale is the strategy level where a macro framework of policy for planning is established (Fabos and McGregor, 1979; Jackman, 1980). Professionals working at this scale are likely to be environmental planners or landscape architects who focus upon landscape values and their importance to the community, the implications of these values for policy development, and the legal framework that will relate to landscapes. The next scale is physical large-scale planning which takes place on a regional scale, followed by physical small-scale planning which deals with planning for communities (Fabos and McGregor, 1979; Jackman, 1980). Professionals working at this scale are likely to be landscape architects or planners who focus upon landscape planning processes and their application within a particular community. They will apply, rather than develop, policies that affect the landscape. Finally, the micro scale involves planning for specific sites, e.g. physical landscape design, or a master plan for recreation (Fabos and McGregor, 1979; Jackman, 1980). Jackman (1980) believed most landscape work in New Zealand has been in this final category. These managers may be landscape architects or landscape managers who will have an understanding of broad landscape values and planning policies, but focus upon physical development, installation and management of single sites. Thus landscape managers operate within the overall land use framework developed by planners and landscape architects (Fabos, 1979b).

The landscape manager's role is to optimise landscape values and achieve the goals of landscape management. This is achieved through the ability to plan, design, and manage landscapes (Laurie, 1986; Motloch, 1991), and to recognise, analyse and resolve problems in the landscape (Jackman and Treeby, 1984). This may involve creating and managing landscapes for life support and life quality purposes, or for human use and enjoyment (Booth, 1983; Jackman, 1986). Landscape professionals may be involved in site planning, landscape design, urban design, landscape management, and landscape evaluation and planning (Laurie, 1986, p 11). Cobham (1990) stressed the 'ambidextrous nature of the management task' and the need to manage multiple tasks for a variety of ends, i.e. the complexity of managing variable goals and values.

A sound landscape management framework is needed to achieve these ends. This is based upon a framework of three categories: 'understanding, management process, and technical skills' which was synthesised from views expressed in Bromley (1990), Cobham (1990), Hitchmough (1994, p 14), Holliday (1990), Jackman (1980), and Laurie (1986). First, a thorough understanding of landscapes is needed. This starts with an understanding of landscape components and the landscape continuum, including the natural and human processes that influence landscapes. Natural processes will focus upon the biology and life behaviour of plants which underpin the selection, performance, management and renewal of individual plants in the landscape. Human processes will focus upon cultural systems and social and aesthetic processes associated with landscapes. The interactions between people and landscape are particularly important, especially the management implications of people's attitudes, preferences, and responses. Landscape designers will also need an understanding of design and aesthetics. All of the previous knowledge underpins an understanding of the values of landscapes and their measurement, and the relationships between different values. Finally, knowledge of political and legal processes that impact upon landscapes must be related to management decisions.

Second, a set of management processes will be needed for planning and design which can be used for evaluation, synthesis and problem solving. These will be based upon basic management theory, developed to suit landscape management. Particular skills and knowledge are needed to operate the design and planning processes, and landscape professionals must be conversant with their application in different scenarios.

Third, a series of technical skills and technologies are needed to implement the plan or design. Management skills such as scheduling, planning of daily operations, allocation of equipment and resources, and staff scheduling will be needed. Skills in plant use, including techniques for establishment, growth, maintenance, and replacement of vegetation will be needed. Maintenance programming and technical skills will be needed for managing a wide range of landscape types on a daily basis. The three components described above (understanding, management process and technical skills) are combined into a management framework for the landscape that is being managed.

1.3 Botanic gardens, arboreta and plant collections

1.3.1 Roles and functions

A botanic garden is a human-made landscape containing a scientifically ordered collection of documented and labelled plants (Heywood, 1987; WWF and IUCN, 1989). An arboretum is a botanic garden devoted to trees, shrub and climbers (Byrd, 1989; WWF and IUCN, 1989). There are about 1500 botanic gardens world wide and they have scientific, educational and recreational functions (Byrd, 1989; Eloff, 1987; Given, 1986; Morley, 1993; Oates, 1993; Raven, 1989; WWF and IUCN, 1989). In the past, operation of many botanic gardens focused upon exploration and introduction of economic plants and as a result many gardens gave rise to forestry and agriculture departments and experimental stations (Given, 1993; WWF and IUCN, 1989). When the exploration functions diminished the emphasis shifted to horticultural skills, and in recent years the conservation role has been highlighted (WWF and IUCN, 1989). About 800 botanic gardens practice conservation and contain about three million accessions worldwide (Groombridge, 1992).

Plant collections (as an official entity) are a relatively recent development, first proposed in Britain in 1978 (Brickell, 1979). In Britain a plant collection is a definitive collection of species, hybrids and cultivars within a genus or part genus (Lowe, 1988, 1991; Taylor, 1988). The British collections focus on ornamental plants with the aim of conserving garden plants and developing programmes in education and research (Lowe, 1988; NCCPG, 1994; Sanecki, 1989; Taylor, 1985b; Taylor, 1988). Although the focus is on garden plants it is clear that species are involved, as shown by examination of Taylor's work and the British collections list (NCCPG, 1994; Taylor, 1988). The British Scheme has 600 collections of 400 genera which conserve 50,000 species and cultivars (NCCPG, 1994). Groups in Australia, America and France have developed schemes after the British model (Anon., 1994; Cross, 1990). In New Zealand there are many unofficial plant collections, but there is no official designation of collections, nor any nationally coordinated Plant Collection Scheme. The Royal New Zealand Institute of Horticulture (RNZIH) initiated a scheme (RNZIH, 1990) and preliminary data suggested a wide range of both plants and collections (Hammett, 1993; K.Hammett, personal communication, September 1994).

The three components of plant collections and arboreta are living collections, the library and the herbarium (Anon., 1991; Eloff, 1989; Morley, 1993; Raven, 1989; Sanecki, 1989; Stungo, 1982). Each of these is necessary to support the scientific and educational roles, but the principle component is the living collection (ARA, 1989; Byrd, 1989; Graham, 1995; Oates, 1993; Raven, 1989). Collections may have either a taxonomic or conservation focus (Rae, 1993). Taxonomic collections contain a broad range of species from a taxonomic group but with only a few specimens of each (Rae, 1993), e.g. the British NCCPG collections which focus on particular genera. These collections are valuable for research, horticulture and education, but not particularly useful for species conservation as they have insufficient individuals of any one species (WWF and IUCN, 1989). On the other hand, conservation collections focus on fewer species and contain enough individuals to represent the genetic variation of that species (Rae, 1993). A viable conservation collection should contain at least 500 interbreeding individuals and must be managed according to the principles of population biology and genetics (Burton, 1989; WWF and IUCN, 1989).

Collections may be physically arranged in several ways. The traditional method follows a classification system where genera or families are found together in the garden (Byrd, 1989; Lighty, 1989; Simmons, 1986). For example, plants in the Arnold Arboretum are arranged by the Bentham and Hooker classification system (Ashton, 1989). Plants can also be arranged in habitat or geographic groupings, or in aesthetic groupings and garden styles (ARA, 1989; Byrd, 1989;

Graham, 1995; Percival and Morton, 1995; Simmons, 1986). At the same time plants should be favourably displayed, i.e. the scientific arrangement should be merged with good design (Graham, 1995; Lighty, 1989). Olmstead's Arboretum in Central Park, New York, is a combination of taxonomic, habitat and aesthetic systems (Byrd, 1989; Lighty, 1989).

The collections must be supported by accurate and current documentation as this is fundamental to the role of botanic gardens and plant collections (ARA, 1989; Ashton, 1989; Given, 1984; Heywood, 1989a; Oates, 1993; Simmons, 1986; Walter, 1989; Zander, 1980). Indeed, it is comprehensive inventory that distinguishes a botanic garden from a park and gives it credibility as a scientific and educational institution (ARA, 1989; Heywood, 1989a).

1.3.2 The scientific role

The scientific functions of botanic gardens and plant collections are based upon the living collections and include research into taxonomy, ecology and plant cultivation; conservation using strategies such as seed banks, ex-situ cultivation and tissue culture; introduction and propagation of new plants; cultivar development and testing; monitoring of plant trade; and study of plant use in urban environments (Andreev, 1989; Anon., 1993; ARA, 1989; Given, 1986; Given, 1993; Groombridge, 1992; Heywood, 1989b; Jusaitis, 1995; NCCPG, 1994; Page, 1988; Raven, 1989; Sanecki, 1989; Swaminanthan, 1989). In the last decade the conservation role has become prominent, stimulated perhaps by the prediction that one quarter of plant species will be extinct by the year 2050 (Raven, 1989; WWF and IUCN, 1989). While it is recognised that in-situ methods are the best way to conserve plants, sometimes this is not possible and ex-situ methods must be used (Simmons, 1986; WWF and IUCN, 1989). Indeed, the ex-situ role of botanic gardens is a key component in overall conservation strategies (Given, 1993; Simmons, 1986; Simpson and deLange, 1993; WWF and IUCN, 1989) with over fifty thousand species requiring ex-situ strategies (WWF and IUCN, 1989).

The objectives of a botanic garden in ex-situ conservation should include the following (Andreev, 1989; Bramwell, 1978; Given, 1981, 1987; WWF and IUCN, 1989):

1. To have threatened plants in cultivation for insurance against loss in the wild.
2. To have local endemics in cultivation.
3. To save species whose habitat has been destroyed.
4. To research the biology and behaviour of threatened plants.
5. To cultivate sufficient numbers of a species to prevent genetic erosion.
6. To get species into garden cultivation.
7. To have material available for research, assessment, economic use.

8. To have collections available for education and public display.
9. To propagate plants suitable for reintroduction or reinforcement in the wild.
10. To provide technical information to politicians.

Conservation through ex-situ collections has disadvantages. Species are prone to genetic erosion, poor representation of variation, selfing in cultivated 'populations', risks of hybridisation, poor survival in cultivation, and loss of adaption for wild living (Burton, 1989; Groombridge, 1992; WWF and IUCN, 1989). Therefore conservation collections must be properly established and scientifically managed if a species is to be adequately conserved in a botanic garden. Issues such as adequate sampling and cultivation techniques, maintenance of adequate population size, and good documentation must be addressed (WWF and IUCN, 1989). Unfortunately, most botanic gardens are inadequate in these respects (Groombridge, 1992; WWF and IUCN, 1989).

Conservation can also be achieved through taxonomic collections, although with a different focus. There is a vast range of ornamental plants (Hutchison, 1993; Lord, 1991) but over half this range is considered at risk, prompting actions for its management and conservation (Brickell and Sharman, 1986; Lowe, 1988; Lowe, 1989; Taylor, 1988). In general it is not possible to conserve a species in a plant collection because of the number of individuals needed (WWF and IUCN, 1989). Cultivars, however, can be conserved as they are a specific slice of genetic variation which is vegetatively propagated so interbreeding individuals and genetic variety are not required. Taxonomic collections and ornamental plants represent the need to conserve the human values of plants; while many cultivated plants might be considered unworthy by the biologist (because they are not wild species), they are an important part of human culture and have human values such as historic or aesthetic importance (Brickell and Sharman, 1986).

There are varying views on which groups of plant should have priority for ex-situ conservation. At the third International Botanic Gardens Congress, it was proposed that the highest priority should be given to threatened species, followed by species in threatened habitats, rare species, medicinal species, ornamentals, and finally wild relatives of crop plants (Anon., 1993). The Botanic Gardens Conservation Strategy (WWF and IUCN, 1989) put rare and endangered plants as the highest priority, followed by economically important species, species required for ecosystem restoration, species significant for ecosystem stability, taxonomically isolated species, primitive cultivars, and finally semi-domesticates. Economic plants were defined as "medicinal and aromatic; fruits; fibres; oils, waxes and tannins; vegetables; rootcrops; ornamentals; beverages; intoxicants; timber; fuel wood; forage and pasture; wild relatives of crop plants; spices" (WWF and IUCN, 1989). Although there are differences, both lists put wild plants above cultivated plants, although ornamentals are included under economic plants in the WWF list. Despite this broad range of material, Groombridge (1992) suggested that many plants grown in botanic gardens are inappropriate as they have low conservation priority. With respect to plant collections, the selection of plants to be conserved has been subjective, and the value of many ornamental plants is unknown (Lowe, 1989; Porter, 1989).

Botanic Gardens Conservation International (BGCI) is a world body with the purpose of providing a philosophical base for conservation in botanic gardens (WWF and IUCN, 1989). BGCI will maintain a database of collections, help find funding sources, and monitor ex-situ collections on a world scale (Heywood, 1989a; WWF and IUCN, 1989). BGCI maintains a file of rare and endangered plants of the world which has 100,000 records of plants from 400 institutions (Anon., 1992b; Leadlay, 1988; Leadlay et al., 1993). The Centre for Plant Conservation in America fills a similar role (Anon., 1991c). The National Council for Conservation of Plants and Gardens (NCCPG) in Britain is the world authority on plant collections.

While the conservation issue is vital, other scientific roles should not be overlooked. Benefits can be gained from development and testing of new plants for urban areas, plants for erosion control, new cultivars, and new establishment and cultural techniques. Each of these activities can lead to more successful use of plants in the landscape, and therefore a better quality landscape.

1.3.3 The educational and recreational role

In an increasingly urbanised world, greenspaces such as botanic gardens and arboreta will be an important link between people and nature. Already, botanic gardens attract 150 million visitors per year (Given, 1993; WWF and IUCN, 1989). Johnston (1990) suggested that motivation to conserve must be preceded by an awareness of nature, highlighting the educational role as a means of creating awareness of conservation issues (Simmons, 1986).

The educational role involves a paradox in that more than 90% of visitors 'see' the botanic garden simply as a 'nice park' for recreation while the minority realise that the purpose is plant collections (Given, 1993; Hitchmough, 1994; Jellyman, 1993; Neilson, 1985; Robertson et al., 1989). The average visitor cannot understand the scientific arrangement, read maps or find individual plants (Lighty, 1989; Robertson et al., 1989). Therefore, although gardens provide an opportunity to educate visitors about plants and conservation, the majority have no immediate perception of those issues.

Conversely, visitors will respond to visual qualities (Lighty, 1989). A garden should have good visual arrangement and well ordered displays that give visitors an entertaining, interesting and memorable recreational experience (ARA, 1989; Evans, 1993; Jellyman, 1993; Lighty, 1989; Robertson et al., 1989; WWF and IUCN, 1989). Such recreational experience generates public support, which provides opportunities for education and justifies the scientific work. Indeed, most gardens rely upon public support (Morley, 1993), but must also compete with other cultural and recreational institutions (Robertson et al., 1989) highlighting the need for excellent landscape design and visual skills in garden management. Unfortunately, the combination of scientific arrangement and visual qualities is often poor in botanic gardens (Posner, 1989).

1.3.4 Botanic gardens, arboreta and plant collections in New Zealand

New Zealand does not have a national botanic garden, a botanic garden network, or any government funding for gardens (Given, 1984, 1986; Oates, 1993). The 'botanic gardens' in each major city are funded by local authorities who traditionally gave low priority to conservation (Given, 1986; Heenan, 1985). Given (1986) criticised botanic gardens in New Zealand as he believed they were treated as showpieces, with no research or educational activities. Botanic gardens have also been criticised for having poorly defined missions, and no clear concept of rare plant management (Dingwall, 1983; Given, 1986; Heenan, 1985). Conservation activities were poorly developed and collection development was ad hoc, with only seven centres having a conservation policy in 1985 (Given, 1986; Heenan, 1985). In part this is due to a small population base and restricted funding (Oates, 1993). The capacity of gardens to develop a conservation role has been hampered by inappropriate management, inadequate finance, conflicts between gardens, lack of skills and knowledge, and an inability to make commitment to conservation (Given, 1986; Heenan, 1985; Paterson and Burns, 1984).

There are many unofficial plant collections in New Zealand, but no official scheme or designated collections. There is no Plantfinder (a record of plants available in commercial trade), although a study conducted for Chapter 3 showed a wide range of trees available in commercial trade.

In general, the level of inventory of both collections and gardens is low although some plant groups have been recorded such as tree fruits and nuts (Denton, 1991), notable trees (Flook, 1994), horticulture production species (Halloy, 1993), herbs (Herb Federation, 1991) trees (MacKay, 1993), and ornamental flora in general at the Landcare herbarium at Lincoln. A list of threatened native plants requiring urgent recovery has been made (Davis, 1993), and a Red Data Book published (Wilson and Given, 1989). Two botanic gardens (Wellington and Dunedin), three universities (Victoria, Auckland, and Massey) and three private collections have an inventory of some type but otherwise the majority of collections do not have a documented inventory (MacKay, 1993). Few collections are recorded on computerised databases, although International Transfer

Formats (ITF) are being developed for Auckland University, Wellington Botanic Garden, and the RNZIH scheme (M.Oates, personal communication, March 1994).

Various experts have called for a national collections scheme and/or botanic garden network in New Zealand (Given, 1986, 1993; Heenan, 1985; Jolliffe and Oates, 1988; Oates, 1993). The development of a network was discussed by Given (1990a, 1990b) who reported that plant collections had been discussed by both the Nature Conservation Council and the Royal Society in New Zealand. Unfortunately, although various recommendations were made, there was very little action. In recent years, some localised conservation networks for native plants have been established in Wellington and Auckland (M.Oates, personal communication, April 1995).

A Plant Collection Scheme was initiated by the RNZIH, and initial surveys identified 390 genera groups and 97 theme collections (Hammett, 1993; MacKay, 1993; RNZIH 1990). The overwhelming majority of those collections are exotic plants, only 20 generic and 29 theme collections contained native plants. Obviously this pattern may change as more data are collected, but it is an interesting initial observation and raises issues of 'where, when and who' with respect to native plant collections. Just as interesting is the finding that most living plant collections in New Zealand are owned by private individuals, with a minority held by institutions and government agencies. In recent times two government collections (Taupo native plant nursery, Aokautere plant materials centre) have been disbanded (Hammett, 1993; MacKay, 1993). This is interesting when considered against New Zealand's Foundation for Research Science and Technology (FRST) priorities for output 15, land and freshwater ecosystems, (previously output 31) which clearly include both exotic and indigenous flora, and which stressed the importance of plant collections (Lee, 1993). The official collections listed by FRST did not include any living plant collections (Lee, 1993; M.Parsons, personal communication, October 1996), suggesting a discrepancy between the stated priorities for science and the distribution and ownership of plant material.

1.4 Managing landscapes

1.4.1 Management theory

The management of an enterprise is a factor of production that influences its capacity to achieve its goals (Massie, 1979), therefore the landscape manager needs an understanding of the basic management theory that underpins landscape management processes. This section is drawn from management theorists (Griffin, 1990; Johnston et al., 1991; Massie, 1979; Rue and Byars, 1992; Stoner et al., 1985), landscape management experts (Bromley, 1990; Hitchmough, 1994; Kraus and Curtis, 1990; Miller, 1988), and a range of landscape management examples.

The first purpose of management is to use structured decision making and planning frameworks to achieve goals (Bromley, 1990; Griffin, 1990; Massie, 1979). Second, management provides a method to make optimum use of resources, i.e. people, finance, information, facilities and ideas (Bromley, 1990; Griffin, 1990; Massie, 1979). The third purpose is the need to understand and direct constant interaction and change in the enterprise (Bromley, 1990). Finally, a management framework provides a rational way to assess problems and measure performance (Bromley, 1990).

Systematic management takes place in two broad time frames, short term and long term. Business managers refer to long term management as strategic management, which includes consideration of the mission statement, long range goals, key assumptions about the business, broad resource deployment, scope of the business, and the overarching strategies that will be pursued (Griffin, 1990; Rue and Byars, 1992). Short term management includes daily management, which is planned tasks that contribute to goals, and crisis management which is resolution of unexpected events and situations. Effective management is a combination of short term and long term management and results in effective and efficient outcomes and use of resources (Bromley, 1990; Miller, 1988). The long term, strategic position is developed first which then drives the subsequent shorter term activities. Unfortunately many enterprises have no systematic management framework and always operate in crisis mode (Cobham, 1986; FRCC, 1988; Hitchmough, 1994; Selman, 1987). Without the 'anticipation of the future' that is associated with developing long term goals, a high proportion of normally predictable situations will become 'unexpected events' and reactive solutions will be used instead of planned responses.

Systematic management can be inhibited by several factors. The first is underfunding— systematic management takes time and resources and is therefore expensive to undertake (Griffin, 1990; Hitchmough, 1994, p 31; Miller, 1988; Stoner et al., 1985). Underfunding is common in landscape enterprises (Caballero, 1986; Hitchmough, 1994, p 17; Jellyman, 1993; Morgan, 1989; Overbeek, 1979; Tate, 1984), including botanic gardens (Eloff, 1989; Groombridge, 1992; Mangenot and Valik, 1987). Enterprises are also vulnerable to external funding factors such as tax status, inflation, and wage levels (Goodchild, 1984). Systematic management is essential when finance is limited (Hitchmough, 1994; Zander, 1980), but unfortunately many enterprises focus upon short term decisions under those circumstances. Hitchmough (1994, p 270) refers to 'inaction as a convenient option', as there is 'nothing cheaper than doing nothing'. As a result, the long term planning base is deferred, (even though it has considerable benefits) and the money used for short term maintenance. Unfortunately, continual deferment results in 'decline and capitalization' cycles and the quality of the landscape goes into boom and bust cycles (Burton and Matthews, 1989).

The second inhibiting factor for systematic management is expertise, which may not be available in every enterprise (Griffin, 1990). A certain level of knowledge is needed to recognise problems and develop solutions (Hitchmough, 1994, p 17; Trudgill 1990). For example, managers may be aware of the need to manage in a general sense, but not realise the particular needs of a biological system (Cobham, 1990). All factors should be recognised, and all parties should agree on the nature of the problem (Trudgill 1990). Minimum knowledge is also needed to implement plans. Standards of work must be sufficient, and employees should have the skills and levels of training to follow the plan (Goodchild, 1984).

The third factor is reluctance to engage in systematic management (Stoner et al., 1985), which Bromley (1990) believed was common amongst environmentalists. Some managers might suggest there is no point in planning as an uncertain future, combined with continuous change, negates its value. Stoner et al. (1985) conceded that one of the key obstacles to planning in small organisations was that the manager did not believe it was useful. Unfortunately this is hard to disprove as there are few landscape studies (Hagar et al. (1980) and Miller and Marano (1984) excepted) which illustrate that the systematic manager achieves a better result than the reactive manager.

1.4.2 Management skills

Effective managers need four main skills. First, conceptual skills to see the 'big picture' and to think strategically (Griffin, 1990). This includes the ability to think in abstract, and to understand cause and effect relationships in the organisation which, in turn, allows one to see how the organisation fits together and view it in an holistic way. Second, diagnostic and analytical skills are needed to analyse situations and determine causal factors (Griffin, 1990). These skills underpin the ability to define a problem, recognise causes and solve the problem. Third, managers need technical skills relating to daily operations of the organisation (Griffin, 1990). These skills are most needed in the first-line manager, nevertheless top level managers must still have sufficient skill to understand how the organisation operates on a daily basis. Finally, managers need interpersonal skills to communicate with, motivate, and understand other people in the organisation (Griffin, 1990).

The balance of skills depends upon the level of any individual manager (Griffin, 1990). Top managers must have good conceptual and diagnostic skills as these underpin their key planning roles; they have less need for a high level of technical skills. Conversely, first-line managers need a greater level of technical skills but less conceptual and diagnostic skill as they are less involved in top level planning.

1.4.3 Management functions

There are seven basic functions of management: planning, decision making, organising, controlling, directing, communicating, and staffing (Bromley, 1990; Christiansen, 1977; Massie, 1979; Stoner et al., 1985). Griffin (1990) subsumed communicating and staffing into the other functions and listed only the first five. The functions are all interrelated and likely to occur simultaneously (Griffin, 1990). The need for these functions increases as an enterprise becomes more complex. The first four functions are relevant to this project.

(i) Planning

Planning is the key function and is a prerequisite for all other functions, as each depends upon thinking in advance of the actual activity (Christiansen, 1977; Massie, 1979; Miller, 1988). Planning takes place in both long and short term time frames, and therefore underpins long term and short term management. Planning involves setting goals, analysing the enterprise, developing objectives and strategies to achieve those goals, and then implementing the plan. Effective implementation is essential; making a plan and not using it is as ineffective as not making one in the first place (Stoner et al., 1985). The final step in planning is monitoring and control where progress is checked and adjusted to ensure that the plan is being achieved. Development of plans is central to the management aspects of this research, therefore this aspect is discussed in more detail in Chapter 4.

(ii) Decision making

Decision making is also a key function as each other function depends upon the capacity to make rational, defensible decisions. Decision making is the device by which courses of action are chosen from available alternatives. The important aspects of the process are the notion of choice, the use of mental processes at the conscious level, and the specific intent of using the process to achieve an objective (Massie, 1979). Decision making involves a series of steps that relate to gathering information, developing and selecting alternatives, and implementing the best alternative. The process can be conducted individually or as a group activity. Decision making is also discussed in more detail in Chapter 4.

(iii) Organising

Plans and decisions require suitable organisational structure for both development and implementation (Griffin, 1990; Matthews, 1989; Rue and Byars, 1992; Stoner et al., 1985). Poor organisational structure, such as a lack of clear authority, or poorly defined hierarchy can inhibit management processes (Eloff, 1989; Hitchmough, 1994, p 17). In the Emerald Necklace parks in Boston (a complex of five interconnected parks), three different authorities used varying policies to manage the five parks resulting in serious inconsistencies of output (Burton and Matthews, 1989). Schermerhorn (1989) proposed that slow or poor decision making was a major symptom of the need for changes to the structure of an organisation.

Organisations move through different structures as they grow and mature (Rue and Byars, 1992). First is the craft stage which is characterised by an absence of formal policies, objectives and structure, with operations generally centring around one individual. Next is the entrepreneurial stage where sales and profits rise rapidly, usually making the business more complex and making some type of structure necessary. Third is the professional management stage where the organisation engages a professional manager who uses the management functions. This stage is characterised by written policies and plans. As an organisation moves from the craft to entrepreneurial stages an organisational structure must be developed otherwise the business may collapse (Rue and Byars, 1992).

(iv) Control

Finally, effective management requires the control function. Others use 'monitoring' (McCarthy and Deans, 1983) 'review' (Hitchmough, 1994) and 'evaluation' (Kraus and Curtis, 1990) to describe the same role. Plans will not be successful unless progress is monitored, and adjusted if necessary to ensure that objectives are reached (Stoner et al., 1985). Without control the result may be much activity, but little actual achievement of goals (Massie, 1979). The control function measures actual performance against expected performance and identifies discrepancies, therefore defining progress and allowing corrections to be made. Unexpected consequences can be identified, and anticipation of future problems is improved (Massie, 1979; McCarthy and Deans, 1983; Rue and Byars, 1992). The control function requires the enterprise to have a predetermined goal, a means of measuring performance and comparing it with expectations, and a way to adjust activity in the light of the previous comparison (Hitchmough, 1994, p 65; Johnston et al., 1991; Rue and Byars, 1992).

1.4.4 Are landscapes managed?

Many landscape practitioners recognise the benefits of using systematic management practices (Bell and Lucas, 1989; Bromley, 1990; Clark and Kjelgren, 1989; Cobham, 1990; Goodchild, 1984; Kirby, 1986; Lewis, 1990; Miller, 1988; Sales, 1988; Sharon, 1987; Smith, 1991; Talarchek, 1987; Towler, 1986a; Weinstein, 1984). Indeed, there is a recent trend towards new texts on the subject (Bromley, 1990; Cobham, 1990; Hitchmough, 1994; Kraus and Curtis, 1990; Miller, 1988). The need to have accurate information as a basis for decision making is recognised (Cobham, 1986; Crossen, 1989; Lindhult, 1987; Miller, 1988; Sandiford, 1989; Talarchek, 1987), as is the need to have clearly defined objectives (FRCC, 1988; Lindhult, 1987), and a means of setting priorities (Beckett and Dempster, 1989; FRCC, 1988).

Although the value of systematic management is often recognised, implementation does not necessarily follow (Gerhold et al., 1987). Kirby (1986) noted that there were few serious attempts to use systematic management practice (in Britain) until the world recession of the 1970s when funds became limited. Others were also critical, suggesting that landscape management was ineffective (Cobham, 1990), that management plans were the exception rather than the rule (McNeely and Miller, 1983), and that landscapes (American parks) suffered from a lack of planning (Haber, 1986). Long term plans were seldom developed and more emphasis was needed on long range decisions (Hitchmough, 1994, p 17; Selman, 1987). Landscape management frequently had an inconsistent, ad hoc approach (Cobham, 1986; Lewis, 1990) with poorly developed objectives and crisis management (Burton and Matthews, 1989; Cobham, 1986; Coyne, 1988; FRCC, 1988; Kielbaso et al., 1982; Lewis, 1990; Sharon, 1987; Smith, 1991).

The result was landscape degradation (Burton and Matthews, 1989), loss of cohesion in historic landscapes (Goodchild, 1984; Sales, 1988), and inability to produce viable long-term landscapes (Coyne, 1988; Lewis, 1990). Tree populations declined in both natural and created landscapes (Burton and Matthews, 1989; Cobham, 1986; Elliot, 1988; Sharon, 1987; Towler, 1986a). The Forestry Research Coordination Committee (FRCC, 1988) in Britain suggested that tree management lacked objectives and policies and that "the policy most commonly demanded by the public, and therefore advocated, is one of simply replacing existing trees as they die". Furthermore, they felt that "management concepts are ultraconservative and have changed very little in response to the changing pressures and alterations in land use." Landscape management was too often reactive and ad hoc (Cobham, 1986; FRCC, 1988; Hitchmough, 1994; Selman, 1987) and would remain that way until better information and processes were developed (Cobham, 1986; Kirby, 1986). This was an unfortunate situation considering that long term quality of human-made landscapes depends upon systematic management practice.

1.4.5 Landscape management processes

Processes for managing landscapes should be based on sound management principles which have been developed to suit landscapes, in this case the single site. The two common landscape management processes which operate at site scale are the design process which focuses upon developing new landscapes, and the management process which focuses upon existing landscapes. This project focuses upon the management process, the design process is not immediately relevant.

Investigation of the literature reveals an apparently wide range of processes for managing landscapes, but it is important to recognise that many, while containing useful principles, are not suitable for single site management. In particular there are several planning processes which operate at a very broad scale and at the policy level of landscape planning, e.g. the Metland technique (Fabos, 1979b), the Landep technique (Zonneveld and Forman, 1990). These processes usually involve an 'investigate, evaluate, plan, implement' sequence that is logical, but the breadth of their application makes them unsuitable for a single site.

Other practitioners have considered single site management and a variety of processes have been discussed. The discussion below is synthesised from the British Countryside Commission process (Bromley, 1990), the British Nature Conservancy Council process (Bromley, 1990), the farm conservation plan (Burnett, 1989), the ADAS integrated land management plan (Haigh, 1988), urban forest planning (Miller, 1988), historic landscape management (Banks, 1988; Cobham, 1985; Marquis-Kyle et al., 1992; Sales, 1988), urban landscape management (Hitchmough, 1994; Lewis, 1990), and parks and garden management (Morgan, 1991; Wittkugel,1988; Wright, 1982). These processes differ in detail but each follows a similar sequence of: setting goals, analysing the enterprise, developing objectives and strategies to achieve those goals, and monitoring progress to ascertain that the plan is being achieved.

The first step, setting goals, occurs within the context of the philosophical position and purpose of the enterprise. This is generally expressed in the mission statement which states the overall purpose, and guides subsequent decisions (Byrd, 1989; Robertson et al., 1989; Stoner et al., 1985). Each plan will have its own particular goal(s) within the context of the mission (Countryside Commission model in Bromley, 1990).

Next, both plans and decisions need information as a fundamental input. Each of the aforementioned processes includes a comprehensive survey of the landscape and all the features relevant to the plan (Burnett, 1989; Cobham, 1985; Countryside Commission in Bromley, 1990; Haigh, 1988; Miller, 1988; Morgan, 1991; Nature Conservancy Council in Bromley, 1990; Peterken, 1981). Inventory does not, however, indicate the importance of a resource, therefore an evaluation step is needed. Values must be identified along with significant features (Burnett, 1988; Haigh, 1988; Nature Conservancy Council in Bromley, 1990; Peterken, 1981). Interactions and conflicts between values are of interest, as are the agents of change that will influence the landscape (Countryside Commission in Bromley, 1990; Haigh, 1988; Miller, 1988).

Goals and objectives are developed next (Cobham, 1985; Countryside Commission in Bromley, 1990; Haigh, 1988: Miller, 1988; Morgan, 1991; Nature Conservancy Council in Bromley, 1990).

Some goals will be at an overview level to establish a viable long term framework (Haigh, 1988). Subsequent goals should have different time spans; long range, medium, short, annual (Cobham, 1985; Miller, 1988; Wright, 1982, p 137). Short and medium term goals should lead to long term goals, while long term goals should be broken down into shorter term goals. Goals should be prioritised in each time frame (Miller, 1988).

Detailed actions are outlined in documents variously called strategies, plans, or programmes (Countryside Commission in Bromley, 1990; Haigh, 1988; Peterken, 1981). These may include detailed proposals for capital and land management activities, design of new features, identification of new projects, planting and removals (Burnett, 1988; Haigh, 1988; Miller, 1988; Nature Conservancy Council in Bromley, 1990). Once these planning steps have been completed, the strategies can be implemented (Cobham, 1990).

The final step is feedback and monitoring to evaluate progress and see if the plan is being achieved (Countryside Commission in Bromley, 1990; Miller, 1988; Morgan, 1991; Nature Conservancy Council in Bromley, 1990; Peterken, 1981).

There is a high level of consistency about the basic process, but how should it be applied to a botanic garden or arboretum? Are there any particular characteristics of the arboretum that will require the planning process to be modified in any way? Will the purpose and mission of the enterprise influence the planning process used? What type of information will be needed? What should be included in an inventory of an arboretum? How should an arboretum be evaluated? What values should be measured and are there methods available for that measurement? What types of strategies will be needed? How should these be developed? These, and other questions, must be answered if the basic theory is to be successfully applied to an arboretum. These issues will be considered in this project as a management process is developed for the Eastwoodhill Arboretum.

1.4.6 Managing arboreta and the Eastwoodhill Arboretum

Botanic gardens, arboreta and plant collections are human-made landscapes, with a contrived plant diversity, kept in a particular state by intervention. They are not self-sustaining, yet a key purpose of an arboretum is to conserve plant material. Therefore, important species, collections, and displays must be perpetuated by management action.

Unfortunately, deterioration of human-made landscapes containing important vegetation is frequently reported. Ageing and increasingly poor condition of vegetation is a common problem; tree populations become over-mature, overgrown or damaged, and shrub layers deteriorate or disappear (Beach, 1985; Beckett and Dempster, 1989; Cobham, 1985; Davis, 1986; Hall, 1974; Keen, 1985; Wright, 1982). Features such as lakes and streams may become overgrown and silted-up (Keen, 1985; Wright, 1982). Botanic gardens deteriorate into well maintained public parks (Heywood, 1987). Beach (1985) reported that Thorp Perrow Arboretum in Britain was over-planted with the result that many important trees were suppressed. A great deal of clearing of the site is often needed before the information needed for a planning framework can be obtained (Beach, 1985; Davis, 1986).

Each of these changes can be managed or reversed with appropriate landscape management practice, to ultimately produce a good quality landscape that will achieve the mission of the enterprise. It has already been shown that systematic landscape management practice, while recognised by some, is not universally used. Management of botanic gardens and arboreta has been criticised by world authorities, who suggested that many were badly organised and more professional and coherent management was needed (Eloff, 1989; Groombridge, 1992; WWF and IUCN, 1989). Heywood (1987) suggested that collections were rarely managed under any clearly articulated policy, and collection management was determined by a combination of fashion and the individual interests of those in charge of daily operations. This is precisely the situation that Sales (1988, 1989, 1990) has repeatedly urged managers to avoid.

What type of management system is needed to manage plant collections in human-made landscapes and to reconcile the need for perpetuation against the fact of inevitable change and decay? Such a system must focus upon management of biological values as these are the *raison d'etre* of an arboretum. At the same time, visual values must also be taken into account as these are responsible for attracting enough visitors to keep the enterprise viable. Next, the system must focus upon deliberate and planned vegetation management, to establish a systematic method for vegetation renewal in a landscape that cannot generate that renewal of its own accord. Finally, there must be a rational and systematic means to make those decisions, so a management and planning structure will be needed. For the purpose of this discussion I will call this system the 'botanic garden management system'. Such a management system should focus upon both management processes and inputs. The inputs will be a philosophical position, knowledge, finance, and organisational structure. Management processes will focus upon the planning and decision making framework as these are the pivotal management processes.

This research focuses on long term management of the plant collection at the Eastwoodhill Arboretum and considers its management framework. What are the issues that confront the Trust Board at Eastwoodhill? How should management inputs and processes be used at Eastwoodhill? A 'botanic garden management system' is required that encapsulates a systematic planning and management framework with a primary focus on biological value, and a systematic method of vegetation management.

Are there any factors that will influence the development of that framework at Eastwoodhill? The plant collection was considered (but not proven) to be important in New Zealand and was thought to contain plant material that was unique in this country. At the same time deterioration of the site led to a drop in condition of many of the trees and a reduction in visual value. In addition, management of the Arboretum was limited with respect to management processes and inputs (landscape management expertise, limited finance, and an insufficient labour force). When this research started a complete inventory did not exist, and the components that were available were out of date. As has already been explained in section 1.1, the Trust Board had not yet established a planning framework or developed any long term plans.

In addition, the 'botanic garden problem' (having a biological purpose but needing good visual values to attract public) is exacerbated at Eastwoodhill because it is in a remote rural area in a remote part of the country. Visitors, whether they are scientific or recreational, must travel a considerable distance to reach the Arboretum, therefore the collection must be good enough justify that effort and expense. Thus the attraction (the biological qualities of the collection for the scientific visitor, the visual qualities for the recreational visitor) must be maintained above a certain level which allows Eastwoodhill to 'compete' with alternative sites. For example, emerging new plant collections in other parts of the country that are more accessible, younger and in better condition, may prove more appealing to the scientific visitor than Eastwoodhill. Similarly, the recreational visitor may be reluctant to travel 35km from Gisborne to Eastwoodhill when other possibilities, different but equally interesting, are closer. Thus, both biological and visual value of Eastwoodhill must be excellent to make up for the disadvantage of distance. The problem is exacerbated even more when a site is in poor condition, as Eastwoodhill has been, as the poor visual qualities make it very difficult to attract the needed visitors. This introduces an extra step into the management system, the condition of the site must be restored back to an acceptable base line before long term vegetation renewal plans can be developed.

In this research a methodology was developed to address the key collection management issues at the Eastwoodhill Arboretum. These are: (i) the need to fulfill the role of an arboretum, which requires a significant living collection that is conserved in the long term, (indeed, Eastwoodhill has a statutory requirement to be an arboretum), (ii) the need for Eastwoodhill to have high biological and visual value to achieve its role and compete with other institutions, and the need to do this with a resource of suspected but unsubstantiated significance that is not in good condition, (iii) the need to develop a systematic management system to sustain a human-made landscape; and (iv) the need to develop a planning framework and overcome the problem of limited management inputs.

Combining the previous discussions on landscapes, botanic gardens, landscape management processes, and Eastwoodhill, it is proposed that a management system can be developed which will address those key problems by developing effective and efficient management processes and inputs. Such a management system can be used to realise the biological and visual values that are needed and therefore achieve the role of the Arboretum. The following collection management issues were addressed in this research:

1. Comprehensive inventory was needed to provide data for planning. The existing inventory was out of date, did not include any maps, and had no means of accurate tree location. This is addressed in Chapter 2 on inventory.
2. Evaluation was needed to determine the importance of the resource. This would provide a basis from which both goals and priorities could be developed. This is addressed in Chapter 3 on evaluation.
3. A planning mechanism and organisational structure was needed which could be used to develop decisions and plans. This should include (i) a planning and decision making method, (ii) a suitable organisational structure, and (iii) suitable expertise to make the decisions. This is addressed in Chapter 4 on the workshops.
4. A management process was needed which could be used to develop goals, objectives and strategies to manage and perpetuate the collection. Goals are considered in Chapter 3, where possible priorities are recommended following the evaluation, and again in Chapter 5 following the activities of the decision making group. Development of strategies for managing the collection, including plans for parks and genera, are found in Chapter 6.

Goal

To develop and apply a landscape management process to the plant collection at the Eastwoodhill Arboretum that includes stages in inventory, evaluation, setting objectives, and developing strategies (with an organisational structure to achieve the latter two stages). Successfully implemented, this process could form the basis of a long term management framework for the plant collection.

Chapter 2

Developing an inventory of the plant collection at the Eastwoodhill Arboretum

Acer japonicum cultivar, Rock Point Pond, April 1993

2.1 INTRODUCTION AND REVIEW

An inventory is the foundation for systematic management of a landscape as it provides information needed in subsequent stages of the management process, thereby allowing the landscape to be planned and designed in a rational way and directed towards its goals. Without information from an inventory it will be impossible to understand the site, evaluate the site, develop defensible objectives or priorities, or form a management plan. Information can also be used to test the feasibility of proposed strategies and provide a baseline for future monitoring. Repeated data collection over time gives a picture of long term landscape change, which is particularly important when managing vegetation in human-made landscapes that must be sustained by systematic management.

In the absence of an inventory, some form of crisis management will develop as there is no information from which the 'long term' and 'short term' management framework can be developed (as explained in section 1.4). Short term decision making will dominate and decisions will be ad hoc as the fundamental component, information, is missing. It will be impossible to develop plans because, without information, the manager cannot move beyond daily problem solving or relate daily operations to long term goals (Amir and Misgav, 1990; Kielbaso, 1990; Lewis, 1990; Lobel, 1983; Tate, 1985). Unfortunately a lack of information is common in landscape management. This problem has been reported for urban landscape management (Hitchmough, 1994; Kielbaso et al., 1982; Tate, 1984), countryside management (Blacksell and Gilg, 1981), national parks (Stohlgren et al., 1994) and botanic garden and plant collection management (Brickell, 1979; Given, 1986). Information is also the basis for horticultural research (Marshall, 1983), park planning (Christiansen, 1977), conservation of species (Zander, 1980), and restoration of historic landscapes (Miles, 1991). The problem has been quantified for some urban forest situations. According to Reeder and Gerhold (1993), Rubens (1978), and Kielbaso (1990), less than 40% of urban forest managers had an inventory, and the majority (62-72%) used crisis management. Miller (1988) reported that city foresters spent 64% of their budgets on tree management, but only 22% of managers had accurate knowledge of the tree resource.

This chapter outlines the principles for making an inventory, the types of information that should be collected, and methods for recording that information. An inventory of Eastwoodhill Arboretum is then reported and discussed. This inventory fulfilled two purposes: an inventory of the Arboretum, and data for this project.

2.1.1 Principles of inventory

The purpose of an inventory is to collect and store the information needed to describe and understand a site (Fabos and McGregor, 1979; Miller, 1988; Rodiek and Wilen, 1980). The three stages in developing an inventory are planning, implementation, and operation (Miller, 1988; Ziesmer, 1978).

In the planning stage, one identifies the information needed and how it should be recorded (Austin, 1991; Miller, 1988; Ziesmer, 1978). Ziesmer (1978) used an 'information needs' analysis to identify the information needed at various levels of management, and compared that with the information already available. This indicated whether or not an inventory was needed, the type required, and what form it should take. One of several types of inventory might be selected (described in section 2.1.2), including the cover survey, partial inventory, specific problem inventory and complete inventory. Next, the components of the inventory are selected, including maps, plant records and written documents (described in sections 2.1.3-2.1.5). Finally, specific information should be defined, e.g. size of a tree might be measured by height, height to the base of the crown, dbh (diameter at breast height), and crown spread. A range of variables that might be used are outlined in section 2.1.6.

In the implementation stage, field work is done and the information is collected. As the information must be complete, accurate, consistent, and with sufficient detail, recording protocols are needed (Annett, 1990; Chan and Cartwright, 1978; Collyer, 1983; Gerhold and Sacksteder, 1979; Gerhold et al., 1987; Lindhult, 1987; Sandiford 1989). Recording protocols should be prepared in advance and will include base plans for mapping, standard field notebooks or survey forms, data categories such as name codes and standardised assessment classes for factors such as health, quantity of damage or disease incidence. A well developed set of protocols is essential to ensure consistency, particularly when more than one person is involved in the field work. Some recording, particularly plant identification and assessment, needs expert knowledge therefore suitably skilled staff must be available to make the inventory (Annett, 1990; Miller, 1988; Thurman, 1983b). If mapping is involved the staff must have relevant surveying skills.

Once the field work is completed the information on the field sheets is formed into the permanent components of the inventory, i.e. maps, plant files and written documents. These permanent components must also be complete, accurate and consistent therefore protocols may be needed to ensure field data is properly entered onto the permanent record. When large quantities of information are involved the data can be coded, which reduces recording time and space for storage (Hunt, 1977; Marshall, 1983). As the completed records are used as a management tool, they must be easy to access, sort, and understand. Different subsets of information may be needed for various planning purposes, e.g. numbers of a particular genus, trees of a particular origin, portion of the population in a certain age class.

The operational phase of the inventory occurs when the information is used in the management process. It is the *use* of data that is critical, the information itself is static and does not constitute plans or decisions (Annett, 1990; Given, 1981; Jackman, 1980; Miller 1988). For example, Kielbaso (1990) found that although 38% of city arborists had an inventory of their urban tree population, only 16% had developed long range plans.

The information must be current to be an effective management tool; old information may lead to poor decisions and inhibit management (Cullen et al., 1985; Maggio 1986; Thurman, 1983b). Therefore, a strategy for regular updating is required (Annett, 1990; Crossen, 1989; Gerhold et al., 1987; Hunt, 1977; Lindhult, 1987; Maggio, 1986; Massey et al., 1979). A portion could be done each year, or the whole inventory updated at set intervals, depending upon resource availability.

2.1.2 Types of inventory

Different types of inventory focus upon different information from different portions of the landscape. The type selected will depend upon the information needed, the accuracy required, and the resources available for the task (Cullen et al., 1985; McBride and Nowak, 1989).

A cover survey is the least comprehensive inventory as individual plants are not recorded. The general canopy is quantified and monitored (usually from aerial photographs), and changes in total vegetation pattern are used in management decisions (Smiley and Baker, 1988). The scale is generally large, for example 1:25,000 (Harkness, 1983; Kirkpatrick, 1990; Rogers and Rowntree, 1988; Spencer and Kirby, 1992), or 1:18,000 (Nilon, 1991). Cover surveys have been used to describe habitat changes in urban parks (Rogers and Rowntree, 1988), distribution of urban trees (Nelson, 1994), changes in woodlands over time (Spencer and Kirby, 1992), management needs for different vegetation types in Australian National parks (Kirkpatrick, 1990), and to study vegetation patterns in Alabama (Wang, 1988). Wang (1988) concluded that the method gave a quick and low cost description of tree communities.

A partial inventory records samples of the population and then extrapolates the result to describe the whole population (Smiley and Baker, 1988). This method is useful for describing general patterns in the population (Jaenson et al., 1992; McBride and Nowak, 1989) but has insufficient information for detailed maintenance or other plans (McBride and Nowak, 1989). The advantage of the method is its comparative speed and cost in obtaining data on large populations, particularly when finance is limiting (McBride and Nowak, 1989; Miller, 1988).

A 'stratified random sample' is a partial inventory which divides a site into segments and takes a random sample from each one (McBride and Nowak, 1989). Jaenson et al. (1992) used this method to assess the condition of street trees within a city and found that it was 90% accurate for trees with a known inventory. Allison and Peterken (1985) and Barr and Whittaker (1987) measured large scale change in tree cover in Britain with random sampling methods. Another type of partial inventory is the 'stratified systematic sample', which divides a site into segments and then uses fixed placements to locate samples (McBride and Nowak, 1989). Both types of partial inventory rely upon suitable sample sizes and locations. This issue has been investigated by Jaenson et al. (1992), Sun and Bassuk (1991), and Valentine et al. (1978) who all tested sampling methods that proved 90% accurate in describing a known population.

Smiley and Baker (1988) described the 'specific problem inventory' which records every plant, but only for one condition such as disease incidence. Rodgers and Harris (1983) used a type of specific problem inventory when they surveyed the status of Pecan trees in Texas for disease incidence.

The final, and most detailed method, is the complete inventory which involves a comprehensive survey of the site. This is time consuming, but essential when a precise record of the landscape is needed, such as for urban tree management, arboreta and complex gardens, historic landscapes, and as a basis for planning (Goulty, 1993; Jungst, 1983; Maggio, 1986; Marshall, 1983; Smiley and Baker, 1988). A complete inventory results in a record for each plant in the population with several categories of information recorded for each one (Smiley and Baker, 1988). Physical features of the site are also recorded including circulation, structures, topography, slope, land use, vistas, archaeological features, landmarks and vantage points (Jackman, 1980; McCann, 1992; Phibbs, 1983). The permanent components of a complete inventory are plant records, written documents, and maps. The latter are an essential component as they are the only feasible way to accurately locate individual plants and features (McBride and Nowak, 1989; Warwick and Williams, 1993). The map is the executive document from which other documents are derived (McBride and Nowak, 1989).

2.1.3 Components of an inventory: maps

Maps are required for any complete inventory where a precise record and location of individual plants is needed, such as conservation planning (Pressey and Bedwood, 1991), field surveys of cultural landscape (McCann, 1992), park management (Stohlgren et al., 1994), historic landscapes

(Phibbs, 1983), and arboreta and plant collections (Cross, 1990; Johnson, E. 1989; Sales, 1990; Stungo, 1982). Partial inventory and specific problem inventories may also use maps to locate sample plots or trees, or divide sites into manageable areas (McBride and Nowak, 1989). Maps should show relevant physical features of the site, position and name of each plant, and a reference number for each plant.

The first stage in mapping is development of a base plan, usually from aerial photographs. A tracing is made that shows features such as property boundaries and internal divisions, buildings, paths and tracks, waterways, fences, and general areas of vegetation. Key features that are easily recognised on the photograph are marked on the base plan as reference points for the field survey. A clear photograph will allow a considerable range of site features to be marked on the base plan, assuming, however, that the photograph is at a scale where the features can be readily distinguished.

The base plan may be developed at a different scale to the original photograph. This depends upon both the photograph and the type of inventory being made. Broad scale cover survey mapping may be at 1:25000, with single site cover surveys at perhaps 1:2400 (Maggio, 1986) or 1:1250 (Rollinson, 1987). The most suitable scale will depend upon vegetation and the type of inventory. Larger scales are needed as vegetation becomes more dense and the inventory more complex, e.g. McBride and Nowak (1989) reported a site survey at 1:400, and Goodwin (1996) proposed 1:100 or 1:200 as suitable for tree mapping.

Next, the base plan is taken into the field and site information is added. The base plan is 'ground verified' by checking ground measurements against those on the plan. This ensures that reference points on the base plan are correct on the ground, and allows the surveyor to account for any distortion that may have been created by the photographs. This is particularly important where vegetation is dense, the photograph is not clear, or the terrain is not flat as each of these conditions can cause distortions in the photographs and therefore the base plan. When the base plan is accurate, vegetation and other relevant features can be plotted. McBride and Nowak (1989) described five plotting techniques for recording trees on a map:

Non stratified direct tree mapping

This method assigns a number to each tree and plots it, with an approximate location, on the base plan. Trees are positioned on the map 'by eye' and without any measurements being taken. This is only suitable for small sites with a low density of vegetation.

Stratified direct tree mapping

This method follows the same principle as non-stratified direct tree mapping, but is suitable for larger sites. The site is divided into zones with logical physical boundaries (e.g. roads or paths) and trees are plotted zone by zone. Positioning of the trees is again 'by eye' and therefore the method is limited when vegetation becomes too dense.

Systematic location without mapping

Here the site is divided into zones; each zone is recorded by starting at a nominated point and recording trees sequentially as they are encountered. Trees are located again by finding the starting point and counting through the sequence. This method is suitable for small parks with low density but is not suited to complex sites where tree location may be misread.

Grid reference

This method works from a grid overlaid onto a base plan. The grid should be either surveyed on the ground, or drawn on the map and estimated on the ground. Trees are mapped within each cell. Cell size will vary with the complexity of the site; Utah State Arboretum was mapped with cells of 6×6m, and Reed Kepler park (in America) with cells of 30×30m (McBride and Nowak, 1989). McPherson et al. (1985) used a grid reference system with grids at either 16×16m or 6×6m to locate trees in a park. A key advantage of this system is that it can be organised to be compatible with Geographic Information Systems (GIS).

Triangulation

Plant locations are plotted by triangulation from known reference points. More reference points and good sight lines are needed as tree density and site size increase. Westonbirt Arboretum in Britain was mapped using compass bearings from known reference points (McBride and Nowak, 1989).

Systematic location without mapping is the fastest of these methods, but also the least accurate as it records, but does not plot, individual trees. Triangulation is the most accurate but most time consuming. The grid reference system combines accuracy with efficient use of time (McBride and Nowak, 1989). In recent times more sophisticated methods have become available for recording map data, e.g. aerial photograph information may be digitised directly onto a computer, or trees may be plotted by global positioning (Goodwin, 1996; Sorvig, 1995). Survey equipment may be linked directly to a computer and map records automatically created. For example, Kirkpatrick (1990) used remote sensing data to map vegetation types, and Wang (1988) used Landsat Thematic data to map city vegetation.

Final plans may be drawn manually or by computer. Each requires accurate information as input, but manipulation of drawings is much easier with a computer than by manual methods. Additions and alterations, such as changes in scale, can be made easily and without re-drawing the whole map (Collyer, 1983). Similarly, changes in plant files can be automatically transferred to the map in systems where plant files are linked to the maps. Computer technology is obviously an advantage, but these systems may not be available to every enterprise and manual methods may have to be used as effectively as possible.

2.1.4 Components of an inventory: plant files

2.1.4.1 Catalogue

A catalogue is often used to list diverse vegetation on complex sites. Catalogues usually contain an alphabetical list of plants with limited other information for each plant such as common name, geographic origin or location on the site. On some sites the catalogue may be the only form of plant file, while on other sites the catalogue may be associated with more complex plant records where it would be a form of index for those records. Catalogues are used for historic sites, parks, arboreta and plant collections (Sales, 1989, 1990; Stungo, 1982).

2.1.4.2 Plant records

In some inventories a comprehensive record is needed for each plant, and often involves many pieces of information. Botanic gardens and arboreta need complex plant records to cover the biological information required to describe the plant and its source, e.g. name, synonyms, precise geographical source of the accession, verification, and collecting details. This information is deemed necessary to scientifically manage the plant in cultivation. The Kew Gardens system has about 50 categories of information, the International Dendrology Society has 30, and the British Plant Collection Scheme has 10 basic and 6 optional categories.

Such a large number of data categories needs a consistent record format and several of these are available. A well known record format for tree collections is the International Dendrology Society (IDS) record card (International Dendrology Society, 1983). This format was developed by the Society as a standard way to record tree collections and can be used as a card or computer file. It was based upon the Kew Gardens card which was used to record the Kew Gardens collections. The British Plant Collection scheme also has a standard record card (Lowe, 1991). In fact there are innumerable possible options for record formats, and individual enterprises customise their records resulting in a plethora of different records that are not generally comparable.

The International Union for Conservation of Nature and Natural Resources (IUCN) addressed this problem and proposed that a common record format, the International Transfer Format (ITF), be developed for botanic gardens and arboreta. A common format would allow data exchange and development of a worldwide set of information that could be used in an international conservation effort. The ITF is administered by Botanic Gardens Conservation International (BGCI) in London where the main database is held. BGCI has information on 1600 gardens and 100,000 plants on the database (Anon., 1992b; Leadlay et al., 1993).

The ITF system is based upon four basic data categories essential for information exchange: accession data, plant name data, verification data, and source and origin data (Cullen et al., 1985). The ITF places this information in 33 fields of specified construction and arrangement (IUCN, 1987a). Additional fields can be added by individual garden managers as needed. As the format can be developed on any computer software or hardware, any enterprise can use the ITF irrespective of their computing resources. The format can also be used as a manual record card if necessary. The principles of the system and its use, and data collection are discussed by Anon. (1992b), Leadlay (1988), Leadlay et al. (1993) and Wymer (1988). The common core of specified fields can be exchanged worldwide by an exchange of disks and the capacity to read an ASCII file. In New Zealand, the Wellington Botanic Garden, Auckland University and the RNZIH are developing ITF formats for their plant records.

Irrespective of the record system used, some management of records is necessary. Plant records are often divided into 'current' files and 'dead' files (Gerhold and Sacksteder, 1979; Hunt, 1977; Watson and Hardy 1987). Records are transferred from 'current' to 'dead' when a plant dies or is removed. The 'dead' file is important for tracking change in a population, identifying mortality factors, and monitoring species performance (Gerhold and Sacksteder, 1979; Hunt, 1977).

A variety of outputs should be possible from the plant records including individual plant records or lists by genera, areas, or size categories. Profiles of various factors are also desirable. For example Weinstein (1983) developed profiles for the condition of dominant species, condition of trees in public places, and the percentage of dead wood in the population. Each of these outputs can be used in decisions about the landscape and its management.

2.1.4.3 Reference numbers

A reference number will be needed when large numbers of records are involved, or when individual records need to be separated. This number is a unique identifier which remains with the plant and its record and separates different examples of the same species, provides a clear link between the plant in the field and its record, provides a link between database and map information, and provides an identifier which is independent of the plant name, which is potentially subject to change.

A reference number can take one of two main forms. It may be an arbitrary but unique number that simply acts as a tag, which is often used for street tree records. Otherwise it may be the more complex accession number form as used in botanic gardens and plant collections. Accession numbers are usually coded to provide several pieces of information about a plant. For example, the first two digits often indicate the year of accession, other digits may indicate the *n'th* accession for that year, or a number for that particular individual of that species. Botanic gardens, the International Dendrology Society, and British Plant Collections Scheme have methods for generating and using accession numbers (International Dendrology Society, 1983; IUCN, 1987a; Lowe, 1991). Ideally a plant should be physically tagged with the accession number.

2.1.4.4 Herbarium samples

A useful way of recording individual plants is to make an herbarium sample. The dried sample acts as a reference and can be used for further study. Herbarium samples are required as part of the record of plant collections (Anon., 1989; Anon., 1991; Sanecki, 1989; Stungo, 1982; Taylor, 1988) and are an essential component of botanic gardens and arboreta (Ashton, 1989).

2.1.5 Components of an inventory: written documents

Although plant records often form the bulk of an inventory, written records may also be relevant. Financial records, visitor surveys and historical searches may be needed depending on the type of enterprise and the objectives being addressed (Bromley, 1990; Marshall, 1983). Archival searches and a record of site history are essential for historic sites (Bromley, 1990; Goulty, 1993; Marshall, 1983; Phibbs, 1983). A review of previous management of the site may be necessary (Miller, 1988; Peterken, 1981). Investigation of ecological history and an analysis of factors that will influence change in a tree population can also be included (Miller, 1988; Peterken, 1981. The design of historic gardens may have to be investigated to understand the visual effects (Moggridge, 1986). In other situations the written record may have less relevance. For example, street tree inventories generally focus upon tree records and require little written documentation (Miller, 1988).

2.1.6 Variables to record

Numerous variables can be recorded in an inventory. The basic plant record should contain the name of the plant, the source of the plant, and its location (Cullen et al., 1985). Further to the basic record, there is a vast range of variables which can be grouped into categories such as location variables, condition variables and plant variables. Information might include permanent features such as name or location, or transitory features such as pest incidence or work needed (Miller, 1988). There may be a combination of objective measurements such as height, location, soil, and subjective measurements such as condition, hazard, and disease incidence (Barrell, 1993). A summary of the variables that might be used in an inventory is shown below (Chan and Cartwright, 1979; Cobham, 1990; Crossen, 1989; Cullen et al., 1985; Gerhold and Sacksteder, 1979; Gerhold et al., 1987; Hitchmough, 1994; Kelsey and Hootman, 1988; Lindhult, 1987; Marshall, 1983; Miller, 1988; Smiley and Baker, 1988; Weinstein, 1984):

Tree characteristics provide a profile of the tree:	
Record data:	ID number, date, name.
Accession data:	Origin, date, type of plant material, collector.
Verification data:	Source and date of confirmation of identity.
Species factors:	Species, plant type, hardiness, pest and disease resistance, aesthetic value, life expectancy, ultimate height, age.
Size factors:	Height, diameter at breast height (dbh), spread.
Condition factors:	root condition, percentage dead wood, crown condition, trunk condition, level of damage, vigour, health, evaluation of hazard.
Function:	Function in landscape, landscape value, aesthetic rating.
Action data:	Management and maintenance needs, work priority, work completed, rotation for next generation.
Environmental characteristics describe the condition of the site:	
Growing:	Soil, slope, moisture, shade/sun, amount of space available.
Physical:	Parking, wires, underground services, traffic conditions.
Planting sites:	Potential sites for new trees.
Location characteristics ensure that the tree can be readily located for management activities:	
Location:	Street address, placement in relation to road and curb, grid square, park zone.
A work record keeps track of work done to the tree.	
Work record:	Date of work, work carried out, name of person doing work.

Most inventories would use a selection of these variables — use of all categories will be the exception. Which variables are selected will depend upon the type of enterprise and its objectives, intended use of the information, and resources available for making the inventory (Crossen, 1989).

2.1.7 Computerisation of records

There are manual and computerised recording options for each inventory component (Cullen et al., 1985; Zander, 1980). Manual systems can be effective, but are slower than computerised options. Manual plant records are usually contained in an accession book and card file, which only allows indexing by name or number, any other type of indexing requires cards to be physically re-sorted (Walter, 1989). Manual systems must be rewritten to be updated, and common information must be repeated for each record. Generally there is only one copy, and therefore only one point of access (Walter, 1989).

A computer system can handle large volumes of data and process it quickly. A variety of output options are usually available, with higher quality presentation than manual methods (Marshall, 1983). Computers can combine, sort, index and manipulate data in a variety of ways (Annett, 1990; Barker, 1983; Maggio, 1986), making information available that was previously too expensive to obtain (Barker, 1983; Grainger and Thompson, 1983). Accumulated data allows tracking of trends in a plant population, and can be used to predict future patterns in the population (Barker, 1983; Collyer, 1983; Thurman, 1983a). Networking is an important advantage for plant collections and botanic gardens as it provides the opportunity to manage a population as a local, national, or international resource (Cullen et al., 1985).

Annett (1990) suggested that computer systems were not economical for less than 4000 records, although this will change as computers become cheaper. In a large inventory a computer system will give economies of scale, e.g. Walter (1989) reported the Arnold Arboretum computer database which contained 13560 accessions with a potential for 564 fields for each accession. The computer database at Kew had 80-100,000 records in 1977 (Hunt, 1977).

Although the benefits of computer storage are obvious, computer systems may be beyond the means of small gardens or those under resource constraints. Moreover, the computer is simply a useful tool, and does not turn a poor manager into a good one (Annett, 1990) or remove the need for field work or planning of the inventory (Chan and Cartwright, 1979). Similarly a computer system cannot overcome faults of inconsistent and incomplete records (Collyer, 1983; Walter, 1989). Unfortunately the benefits of a properly managed inventory are often attributed to the computer itself, when the technology is just the vehicle for better information management. It is not the purpose of this research to investigate the options in computer technology, but the advantages of such systems are recognised.

2.1.8 Eastwoodhill Arboretum

As Eastwoodhill is an arboretum it should have a complete inventory that includes maps, plant records and relevant written documents. Although the collection was catalogued four times between 1965 and 1982 (Berry, 1976, 1980, 1982; Cook, 1965), a complete inventory was not formed. The 1965 catalogue contained an alphabetical list of plants in the collection, with brief comments on their location, but no map. Later catalogues (Berry, 1976, 1980, 1982) also contained an alphabetical list of plants with name, common name, origin, source and date of planting (when known), approximate height, and approximate location given for each one.

The location for each plant was given as a code (e.g. L9) which related to a grid (reported as 40 × 40m) that was superimposed onto an A4 map of the physical features of the property. The map was in the front of the catalogue and placed the plant within a 0.16ha area. Theoretically the plant could be found by locating the grid square in the field and searching for the plant. In practice, however, only about half the grid had been surveyed onto the ground and many pegs were missing, making grid squares hard to find. When the square was located, one often had to search through dense vegetation and up to 130 plants per square to find the plant in question. At the same time, the map scale (which would be 1:3000 with a 40 x 40m grid) made individual plants very difficult to locate accurately from the map. It was impossible to map the collection at that scale, and at the time a more convenient scale was not attempted.

In the summer of 1978/9 the Trust Board initiated a project to map the collection at a scale of 1:200. About one third of the Arboretum area was plotted as individual grid squares onto separate sheets of graph paper. Plants were positioned on the sheet and a key made for each square. Unfortunately the project was not completed and maps for each park were not derived.

2.2 METHOD

When this project was initiated in 1986 the existing inventory contained the previous catalogues, which were no longer current, and the incomplete grid square survey. Consequently, the full extent of the collection and location of each plant was not accurately known. A complete inventory was required as it was necessary to record each plant present in the collection.

2.2.1 Maps and catalogue

The map and catalogue component of this research was started in 1986 using the previous catalogues (Berry, 1976, 1980, 1982; Cook, 1965) and the grid square survey as base documentation. Development of the inventory focused first upon formulation of maps with other documents derived from the maps in a subsequent step.

Logic suggested that the plan of physical features in the previous catalogue could have been used as a basis for mapping. Indeed, this was attempted but proved fruitless as the plan was impossible to ground verify and was subsequently discarded in favour of the grid survey. When aerial photograph information subsequently became available two difficulties emerged. First, the reported scale of the plan was incorrect. Instead of the 40 × 40m grid (scale 1:3000) reported in the plan, ground verification showed that the scale was actually 1:3800, making the grid 50 × 50m. The second problem was that, even when adjusted for scale, the map was inaccurate, particularly through the Circus, Cabin Park and Glen Douglas. At the time these two problems rendered the plan unusable and it was discarded.

Consequently, the base plan for the first series of maps was derived from the grid square survey. The lower parts of the Arboretum were mapped first as these areas had a completed survey. Pear Park, Corner Park, Circus, The Gardens and Cabin Park were originally mapped by the method described below.

Each graphed grid square showed the position of each tree as a cross, and sometimes paths, fences and other physical features. Other graphed grid squares showed only a series of crosses to indicate trees. Graphed grid squares that comprised the park in question were selected, aligned, and traced over to create a rudimentary base plan for the park. Trees, fences, paths and other features were positioned on the plan in the field work stage. In many instances the base plan itself was not accurate and it was adjusted accordingly. The developing map was redrawn and field checked 2-3 times before an accurate plot was achieved. Later, when aerial photograph information became available, the maps derived by this method were redrawn using the more accurate information from the photographs.

Formation of maps for the upper Arboretum, namely Douglas Park, Orchard Hill and Glen Douglas, initially posed a problem as there was no grid survey for these areas. Fortunately, aerial photographs had been obtained by this time and a 1:2000 plan of physical features of the Arboretum produced by the Curator (Clapperton, 1987), was used to create the remaining 1:200 base plans, as described below.

The 1:200 maps for the lower Arboretum had been created from the grid square survey, so a method was needed to relate that grid to the new aerial photograph information. A graphical grid of 50 x 50m squares was constructed at the 1:2000 scale and superimposed over the 1:2000 drawing making a best-fit to the known positions of existing grid pegs. Once the grid was fitted it was extrapolated to create a nominal grid over the remaining portions of the Arboretum (see plan 1 in Appendix 2). The grid was then used to expand the map to 1:200 and create a base plan for plotting the remaining trees.

At this stage the base plan contained only physical features, so major trees were added from the aerial photographs and then used as reference points for field work. The remaining trees were added over several field sessions and the maps drawn and rechecked several times until an accurate plot was achieved. Glen Douglas, Cooks Corner, Douglas Park and Orchard Hill were mapped using this method. The completed map set was produced in 1989 and the catalogue derived from that set. (A revised set of maps was re-surveyed in 1993, but has not been included in this thesis as it has not been reconciled with the catalogue.)

Once a satisfactory set of 1:200 maps had been produced, a catalogue was generated. First, a list of plant material was made for each grid square on the map. Next, lists for each grid square were merged to form a complete alphabetical list of plants for the whole Arboretum. The resulting alphabetical list was checked against previous catalogues (Berry, 1976, 1980, 1982). Once the list was accurate the catalogue was formed by adding other information on each species, i.e. origin and common name, and source information from the previous catalogue. Entries used the same format as previous catalogues. The final task was to add locations according to the new maps. Every plant in the Arboretum had been included in the list so every plant had to be given a location on the map, i.e. each plant in the catalogue is reconciled with the map and vice versa. The new catalogue was completed in 1989 and published. An update was initiated in 1993 but not completed as it was not reconciled against the updated maps.

2.2.2 The previous collection

The collection that exists at the Arboretum today is only a portion of what was originally collected by Douglas Cook. For various reasons the extent of the collection had declined (a subject which will be considered in subsequent chapters), and it was well known, but not quantified, that there were many species that had been present but had not survived. Knowledge of the original extent of the collection was important for four reasons: (i) finding out the identity of material that still existed but was not named, (ii) examining the patterns of change in the collection, (iii) comparing previous and current collections, and (iv) discussions on the future direction of the collection.

Although Douglas Cook made an inventory in 1965, this did not describe the extent of his collecting, as evidenced by copious notes he made in his reference books and various notebooks.

To determine the total extent of the collection those notebooks and reference books were studied and all other acquisitions not accounted for in the catalogue of the current collection were recorded. A companion catalogue was produced which listed the 'previous' collection and noted the date and source of purchase of each plant (if known).

2.2.3 Herbarium and photographs

Many herbarium samples were made as part of the records used for plant identification. The herbarium contains about 1200 specimens, i.e. about half of the species in the collection, and is held at Massey University.

Herbarium samples would not give an accurate representation of some species (e.g. *Malus* fruits and *Camellia* flowers), and approximately 450 photographs and slides were made to record these details.

2.2.4 Database

The volume of information in this inventory lent itself to storage on a computer database. Two sample database formats were produced on a MacIntosh computer using Hypercard software. An ITF format was produced to record individual plants, while an alternative format was developed to record species rather than individuals.

2.2.5 Arboretum management relating to the collection

As the purpose of this inventory was to facilitate planning and management of the collection, it followed that relevant management activity and documents should be recorded. A search of the Arboretum records revealed several relevant documents which were copied and collated. In addition, a summary of information relating to collection management was made which covered Trust Board policies, activities and decisions on that subject.

2.3 RESULTS AND DISCUSSION

The result of the inventory stage of this research was a complete inventory of the Eastwoodhill Arboretum containing maps, catalogues, herbarium samples, photographs and archival information. The inventory described the identity, location and source of plants in the Arboretum. The catalogue of the current collection was published in 1989. The maps, and the catalogue of the previous collection, were reported to the Trust Board in the form of technical reports (MacKay, 1989a, 1989b).

2.3.1 The collection

Eastwoodhill contains an extensive collection of trees, shrubs and climbers which will be discussed using the following definitions:

Current collection:	Those species and cultivars which exist today.
Previous collection:	Those species and cultivars, including repeat acquisitions of the current collection, which were originally collected by Douglas Cook but which no longer exist today.
Total collection:	The current collection plus the previous collection.

The collection is quantified as 'number of species and cultivars' rather than individual plants. Thus *Acer palmatum* is counted as one species, even though there are many individuals of the species in the Arboretum. Similarly, there are 133 different species and cultivars of *Acer* in the collection, which are represented by 200-300 individuals.

The current collection contained 2628 different species and cultivars of trees, shrubs and climbers. There were 1666 species and 962 cultivars from 410 genera and 118 families, primarily of northern hemisphere origin. There were 8 families and 36 genera of gymnosperms, and 110 families and 374 genera of angiosperms. The collection comprised many small groupings, 363 of the 410 genera were represented by less than 10 species and cultivars, only the remaining 47 genera were represented by 10 or more species and cultivars. *Camellia, Rhododendron, Acer, Prunus* and *Quercus* were represented by the largest number of species and cultivars in the current collection (Table 2.1). Genera represented by fifteen or more species and cultivars in the current collection (1655 species and cultivars in total) accounted for 63% of species and cultivars in the current collection (Table 2.1). The record of the current collection is found in parts one and two of the inventory (Appendices 1 and 2). (The records will be discussed shortly).

There were 6-7000 individual plants in total in the Arboretum. The number is approximate because the individuals in the ridge-top mass plantings of conifers, which were established for windbreaks, were not counted. There were 385 individual plants in Pear Park, 839 in Corner Park, 381 and 44 in Circus and IDS ridge respectively, 649 in the Gardens, 252 on Orchard Hill, 1292 in Cabin Park, 1126 in Douglas Park, 306 in Glen Douglas and 182 in Cook's Corner.

Table 2.1 Genera in the 'current' collection represented by 15 or more species and cultivars.

Genus	No. of species and cultivars in current collection
Rhododendron	244
*Camellia**	204
*Acer**	133
*Prunus**	106
*Quercus**	101
*Pinus**	83
*Malus**	62
*Magnolia**	60
Sorbus	49
Syringa	45
Chamaecyparis	39
*Betula**	36
*Crataegus**	35
Abies	34
*Juniperus**	32
*Fraxinus**	31
*Populus**	28
*Alnus**	26
Picea	26
Clematis	26
*Ilex**	23
Viburnum	22
*Aesculus**	20
Buddleia	20
Euonymus	19
Berberis	19
Ulmus	18
*Cupressus**	18
Cornus	17
Fagus	17
Tilia	16
Acacia	16
Philadelphus	15
Lonicera	15

* genera subsequently selected as key genera

Table 2.2 Genera in the 'total' collection represented by 20 or more species and cultivars.

Genus	No. of species and cultivars in the total collection	Percentage lost
Rhododendron	710	66
Azalea	386	unknown
*Camellia**	353	42
*Acer**	182	26
*Prunus**	174	39
*Quercus**	122	17
Syringa	108	58
*Pinus**	93	10
*Magnolia**	92	34
*Malus**	89	30
Clematis	88	70
Chamaecyparis	88	55
Sorbus	74	33
Erica	69	89
*Betula**	54	33
*Juniperus**	51	37
Berberis	51	62
Hydrangea	51	82
*Crataegus**	48	27
Viburnum	48	54
Abies	47	27
*Populus**	47	40
Philadelphus	46	67
Salix	46	71
Cotoneaster	45	69
Buddleia	41	51
Cytisus	39	94
Picea	39	33
Euonymus	38	50
*Ilex**	38	39
*Fraxinus**	37	16
*Aesculus**	32	37
Acacia	31	48
Cornus	29	41
Ceanothus	29	86
*Alnus**	28	7
Lonicera	28	46
Chaenomeles	27	88
Cistus	26	84
Eucalyptus	24	50
*Fagus**	24	29
Deutzia	24	79
*Tilia**	23	30
*Cupressus**	23	22
Thuja	22	45
Daphne	22	59
Ulmus	22	18

* genera subsequently selected as key genera

2.3.1.1 The 'previous' collection

Part three of the inventory (Appendix 3) is a companion catalogue which described the previous collection, those acquisitions which no longer exist in the current collection. There were 3019 species and cultivars which were additional to the current catalogue. The previous collection included 21 extra families and 211 extra genera which were not represented in the current collection. Investigation of Douglas Cook's notebooks also showed that many species were repeated several times, thus the number of individuals was much greater than the list of names suggested. Many species in the current collection appeared again in the previous list, due to repeat purchases.

2.3.1.2 The total collection

When the current collection (2628) was combined with the previous collection (3019) a total collection of 5647 species and cultivars was revealed. There were 3142 species and 2506 cultivars from 621 genera and 139 families in the total collection. Of these, 8 families and 41 genera were gymnosperms, the rest were angiosperms. There were no extra gymnosperm families in the total collection, but there were 5 extra genera. The total collection had 21 additional families, and 211 extra genera compared with the current collection.

Only 87 genera in the total collection were represented by more than 10 species and cultivars, therefore, like the current collection, the total collection contained many small groupings. The largest genera in the total collection were *Rhododendron, Camellia, Acer, Prunus* and *Quercus*, which is the same as the current collection. Table 2.2 shows the genera with the largest number of species and cultivars in the total collection. It is interesting to note the different rates of decline of each genus between the total and current collections, particularly the decline of short lived material. About half of the total collection has been lost over time; those losses and the reasons for them are addressed in Chapter 3 (evaluation) and Chapter 6 (park and genus plans).

The large number of *Rhododendron* in the total collection compared with the current collection reflected Douglas Cook's original goal for that genus (Cook, 1949). The rate of decline of *Rhododendron* illustrates its poor performance at Eastwoodhill, a fact which Cook noted (Cook, undated b). Changes between total and current collections, and other characteristics of the collection, are discussed in detail in Chapter 3.

For the purpose of this project, inventory parts one and three were combined into one file giving a complete list of the total collection in one document. It is a working document only and is not included as an appendix to this thesis.

2.3.2 The records

2.3.2.1 Maps and catalogue of the current collection

The current collection was described by the maps and catalogue (Appendices 1 and 2). The map originals are on A1 size sheets, giving a total of about 40 sheets at 1:200 to cover the 65ha of the collection. Each map showed the relevant grid lines and peg points, physical features such as ponds, tracks, fences and buildings, and finally positions of the plants. Each plant was named and many were given a reference number, (common species were not always assigned a reference number). All plants shown on the maps appeared as an entry in the catalogue. Only a sample of the maps were included in Appendix 2 (reduced to A3 size), as the full set was too bulky for this document.

The catalogue was the written rendering of the maps. It followed the same format as earlier catalogues and listed name, common name, country of origin, source, date of planting (when known), and location according to grid square. Format of the catalogue of the current collection is shown in Figure 2.1. In this example, *Carpinus betulus* was acquired twice. The Hillier acquisitions were found at D10, K11, K12 and L12 respectively and the Appleton acquisition at M5. The cultivar 'Fastigiata' was found in three locations, but the source of those plants was not known. Similarly *Carpenteria californica* had been identified and mapped, but the source was unknown. *Carpinus caroliniana* was present at S5 but was not found at C10 where it was reported to have existed. The plants with +MM indicated that the plant was identified by the person coded as MM, which in this case was the author. The location code H8 under *Campsis* indicated that there was an unidentified member of the genus at that grid square.

2.3.2.2 The 'previous' collection

The record of the previous collection is found in Appendix 3. This document lists all other acquisitions into the collection, in the format shown in Figure 2.2. There were two main groups of plants in the previous catalogue, those marked with '+' and those not marked. The plants without the mark were species and cultivars that were not represented in the current catalogue. In the example in Figure 2.2 three plants (*Caesalpinia coriaria*, *Caesalpinia gilliesii*, and *Callicarpa americana*) are not in the current collection. These plants were obtained in 1949, 1946 and 1935 respectively. The source of the information was listed in each case, so the purchase of *Callicarpa* from D&D (Duncan and Davies) in 1935 was found in the reference represented by 'Bean I lib' (which refers to a note by Douglas Cook in his copy of volume one of Bean's 'Trees and shrubs hardy in the British Isles'). The other species which were marked '+' are in the current catalogue, but as a different acquisition. Thus part three of the inventory records a series of acquisitions additional to the current catalogue, even though some of the same species may be involved.

Campsis: Bignoniaceae

H8

grandiflora (Thunb)Schumann. TRUMPET CREEPER. China H11

x tagliabuana (Vis)Rehd. Hort.

'Mme Galen' Nichols 1988, L5+GC

Carpenteria: Saxifragaceae

californica Torr. California. I10+GC

Carpinus: Betulaceae

betulus L. COMMON HORNBEAM. Europe. H&S 1949, D10+MM

K11+MM K12+MM L12+MM; Appleton 1988, M5+GC (NM);

'Asplenifolia' stock C10

'Fastigiata' PYRAMIDAL HORNBEAM, I3+MM Q2+MM R3+MM

caroliniana Walt. AMERICAN HORNBEAM. E N America.

H&S 1948, S5+MM, not found C10

Figure 2.1 Format of the catalogue for the 'current' collection

Caesalpinia: Fabaceae - Caesalpinaceae

coriaria Tropical America. HZ 1949, (Bean I lib)

gilliesii Argentina. 1946, (Bean I lib)

Calliandra: Fabaceae - Mimosaceae

\+ ***portoricensis*** Mexico, W.Indies. D1931,41, (Bean I lib)

Callicarpa: Verbenaceae

americana N.America. D1935, (Bean I lib)

\+ ***giraldii (bodinieri var. giraldii)*** China. H1935, D1935,45; (Bean S lib)

\+ ***japonica*** Japan. D1935, (Bean I lib)

\+ ***purpurea (dichotoma)*** Korea, Japan. D1939-46, (Bean I lib)

Callicoma: Cunoniaceae

\+ ***serratifolia*** Australia. D1944/47, (Bean I lib)

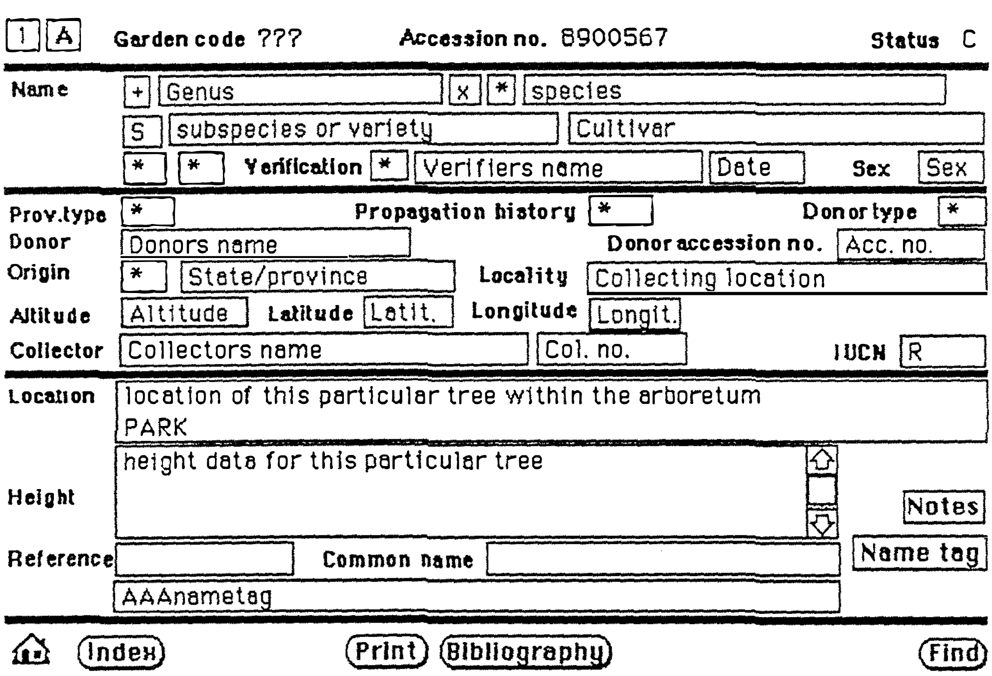
Figure 2.2 Format of the catalogue for the 'previous' collection

2.3.2.3 Database

Two data base formats were developed, an ITF database format (Figure 2.3), and an alternative format (Figure 2.4). Both formats have had some entries loaded, but as database production was not the aim of this study loading was not completed.

The ITF format contained the required fields for that format plus five extra fields. 'Location' recorded the location of the tree in the Arboretum. 'Height' and 'notes' recorded details of the tree. 'Nametag' was the sorting field for the stack. The reference field in the bottom left of the card was to reconcile the identity numbers assigned by this project with an accession number when one is assigned. The ITF card was designed as one entry for each individual tree. Only about 35 ITF entries were loaded.

The alternative card was intended as a record of species in the collection rather than individuals. Its main function was to keep track of the different accessions of a species. There is a distinct advantage in recording this way for the Eastwoodhill collection as many trees do not have known accession information, and conversely, there was considerable accession information which was not associated with a particular tree. It was sensible to keep the two lists together, with the aim of eventually matching if possible. An alternative entry was created for about 1400 species.


1 A Garden code ??? Accession no. 8900567 Status C

Name + Genus x * species

S subspecies or variety Cultivar

* * Verification * Verifiers name Date Sex Sex

Prov.type * Propagation history * Donor type *

Donor Donors name Donor accession no. Acc. no.

Origin * State/province Locality Collecting location

Altitude Altitude Latitude Latit. Longitude Longit.

Collector Collectors name Col. no. IUCN R

Location location of this particular tree within the arboretum PARK

Height height data for this particular tree Notes

Reference Common name Name tag

AAAnametag

Index Print Bibliography Find

Figure 2.3 The ITF database record card

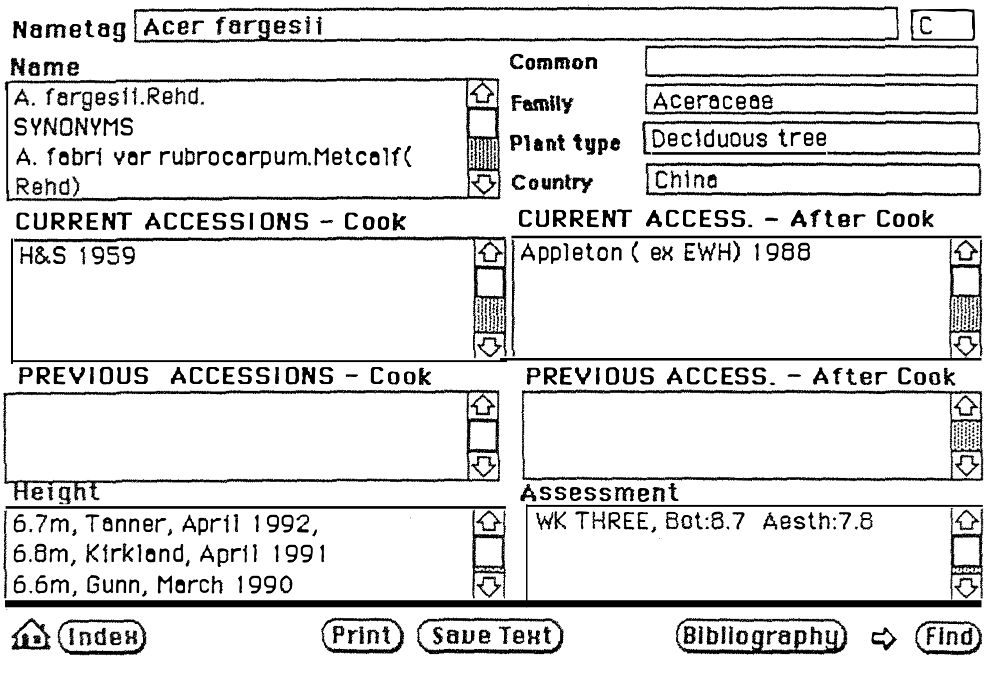


Figure 2.4 Alternative database record card

The structure of both databases was the same and is shown in Figures 2.5 to 2.7. The database was divided into 'stacks', each containing part of the collection arranged in alphabetical order. One moved between stacks using the control card (Figure 2.6). 'Clicking' on the button for the stack transferred the user to that stack. A related button at the stack brought the user back again.

Individual stacks were managed with the index card shown in Figure 2.7. 'Clicking' on a genus in the left hand box caused the computer to generate a list of the members of that genus that had a record, and place that list in the right hand box. 'Clicking' on the species resulted in a transfer to the entry for that species.

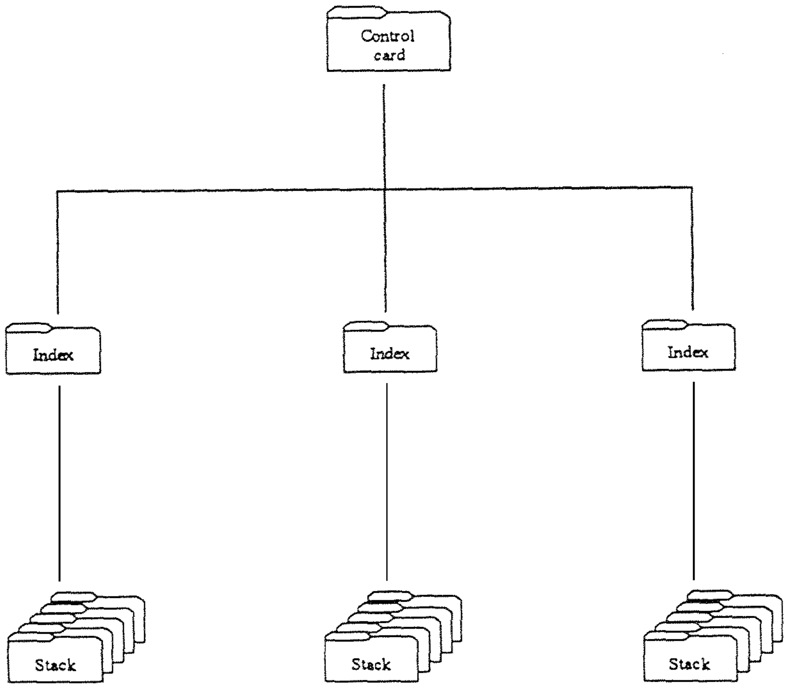


Figure 2.5 Structure of the database

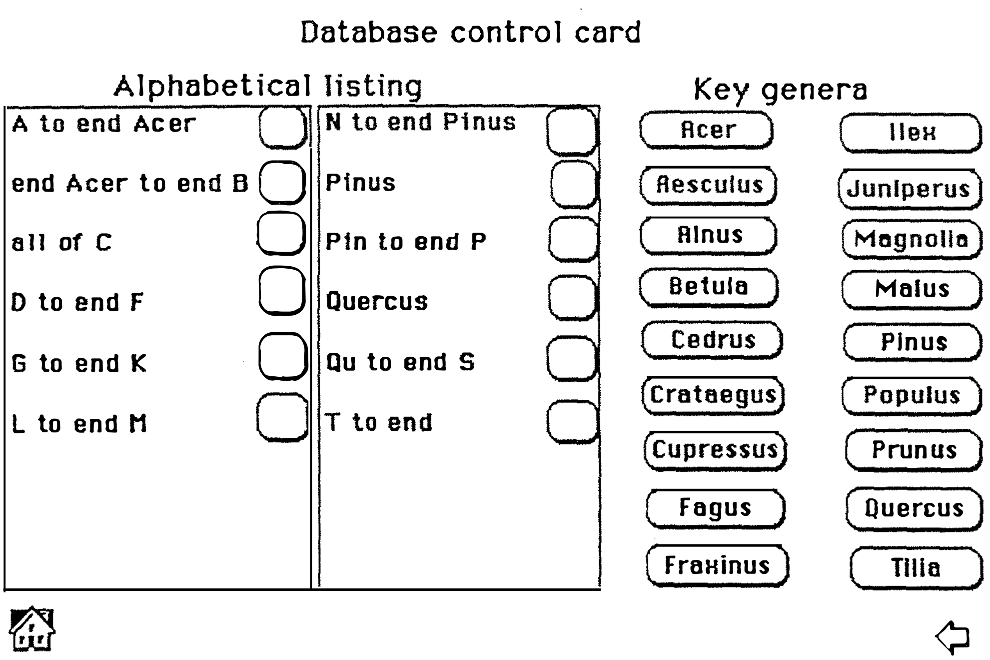


Figure 2.6 Control card for the database

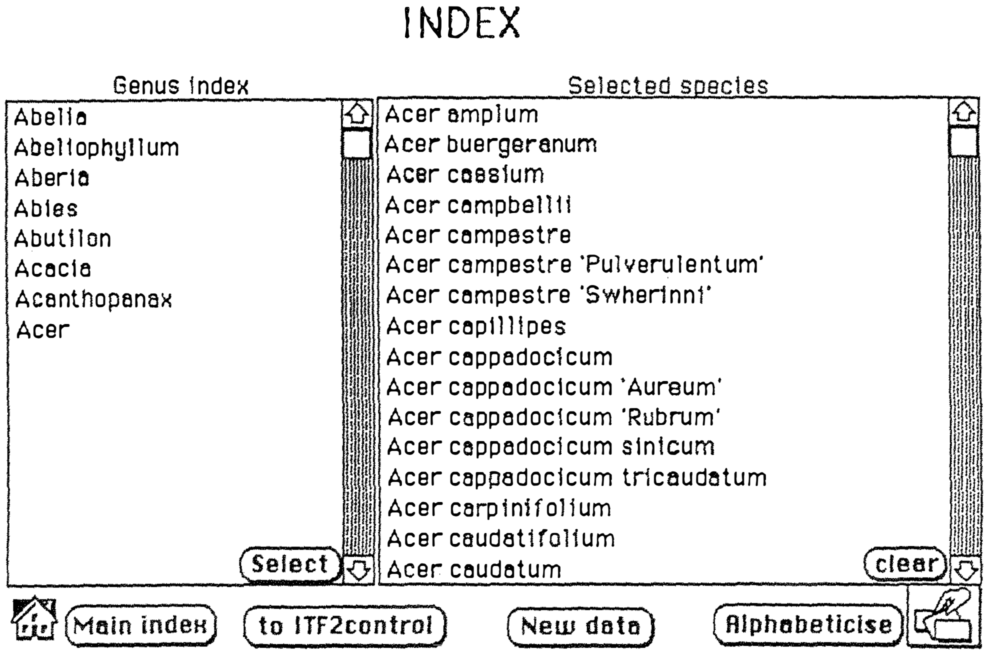


Figure 2.7 Index card for individual stacks in the database

2.3.2.4 Previous management of the collection

Considerable documentation and commentary on previous management of the collection was collated into a working document (not included in this thesis). Relevant information from the time of Douglas Cook up until about 1990 was included in this document. Activity after that period was influenced by this project and this was not considered part of the historical record.

Four aspects of collection management were investigated. First, relevant sections of Douglas Cook's manuscripts were recorded. Although he did not write formal goals, the extracts gave an impression of why he created Eastwoodhill and his intentions for the collection. Second were a series of commentaries from various experts who reported on the collection over the ten years of transition from Douglas Cook's ownership to Trust ownership. Without exception these reports stressed the value of the collection. Third, the Trust Board's approach to collection management was investigated, including the commentary and discussions on the need for planning, and debate and activity relating to the direction of collection development. Information was also collated on other collection management activities, namely acquisition and selection of plant material, planting and removals, arboriculture, tree maintenance, and visitor management and interpretation. Finally, a section on property management illustrated the considerable improvements made to components such as fencing, paths, and housing. This information on collection management is discussed in detail in Chapter 4, which focuses upon development of plans for future management of the collection.

2.3.3 The method of inventory

This inventory fulfilled the requirements of a complete inventory containing catalogue, maps, and written documentation. The recording format was consistent and precise, but had a high manual component. The method and the resources available introduced several unavoidable errors which could be reduced if more sophisticated methods were feasible. Nevertheless, this inventory should serve most management requirements at Eastwoodhill as long as it is kept current.

2.3.3.1 Accuracy

Maps

The maps were accurate to the extent that they recorded every plant and its location as precisely as possible using the grid survey method. Unfortunately, there were several sources of error in the maps, the first being distortion in the aerial photographs used to create the base plan. In this case an error of 1mm on the aerial photograph represented a 2m error on the ground. Aerial photographs used to generate the base plans had a discrepancy of up to 4-5mm between photographs, introducing a potential error of 8-10m in the base plan before field work began. A computer generated map with digitised tree positions would improve the accuracy of the base plan, but it would be impossible to construct a complete map this way because of vegetation density. Considerable field work would still be needed and there would still be a level of error as such a map would be constructed from the same aerial photographs.

In the first draft of the maps the grid was responsible for a significant error. Those first maps followed the positions of the pegs in the ground, and the map was corrected to fit the pegs, but closer examination of the grid on the ground showed it was not accurate. The squares were supposed to be 50 × 50m but many were not. Furthermore, there appeared to be a distortion in the grid at about row F or G where a whole row seemed to be too short. Accordingly, the final version of the maps used the pegs as guides only and gave more emphasis to ground measurements, which led to satisfactory maps at 1:200. This approach, however, introduces some difficulty when translating information to the 1:4500 map in the catalogue. At 1:4500 a small error on the map leads to a large discrepancy on the ground, therefore it can be difficult to indicate a tree on the 1:4500 map in the catalogue, and then expect to find it precisely on the ground.

Errors were also possible at the plotting stage. Extreme crowding in some parts of the Arboretum led to some inaccuracy as it was difficult to establish sight lines in places. Greater accuracy would be achieved if triangulation mapping had been used, but that method would have been more time consuming. Computer plotting methods would also have given greater accuracy, if those methods had been possible for this site.

Plant identification

Plants were identified using two main sources. First, early catalogues were used as a reference as Berry had searched the literature to make many of the difficult identifications (Berry, 1976, 1980, 1982). Second, the curator and the author identified many species. Although each of these people is an expert plantsperson who uses rigorous methods to reach an informed opinion on plant identity, neither is a qualified taxonomist. Some difficult plants were identified by taxonomist Dr W.R. Sykes at the Landcare New Zealand herbarium at Lincoln but otherwise the majority of the material still requires professional verification. Thus, plant material in the collection can be described as identified but not verified. A greater level of accuracy in plant identification would be desirable, and could be achieved with extra work. Herbarium samples have been made for 1200 species in the collection, and these could be used as voucher specimens. Further studies on plant identification is one example of the considerable scope for further projects at the Arboretum.

The other aspect of plant identification that was not addressed by this project was physical tagging of individual trees. A temporary label was attached to many trees as part of the mapping process, but these were not durable and many have fallen off. The accepted criteria for plant collection management requires permanent tags, but two important issues need to be resolved first: the use and assignment of accession numbers, and the time and financial resources needed to make and attach the tags.

Current Catalogue

This catalogue was accurate to the extent that it recorded each plant shown on the maps, and plants were identified using the expertise that was available. Standard reference works were used to check botanical names. A critical aspect of both accuracy and completeness was the need to maintain the link between the catalogue and the maps, and in this project the current catalogue was fully reconciled with the maps.

2.3.3.2 Completeness

The inventory was complete in that every tree within the Arboretum was recorded. This project did not, however, record the material that was outside the current boundary of the Arboretum. Several areas of widely spaced trees within the areas presently farmed were not mapped. Preliminary examination showed that there were some good specimens, but none of the species were critical to the collection. As the Arboretum expands into the farmed area it will be necessary to make a base plan and map those areas.

The archival documents were, to the best of my knowledge, complete. It is possible that hitherto unknown archival information may be found, which can be readily added to the existing file.

Important aspects of completeness were the questions of newly planted material and material held in the nursery. Experience suggested that adding these plants to the permanent record as soon as they arrive would be premature. Even a low level of mortality at establishment finds species being added to the inventory, only to be removed shortly thereafter. There is logic in creating three categories within the files for 'current', 'new' and 'dead' plants. Only the current files would be shown in the current catalogue. 'New' plants could be kept as a separate file and transferred into 'current' once they were suitably established.

In a related problem there was no clear demarcation between 'current' and 'dead' files in this collection. In many instances, local knowledge or archival information confirmed that a plant was 'dead'. In other cases accessions that appeared to be 'dead' turned out to belong to specimens that were not fully identified. Therefore the other accessions were referred to as 'previous' and these could be retrieved if an identification proved to relate to one of these records. Within the 'previous' file a plant could be subtitled as 'dead' if that status was certain.

2.3.3.4 Recording protocols

For this project field records were made in a field notebook. This was adequate for this project, but standard forms should be devised for further recording and updating. As it is likely that future management of the inventory may involve volunteers or more than one person, careful guidelines for recording will be essential.

2.3.3.5 Reference numbers

Most trees in the Arboretum were assigned a reference number for this project. The number was a combination of letters, which indicated the relevant park, and an arbitrary number. This code acted only as a unique number which connected the various parts of the records; it was not an accession number.

This project did not address the question of assigning accession numbers because the year of accession of many trees is unknown or uncertain, making the typical accession number hard to assign. The curator has been investigating this problem and it is likely that a method for assigning numbers will be devised. Those numbers should then be added to the relevant permanent records.

2.3.3.6 Variables recorded

The variables recorded in this inventory were the minimum proposed by Cullen et al. (1985) but this was satisfactory for the purpose of mapping the collection and updating the catalogue. Time and resources did not allow for more extensive recording, but other information will be needed when other aspects of collection management are addressed. For example, maintenance planning requires information on both maintenance problems and history, neither of which was collected in this study. Studies on plant performance require height, diameter and condition measures of each tree at regular intervals. While a small number of these measurements were made in the latter parts of this project, a complete record of these factors was not an objective for the inventory. In future, performance factors will have to be measured to meet some of the goals that have been formulated subsequent to this project. In particular, the Trust Board's goals for education include aspects of plant performance in the East Coast area. These goals, along with other collection management issues, will eventually require an expansion of the variables recorded in the inventory.

2.3.3.7 The permanent record

The permanent record comprised the documents described in the results of this chapter. Although the format was satisfactory, it was not as flexible as it might be if techniques in computer recording were used to the full. Computerisation is a desirable goal, but should not become an end in itself. Given the current age and state of the collection, it is more important to emphasise the use of the information for collection planning, rather than perfecting the information through computerisation.

Computer drawing software could have been used to produce the finished maps, and this would have produced a superior result to the hand drawn maps. Computer drawn maps are easier to update and manipulate and can be readily reprinted when required. They are, however, only as good as the information that goes to create them, and the computer does not circumvent the time required for field work or creation of the map itself, it only makes the end product easier to use and of higher graphical standard. Nevertheless, if time and computer equipment were available it would be desirable to computerise the maps, with the ultimate aim of loading them into a GIS system, thereby gaining the benefits of that type of software.

Similarly, completion of a database system for the plant records would be desirable. A standard such as the International Transfer Format or the International Dendrology Society method should be adopted and, if necessary, customised with extra fields. The database formats produced on Hypercard for this project were not satisfactory as the software had several serious limitations which rendered it unsuitable for databases of the type required. For example, Hypercard is a 'flat' database which immediately limits its capacity to sort information and give multiple points for indexing. These features can be programmed into Hypercard, but the extra work seems hard to justify when other software has superior features. In addition, the software was very slow and prone to failure with only a small number of records (e.g. 2000) on the test database. Splitting the database into stacks solved the problem in the test model, but this is not a sensible solution when large quantities of data are involved, or one wishes to manage all the information as single entity. Finally, the printing options on software version 1.2.5 were too limited. The problem was solved when an appropriate programme segment was written, but the necessary steps were clumsy and slow.

The tree management functions of the database were also limited by the inadequacies of the software. The screen did not allow enough space on the ITF format for the additional information on location, or separation of 'current' and 'previous' accessions. On the other hand, the arboretum format could separate current and previous accessions, but it did not give fine enough separation for location. Furthermore, it recorded all examples of a species in one file, and did not provide a file for each individual. Again this would be easy to modify on better software. Obviously neither test database was linked to the maps, and given the disadvantages of the software, such a link would not be attempted.

A more appropriate software selection is needed to produce an effective database. The MacIntosh software FilemakerPro or Fileforce may prove suitable as each are relational databases which are more flexible and can handle large numbers of records. Whichever software is deemed acceptable, a considerable investment of time will be needed to load all the relevant information.

2.3.4 Operation of the inventory

At the operation stage (Miller, 1988) information in the inventory can be used to adopt a systematic management approach (Annett, 1990; Thurman, 1983b). Deneke (1983) noted a trend towards systematic management, although other survey data (Kielbaso, 1990) showed a 17% increase in crisis management of urban forests between 1974 and 1986. Systematic managers use inventory data as a basis for various evaluations, classifications and plans (Burbridge, 1991; Jackman, 1980; Thurman, 1983b).

Maintenance planning

A significant portion of the daily operations of a landscape are maintenance activities. Wright (1982) believed long term management was an accumulated series of maintenance activities, therefore maintenance activities should be planned in a rational way. The information from an inventory can be used to develop maintenance plans and schedule the actual operations (Crossen, 1989; Gerhold and Sacksteder, 1979; Graham, 1987; Weinstein, 1984). The condition and growth phase of each plant and/or the whole population will indicate particular maintenance operations (Moll, 1988). Factors that influence future maintenance, such as disease development, can be recorded and tracked through a series of inventories (Weinstein, 1983).

Maintenance programming is particularly important in landscapes that must meet specific visual criteria, as the maintenance programme directly contributes to the appearance of the site. Good visual qualities are essential in botanic gardens to generate good recreation experiences that attract public support. This is precisely the situation that confronts the managers of Eastwoodhill; the Arboretum must reach a minimum visual standard to attract the public and generate funds. Therefore, use of inventory information for maintenance planning is important to Eastwoodhill.

Finance and labour management

Inventory information can be used to generate statistics and reports to support financial proposals and budgeting (Crossen, 1989; Weinstein, 1984). Proposals for equipment purchase can be supported by information on the number and types of trees in a population (Tate, 1985; Thurman, 1983b). Efficiencies of workers and equipment can be evaluated, and unit costs of maintenance activities determined (Gerhold and Sacksteder, 1979). Data can also be used for labour planning such as forecasting future workloads (Wagar and Smiley, 1990) and preparing labour budgets (Tate, 1985). Analysis of the state of a population may highlight long term funding needs (Tate, 1985).

Plant growth and development

An inventory provides information on the range, distribution and status of plant material in a landscape (Chan and Cartwright, 1979; Lohmann, 1988; Tate, 1985). Profiles of the presence and number of unhealthy trees can be extracted (Dery Rocray 1983; Gerhold and Sacksteder, 1979; Tate, 1985) leading to the development of suitable maintenance and control programmes (Chan and Cartwright, 1979). Planting sites and trees for removal can be identified (Gerhold and Sacksteder, 1979; Graham 1987; Weinstein 1983), and important or historic trees highlighted (Graham, 1987; Marshall, 1983). In the long term, repeated monitoring of characteristics provides information on patterns of change in the landscape (Barr and Whittaker, 1987) which is essential when managing vegetation in human-made landscapes.

Species performance

Understanding species performance is a key factor in managing vegetation in human-made landscapes because long term decisions for vegetation renewal are derived from knowledge of how a species has performed in a given situation. Inventory records can provide data on critical traits, variation within a population, and problems in specific landscape situations (Valentine et al., 1978). Ultimately such data can be used to breed better trees and make better tree selections (Wagar and Smiley, 1990). Repeated inventory records provide data on plant use, hardiness and performance that can be used in renewal decisions (Chan and Cartwright, 1979; Gerhold and Sacksteder, 1982; Zander, 1980).

Plans for vegetation renewal are essential for any human-made landscape that must meet particular management criteria over time, and Eastwoodhill is one such landscape. The Trust Board must achieve continuity of important species over time as the Arboretum houses an important collection. Particular visual criteria must be met to attract visitors, therefore timely decisions about species renewal must be made to ensure visual continuity. In addition, the Trust Board's educational goals relating to plant performance on the East Coast highlights the need for regular inventory of relevant factors.

Landscape classification systems

Sometimes inventory data can be used to identify homogeneous land units within a larger area, and therefore form a classification system. If no scoring or valuation is involved (data collection without judgement) then the classification is a form of inventory (Fabos and McGregor, 1979). If the categories within the classification involve any type of analysis, judgement or evaluation, then such a classification is a form of evaluation.

2.3.5 Application of inventory information in landscape management

Plant collections and the conservation of horticultural plants

In the last decade scientists have realised that significant numbers of ornamental plants may be lost unless positive moves are made to conserve them (Brickell and Sharman, 1986; Lowe, 1989; Taylor, 1985b). The conservation of these horticultural plants can only be addressed through inventory information (Lowe, 1989; Sales, 1989; Zander, 1980), and there are various schemes to record a wide range of horticultural plants. Plant collection schemes record material in designated collections (Cross, 1990; NCCPG, 1994). The British national tree register lists 80,000 trees of 1600 species and 1200 cultivars (Hallet, 1987). Index Hortensis lists herbaceous plants in cultivation (Trehane, 1989). The British and Australian Plantfinders list sources for 50,000 and 10,000 plants in commercial trade (Hutchison, 1993; Lord, 1991). Although New Zealand does not have a Plantfinder or a collection scheme, some records have been made of notable trees (Flook, 1984, 1994) and plants in collections (Hammett, 1993).

The range of plant material in question translates into a huge amount of information, making defined procedures for plant records essential (Zander, 1980). Both British and Australian plant collections must have a field survey and maps, accurate identification and cataloguing of plant material, herbarium material, and written records (Anon., 1989; Anon., 1991; Cross, 1990; Sales, 1990; Sanecki, 1989; Stungo, 1982). The developing New Zealand plant collection scheme is based upon the British model, therefore collections such as Eastwoodhill are likely to require the aforementioned documentation.

Botanic garden records

The scientific roles of a botanic garden depend upon accurate information on the plants in the garden, indeed, the documentation system of a garden is a prerequisite to its management (Ashton, 1989; Cullen et al., 1985; Given, 1981; Walter, 1989; WWF and IUCN, 1989; Zander, 1980). Plant records of a botanic garden involve more than the vegetative component of the landscape, they are a complex botanical record which must be taxonomically precise, and include enough detail to support scientific study. Botanic garden records must accurately accommodate scientific names, often more than one valid name, common name or family name, separate synonyms, hybrids, and name changes (Walter, 1989). The record must be able to track provenance, propagation history and maintenance history (Given, 1984). There must be a precise link between a plant record, the plant in the ground, and herbarium samples (Michener, 1989), and plants should be taxonomically verified (Ashton, 1989; Michener, 1989).

Botanic Gardens Conservation International is coordinating a major international inventory of important species in botanic gardens. In 1987 there were 17914 threatened plants on the database, 4946 of these were found in cultivation (Anon., 1986; IUCN, 1987). In the United States the American Centre for Plant Conservation is developing national networks and databases on the threatened plants of the USA (Anon., 1991c). These international inventories will provide a world wide set of information that will underpin a coordinated conservation effort.

The inventory requirements of a botanic garden raises important issues for Eastwoodhill. If the Trust Board wishes to fulfill the role of an arboretum then they should commit resources to the development an ITF format and the complex botanic garden record, as the fundamental purpose of an arboretum depends upon suitable information. They could opt for a less complex record, but this stance would overlook two important issues. First, the Arboretum contains species on the world conservation lists; effective management and reporting of those species (and any subsequently obtained rare species) should be done via an ITF record. Second, plant collection schemes may incorporate the ITF into their record format in the future, so that they may report their plant material to BGCI as part of the overall conservation effort. Institutions without that record form will be less able to contribute to that effort or participate in the international network.

Therefore the Trust Board should make a considered and conscious decision about what type of inventory to develop. Although the ITF is more time consuming to develop, it can be done in stages and additional fields can be added to suit specific requirements of the Arboretum. Once operational it would have definite advantages in national and international networking, and would facilitate development of any scientific roles of the Arboretum.

Historic gardens and landscapes

The preservation of historic gardens and landscapes depends upon development of a suitable inventory. Historic landscapes in Britain are recorded by the British National Trust which has maps and lists for 21 important historic collections in the 'woody plant catalogue' (Sales, 1989). In New Zealand historic landscapes are recorded by the Historic and Notable Trees Scheme (Flook, 1985; Flook, 1994), and by the Garden History Society. An inventory should record the history and development of the garden through maps, photographs and archival materials (Miles, 1991; Ramsay, 1992). Sales (1989) believed an investigation of the character and trend of development of a site was essential. This was used to define the objectives and themes of the creator of the historic landscape, and to avoid drift towards the personal preferences of those in charge.

Eastwoodhill is part of New Zealand's horticultural history and the principles of managing an historic site should be considered. The Arboretum was the creation of Douglas Cook, and the Trust Board has already identified the importance of continuing his work (Williams, 1987). Therefore investigation of Douglas Cook's objectives, themes and patterns of development of the Arboretum is essential to the future management of this site. Such data could be used to ensure consistent development that is in keeping with the original patterns developed by Douglas Cook.

Park and countryside management

An inventory is needed for systematic management of both parks and countryside (Christiansen, 1977; McBride and Nowak, 1989). Countryside management in New Zealand is directly affected by the Historic Places Act (1993) the Queen Elizabeth the Second National Trust Act (1977), and the Resource Management Act (1991). It is not the purpose of this research to examine legal aspects of landscape management, but clearly this will influence the future management of New Zealand countryside. A range of organisations are involved with managing New Zealand countryside. Important areas of natural vegetation are identified and protected through the Protected Natural Areas programme (Owen, 1984; Ravine, 1995). The Queen Elizabeth II (QEII) National Trust, the Nature Conservation Council, National Walkways, and Regional parks authorities are also involved with countryside management (Scott, 1984). The QEII Trust is concerned with the preservation of landscapes of cultural, scientific, recreational and scenic value (Evans, 1985). In 1992 the Trust had 593 registered covenants over tracts of land, with another 477 being processed (Anon., 1992). While most covenants cover areas of natural landscape, several significant plant collections and gardens are covenanted including Eastwoodhill, Hackfalls Arboretum, Hollards Gardens, and Tupare garden (T.White, personal communication, September 1993).

2.4 CONCLUSION

If the Eastwoodhill Trust Board wishes to develop a systematic management approach and make effective use of information, it is essential that an inventory of the collection is made and kept current in accordance with the principles of developing and managing an inventory. The maps and catalogue should be maintained and, if possible, a computerised database should be created in accordance with the ITF international standard.

These actions have a series of consequences for management of the Arboretum. First, the Trust Board must clarify its mission for the Arboretum as this has substantial implications for the type of inventory that is developed. If they wish the Arboretum to fulfill a true arboretum role then a complete inventory with maps, catalogue, archival information, and botanic garden plant records will be needed. The inventory described in this project could be used as a baseline inventory and then developed as necessary, particularly with respect to better computerisation, development of ITF records, and development of herbarium specimens. Much of the plant material is not professionally verified, accession numbers have not been assigned, or the trees physically tagged with a number. Whatever developments are made to the inventory, it must also be regularly updated to keep it current and accurate. This has major resource implications. The inventory reported in this project was developed using the resources of Massey University, but in future the Trust Board will need to obtain suitable resources and skilled staff for continued development and management of the inventory. Given the current resource situation, this should be carefully planned and conducted in defined stages.

Second, the Trust Board should clarify its objectives with respect to development and use of the collection as this will influence the specific variables that should be recorded in the inventory. There are two main issues. First, development of systematic maintenance plans will require an expanded inventory including a full record of condition classes, work done and work needed. The long term goal and statutory requirement to 'maintain and develop Eastwoodhill as an Arboretum', plus the increasing age of the collection suggests that maintenance planning is necessary. Second, the Trust Board's science and education goals require an inventory as a fundamental input. Studies on plant performance will need a continuing record of condition class and maintenance work, and studies on plant genera will need accurate archival records.

The possible development of a New Zealand Plant Collection Scheme also indicates that a well managed inventory is necessary at Eastwoodhill. It is quite clear that Eastwoodhill contains a leading plant collection, but a suitable inventory will be needed if the Arboretum is to be an officially designated collection. The New Zealand Scheme will probably follow the British model which requires a current inventory including maps, catalogue and herbarium samples.

Chapter 3 of this thesis shows that the Eastwoodhill Arboretum contains a plant collection that is unique in New Zealand, underpinning the need to develop an inventory as the basis for systematically management. Later discussions also highlight the need to develop a vegetation management programme at the Arboretum, which depends on the information from an inventory. There is compelling evidence that a complete and current inventory needs to be maintained at the Arboretum; indeed it is essential if the Trust is to reach its stated goals.

Chapter 3

Evaluation of the plant collection at the Eastwoodhill Arboretum

Rhododendron 'Fragrantissimum', Gardens, November 1987.

3.1 INTRODUCTION AND REVIEW

Evaluation is the first analytical step in the management process, establishing why a site is valuable and determining the implications for management of the site. Such understanding underpins the capacity to sustain the site in the long term (Church, 1990). Evaluation in general is a complex topic because an evaluation can be focused in a number of ways, at different scales and for different purposes. Fabos and McGregor (1979) proposed that the issues were different at each scale, requiring a range of different methods, and they distinguished country or state scale that dealt with policy level decisions, then regional scale and site scale. This research considers single site scale and the associated processes to measure, understand, and interpret the values of a site. These processes result in a comprehensive understanding of the site that can be used in a variety of ways in subsequent management.

First, the completed evaluation can be used in selection of appropriate goals (and avoidance of inappropriate goals), by focusing on the important values of the site and the features generate that importance. For example, if a site has excellent biological value it is logical to develop goals to sustain that value, and to approach any recreation goals with caution, (to avoid damage to the site). Second, knowledge from an evaluation can be used to manage conflicts over use of a site by indicating which uses will be inappropriate. Berry (1983) used an evaluation to resolve conflict between conservation and recreation uses of a series of woodlands by showing which woodlands were most suitable for each use.

Third, knowledge gained from an evaluation can guide selection of development proposals. Consider a natural environment that is used for recreation. An evaluation reveals that the site contains a rare plant and animal association that might be disturbed by recreation activities, indicating that some recreational developments may not be viable if the flora and fauna values are to be sustained. An evaluation can also be used to test the feasibility of possible management options. For example, perhaps a board walk has been proposed for the previous site; data on the rare plants will indicate whether or not the walk could be installed without damaging the site, and where it should be placed.

Fourth, knowledge from an evaluation is important when finance is constrained. Under these circumstances funds should be directed towards the most important activities, which can only be identified through knowledge of the value and condition of the site (Bartenstein, 1981; Marquis-Kyle et al., 1992). Cost effective management also needs a means of establishing priorities to direct funds to the most important activities (Kirkpatrick and Brown, 1991). Funding applications are more likely to be successful if managers can convey a thorough knowledge of the importance of the site (Dwyer et al., 1983).

In this chapter the notion of evaluation is applied to Eastwoodhill, focusing upon understanding the values of the plant collection and relating that knowledge to its management. At Eastwoodhill the statutory requirement to "maintain and develop Eastwoodhill as an Arboretum" suggests that a significant living plant collection, in excellent condition, organised in a high quality visual display is needed in the long term. Does such a plant collection exist at the Arboretum? Which values determine the adequacy or otherwise of the collection? If such a collection exists what subsequent management actions should be taken? If such a collection does not exist, what different management actions should be taken? The evaluation step addresses these questions and sets the scene for subsequent management decisions.

Although the underlying principle of evaluation (measuring and understanding values of a site) is straightforward, its application can be complex and no comprehensive methodology for a plant collection on a single site was found. Several broad scale planning processes exist for landscapes, which contain some form of evaluation step, and most include a vegetation factor, but those methods do not have a fine enough focus to deal with complex sets of values on a single site. Either the scale is too large, perhaps 1:25,000, or the definitions are too broad to deal with complex vegetation arrays in human-made landscapes. Other useful components exist, e.g. rating scales, but these were not formed into any useful process. The vegetation evaluation techniques that are available for natural landscapes may contain useful principles, but these need to be adapted to human-made landscapes.

To overcome the lack of suitable process, the literature was used to develop a new process for this research. Two broad steps were used. First, a measurement stage to identify values and measure significance of the landscape, and measure condition of the landscape. This generated a 'picture' of the importance of the landscape, highlighted critical features that generated that importance, and recorded condition of the landscape.

MEASUREMENT	PROCESSING
Identify values and measure the significance of the site. ➜ Measure the condition of the site. ➜	Relate these results to the mission and goals of landscape management in general, to the mission and goals of the particular enterprise, and therefore to the management of the site.

In the second step the information was processed by relating it to the mission and goals of landscape management in general, and of the enterprise in particular, then determining the implications for management of the site. At the end of this step possible goals and priorities for subsequent management can be proposed.

The lack of suitable processes, and the complexity of evaluation, means that it is useful to examine the principles and components that are associated with this topic. In general, overall methodology was a topic infrequently addressed in the literature. Conversely, landscape values and their measurement were commonly discussed, but very little information existed on using value measurements in an evaluation process. Measurement of condition was also frequently considered in the literature and various methods for measurement proposed. The final step, processing, was poorly described or explained in the available literature. Therefore it is necessary to draw out some principles for evaluation methodology (section 3.1.1), outline existing approaches and methods and highlight their useful features (section 3.1.2), review relevant landscape values (sections 3.1.3, 3.1.4 and 3.1.5), and consider measurement of condition (section 3.1.6).

3.1.1 Principles of evaluation

The purpose of an evaluation is to understand the values of a site and relate that knowledge to its management, requiring a rigorous method to quantify site values and interpret the resulting data. Unsystematic approaches to evaluation will lead to poor decisions, or even damage (Cocklin, 1988; Margules et al., 1991; Miles and Seabrook, 1977; Roome, 1984). Peterken (1981) emphasised quantitative evaluations, because they gave more explicit criteria and weightings than subjective methods.

It has been reported that acceptable methodology was lacking for environmental evaluation and decision making (Simpson, 1982), nature evaluation in open space planning (Jackman, 1979), habitat evaluation (Spellerberg, 1981), woodland evaluation (Peterken, 1981), reserve selection (Cocks and Baird, 1991; Margules et al., 1991; Pressey and Nichols, 1991), nature conservation planning (Roome, 1984; McNeely and Miller, 1983), garden plant conservation (Brickell and Sharman, 1986), cultural landscape interpretation (McCann, 1992), historic landscape management (Marquis-Kyle et al., 1992), and landscape protection (Taylor, 1990). Quantification and evaluation of such resources can be difficult, particularly if a resource is unique as there will no means for comparison (Miles and Seabrook, 1977). In addition, Stoner et al. (1985) suggested that small businesses and non-profit organisations, typical of many landscape enterprises, generally do not do evaluations.

3.1.1.1 Overall method

Some evaluation methodologies existed in the literature. Melnick (1983) proposed three steps: selection of parameters, application of parameters, and determination of relative significance. Powell (1981) suggested a similar process: designating criteria, application of criteria in a systematic manner which involved quantification, and a system for ranking units of landscape against each other. Miles and Seabrook (1977) had two steps for evaluating recreational value of a site: identification of factors which had significant potential for recreation use, and, assessment of the value of those factors individually and together. Jackman (1980) gave two steps: measurement of each landscape value, and then synthesis of those results.

Each method involved selection and measurement of attributes, followed by some type of processing, but how should these ideas be applied to a particular landscape? Which values should be measured? How should condition be measured? Will the method be different for landscapes in different positions on the landscape continuum? Will the mission of a landscape influence the process? Many of these types of questions have not been thoroughly discussed in the literature.

Two approaches to evaluation were described by Roome (1984). In the first method criteria were set first, the information collected, and the data analysed against the criteria. The outcome was conditioned by the features originally assumed to be important. Comparisons could be made across sites, but site specific criteria may be overlooked. In the second approach an inventory was made first, the criteria selected in light of the inventory, and then the inventory examined. This method permitted more discretion and was not influenced by predetermined criteria. Site specific criteria could be highlighted, but comparisons across sites may not be possible.

Separation of certain parts of an evaluation was recommended. Roome (1984) proposed that subjective and objective elements should be separated. Roper-Lindsay (1986) separated "intrinsic biological values" from "ascribed human values". Margules et al. (1991) separated biophysical factors from managerial and administrative factors, reasoning that the former showed the priority for action, the latter highlighted the management difficulties of achieving that action. Marquis-Kyle et al. (1992) took a similar view with the separation of significance from issues of management, arguing that action should be directly related to significance and not influenced by preconceived management views.

3.1.1.2 The measurement step: concepts

Management of a site is influenced by two concepts: significance and condition, which should both be measured in an evaluation (Melnick, 1983; Roome, 1984; Taylor, 1990). Significance describes the importance of the resource, according to a range of values which are selected and measured (Marquis-Kyle et al., 1992; Melnick, 1983, Roome, 1984; Taylor, 1990). The components of the site that generate that importance are the 'fabric' of the site (Marquis-Kyle et al., 1992). Measurement and interpretation of significance requires a thorough understanding of landscape values and their measurement. The values are relatively easy to identify and are (i) biological values such as life support and environmental quality, and (ii) human values such as economic, recreation, health, visual, and social and cultural values. Measuring these values however, can be difficult as many have characteristics which make them difficult to quantify. Values and their measurement is a lengthy and complex topic discussed in sections 3.1.3, 3.1.4, and 3.1.5.

The second concept, condition, describes the state (health in the broadest sense) of the resource. Present condition, and the likely outcome of change, indicate stability of the site and shows the urgency of any management action needed to sustain the 'fabric' of the landscape (Marquis-Kyle et al., 1992; Roome, 1984). (In this sense urgency reflects priority, it is not referring to crisis management). The poorer the condition of the landscape the more urgently action is required, conversely, a landscape in good condition requires less urgent action. Condition is relatively easily measured and there are a range of indicators for this task. For example, the age distribution of an urban forest shows the need for a planting programme, or the range of species in a bush remnant indicates the type of regeneration programme needed. Measuring condition involves fewer subjective elements than significance, and is not subject to the same level of debate as some of the difficult value measurements associated with significance. Measurement of condition is discussed in section 3.1.6.

3.1.1.3 The processing step: conceptual skills

Measurement of significance and condition is only part of an evaluation; processing skills are needed to interpret the results of the measurement step, understand the implications for the enterprise, and propose actions and priorities for subsequent management. The progression from measurement through to priorities involves two important cognitive steps. First, one must *understand* the 'picture' that the measurements of significance and condition represent. Zonneveld and Forman (1990) described understanding as "systematically ordering the observed data, and then connecting and associating them with each other via mental activity". Next, one should *project* the current picture into the future to understand the likely future situation. Understanding and projection skills enable one to view a whole task in abstract and think of the implications of a management scenario (Stoner et al., 1985). This overview skill underpins the ability to identify and anticipate decisions that need to be made in the future (Bromley, 1990).

Interpreting the future picture against the current one indicates action that should be taken to sustain the fabric of the site and ensure the enterprise achieves its goals. This is a form of discrepancy analysis where one looks for differences between the required outcome and the actual outcome (Kraus and Curtis, 1990). For example, a street tree population with a majority of mature trees indicates a major tree loss in the future, thus a replanting programme is needed to sustain the population. Looking backwards and comparing previous data with current data can also reveal useful information about change in the landscape (Miller, 1988). These comparisons are related to the mission to determine the likelihood of achieving the mission. Ultimately one arrives at a series of key problems that must be addressed, thereby foreshadowing goals and priorities.

These cognitive skills for 'future sense' are essential for evaluation, and indeed the whole planning process. The manager should be able to examine the future and consider developments and events that do not presently exist, possible outcomes of various courses of action, and the potential for and influence of change. The capacity to do this depends on data (Margules et al., 1991; Pressey and Nichols, 1991; Spellerberg, 1981; Stoner et al., 1985), but as demonstrated in Chapter 2, many landscape managers either do not have, or do not develop, the necessary data or engage in systematic management.

3.1.1.4 The processing step: practice

There are two general methods for processing. The first is the informal method which is qualitative and is done by studying the detailed information until a overview emerges in the mind (Hansen and Jorgenson, 1991). This approach is useful for processing a range of information which is measured in different units, and overcomes the problem of forcing data into inappropriate units for equations (Cocklin, 1988). The disadvantage is that interactions may not be apparent (Cocklin, 1988). Hansen and Jorgenson (1991) suggested that this method was the norm in classical planning schools (McHarg; Lynch's spatial and visual analysis).

The second method is formal evaluation which is quantitative and uses an equation to turn all information into a single score. There are two ways to do these comprehensive assessments (Cocklin, 1988). First, methods such as cost-benefit analysis (CBA) measure every value in the same unit (dollars) and rank alternatives by economic efficiency. CBA allows comparisons to be made across all factors, but it cannot cater for factors that cannot be measured in dollars (Cocklin, 1988). In the second approach complex equations are used to process information measured in different units. For example, Pressey and Nichols (1991) used a mathematical algorithm to process data and prioritise reserves. Cocklin (1988) concluded that the second form of equation was best, but conceded that actual methodology was not well developed. Whatever the processing method, Cocklin (1988) suggested that subsystems should be visible in the analysis so that operation of the parts was apparent, e.g. averaging values may cause valuable sites to be hidden by a low score on one variable (Margules et al., 1991), unless the parts are apparent.

Mapping is a common way of processing and can be used for either qualitative or quantitative processing. Each parameter is shown on a map with suitable graphics to show the distribution and level of each parameter, e.g. high, medium and low value. The overall pattern of parameters is processed to determine which areas of the site are most/least important or in best/worst condition.

Berry (1983) mapped three values for a series of woodlands, thus showing the best potential use for each area. The McHarg environmental planning method uses mapped processing, the more layers of shading for any area (one layer for each parameter) the more important the area. Interpreting the maps is usually informal with an holistic conclusion being reached by the examiner. Maps can also be used for quantitative processing. Cocks and Baird (1991), converted selection criteria into equations, applied these as a GIS overlay, then highlighted critical areas through computer processing. Coughlin and Strong (1991) also used a mathematical method in which they divided a test area into cells on a map, then calculated the potential change in each cell to show the economic benefit of a proposed plan.

Processing may involve weighting values and resolving conflicts between them. Undue emphasis on any one aspect of significance should be avoided (Marquis-Kyle et al., 1992). Lemons (1987) criticised the US National Parks Service management of conservation versus recreation values in this regard. He believed that the parks were managed as if all values were equally weighted, when they were actually unequal and had some conflicts. Indeed, conflict between recreation and conservation values is common (Cocklin, 1988; Haber, 1986; Jim, 1986a). Conflict is also almost inevitable between ecology and economics, because of the differences in time horizons (Cocklin, 1988; Zonneveld and Forman, 1990).

Processing generates a 'picture' of the landscape in a local, regional, or national context (Berry, 1983; Melnick, 1983). That 'picture' shows the importance of the landscape, identifies the fabric of the landscape, and the condition of that fabric. Relating the 'picture' to the enterprise's mission and goals, shows the critical issues relating to continuation of the landscape, therefore foreshadowing goals and priorities that will need to be established. Development of goals and priorities should be driven by long term needs, not by daily operations (Bartenstein, 1981), or by political or topical factors (Cocks and Baird, 1991). A hierarchy of goals is also necessary, to show which actions should be placed highest on the priority list. For example, most botanic gardens place biological goals before recreational goals as this relates to the purpose of a botanic garden. This highlights an important feed-back loop in the management process; converting the measurement results into actions and priorities depends on the presence of ranked goals.

3.1.2 Other approaches and processes

The lack of evaluation processes for single site management suggests that it may be useful to examine other processes for relevant principles. An evaluation can be focused for a particular purpose, and at different stages in the management process. It can be used as a planning tool on large areas or multiple sites, focusing on long term land use or investment decisions (Penning-

Rowsell, 1989) such as reserve selection (Lucas and Synge, 1981; Margules et al., 1991; Spellerberg, 1981). It can be used as a selection tool, to compare strategies, make impact analyses, and select the best development proposal (Fabos, 1979a; Penning-Rowsell, 1989). Evaluation can also be used as a monitoring tool, to measure performance and achievement of objectives (Kraus and Curtis, 1990). The approaches differ in detail, but each has the common principle of gathering and interpreting information relating to landscape values, thus they may include principles and methodologies that are applicable to this research. Landscape classification, broad scale planning processes, environmental impact analysis, and evaluation of outcomes will be considered.

(i) Landscape classification systems

A landscape classification system categorises areas together if they have common attributes (Brown et al., 1980; Burbridge, 1991; Fabos, 1979b; Jackman, 1980; Peterken, 1981; Spellerberg, 1981). Classifications may be descriptive only and occur as part of the inventory stage (Fabos and McGregor, 1979), where a logical way of describing large, complex, and variable landscapes is needed. These classifications are part of the preparation for an evaluation (Cooke and Kirby, 1994; Fabos and McGregor, 1979). Classifications may also be evaluative and occur as part of the evaluation stage, e.g. a land use capability classification is probably evaluative. Classification systems may cover large areas, usually regions or even countries. They operate at a typical scale of 1:25,000 which cannot give adequate definition of a single site (Penning-Rowsell, 1981) and are clearly incompatible with the need to identify individual plants at scales of 1:200 or more.

(ii) Broad scale planning methods

The Metland and McHarg planning processes, the Leopold matrix, and the Lynch landscape analysis method are comprehensive landscape planning methods. They use a wide set of factors and operate at a broad scale. In general their scale does not give enough detail for a single site, and their vegetation factors do not have a fine enough resolution for single site landscape management. In general they focus on selecting the best use, not on managing a site once the use has already been determined.

The McHarg planning method was developed for examining natural sites with respect to development proposals (Hansen and Jorgenson, 1991; McHarg, 1969). Overlay mapping is used to find the best location within the site for each proposed use, and at the same time reveal areas sensitive to development. The method can be used to identify impacts and show geographical extent. It is normally applied to large scale developments, (e.g. 25,000 km with cells of 500 x 500m), with many variables recorded for each cell, and each variable rated on a scale of 1-5. Although the McHarg method is commonly used on large areas, the principle of overlay mapping could be adapted to single sites.

The Metland planning technique was developed by Fabos for environmentally sensitive land use planning (Fabos, 1979a). The process has three broad phases. First, investigation of water resources, hazards, development suitability and ecological stability (Fabos, 1979b). Second, an evaluation of the trade-off consequences of different development options. The final phase is implementation. These steps follow a logical sequence but the method operates at a huge scale and breadth compared to that needed for a single site.

Wilson (1980) criticised both the McHarg and Metland methods, suggesting that they could not be applied in New Zealand in their original form because their relative scale was too large for New Zealand conditions, and the resource input needed to operate them was well beyond what was typically available here. Jackman (1980) also criticised the Metland technique, suggesting that it did not accommodate visual, social or cultural values very well. Following work in the United States, Jackman (1986) proposed a modified method for New Zealand, based on ten categories of information. He proposed that the construct could be used as a national classification and planning base (Jackman, 1986).

Spellerberg (1981) described the Leopold matrix which combined 100 actions (e.g. modification, burning) with 80 environmental factors (e.g. flora, fauna) to give 8800 potential interactions. Each interaction is rated 1-10 for both magnitude of impact and importance of impact. Spellerberg (1981) criticised the method as it had no mechanism for focusing on the most important factors, and no means to discern the time frame of an impact. Neither did it provide explicit criteria for assigning ratings to the interactions. Finally, the matrix could not be synthesised into an aggregate result and had to be interpreted informally. This method is focused upon impact, and although its list of factors may be interesting, it is not immediately useful for an evaluation of significance.

Lynch's spatial and visual analysis is a method to evaluate visual quality of a landscape (Hansen and Jorgenson, 1991). Physical elements of the landscape are classified into 'paths, edges, districts, nodes, and landmarks' by which people spatially orient themselves (Mudrak, 1982). This information is mapped to produce an image map which shows areas of visual significance and spatial divisions (Hansen and Jorgenson, 1991; Mudrak, 1982). This method would be useful for a visual analysis of Eastwoodhill for landscape design purposes, but that subject is not being addressed in this research.

(iii) Environmental impact assessment

Environmental impact assessment (EIA) is a planning tool for considering the impact of different development proposals and then selecting the best option for a site. It is usually used as a defensive or protective tool, focusing upon change rather than significance. It is not intended for existing landscapes, although Romaya (1987) used EIA to measure landscape enhancement by measuring impact before and after improvement. The prime function of EIA is to select a future scenario, thus it is much broader in its purpose than is required in this research. Here the focus is on 'how to manage this arboretum', the broader scenario of 'being an arboretum' is not in question.

EIA establishes quantitative values for environmental components before, during and after an action (Jorgenson, 1991). Jorgenson (1991) outlined five steps in EIA: impact identification, impact prediction and measurement, impact interpretation and evaluation, identification of monitoring requirements and mitigating measures, and finally communication of impact information to decision makers. This follows a similar sequence to the 'identify, measure and interpret' process proposed earlier in this chapter, reinforcing the approach being taken here.

Jorgenson (1991) described six main methods for Environmental Impact Assessment (EIA), two of those are relevant here. The first and simplest form is the checklist of which there are three types. A simple list merely lists relevant factors. A descriptive checklist measures the factors, but does not show which ones are important. A scaling checklist measures each factor, then includes a 'threshold of concern' which indicates when a factor becomes important to the decision. The 'best' alternative has the most positive and least negative impacts. The disadvantage of checklists is that they cannot weigh factors against one another.

The other relevant method of EIA is overlay mapping (Jorgenson, 1991). Different layers show the areas likely to be affected by a project, the more shading the greater the impact. This method is useful for showing spatial impacts, but does not show aspects such as probability of impact, time, or reversibility (Jorgenson, 1991). Spellerberg (1981) included McHarg overlay mapping as an EIA method.

(iv) Evaluating outcomes

There are also methods for evaluating outcomes, which occurs at a later stage in the management process. This type of evaluation determines the extent to which an enterprise is meeting its objectives (Kraus and Curtis, 1990). Outcomes are measured against objectives in seven aspects of the enterprise: philosophy and goals, administration, programming, personnel, facilities, and evaluation (Kraus and Curtis, 1990). Obviously this use of evaluation assumes that the enterprise has some objectives in the first place, and is attempting to use some type of strategy to work towards them; it is clearly premature for enterprises which do not have objectives, strategies, and management structures in place.

3.1.3 Significance: understanding landscape values

Determining significance requires a thorough understanding of landscape values and their measurement. This often presents a problem as many of those values are intangible, subjective, indirect, or non-market factors which are difficult to measure and often overlooked in decision making (Church, 1990; Downing and Roberts, 1991; Jackman, 1980; Jackman and Treeby, 1984). Measurement of human values of landscapes is clouded by issues of perception, preference, and subjectivity, yet an understanding of these values is crucial to rigorous evaluation of landscapes.

Values should be considered from three angles. First, different types of values should be examined; biological (life support, environmental improvement, products and services), and human (economic, recreational, historical, visual, social and cultural). Second, economist's classification of values as direct (traded in a market and has a market price) or indirect (not traded and has no market price) should be understood. Third, the relationship between landscape values and economics should be appreciated.

3.1.3.1 Landscape values: Intrinsic biological values

Plants and landscapes have two fundamental (and indirect) biological values: life support values and environmental improvement values. Life support values of plants and ecosystems make the world habitable by generating oxygen and removing carbon dioxide, regulating climate, protecting soils, stabilising climate and hydraulic functions, storing and cycling nutrients, and containing genetic resources (Folke, 1992; McNeely, 1988). These functions have been called ecosystem services (Pearsall, 1984), ecosystem value (Lemons, 1987), and non-consumptive value (McNeely, 1988).

The environmental improvement value of plants can be used to improve the quality of an environment that is poor or damaged. Vegetation can ameliorate temperature, manipulate air movement, influence humidity and the dissipation of precipitation, control noise, reduce pollution, reduce erosion, recycle waste, and maintain water quality (Coughlin and Strong, 1991; Grey and Deneke, 1978; Miller, 1988). These effects are frequently used to improve city climates and make cities more congenial for human living (Bernatzky, 1978; Grey and Deneke, 1978). Plants are also used to repair areas after industrial damage, e.g. mining, and to restore areas of natural habitat (Evans, 1983; Hosking, 1989).

Living systems also provide direct values such as traded economic products and services derived from landscapes. These include consumptive uses such as recreation, tourism, research and education (McNeely, 1988), and productive uses such as medicinal, food, fibre, construction, and ornamental plant products (Davis, 1988; Folke, 1992; Hall, 1974; IUCN, 1987).

As the source of so many fundamental benefits, living plants and functioning ecosystems are part of the 'natural capital' of a country and are recognised as essential for future development (Folke and Kaberger, 1992; McNeely, 1988). In New Zealand the Resource Management Act uses the term "natural and physical resources" and includes land, water, air, soils, minerals, energy, and all forms of plants and animals (both exotic and native) under that definition (Resource Management Act, 1991). Under the Act people managing those natural and physical resources will "have particular regard to" a series of items including maintenance and enhancement of the quality of environment, maintenance and enhancement of amenity values, and intrinsic values of ecosystems (Resource Management Act, 1991 section 7). "Intrinsic values" of ecosystems includes biological and genetic diversity, and "the essential characteristics that determine an ecosystem's integrity, form, functioning, and resilience" (Resource Management Act, 1991, section 2). Thus, current legislation in New Zealand encompasses the idea of intrinsic biological values and their management.

Clearly, such important resources require rigorous and systematic management if the values derived from them are to be enjoyed in the future. The need for improved management of biological resources has been noted for reserve selection (Cocks and Baird, 1991; Margules et al., 1991; Pressey and Nichols, 1991), management of natural areas (McNeely and Miller, 1983), and ecological evaluation (McNeely and Miller, 1983). On the world scene McNeely and Miller (1983) reported that although the IUCN had defined ten landscape types that should be managed, only 'nature reserve' and 'national park' had been fully examined and good management practices developed. Other types such as 'protected landscape' and 'multiple use area' had received less attention and therefore had poorly developed management methods (McNeely and Miller, 1983).

The interaction between 'natural capital' and economics is crucial to the successful management of those resources, and this topic is discussed in section 3.1.3.4.

3.1.3.2 Landscape values: Ascribed human values

(i) Economic value

Landscapes benefit people in economic terms. The direct values provide jobs and products which are part of the economy, e.g. jobs in landscape, parks and tourism industries, and products such as medicines, food, and fibre (Folke; 1992; WWF and IUCN, 1989).

(ii) Recreational value

Many landscapes are used for recreational purposes, although the landscape is often simply a venue and is valued for the range of activities that are possible rather than the intrinsic landscape qualities. It has already been pointed out that recreation is important in botanic gardens for attracting the public (and therefore finance) that supports the botanical purpose. Two main factors influence the recreation value of a site: accessibility and attraction.

Accessibility to the site strongly influences the likelihood of visitors selecting the site in the first instance (Berry, 1983; Briggs and France, 1981; Miles and Seabrook, 1977). Miles and Seabrook (1977) believed that people would travel about thirty miles for a day visit, although willingness to travel was reduced if there were substitute facilities closer at hand. Therefore access was more of a problem as the number of substitute sites increased (Miles and Seabrook, 1977). Once the visitor arrives accessibility within the site is important in determining how long they stay (Berry, 1983).

Qualities of the site that attract visitors also have a strong influence on its recreational value. Miles and Seabrook (1977) proposed 'inherent attraction' as a key parameter, i.e. capacity of the site to attract people without coercion. For example, equitable climate and scenic quality attract people to many popular holiday destinations. 'Participatory attraction', or the capacity for people to be involved in something when they get there, is another important parameter (Miles and Seabrook, 1977). For example, presence of water is often a good indicator of recreational value as it supports boating, swimming, and fishing (Berry, 1983). If a site is unique in some way it will have a greater attraction for visitors, indeed, uniqueness can be used on remote rural sites to overcome the problem of accessibility (Miles and Seabrook, 1977). Uniqueness is also a measure of the sensitivity of the site to substitute sites (Miles and Seabrook, 1977). Although uniqueness is a useful indicator it can be difficult to measure as there are often no standards against which measurement can be made (Miles and Seabrook, 1977).

Recreational value frequently conflicts with biological value as excessive recreational use can damage a site (Cocklin, 1988; Haber, 1986; Lemons, 1987). Clearly there is a management process involved in balancing the conflicting values. On one hand are the demands and preferences of different population groups for recreation (Jim, 1986a), on the other hand, is the carrying capacity of sites and the influence of use on biological processes. Miles and Seabrook (1977) proposed four ways to manage the conflict. First, recreational activities can be organised for minimal ecological change, e.g. Lemons (1987) believed access should be limited to avoid damage caused by excessive numbers of visitor. Second, the essential characteristics are retained, but other ecological changes resulting from use are accepted. Third, sensitive elements of the ecosystem can be replaced with more resilient components. Finally, changes brought about by use can be ignored. Lemons (1987) argued against this option as it damages the ecosystem which generates other values.

(iii) Historic value

Some landscapes have historic value because they represent human culture and provide insights on past communities (DeLambert, 1986; Goulty, 1993; Hackett, 1980; Millman, 1979). Various types of landscapes may have historic value such as archaeological sites, sites of important events, wilderness, primeval forest, areas of outstanding beauty, and park and garden landscapes (Hackett, 1980). Gardens may illustrate a landscape fashion of a particular time, illustrate the evolution of garden design, contain important horticultural collections, or be associated with important people or houses (Boisset, 1980; Goulty, 1993; Greenoak, 1988; Kunst and O'Donnell, 1981).

The management of landscapes with historic value is interesting because the notion of significance is already recognised as a management tool (Birnbaum, 1996; Goulty, 1993; Hackett, 1980; Hawker, 1992; Hitchmough, 1994, p 478; Taylor, 1990). A set of guidelines, based upon the architectural Venice Charter, have been used to ensure consistent judgement of historic sites (Bourke, 1983). A modification of this charter is used in heritage management in Australia (Davis, 1988; Taylor, 1990) and a similar charter has recently been produced for use in New Zealand.

Management of historic value is also interesting because it illustrates an interplay between significance and condition. The significance of historic gardens is usually related to particular physical configurations and visual features which are made from plants, but these change (and ultimately deteriorate) over time (Anthony, 1975; Boisset, 1980; Bourke, 1983; Neilsen, 1993; Ramsay, 1992; Sales, 1975). To remain significant the fabric of the site must also be in good condition. Precise manipulation of change is needed to ensure continuity of condition, otherwise significance will decline as the living components that constitute the historic merit deteriorate. This interplay also exists in botanic gardens where significance is based upon living plants.

(iv) Scenic or visual value

Many landscapes are valued because they appeal to the visual sense, and a range of factors have been identified which either increase or diminish perceived scenic quality. Presence of vegetation, particularly trees, increases perceived visual quality (Dwyer et al., 1989; Getz et al., 1982; Herzog, 1987; Mudrak, 1982; Schroeder 1982; Schroeder, 1990; Ulrich, 1986). The most preferred landscape scenes contain a majority of natural rather than human-made elements; well maintained grass, water, trees and paths; long views and open areas; peace and quiet; and an absence of crowds (Dwyer et al., 1989; Schroeder, 1982; Schroeder, 1990; Talbot and Kaplan, 1984; Ulrich, 1986). The factors that decrease perceived quality include poor maintenance, too many human-made objects, graffiti or litter, overcrowding, large monotonous areas empty of any landscape features, disordered or overly complex scenes, dense vegetation, rough surface textures, restricted depth, and incongruous sounds or any type of threat (Schroeder, 1982; Schroeder, 1990; Talbot and Kaplan, 1984; Ulrich, 1986).

Various models have been proposed to measure scenic value. The first is the ***expert model*** (Jackman, 1986; Swanwick, 1989; Ulrich, 1986) where scenic value was measured by examining physical features of a scene that relate to preference such as line, form, colour, shape, texture, and presence or absence of elements (Crofts, 1975; Swanwick, 1989; Ulrich, 1986; Uzzell, 1991). The US Department of Agriculture visual management system (Ulrich, 1986), the Manchester University model (Rackham, 1980), the Leopold Matrix and the McHarg method (Uzzell, 1991) belong in this category. Critics argued that this approach did not account for the response of the viewer and was unreliable and could not predict quality (Amedo et al., 1989; Clamp, 1981; Ulrich, 1986; Uzzell, 1991). (This approach has also been called the professional model (Swanwick, 1989; Ulrich, 1986), the ecological model (Uzzell, 1991), the measurement technique (Turner, 1975) and the surrogate components technique (Crofts, 1975)).

The ***psychophysical model*** addressed the basic flaw of the previous model and developed mathematical relationships between physical features and perception of users (Uzzell, 1991). Ulrich (1986) described a version of this model in which a good fit was obtained between preference and physical features of a particular forest environment. Nevertheless, the model could not explain why those physical features were preferred, and only worked on its own forest type.

The ***cognitive*** (psychological) model focused on predicting which scenes would be preferred by emphasising cognitive and affective reactions and behavioural consequences (Gimblett et al., 1985; Ulrich, 1983, 1986; Uzzell, 1991). The information processing model is the predominant theory here and asserts that people respond to both 'content' and 'process' features of a scene (Herzog, 1987; Kaplan, 1985; Ulrich, 1983). The 'content' factors that elicit positive responses are water, vegetation (particularly trees), and landform (Dwyer et al., 1989; Gimblett et al., 1985; Herzog, 1987; Lamb and Purcell, 1990; Ulrich, 1986). Content factors that generally elicit a negative response include vandalism, litter, and crowds (Dwyer et al., 1989).

The process features of a scene are those which make it easy to 'read' and which generate interest or initiate movement (Dearden, 1984; Gimblett et al., 1985; Herzog, 1984, 1987; Ulrich, 1986; Woodcock, 1984). Thus viewers respond to the complexity of the scene, the order imposed upon that complexity by a pattern or focal point, presence of landmarks, boundaries, and pathways, and finally the degree of mystery in the scene. Depth of view influences spatial orientation and the inclination to enter the scene. A sense of familiarity makes movement more likely. Surface texture influences perception of ease of movement, with smooth textures favouring movement. Finally, the viewer is more likely to participate if they feel safe in the area.

The final model is the ***phenomenological model*** (Uzzell, 1991), also called humanistic studies (Swanwick, 1989), and regarded by some as part of the experiential model (Jackman, 1986). This model emphasised feelings, interpretations and expectations (Uzzell, 1991) and the works of Lowenthal, Jackson, Meinig, and Tuan belong here (Swanwick, 1989; Uzzell, 1991). This group of theories considers interrelationships between people and landscapes and does not attempt to develop predictive models (Swanwick, 1989).

There is considerable debate about the theoretical framework underlying these models (Gimblett et al., 1985; Uzzell, 1991), indeed some authors believe there is no clear framework (Appleton, 1975; Carlson, 1993; Gimblett et al, 1985; Swanwick, 1989; Zube, 1984). Each model can measure response, and provide useful information, but Uzzell (1991) claimed that none was particularly effective at predicting response. Conversely, Ulrich (1986) suggested that much of the variation in response could be explained, particularly using the cognitive model. Clearly this is an area that needs more work and research by scientists such as Appleton, Kaplan, Lewis, Lowenthal, Schroeder, Ulrich, and Uzzell is relevant.

The critical point for this research is that visual value demonstrates the presence of a deep and complex relationship between the physical and visual features of a landscape and visitor response to that landscape. The existence of that relationship has strong implications for the management of any landscape which must attract public or create a marked visual impression. Managers of botanic gardens, therefore, must realise that the capacity of the garden to attract public is integrally tied to the physical and visual management of the site.

(v) Cultural and social values

Landscapes have many benefits which come under the category of human well-being and social development (Relf, 1992). Landscapes have positive effects on physical health, mental health and stress (Hull, 1992; Lemons, 1987; Schroeder, 1990). Community identity and social development are improved through interaction with good landscapes (Hull, 1992). Landscapes have therapeutic benefits (Lemons, 1987), and symbolic and religious value (Dwyer et al., 1991; Lemons, 1987). Social and cultural values involve emotive issues which are not always compatible with the rational arguments of decision making (Dwyer et al., 1991), making these values particularly difficult to measure (Dwyer et al., 1991; Hull 1992; Schroeder, 1990).

3.1.3.3 Direct versus indirect values

To appreciate the difficulty of measuring some values, one should understand the economist's description of values as either direct or indirect. The distinction is important as it has a major influence on the way values are treated in economic analyses. A direct value is the benefit one obtains by using a resource (Church, 1990; Downing and Roberts, 1991), which can be divided into consumptive uses and productive uses (McNeely, 1988). The former includes activities such as recreational use, or use of an area by indigenous people where the resource is used without passing through a market. Productive use value relates to the commercial harvesting of the resource where a commercial product is produced and sold. It is the only value category that has a market price. Plants and landscapes clearly provide a variety of direct values.

Indirect values are not traded, do not have a market price, and accrue even if one does not visit the site. These are collectively larger than direct values, indeed, they are often generate the direct values (McNeely, 1988). The first indirect value is non-consumptive use, particularly the life support function of landscapes and ecosystems (McNeely, 1988), which have already been described in section 3.1.3.1. Pearsall (1984) called these functions 'ecosystem services', and included genetic diversity in this category. (Groombridge (1992) placed genetic diversity in option value).

Option value is the second indirect value, and is the value of having the option of using a resource in the future, i.e. the premium paid for guaranteeing future access (Church, 1990; Downing and Roberts, 1991; Groombridge, 1992; Lemons, 1987; McNeely, 1988). This value is not easy to measure, indeed, it may not be positive (Groombridge, 1992). The concept of option value is used to stress the economic importance of conserving biodiversity, and is supported by the discovery of hitherto unrecognised values in hitherto unrecognised plants (Groombridge, 1992).

The third indirect value is existence value, which is the value placed upon a resource simply because it exists (Church, 1990; Downing and Roberts, 1991; Groombridge, 1992; Lemons, 1987; McNeely, 1988; Pearsall, 1984; Schroeder 1990). This is also known as bequest, vicarious, stewardship, or intrinsic value (Groombridge, 1992). An example of existence value is the high level of public opinion in favour of protecting rare species, even though most people have never seen those species (Pearsall, 1984). Existence value is a valid value which satisfies an element of demand, but that demand is not well understood (Pearsall, 1984). Existence value has not been studied much because it has a psychological basis and no useful theories had been developed for its measurement (Groombridge, 1992). Groombridge (1992) suggested that some see existence value as the luxury of the rich, and noted that it was not possible to confirm or deny the assertion with current levels of data.

Related to the indirect benefits are a series of in-absentia benefits associated with landscapes (Church, 1990; Pearsall, 1984; Schroeder 1990). These were discussed in some detail by Pearsall (1984) who described two benefits that have not already been mentioned. The residual benefit is the carry-over effect that continues after one has left the landscape site, e.g. the well-being from a day out in the countryside persists after one has returned home. The vicarious benefit accrues to someone other than the visitor. (Clearly not the same sense of 'vicarious' as used by Groombridge). For example, a beautiful picture of a landscape may give enjoyment to people other than the artist. Pearsall (1984) argued that in-absentia benefits were key motivators and had a strong influence on funding decisions, e.g. Americans voted to make a national park in Alaska much larger even though most had never been there. Understanding indirect values such as these is important in appreciating the interaction between landscape values and economics.

3.1.3.4 Landscape values and economics

The relationship between environments and economics is a key issue for landscape managers. Landscapes are part of the 'natural capital' of the world which provides a wide range of benefits, and which must be rigorously managed if people are to continue to enjoy those benefits. But conventional economic thinking is not necessarily in tune with the need to sustain natural capital and has frequently been counterproductive, even damaging, to environments (Easton, 1995; Folke and Kaberger, 1992). It is necessary, therefore, to consider the interaction between environments and economics and highlight the difficulties for the landscape manager.

Economics is the study of human preference and is focused on market price for goods (Groombridge, 1992; McNeely, 1988). This immediately presents a problem for the landscape manager as many landscape values have no market price; they are a valuable public good derived from a functioning ecosystem (McNeely, 1988). Economists make decisions based upon the ratio of financial benefit to financial cost of a course of action; if the benefit outweighs the cost the action goes ahead. As landscape values are difficult to measure in economic terms, they are often overlooked or left out of decision making (Coughlin and Strong, 1991; McNeely and Miller, 1983). Therein lies the crucial problem, the capacity to recognise and properly price costs and benefits.

A key problem is lack of data and unbalanced analyses. First, there are conceptual gaps between ecology and conventional economics, e.g. traditional ways of measuring national income show use of natural resources as income, when natural capital is actually declining (McNeely, 1988). Second, environmental valuations should use total economic value, yet some values are excluded due to a lack of data or methodology and in practice only appropriable values are used (Groombridge, 1992; Hampicke, 1994). Unfortunately the indirect values (most landscape values) are usually omitted as these are too difficult to measure (Groombridge, 1992). This gives a biased analysis as those values are often larger than the easily measured direct values (McNeely, 1988). Third, better methods are needed to quantify values, i.e. methods to measure climate control, pollution control, genetic resources and other landscape values (McNeely, 1988). Fourth, McNeely (1988) believed that, even when they are included, many biological resources are seriously underpriced leading to incorrect data being used in analyses. Fifth, many of the intangible costs of depletion of a resource are not included in calculations, making the monetary gain from use look larger than it really is. When properly calculated the figures often show that, once a resource is depleted, the cost of rebuilding it far outweighs the revenue gained from its harvest (McNeely, 1988; Hampicke, 1994). Sixth, social benefits of conserving bioresources are often not reflected in market price and therefore often not recognised in Cost Benefit Analysis (Hampicke, 1994). Thus social costs and benefits are ignored and exploitation goes ahead based on incomplete data.

There are some methods available for pricing indirect values, although each has limitations (Groombridge, 1992). These are changes in productivity, contingent valuation, hedonic pricing, and travel cost (Groombridge, 1992). The change in productivity approach models the relationship between supply of resources and the economic value of production, e.g. the influence of soil degradation on agricultural production (Groombridge, 1992). Comparing the equation for degraded versus non-degraded situations shows the value of the environmental resource.

Contingent valuation uses willingness to pay (WTP) as a measure of environmental quality (Groombridge, 1992). A hypothetical market situation is used in which people are asked to put prices on items not normally marketed. Contingent valuation is often considered unreliable because the derived values depend on individual perceptions of a wide range of background factors, and there can be wide variation between people's stated intentions and their actual action in the marketplace. The method is based on the premise that value can be measured by willingness to pay, but this may not always be true when dealing with a broad range of human values (Groombridge, 1992; Hampicke, 1994). In spite of the difficulties, contingent valuation is considered the only way to measure option and existence value (Groombridge, 1992).

Hedonic pricing is based on the notion that value of non-market items is built into the price of other marketed goods, e.g. well landscaped surroundings are reflected in property price (Anderson and Cordell, 1988; Groombridge, 1992; More et al., 1988). The economist dissects that price to determine the value of the environmental component. Groombridge (1992) suggested that hedonic pricing was a complex and ponderous technique which needed simplifying assumptions to make it work. It also had a large data requirement which was a key disadvantage (Groombridge, 1992).

The travel cost method determines value by analysing the amount of money visitors spend to get to and use a landscape (Groombridge, 1992). It is typically applied to ecotourism and recreational sites, e.g. visitor value of an arboretum was $20.43 per visitor per visit (Downing and Roberts, 1990), and a visit to a conservatory was valued at $12.71 (Dwyer et al., 1989). Dwyer et al. (1983) noted that the method did not take non-users into account, nor did it give any information on how site attributes (e.g. spatial configuration, tree management, or good maintenance) influenced the value to users.

Returning to the key problems, the second one is time frame. Economists tend to take a short term view (1-4 years, maximum 50 years, (Folke and Kaberger, 1992)) whereas environmental managers tend to take a long term view. When resources are used over time, (such as investments in conservation which have a long time period before the 'pay-off'), their value is converted into a present value. This calculation is acutely sensitive to discount rate and time horizon, and if discount rates favour the immediate time frame the result will be depletion rather than conservation (Easton, 1995; Groombridge, 1992; McNeely, 1988). Groombridge (1992) suggested that immediate gains in productivity are usually favoured over environmental goals, therefore loss of natural capital is inevitable.

Groombridge (1992) concluded that the aforementioned economic approaches inevitably lead to loss of natural capital. At the same time McNeely (1988) argued that conservation of natural capital was a precondition to economic development, as future consumption depended upon the existence of that natural capital. Thus, the weaknesses of conventional economic approaches to environments are doubly unfortunate, particularly given the predominance of the economic standpoint in world affairs. Fortunately, the discipline of environmental economics attempts to improve the relationship between environment and economics (Folke and Kaberger, 1992), but these approaches are not always used.

3.1.4 Significance: measuring landscape values

The first step in measuring the values described in section 3.1.3 is the selection and relative weighting of values. Selection is directed by knowledge of the enterprise and the values that logically relate to its mission and goals, and a thorough knowledge of the range of values. Different sets of values will be needed for different sites and purposes, e.g. Rackham (1980) measured ecological, archaeological and visual value for conservation purposes in Britain. Berry (1983) measured visual, ecological and recreational value for woodland management. Hackett (1980) considered aesthetic and historic value for heritage conservation.

Selection and weighting decisions are often controversial. In the past there was a preoccupation with visual assessment and other values were either overlooked or not recognised (Haynes, 1981; Jackman, 1980; Jackman and Treeby, 1984; Lamb and Purcell, 1990; Penning-Rowsell, 1981; Russell, 1989; Swanwick, 1989). Values may be unrecognised or discounted if decision makers are disinterested or uninformed (Marquis-Kyle et al., 1992). Different people may give different weighting to the same set of values (Donadieu, 1993), e.g. people gave different weightings to factors in a survey of street tree suitability (Sommer et al., 1993). Such differing views may involve conflicts between values (Cocklin, 1988). Awareness of possible conflicts is necessary at the measurement stage, but decisions on these interactions usually take place at the processing step.

The context of value measurement must also be determined. Sites may be significant on a local, regional or national scale (Goulty, 1993; McCann, 1992; Melnick, 1983; Peterken, 1981, p 255). The context will be influenced by the mission of the enterprise and by preliminary examination of raw inventory data. For example, if the mission requires a nationally important plant collection, value would have to be established in a national context.

Next, suitable attributes for measuring the values must be chosen. Berry (1983) gauged recreational value of woodlands by measuring accessibility, presence of water, and size of woodland. Biological value can be measured using indicators such as diversity, size and rarity. Hackett (1980) used rarity and historic interest to measure historic value. Penning-Rowsell (1981) claimed validity was a major problem in most landscape evaluations and that the link between values and the factors used to measure them had not been properly tested. In his view most value measurements were based on deductive rather than empirical premises and were therefore open to debate.

Several types of attributes can be used to measure values. Roome (1984) described absolute measures, relative measures, and indirect measures. Marquis-Kyle et al. (1992) also referred to predicted parameters.

(i) Absolute measures are attributes with a physical, objective or scientific basis. They are measured directly through field measurements or archival searches, e.g. size, age, number, species, rate of usage, patterns of use, or length of visits. The measurements are obtained from the site itself, records and reports, and direct observation of facilities and activities (Kraus and Curtis, 1990).

(ii) Relative measures are attributes with a scientific basis that are measured by the manager using a suitable test population or other data. For example, a diversity index measures biological value (McPherson and Rowntree, 1989), travel cost and contingent valuation (Church, 1990) measure human values using a formula operated by the manager.

(iii) Indirect measures involve subjective measurements, often related to human values. Measurements may be done by a test population or a group of professionals. The measurements are based on assumptions about the relationship between site characteristics and value (Roome, 1984), e.g. recreation value can be measured by accessibility. The measurement is made through users (or non users) opinions, typically using methods such as interviews, surveys, and checklists.

(iv) Predicted parameters are proxy measures that reflect value indirectly (Marquis-Kyle et al., 1992). For example, site size might indicate diversity, physical characters might indicate scenic value. Predicted parameters can save costs, but their accuracy relies upon accuracy of the predictive function and very few predictors are reliable over a range of circumstances (Marquis-Kyle et al., 1992).

Measurement of values can also be controversial. Some argue that the public should make judgements about human values (particularly scenic value), because professional opinions do not reflect those of the wider community (Amedo et al., 1989; Uzzell, 1991; Uzzell and Lewand, 1990). Other studies contradicted this conclusion (Gold, 1986; Schauman, 1988b; Sommer et al., 1992), indeed Swanwick (1989) concluded that there was no consensus on the issue. Evaluations done by outside experts are more likely to be impartial, and may bring useful expertise to bear (Kraus and Curtis, 1990).

Measurement also involves an understanding of what is actually being measured; preference or value. Consider the categories of values proposed by Lemons (1987):

(i) Individual preference. An individual subjective choice.

(ii) Market price. The value according to market price. This is ultimately a measure of individual preference as it reflects how much an individual is willing to pay.

(iii) Individual good. This is what is best for a person, even though they do not always choose it due to lack of knowledge or education.

(iv) Social preference. A type of social will expressed through culture, religion and politics; a consensus of individual preferences. Individual preference may conflict with social preference. Social preference is taken to be more important than individual views.

(v) Social good. Lemons describes this as a vague definition, ‘the greatest good for the greatest number’.

Generally it is social good, not individual preference, that drives landscape management for the community. Unfortunately social good cannot be measured directly, and must be described through a synthesis of individual measurements. Therefore methodology must be precise otherwise the result may not reflect social value, and lead to incorrect decision making. This distinction between preference and value has not been clarified in many discussions of landscape values, particularly with respect to scenic values. Consider an analogy. Two different brands of car might both be worth $50,000, i.e. are of equal value, but an individual may prefer one over the other. Thus, at one level a person agrees that the two cars have the same value, yet they express different preference about each one. Methodology for measurement of scenic value of landscapes has yet to solve this dilemma and devise a consistent way of measuring value without being unduly influenced by individual preference.

The human judgements involved in some value measurements often causes those measurements to be questioned on the basis of subjectivity. It may be impossible to completely remove subjectivity from some value measurements, e.g. data such as visitor surveys appear to be objective, but hide subjective judgements within the questions (Lemons, 1987), e.g. the selection of values to be measured is subjective, even though the subsequent measurement may be objective (Berry, 1983). Sometimes subjective measurements have to be used, simply because there is no other information available (Miles and Seabrook, 1977). Although this is not ideal it does provide a relative comparison (Berry, 1983).

Collectively, these issues of value measurement present a difficult problem for the landscape manager. The problem is worst for those intangible, indirect, non-market values which dominant landscape value measurement. The only solution to this problem is research and rigorous methodology.

3.1.5 Measuring biological value

Biological value is the focus of this research and is quantified with indicators which measure the characteristics of vegetation such as diversity, rarity, size, and representativeness (Goldsmith, 1988; Kirby, 1993; McPherson and Rowntree, 1989; Peterken, 1981; Spray, 1980). For example, Rackham (1980) measured biological value by combining amount of vegetation, habitat weighted for diversity and rarity of species within that habitat, and portions of urban and agricultural land in each cell. Spray (1980) measured ecological value by combining size with habitat value and diversity. The aforementioned indicators were originally used on the interrelated populations of natural ecosystems, but can be applied to artificial populations in human-made landscapes, e.g. McPherson and Rowntree (1989) and Welch (1994) used a diversity index to evaluate street tree populations, and Moll (1988) used size and volume to evaluate an urban forest.

There is no standard way to combine the indicators into a biological value, in part caused by the difficulty of comparing and weighting factors in an acceptable way. Thus, factors should be measured individually and then synthesised informally (Cocklin, 1988; Hansen and Jorgenson, 1991).

(i) Diversity

Plant diversity describes the number and extent of species or plant communities in an area (Noss and Cooperrider, 1994; Peterken, 1981; Spellerberg, 1981). There are three different ways to define diversity: alpha diversity is the number of species within a habitat, beta diversity is the rate of compositional change between habitats, and gamma diversity the combination of the previous two (Noss and Cooperrider, 1994; Peet et al., 1983). Greater diversity is considered to be more valuable than a smaller number of species (Peterken, 1981). Greater diversity in natural populations gives greater stability, greater resistance to change, and faster recovery after damage (Berry, 1983). Diversity can be measured at global, regional or local scale, e.g. at the global level South America contains areas of the highest biological diversity in the world.

Diversity in human-made landscapes is not a natural phenomenon, as planting is usually determined by the design or criteria of the manager. Nevertheless, the concept of diversity can be applied to those populations. Plant collections, botanic gardens and arboreta represent a wide diversity of plants, as shown by the records of Botanic Gardens International (Leadlay et al., 1993), the NCCPG plant collections records (NCCPG, 1994), and records of plants in commercial trade (Lord, 1991). In addition, Lowe (1989) proposed that there was a wide plant diversity in gardens (in Britain) which was not available in commercial trade and which could only be found through surveys (Lowe, 1989). Preliminary data for New Zealand supports the same pattern (Hammett, 1993; MacKay, 1993). Other researchers reported high diversity in park and garden landscapes, e.g. over 700 species in parks in Prague (Profous and Rowntree, 1993), and Richards (1992) claimed that urban forests were more diverse than natural forests.

Conversely, others reported low levels of diversity in human-made landscapes. Several studies showed low levels of diversity in urban forests, with reliance on a small number of species (DeGraaf, 1985; Lesser, 1996; Paris and Munro, 1989; Pickering and Perkins, 1982; Profous, 1992; Rhoads et al., 1981; Stevens and Richards, 1986). Weinstein (1984) found a similar pattern in Central Park in New York, with a small number of species accounting for a large proportion of the population. Diversity in urban forests is recognised as an important buffer against harshness of urban environments (McPherson and Rowntree, 1989). The danger of low levels of diversity is illustrated by the impact of Dutch Elm disease on the landscape. At the same time, Richards (1993) pointed out that low diversity in urban landscapes often occurs because nothing else will grow.

(ii) Diversity: composition

The composition aspect of diversity refers to the mixture of species within a population. In natural landscapes this is generated by the sum of natural processes and results in different compositions on different sites, e.g. in northern regions species a,b,c,d are present, while in southern regions c,d,e,f are present. In human-made landscapes composition is directed by human design or management. Such management is particularly important in botanic gardens because, (i) plant composition is the fabric of botanic gardens and fundamental to their purpose, (ii) changes in composition alter the fabric, and (iii) systematic management is needed to sustain that fabric over time.

Monitoring composition over time is an important management tool which illustrates change in the population as it moves through its collective life phases. Loeb (1993) found that 59% of plants had disappeared from Central Park over a 125 year period. Some were removed, others succumbed to severe winters but others had died because of deterioration of the park. Davis (1987) found that 20% of the trees in Hertfordshire had been lost in the last twenty years. Spencer and Kirby (1992), Allison and Peterken (1985), and Harkness (1983) also measured long term change in tree populations and reported changes and losses over time. Knowledge of these changes foreshadows management actions needed to perpetuate those landscapes.

Richards (1979) focused more closely, considering changes in species mixes over time and found that some species survived better than others. In his study 75% of *Acer saccharinum* survived compared with 47% of *Acer saccharum* and 30% of *Gleditsia triacanthos*. These shifts in composition were caused by sensitivity to cultural conditions and management activities, but also by differences in natural life span. Dawson and Khawaja (1985) highlighted the problem of short lived species in a study of an original population containing *Populus, Ulmus* and *Acer*. Fifty years later the short lived species had disappeared and the population was dominated by *Acer*. Paris and Munro (1989) reported a similar composition shift in a street tree population as short lived *Rosaceae* species died out. These observations have two implications. First, they indicate species that are less suited to that particular landscape. Second, they indicate which actions must be taken to perpetuate the vegetation, e.g. in Dawson's population the *Populus* and *Ulmus* need more frequent replanting than the *Acer*.

Composition may also refer to the genotypic mixture of a population of one species, which has important genetic implications as this influences a species capacity for evolution and adaptation. Factors such as genetic drift, genetic erosion, and representativeness are important factors in population management (Burton, 1989; Groombridge, 1992; WWF and IUCN, 1989). Minimum population numbers for genetic integrity are often specified (Burton, 1989; WWF and IUCN, 1989), indeed, this is essential when species conservation is the goal. This highlights the important distinction between conservation collections and taxonomic collections (Rae, 1993). Many botanic gardens and plant collections are taxonomic collections, simply because they do not have the space to accommodate the number of individuals needed for genetic conservation.

(iii) Diversity: dominance

Dominance refers to the numbers of individuals (as opposed to species) within a population. Two populations might have the same number of species but quite different patterns in the number of individuals of those species. Thus one site might have many species 'A' with few species 'B', and another site many 'B' with few 'A'. On natural sites dominance is the result of combinations of natural processes, causing certain mixtures of individuals to occur. Observing the patterns of dominance provides insights into the natural processes that are occurring on the site.

Once again, dominance in human-made populations is not a natural phenomenon but one that is driven by design or management of the site. Several studies have shown street tree populations dominated by a few genera or species, e.g. DeGraaf (1985) recorded a population dominated by *Acer*; 96% of trees in Vancouver were from 16 genera, 37% were *Prunus* (Paris and Munro, 1989); four species accounted for 65% of street trees in Prague (Profous and Rowntree (1993); nine out of 25 species accounted for 72% of the urban forest population (Chacalo et al., 1994). In a park landscape Weinstein (1984) found that ten species accounted for 65% of trees in Central Park.

(iv) Rarity

Rarity is an accepted basis for biological value and management action, but this assumes that rarity can be measured (Berry, 1983; McIntyre, 1992). Establishing a definition can be difficult as rarity can have many meanings and includes subjective elements (Ayensu, 1981; Given, 1981; Good and Lavarack, 1981; Harper, 1981; McIntyre, 1992). Rarity might be defined as a species with few individuals (Spellerberg, 1981; Ayensu, 1981), or one that occurs in few places (Spellerberg, 1981). Determination of rarity is complicated by the need to establish correct identity; taxa which appear to be of limited distribution may be mutants, unusual phenotypes or hybrids without legitimate species rank (Ayensu, 1981). Similarly, taxa may be considered rare when in fact they are inconspicuous or inaccessible (Ayensu, 1981). Rarity may also be either spatial or temporal (Harper, 1981).

Rabinowitz (1981) proposed that categories of rarity should be based on three aspects of a species: geographic range, habitat specificity and local population size. McIntyre (1992) examined these categories in relation to Australian flora where most listed plants fitted the 'endemic' category which have a narrow habitat, small geographic range, and a dominant population somewhere within the range. McIntyre (1992) claimed that other forms of rarity, such as sparse or widespread species, were poorly documented and never appeared on the lists. Similarly, Jusaitis (1995) suggested that rarity was often defined on the basis of herbarium samples, with few samples assumed to represent a limited population. Often this simply reflected a poor collecting pattern, stressing the need for good field work as a basis for defining rarity (Jusaitis, 1995). In light of these difficulties, the determination of rarity and establishment of conservation priorities is often based on incomplete data (McIntyre, 1992; Good and Lavarack, 1981).

Rarity of species in human-made landscapes can be measured using frequency in collections or commercial trade. Frequency in cultivation has been measured for botanic gardens and arboreta by BGCI (Leadlay et al., 1993), for tree collections (Lear, 1990, 1994), and for horticultural plants in Britain using the 'pink sheet' system (Sanecki, 1986). (The 'pink sheet' was a designation of rarity determined by the qualitative opinions of an expert panel). Frequency in commercial trade (in Britain) is found in a 'Plantfinder' which lists the sources of commercial supply of a species. For example, more than 25,000 species in the British Plantfinder (of a total of 50,000) had only one source of supply, suggesting a considerable proportion of horticultural plants in that country were in a precarious position (Lowe, 1989).

Once the rarity of a species has been determined the level of significance must be established. Wild species in natural landscapes have been delineated in several ways. Ayensu (1981) defined occurrence on three or less sites as endangered. The original British Red Data Books included all species recorded in fifteen or less 10km squares since 1930 (Crompton, 1981). Measures of rarity for species in natural populations now commonly use the IUCN categories to describe each species (Extinct, Endangered, Vulnerable, Rare, Indeterminate, Insufficiently known). These categories have recently been revised to give a more objective set of descriptors (Groombridge, 1992, p 234). Yardsticks for horticultural plants are generally more arbitrary, e.g. designation of 'pink sheet' plants in Britain was done by expert opinion rather than any quantification (Sanecki, 1986). Lowe (1989) defined horticultural plants available from three or less sources as rare.

Much of the debate over definitions of rarity seems to relate to separation of significance, condition, and management issues, e.g. rarity and degree of threat measure two different things (Given and Norton, 1993). Definitions of rarity that include factors such as vigour, degree of threat, or threat factors are combining significance (rarity) with condition. Likewise, a system which separates rare and stable from rare and declining (Ayensu, 1981) is measuring both significance and condition. A system which differentiates between rare and reserved versus rare and not reserved (Ayensu, 1981) is measuring both significance and management factors.

(v) Representativeness

Representativeness describes the extent to which an area of vegetation represents its type, e.g. lowland coastal forest of the Manawatu region. It is important to conserve a maximum range of species or vegetation types (Berry, 1983). Therefore in natural landscapes one might preserve an example of each of rainforest, dry forest, mountain forest, tundra, alpine meadow, grassland, and any other relevant types. In human-made landscapes representativeness will be difficult to apply as these 'vegetation types' are man-made, however, it can be applied to garden plants such as the conservation of a cultivar range. Brickell and Sharman (1986) pointed out that it was impossible to conserve each of the thousands of cultivars of some species, so a selection of representative types was required.

(vi) Size

Size of a site is an important indicator of biological value because larger sites are more stable than small sites (Berry, 1983; Peterken, 1981). Larger areas are better for conservation as they usually contain more species and are therefore more representative (Peterken, 1981; Spellerberg, 1981). As size declines so does species number (Noss and Cooperrider, 1994; Raven, 1987) until the community cannot sustain itself (Spray, 1980). Although size is primarily a measure for natural populations, it is also an important criterion when gauging tolerance of created landscapes to human pressure. Site size is an absolute indicator which is easily measured, e.g. Rackham (1980) used the area of vegetation in each cell.

Isolation is related to size. The more isolated an area of vegetation, the less its biological value as isolated areas are often less stable and therefore less persistent (Berry, 1983; Spray, 1980). Isolated woodlands often behave as ecological islands where the equilibrium of species is determined by island size, remoteness, stability of environment, and species richness (Spellerberg, 1981). Small, isolated woodlands often suffer more pressure from human use than their larger counterparts.

3.1.6 Measuring and interpreting biological condition

Condition measures the physical state of a landscape, indicating the need to take to action to sustain the value of that landscape. For example, Davis (1987) reported considerable tree loss in woodlands in Britain due to neglect and over-maturity. There was no natural regeneration and a complete loss of woodland was inevitable unless some action was taken. The principle behind measuring condition is to establish the current health (in its broadest sense) of the living components of the landscape, and then consider the future implications of those results.

Condition, and the associated notion of urgency, are important concepts when managing biological change in the landscape. The need to manage change is exacerbated when a landscape is focused upon a specific composition, such as historic gardens of a specific format or period, or plant collections which depend on particular species composition. These human-made landscapes represent a series of overlapping life cycles, each requiring eventual replacement (Sales, 1989). Their management involves manipulating a series of ongoing growth and decay processes (Neilsen, 1993; Sales, 1975), continually appraising the flow of a population through its normal life cycle and determining the right point for replacement.

Condition can be measured at two scales, the individual plant or the whole population. This chapter focuses upon whole populations, while condition of individual plants is considered in Chapter 6.

(i) Using rating scales to measure condition of individuals

Condition can be measured by applying rating scales to individuals in the population, measuring factors like health, degree of damage, and life expectancy of individual plants. The results can be aggregated to show the average rating for the whole population (Moll, 1988; Weinstein, 1984). Rating scales were not applied to all plants in the population at Eastwoodhill because the task was too large. Scales were used in the specific exercises discussed in Chapter 6 and their application is considered in detail in that chapter.

(ii) Measuring condition of populations

The state of a whole population can be measured by its maturity or stage of succession. In a natural forest vegetation often progresses through distinct successional stages before it reaches the final climax formation. Observing the progress through those stages provides useful information on the state of the forest. Human-made vegetation arrays do not have natural, interrelated successional stages in this way, but the related concept of maturity can be measured. For example, an urban planting in which most of the trees are over-mature indicates the need for a major re-planting programme. Another planting in which the trees are still approaching maturity does not have the same requirement. Thus, stage of maturity of a population provides information on the need for renewal of that population.

Various factors, such as age, size and diameter at breast height (dbh), are linked to maturity and can be used to measure maturity. (Noting that the relationship is often complex and species specific). Researchers have examined profiles of age (Barr and Whittaker, 1987; Campbell, 1985; McPherson and Rowntree, 1989; Workman, 1982), size (Stevens and Richards, 1986), dbh (Wray and Mize, 1985), or age/class patterns (Moll, 1988; Spellerberg, 1981). For example, Moll (1988) proposed that average age of a population could be used to describe the condition of the urban forest, and that urban trees were most valuable from 5 inches trunk diameter until about 30 years old, (when the useful life of the tree was considered to be 32 years). Age classes can be used to determine the maturity of a population by comparing actual age with expected life of a species, e.g. *Malus sp* will be in the final phases at about 50 years whereas *Quercus sp* might be still maturing at the same age.

These factors might be used in combination to describe a population. Moll (1988) measured size, volume, average life span, changes in tree mortality, and plantings versus removals. He found that urban forests were declining, with a replanting rate of only 12-25% of removals. Zipperer et al. (1991) examined the condition of street tree populations using percentage damage, species composition, and trunk diameter.

Repeated profiles over time can be used to track the movement of a population through its life phases. The profiles show any gaps in continuity of a population, e.g. Loeb (1993) found the intermediate range trees in Central Park were insufficient for regeneration of *Acer, Quercus* and *Ulmus*. Profous and Rowntree (1993) identified a similar gap in intermediate size trees in a street tree population in Prague. Zipperer et al. (1991) used dbh distribution to predict a shortage of mature trees in the future of a population, due to insufficient small trees at the time of study. Green (1984) predicted 53% loss of trees in his study area over the next twenty years.

Measurement of condition is much less controversial than measurement of significance as the biological indicators are more objective. What can be difficult, however, is the interpretation of those measurements with respect to manipulation of the population. This is not surprising given that human-made landscapes and the dynamics of artificial populations are not well described, making the outcome of management actions difficult to predict.

3.1.7 Eastwoodhill Arboretum

Eastwoodhill Arboretum contains an extensive plant collection that has both biological and human values. The Arboretum is used for recreation, has considerable visual merit, and is part of the horticultural history of New Zealand. The initial focus, however, must be upon biological value of the plant collection as this underpins the purpose of an arboretum in general, and the Trust Board's responsibility to "maintain and develop" the Arboretum in particular (Eastwoodhill Act, 1975). The management plan recognised the collection as the backbone of the Arboretum, and as the key to achieving the mission (Williams, 1987, p 50).

Expert, but unsubstantiated, opinion proposed that the Arboretum had significant biological value (Goodwin, 1964; Jackson, 1964; Jew, 1972; Salinger, 1964,1971; Sykes, 1964; Sykes, 1972;

Weston, 1971; Yeates, 1964). In the management plan Williams (1987) also asserted that the collection was significant, but did not support the assertion with an evaluation. If the aforementioned views on significance were correct, an examination of condition would also be important. Early reports commented on the overcrowding within the Arboretum and deterioration of the collection (Jew, 1972; Skipworth, 1976) and since 1975 there had been considerable physical change to the property as clearing work was done (Williams, 1987).

Early examiners of the collection recommended that an evaluation should be conducted (Jew, 1972; Weston, 1971), as did the management plan (Williams, 1987), but prior to this research there was limited evaluation of the collection. The Trust Board had an inventory of the collection (Berry, 1976, 1980, 1982), and some manipulation of information was initiated including a planting plan which outlined how various areas of the Arboretum should be developed, a list of plants that should be propagated, and a list of plants that should be acquired for the collection (Berry, 1979, 1980a, 1981). Although these were important documents, and are still used as reference material, none constituted a formal evaluation. A more comprehensive examination of the collection was required.

Goal

To evaluate the Eastwoodhill Arboretum collection, measuring significance and condition of the collection and then processing this information in relation to the mission and goals of the enterprise, thereby identifying potential goals and priorities for future management of the collection.

3.2 METHOD

3.2.1 Introduction

Evaluation of the plant collection at Eastwoodhill should primarily focus upon biological value as the presence of a significant living plant collection is central to the role of an arboretum. The evaluation should also be driven by the requirements of the mission, goals and objectives of the enterprise, which indicate factors that might be measured.

Documentation from Eastwoodhill gave limited guidance for planning an evaluation. The Eastwoodhill Trust Board does not have a formal mission statement; the nearest substitute was in the Eastwoodhill Trust Act (1975) which stated that "the primary function of the Board shall be to maintain and develop Eastwoodhill as an Arboretum", and as a second role "the Board shall use its best endeavours to make Eastwoodhill available to the public for its education and recreation." If this is accepted as a nominal mission, then biological value is placed in the primary position by the need to "maintain and develop Eastwoodhill as an Arboretum", reinforcing the need for a biological evaluation. Recreation is clearly in the secondary position, which is in keeping with the typical balance of values for botanic gardens and arboreta.

The goals of an enterprise should also indicate factors to be measured in an evaluation. Different approaches to collection development were frequently discussed by the Trust Board, but they did not develop a consensus on future characteristics of the collection and long range goals were not defined. Indeed, the Board was urged to clarify its objectives regarding the collection and select a theme to concentrate upon (Advisory, 1983; Chavasse, 1978; Greenwood, 1976; Jew, 1972; Taylor, 1980). As the Trust Board has yet to reach a consensus on this issue, all proposed collection developments should be considered. These were:

(i) Northern hemisphere trees and shrubs. (Advisory, 2.11.79; Greenwood, 1976; Sykes, 1964; Williams, 1987).

(ii) Focus on certain genera, including *Abies, Acer, Aesculus, Alnus, Betula, Cedrus, Cupressus, Eucalyptus, Fagus, Fraxinus, Ilex, Magnolia, Malus, Nothofagus, Picea, Pinus, Platanus, Podocarpus, Populus, Prunus, Quercus, Sorbus, Tilia, Ulmus,* (Chavasse, 1976; Jackson, 1964; Skipworth, 1976; Sykes, 1972). *Acer, Aesculus, Betula, Buddleia, Euonymus, Fagus, Fraxinus, Juniperus, Larix, Nothofagus*, were noted as doing well (Cook, 1949, p 191). *Quercus, Rhododendron, Azalea, Camellia* (Cook, undated d).

(iii) Geographical planting patterns, including Chilean, Asiatic, North American and South American (Advisory, 1978; Advisory, 1980; Chavasse, 1976, 1976a).

(iv) Geographic and/or generic plantings (Williams, 1987, p 51).

(v) Plants climatically suited to the region (Greenwood, 1976).

(vi) Rare and endangered plant material (Williams, 1987). Rare conifers and American species, (Berry, 1978).

(vii) A native forest area (Chavasse, 1976).

(viii) Overseas species of genera indigenous to New Zealand (Greenwood, 1976).

(ix) Nut tree species and clones (Chavasse, 1976; Greenwood, 1976).

The Trust Board adopted a geographic approach twice (Board minutes, 9.2.78; Williams, 1987) and a limited geographic approach once (Board minutes 12.12.78). It adopted the notion of generic planting twice (Board minutes, 12.12.78; Williams, 1987), but rejected the same idea at another time (Advisory, 1985). It rejected the notion of organised plantings (Advisory, 1985; Board minutes 12.12.78; Board minutes 6.11.79) and supported the idea of mixed plantings with no particular theme (Advisory, 1985; Board minutes 12.12.78; Board minutes, 6.11.79; Board minutes

20.9.86). The Board accepted a rare conifer collection, rare Asian and American collections, and rejected the native area, the eucalyptus collection and the Chilean collection (Berry, 1978).

Without the knowledge that might have been provided by an evaluation, the Board had no yardstick to examine the proposals for collection development. They could not substantiate or defend any particular goals for collection development, or determine the impact of any proposal on the future of the collection. Development of strategies to implement any particular collection theme was also inhibited by lack of data. Generic and geographic themes were proposed in the 1987 management plan (Williams, 1987), but no evidence was provided to support their feasibility. None of the other themes suggested above were examined, so none could be supported or refuted on rational grounds. Both Jew (1972) and Weston (1971) recognised the potential of the collection, but stressed that the potential would not be understood or realised without thorough analysis.

Although the Board could not resolve the development issues without more data, the debate indicated factors that should be examined in an evaluation. Clearly issues relating to geographic, generic, and rarity patterns should be examined. This is compatible with the major indices of biological value discussed in section 3.1.5, i.e. diversity and rarity. Biological significance of the collection was determined with the following attributes:

(i) Diversity. An examination of the diversity within the collection.
- Size and distribution of genera within the Arboretum.
- Geographic origin of the plant material within the collection.
- Distribution of evergreen plants within the Arboretum.

(ii) Rarity. An examination of the rarity of species and cultivars in the collection.
- Comparison with other collections.
- Presence of any internationally rare or endangered species.
- Availability of species and cultivars in commercial trade.

Condition of the collection was determined using two attributes:

(iii) Condition of the collection
- Average age in each park
- Density and overcrowding

(iv) Change in the collection over time

A number of investigations were conducted to measure the attributes described above.

3.2.2 Measuring significance of the collection: diversity

The range and representation of genera within the collection was the first measure of diversity; species and cultivars in each genus were counted and ranked for number in the collection. Distribution of major genera in the collection was determined by plotting the position of each member of the genus onto an A5 map of the Arboretum (approximate scale 1:5500). The resulting map illustrated any existing pattern for that genus.

Plants were then categorised according to their geographical origin using the broad regions of Asia, Europe, North America, Mexico, South America, Australia, New Zealand and South Africa. Asia and Europe were separated at Pakistan. Outlying islands were categorised with the nearest continent. A separate category was used for plants that had no wild origin and were developed in the horticultural industry, e.g. by nurseries or arboreta.

Finally, distribution of evergreen plants was plotted onto an A3 Arboretum map (scale approximately 1: 2800).

3.2.3 Measuring significance of the collection: rarity

3.2.3.1 Comparison with other collections

The inventory showed an extensive collection, and various experts had proposed that the collection was the best of its kind in New Zealand (Goodwin, 1964; Jackson, 1964; Sykes, 1964; Sykes, 1972; Yeates, 1964). To substantiate this view Eastwoodhill was compared with other woody plant collections. In 1990 a survey was made of 35 other plant collections owned by New Zealand members of the International Dendrology Society, who are known collectors of rare and interesting plant material in New Zealand. The survey targeted 17 major genera as the task of surveying each collection for every genus at Eastwoodhill was too large.

A survey was needed as only three of the 35 collections had catalogues and it was not possible to simply cross-check inventory lists. A survey form was created for each genus in the survey by listing the species and cultivars at Eastwoodhill. Participants were asked to 'tick the box' to indicate that they had the species in their collection, and then add age and source of their material (if known). They were also asked to list any additional members of the genus that they had in their collections, but which were not on the Eastwoodhill list. The returned survey forms were used to create a master-list which showed which collections held each species.

3.2.3.2 Rare and endangered species

The number of rare and endangered species present at Eastwoodhill was determined by consulting the list of threatened temperate trees (Lear, 1990, 1994) and the IUCN threatened plant lists (IUCN and BGCI, 1989; IUCN BGCI and Nanjing Botanic Garden, 1990; Threatened Plants Committee 1980, 1986; Threatened Plants Unit 1983, 1984). A list was made of the relevant species.

3.2.3.3 Availability in trade

The value of the Eastwoodhill collection would be greater if any significant portion of the species or cultivars were not available from commercial sources. A survey of commercial plant producers was conducted to determine the number of species and cultivars in the collection that were available in commercial trade. In 1992 one hundred and twenty nurseries growing exotic, northern hemisphere, woody genera were selected from the New Zealand Nursery Register (New Zealand Nurserymens Association, 1991) and a catalogue was requested. Seventy four replies were received. Information in the catalogues was combined to produce a master-file which recorded the number of suppliers for each species and cultivar at Eastwoodhill.

3.2.4 Measuring condition of the collection

Average age of trees in each park within the Arboretum was used to indicate the condition of those parks (Moll, 1988). Older trees will be further through their life cycle, and more likely to need replacement than younger trees. Stem density in each park would indicate the degree of crowding in that park. Overcrowding has resulted in poor condition of some trees in the Arboretum due to damage and poor structural formation.

Condition can also be measured by examining changes over time in the collection, therefore comparisons were made between the 'total' collection and the 'current' collections. Genera in the 'total' and 'current' collections were ranked for number of species and cultivars, then the decline of each genus was calculated by expressing 'current' number as a percentage of 'total' number.

3.2.5 Processing

The results of each investigation were ranked to show the most significant genera in each case. An overall ranking of genera for significance was developed. In the processing step the measurement results were analysed against the mission and goals of the Arboretum and some priorities proposed.

3.3 RESULTS AND DISCUSSION PART ONE: SIGNIFICANCE

3.3.1 Diversity

3.3.1.1 Composition

The current collection contained 1666 species and 962 cultivars from 410 genera. Included in the species category were species, botanical varieties of species, and hybrids given species status. Included in the cultivar category were cultivars and hybrids given cultivar status. *Rhododendron* and *Camellia* had the largest number of species and cultivars in the current collection, followed by *Acer, Prunus* and *Quercus* (Table 3.1). Only 47 genera were represented by more than 10 species and cultivars, but these (1804 species and cultivars) accounted for 69% of the species and cultivars in the current collection.

Superficially the total collection appeared to have a similar pattern with the same genera occupying the first five places as in the current collection (Table 3.2). There were 87 genera in the total collection represented by more than 10 species and cultivars, which accounted for 67% of species and cultivars in the total collection.

At a more detailed level it is clear that there has been considerable change between the total and current collections. About half the genera in the total collection have lost between 50% and 94% of their species and cultivars, resulting in a major change in the composition of the collection. This issue is considered in detail in section 3.4.2 where changes between the total and current collections are related to condition of the collection.

3.3.1.2 Distribution of major genera within the Arboretum

Appendix 4 contains distribution maps for each major genus in the collection. Some broad patterns are evident. Some genera are concentrated in particular parks (Table 3.3), providing the raw material for a generic layout, but it needs reinforcing and a long term plan developed to ensure its continuity. For example, current plantings of *Tilia* could be developed into a generic layout, with few replacement problems in the medium term because the trees are long lived. Distributions of other genera, such as *Sorbus* and *Crataegus*, could also be developed into a generic layout, but they have immediate renewal problems. Development of a generic layout for those collections requires a major renewal strategy for the existing material as well as any additional plantings.

The distribution patterns also illustrated that some species were regularly repeated throughout the Arboretum and clearly have a structural role as background plantings, e.g. *Quercus robur, Q.rubra, Q.palustris, Prunus serrulata, Fraxinus excelsior, F.* 'Raywoodii', and *Cedrus atlantica f. glauca.*

Table 3.1 Ranking of genera for number of species and cultivars in the 'current' collection

GENUS	No. of species and cultivars in the current collection	GENUS	No. of species and cultivars in the current collection
Rhododendron	244	*Lonicera*	15
Camellia *	204	*Philadelphus*	15
Acer *	133	*Cotoneaster*	14
Prunus *	106	*Gleditsia*	13
Quercus *	101	*Salix*	13
Pinus *	83	*Cryptomeria*	12
Malus *	62	*Thuja*	12
Magnolia *	60	*Eucalyptus*	12
Sorbus	49	*Platanus*	11
Syringa	45	*Podocarpus*	11
Chamaecyparis	39	*Nothofagus*	11
Betula *	36	*Spiraea*	10
Crataegus *	35	*Photinia*	10
Abies	34	*Cedrus*	10
Juniperus *	32	*Carpinus*	10
Fraxinus *	31		
Populus *	28		
Alnus *	26		
Picea	26		
Clematis	26		
Ilex *	23		
Viburnum	22		
Aesculus *	20		
Buddleia	20		
Euonymus	19		
Berberis	19		
Ulmus	18		
Cupressus *	18		
Cornus	17		
Fagus *	17		
Tilia *	16		
Acacia	16		

This table includes the 47 genera represented by 10 or more species and cultivars.
* Genera subsequently selected as key genera

Table 3.2 Ranking of genera for number of species and cultivars in the 'total' collection

GENUS	No. of species and cultivars in the total collection	% lost between total and current collections	*GENUS*	No. of species and cultivars in the total collection	% lost between total and current collections
Rhododendron	710	66	*Thuja*	22	45
Azalea	386	unknown	*Daphne*	22	59
Camellia *	353	42	*Ulmus*	22	18
Acer *	182	66	*Pittosporum*	18	50
Prunus *	174	39	*Cryptomeria*	17	29
Quercus *	122	17	*Rosa*	17	88
Syringa	108	58	*Protea*	17	94
Pinus *	93	10	*Escallonia*	16	68
Magnolia *	92	34	*Jasminium*	16	56
Malus *	89	30	*Cedrus* *	15	33
Clematis	88	70	*Spiraea*	15	33
Chamaecyparis	88	55	*Grevillea*	15	53
Sorbus	74	33	*Podocarpus*	15	26
Erica	69	89	*Abutilon*	15	86
Betula *	54	33	*Gleditsia*	14	07
Juniperus *	51	37	*Nothofagus*	14	21
Berberis	51	62	*Weigelia*	14	57
Hydrangea	51	82	*Vaccinium*	14	92
Crataegus *	48	27	*Larix*	13	76
Viburnum	48	54	*Ligustrum*	13	30
Abies	47	27	*Photinia*	13	23
Populus *	47	40	*Nerium*	13	61
Philadelphus	46	67	*Genista*	13	84
Salix	46	71	*Juglans*	12	25
Cotoneaster	45	69	*Melaleuca*	12	41
Buddleia	41	51	*Taxus*	12	25
Cytisus	39	94	*Banksia*	12	75
Picea	39	33	*Hypericum*	12	66
Euonymus	38	50	*Citrus*	12	75
Ilex *	38	39	*Callistemon*	11	18
Fraxinus *	37	16	*Carpinus*	11	09
Aesculus *	32	37	*Gaultheria*	11	90
Acacia	31	48	*Tsuga*	11	54
Cornus	29	41	*Sophora*	11	36
Ceanothus	29	86	*Platanus*	11	0
Alnus *	28	07	*Pieris*	11	81
Lonicera	28	46	*Ribes*	11	63
Chaenomeles	27	88	*Vitis*	10	40
Cistus	26	84	*Mahonia*	10	50
Eucalyptus	24	50	*Rhus*	10	40
Fagus *	24	29	*Styrax*	10	60
Deutzia	24	79	*Hamamelis*	10	60
Tilia *	23	30	*Hebe*	10	70
Cupressus *	23	22			

This table contains the 87 genera represented by 10 or more species and cultivars.
* Genera subsequently selected as key genera

Table 3.3 Location of major genera within the Arboretum

GENUS	LOCATIONS
Abies	Orchard Hill, the main walk in Douglas Park, occasional individual plants.
Acer	Throughout the Arboretum, concentrated in Pear Park, Circus and IDS Ridge.
Aesculus	Circus, but this grouping does not contain all the major species.
Alnus	Glen Douglas, Circus.
Berberis	Orchard Hill, scattered individuals elsewhere.
Betula	Throughout the Arboretum, Circus.
Camellia	Gardens, Cabin Park.
Carpinus	Glen Douglas.
Cedrus	Throughout the Arboretum.
Crataegus	Pear Park, Orchard Hill.
Cupressus	Corner Park and The Gardens. Occasional specimens elsewhere.
Fagus	No particular concentrations except for the Beech Wood which is one species.
Fraxinus	Pear Park. F.excelsior and F. 'Raywoodii' frequent as background planting.
Gleditsia	Circus.
Ilex	Orchard Hill, some others elsewhere.
Juniperus	Pear Park, some others elsewhere.
Magnolia	No particular pattern. Greatest numbers in the Gardens and Cabin Park.
Malus	Throughout the Arboretum. Concentrations in Pear Park, Cabin Park, Orchard Hill, Douglas Park.
Picea	Orchard Hill, main path in Douglas Park.
Pinus	Orchard Hill, single species planting in Black Forest.
Platanus	Pear Park.
Populus	No particular pattern, scattered specimens throughout the Arboretum.
Prunus	Widespread and scattered, one concentration on Orchard Hill. More specimens in the central part of the Arboretum.
Quercus	Throughout the Arboretum, but when Q.palustris, Q.robur and Q.rubra are removed three concentrations are apparent in Pear Park, Douglas Park, and Glen Douglas.
Sorbus	Glen Douglas, scattered specimens elsewhere.
Syringa	Upper Douglas Park.
Tilia	Pear Park, Circus.

The pattern for the parks showed that some parks had more notable collections than others (Table 3.4). Pear Park had the greatest number of genera concentrations, followed by Orchard Hill, the Circus, Douglas Park and Glen Douglas. Conversely, Corner Park, the Gardens and Cabin Park were comprised of mostly mixed plantings, with no particular genera predominating. These results have clear implications for the preservation, future development and composition of each park as some clearly contained more of the 'fabric' of the collection than others. This suggests that a higher priority should be given to Pear Park, Orchard Hill and the Circus over the other parks.

Table 3.4 Distribution of major genera in each park

PARK	GENERA
Pear Park	*Acer, Crataegus, Fraxinus, Juniperus, Malus, Platanus, Quercus, Tilia*
Corner Park	*Cupressus*
Circus	*Acer, Aesculus, Alnus, Betula, Gleditsia, Tilia*
Gardens	*Camellia, Magnolia,*
Cabin Park	*Camellia, Magnolia, Malus*
Orchard Hill	*Abies, Berberis, Crataegus, Ilex, Malus, Picea, Pinus*
Douglas Park	*Abies, Malus, Picea, Quercus, Syringa*
Glen Douglas	*Alnus, Carpinus, Quercus, Sorbus*

3.3.1.3 Geographic origin of plant material in the collection

Seventy three percent of species and cultivars in the current collection originated in the northern hemisphere, 10% from the southern hemisphere and 15% were of horticultural origin (Figures 3.1 and 3.2, Table 3.5). (The final 2% were not assigned as these were plants listed by Douglas Cook, but which had unconfirmed names).

The largest geographical origin of plants in the collection was Asia, which accounted for 41% of the current collection, then Europe (15%), and North America (14%). The remaining 12.5% covered all other regions of origin. Plants of horticultural origin accounted for 15%. The total collection had a similar distribution with 62.5% from the northern hemisphere, 11.5% from the southern hemisphere and 22% from horticultural origin. Asia was the largest geographical source for the total collection (37%), followed by horticultural (22%), Europe (13%), and North America (11%).

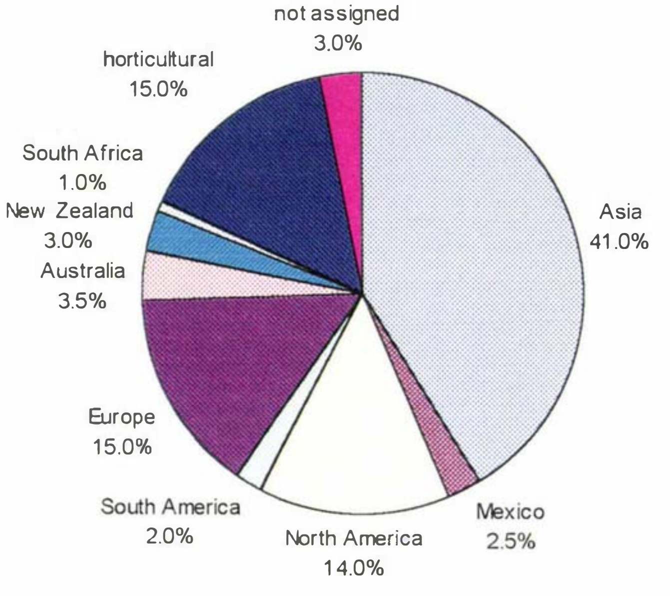


Figure 3.1 Pie diagram of the geographic origin of the current collection.

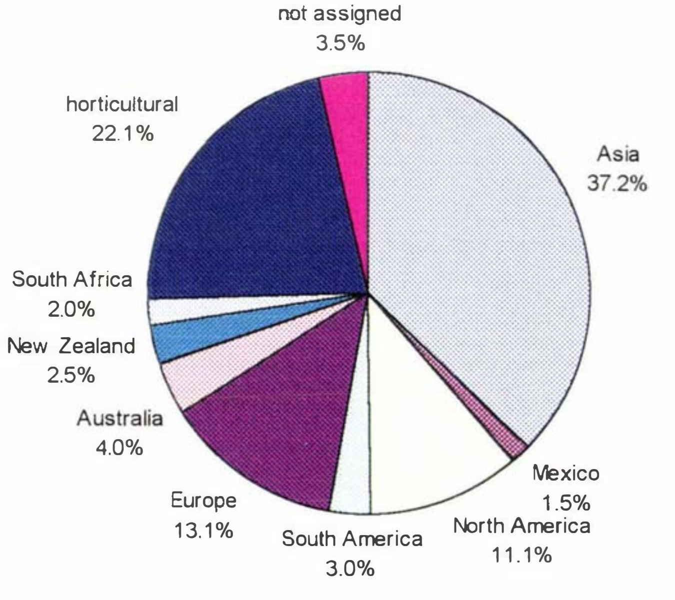


Figure 3.2 Pie diagram of the geographic origin of the total collection

Table 3.5 Geographic origin of the species and cultivars in the Eastwoodhill Collection.

REGION	CURRENT COLLECTION	PREVIOUS COLLECTION	TOTAL COLLECTION
	Number of species and cultivars	Number of species and cultivars	Number of species and cultivars
Asia	1084 (42Rh)	990 (182Rh)	2074 (224Rh)
Europe	390 (3Rh)	352 (5Rh)	742
North America	361 (4Rh)	254 (1[illegible]Rh)	615
Mexico	64	21	85
Northern hem.	**1899**	**1617**	**3516**
South America	59	117	176
Australia	93	144	237
New Zealand	89	50	139
South Africa	26	95	121
Southern hem.	**267**	**406**	**673**
Horticultural	388 (188Rh)	856 (645Rh)	1244 (833Rh)
Not assigned	74	140	214
Other	**462**	**996**	**1458**
GRAND TOTAL	**2628**	**3019**	**5647**

Notes.
1. There were 208 plants that were not assigned to a geographical group.
2. 'Rh' indicates the number of Rhododendron that are included in the numbers.

A number of observations can be made about the differences in geographic origin of the species and cultivars in the total and current collections. The approximately 10% difference in the two patterns is almost solely attributable to *Rhododendron* hybrids. (Current collection 72% northern hemisphere, total collection 63% northern hemisphere; this difference was due to the large number of *Rhododendron* hybrids in the horticultural category in the total collection). The biggest loss was from the horticultural category, mostly caused by the loss of *Rhododendron* hybrids. This rate of loss illustrated what Douglas Cook ultimately realised, that *Rhododendron* was not suited to the climate of the East Coast (Cook, 1950b, undated b) nor the sparse management regime at Eastwoodhill. The next largest loss was from the Asian origin group, but although the loss in numbers was large, in percentage terms it was in proportion to the other losses and hence it remained the largest group. Finally, the decline of material from Australia and South America was interesting. These land masses were the closest Gondwana neighbours to New Zealand, yet the material from these regions seems to have done poorly.

The comparison between the geographical sources of the total and current collections did not raise any serious issues about composition of the collection as the pattern has remained similar over time. The result, however, provides important background data for future development of the collection. The large portion of Asian material coupled with the predominance of northern hemisphere material suggests that objectives for collection development should reflect this pattern. Collections from other geographic regions should probably be secondary objectives. Lists of plants that were previously in the collection could provide a basis for planning any future collection representing each region.

3.3.1.4 Deciduous versus evergreen

The distribution of evergreen species within the collection is shown in Figures 3.3-3.5. Douglas Cook's planting of conifers on ridge-tops for windbreaks is quite apparent, as are his conifer plantings through the Black Forest and on Orchard Hill, otherwise the planting of evergreen material seems quite random. The distribution of evergreen material can readily be seen in the mid winter photographs (Figures 3.3, 3.4). The absence of any particular pattern, (apart from the conifers on ridge-tops), has few implications for the future of the collection, although the visual effect created by the conifer plantings will be important for any new landscape development outside the current Arboretum area.

Figure 3.3 Mid winter photograph, June 1989.

Figure 3.4 Mid winter photograph, September 1989.

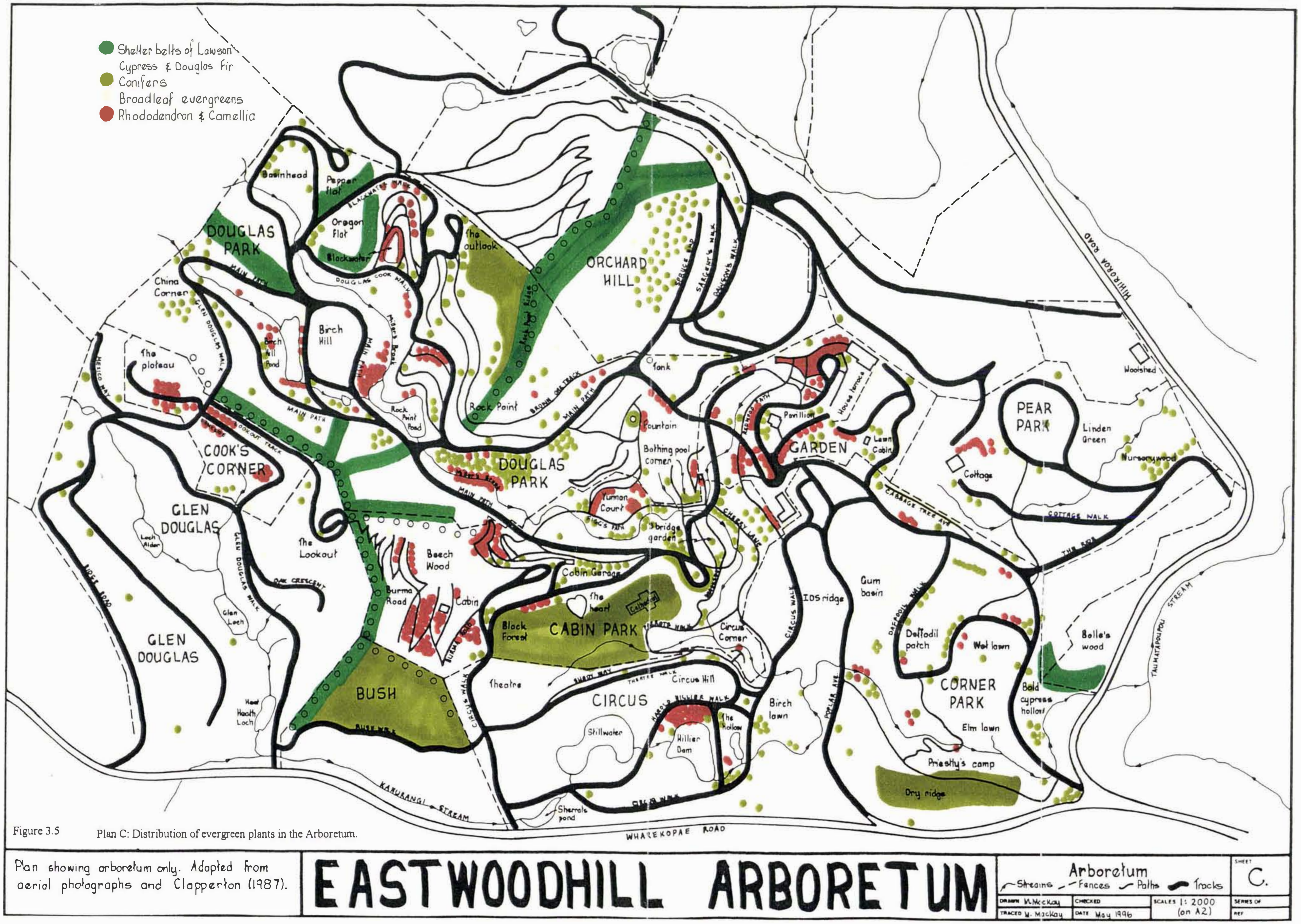


Figure 3.5 Plan C: Distribution of evergreen plants in the Arboretum.

3.3.2 Rarity

3.3.2.1 Comparison with other collections

When compared to other collections of exotic trees and shrubs it was apparent that Eastwoodhill was highly significant (Table 3.6). The full survey data was too lengthy to be included in this thesis but can be found in MacKay (1990a).

Of the seventeen genera surveyed Eastwoodhill had the largest collection for *Acer, Aesculus, Alnus, Betula, Fagus, Fraxinus, Ilex, Magnolia, Malus, Prunus,* and *Tilia*. Eastwoodhill did not have the largest collection for either *Quercus* or *Pyrus*, taking second place to Hackfalls Arboretum. Eastwoodhill was important for the coniferous genera investigated but it did not take top rank for any genus because there were a number of notable conifer collections in New Zealand which were more extensive than Eastwoodhill. For *Abies, Picea,* and *Pinus,* Eastwoodhill was third. Eastwoodhill did not meet the 30% threshold for *Juniperus*, due to the large number of cultivars of that genus held in two other collections. Eastwoodhill's collection of this genus focuses on species, when the cultivars of *J.chinensis, J.communis, J.horizontalis, J x media, J.sabina, J.scopularum, J.squamata* and *J.virginiana* were removed from consideration then Eastwoodhill took second place.

The overall results showed the significance of different genera. First, if Eastwoodhill contained 100% of the members of a genus that were present in New Zealand (as found in the survey) then Eastwoodhill's collection would be significant. The higher the percentage the more significant the genus, thus the most significant genera were *Alnus* (87%), *Acer* (85%), *Fagus* (81%), *Tilia* (80%), *Malus* (91%), *Fraxinus* (76%), *Aesculus* (76%), and *Betula* (70%). Second, species which are present in three or less collections are considered to be at risk (Lowe, 1988); the higher the percentage in three or less collections the greater the risk. The genera at risk were *Malus* (91%), *Juniperus* (87%), *Pyrus* (85%), *Fraxinus* (81%), *Tilia* (80%), and *Ilex* (75%). Eastwoodhill had the largest collection for four of these six genera. Conversely the most secure genera were *Pinus* (42%), *Abies* (44%), *Fagus* (45%), *Alnus* (50%), *Betula* (52%), and *Picea* (53%). Eastwoodhill had the largest collection for the two broadleaf genera, but was ranked fourth for each coniferous group.

In a separate but related study a wider range of collections and genera were surveyed (MacKay, 1993). This emphasised the relative risk of *Malus, Pyrus, Ilex,* and *Tilia*. *Fraxinus* appeared to be more secure, but when common cultivars were removed the species were still at risk. *Juniperus* was more frequent than the first survey had suggested. The extra genera considered in the second survey revealed that *Crataegus, Euonymus, Sorbus* and *Carpinus* were also at risk due to low frequency in collections. For each of these genera the largest collection was at Eastwoodhill.

Table 3.6 Summary of a survey done to compare Eastwoodhill with collections belonging to International Dendrology Society members in New Zealand.

GENUS	Number of species and cultivars found in the collections survey [z]	Number of species and cultivars of that genus at Eastwoodhill	Number at Eastwoodhill as a percentage of Number in the survey [y]	Number of species and cultivars in the survey found in three or less collections [x]		Sites with the largest collection of each genus [w]
	S+C=N	Number	Percentage	Number	Percentage	Collection code
Abies	59+06=65	35	53%	29	44%	55 65 47 E
Acer	90+63=153	131	85%	81	54%	E (06 22)
Aesculus	16+10=26	20	76%	15	60%	E (104)
Alnus	26+06=32	28	87%	16	50%	E 06
Betula	43+08=51	36	70%	27	52%	E (104 22)
Fagus	07+15=22	18	81%	10	45%	E 104 22 (19)
Fraxinus	35+08=43	33	76%	35	81%	E (06 101)
Ilex	27+21=48	24	50%	36	75%	E (22 06)
Juniperus	41+102=143	32	22%	125	87%	47 55
Magnolia	44+87=131	63	48%	80	61%	(E 22 104 52
Malus	34+40=74	58	78%	68	91%	E
Picea	41+24=65	27	41%	35	53%	55 47 (65 E 22)
Pinus	124+07=134	83	61%	57	42%	65 47 55 E 22
Prunus	51+79=130	61	42%	91	70%	(E)
Pyrus	13+01=14	6	42%	12	85%	06 E
Quercus	153+20=173	98	56%	129	74%	06 E
Tilia	19+02=21	17	80%	17	80%	E (19)

z. S + C=N. This notation indicates that the number of species and cultivars found in the survey (N), is made up of a number of species (S) plus a number of cultivars (C).

y. This shows the number of species and cultivars at Eastwoodhill as a percentage of the number of species and cultivars found in the survey. This gives and indication of the extent to which the Eastwoodhill collection represents that genus in New Zealand. The larger the percentage the more representative the collection at Eastwoodhill.

x. Number in three or less collections. This gives an indication of the scarcity of the genus as a whole. The higher the percentage that is found in three or less collections, the more at risk the genus is in New Zealand.

w. Sites with the largest collection of each genus found in the survey. 'E' is the code for Eastwoodhill. The numbers are codes for other plant collections in New Zealand. Collections are listed in descending order, the site with the largest collection of the genus is listed first. The collections listed have more than 50% of the species and cultivars of the genus, as found in the survey. Those in brackets hold 30-49% of the species and cultivars of the genus, as found in the survey.

The data in this table were taken from MacKay (1990a).

The second study also supported the security of *Abies*, *Pinus*, and *Picea*. *Podocarpus*, *Cedrus*, *Viburnum*, *Magnolia* and *Cupressus* were also relatively secure with less than 40% found in three or less collections.

The second survey also showed different collection rankings for some genera. Eastwoodhill still had the largest collection for *Acer*, *Aesculus*, *Fagus*, *Fraxinus*, *Ilex*, *Malus*, *Prunus*, and *Tilia*. It retained its position for *Abies*, *Juniperus*, *Picea*, *Pinus*, and *Quercus*, but dropped to second place for *Alnus* and *Betula*, to third place for *Pyrus*, and fifth for *Magnolia*. Eastwoodhill remained the most significant plant collection in the survey, but the changes in individual genera illustrate the rate at which new collections are developing. The changes for *Alnus* and *Betula* occurred in the four years since the first survey. Similarly two of the *Magnolia* collections which now outrank Eastwoodhill are relatively recent developments (but were not included in the first survey).

The results on frequency in other collections were useful, but they must be interpreted with some care. The presence of common cultivars in many collections can make a genus appear more abundant, but if those cultivars are removed the species may still be at risk. *Fraxinus* and *Juniperus* were in this category. Furthermore, the conclusions were based on data from those collection holders who were able to respond to the survey. Potentially important collections of some genera, e.g. *Magnolia* and *Ilex*, were not included because the owners were unable to reply to the survey. These problems could be minimised if additional data were obtained.

3.3.2.2 Rare and endangered species

There were 102 species at Eastwoodhill, or 3.9% of the collection (Table 3.7), that were internationally listed as rare or endangered. For some species data was available on degree of threat and frequency of plants in collections (Lear, 1990). *Pinus* accounted for the greatest number of rare or threatened species at Eastwoodhill, followed by *Picea*, *Abies*, *Cupressus* and *Juniperus* (Table 3.8). The broadleaf genera with the greatest number of rare and endangered species were *Magnolia* and *Quercus* with four species each.

The limited number of internationally rare and endangered species within the Eastwoodhill collection shows that this is not an important collection attribute, although it could be considered as a future collection theme. While the Arboretum could be a repository for other endangered species, there is presently no sound basis to claim significance in this area. This is in direct contrast to the importance of the collection in a national context.

Table 3.7 List of rare and threatened species at Eastwoodhill [z].

SPECIES	IUCN categories for degree of threat [y].		IDS category for frequency in collections [x].
	Regional	World	
Abies cephalonica	?		
Abies fraseri	I	I	
Abies georgii	V	V	W
Abies kawakamii		R	
Abies koreana	R	V	W
Abies nebrodensis	E	E	C
Abies numidica	V	V	C
Abies pinsapo	R	V	W
Acer miyabei		?	
Araucaria araucana	V	V	W
Araucaria cunninghamii	K	?	
Araucaria heterophylla	V	V	D
Arbutus canariensis		V	
Austrocedrus chilensis	V		
Betula medwedewii		?	C
Betula raddeana		R	D
Calocedrus formosana	R	E	D
Calocedrus macrolepis	V	?	
Camellia chrysantha	R	R	D
Camellia granthamiana		E	D
Carpenteria californica		I	
Cedrus deodara	?	R	
Cedrus libani var. brevifolia	R	R	C
Cephalotaxus drupaceae	?	?	
Cephalotaxus fortunei	?	?	
Chamaecyparis funebris	?	?	
Corylus chinensis		V	
Corylus colurna		?	
Cunninghamia konishii		V	W?
Cunninghamia lanceolata	?	?	
Cupressus cashmeriana	?	?	
Cupressus chengiana	V	V	
Cupressus goveniana	I	R	C
Cupressus guadalupensis var forbesii		V	
Cupressus sempervirens	I	I	
Cupressus macrocarpa	R	R	
Davidia involucrata ssp. involucrata	R	R	W
Emmenopterys henryi	R	R	
Eucommia ulmoides	R	R	W

.....continued

SPECIES	IUCN categories for degree of threat [y].		IDS category for frequency in collections [x].
	Regional	World	
Eucryphia moorei	V		C
Fraxinus mandshurica	V	V	
Ginkgo biloba	V	R	W
Glyptostrobus pensilis	R	V	
Ilex perado var. platyphylla	V	V	
Illicium parviflorum		I	
Jasminium azoricum	V	V	
Juglans hindsii		I	D
Juniperus cedrus	E	V	D
Juniperus drupaceae			
Juniperus excelsa	I		
Juniperus oxycedrus		?	
Juniperus phoenica		?	
Juniperus rigida	I	?	
Keteleeria davidiana		R	
Kolkwitzia amabilis	R	R	
Lyonothamnus floribundas floribundas	I	D	
Magnolia cylindrica	V	V	W
Magnolia officinalis var. biloba	V	V	W
Magnolia sieboldii	?		
Magnolia wilsonii		V	
Malus florentina	R	D	
Malus sikkimensis	R	R	
Malus trilobata		R	
Manglietia insignis	V	I	C
Metasequoia glyptostroboides	R	E	W
Nothofagus moorei		?	
Paulownia kawakamii		?	
Philadelphus coronarius			
Picea brachytyla	V	V	
Picea koyamae	R	R	C
Picea mexicana	R	R	D
Picea obovata	V	V	D
Picea omorika	V	V	D
Picea smithiana ssp. smithiana	R	?	
Picea spinulosa	?	R	
Pinus armandii ssp. armandii	?	?	
Pinus canariensis		R	
Pinus coulteri	R	R	
Pinus culminicola	R	E	
Pinus gregii	R	R	

......continued

SPECIES	IUCN categories for degree of threat[y].		IDS category for frequency in collections[x].
	Regional	World	
Pinus johannis	?	R	
Pinus koraiensis	?	?	
Pinus massoniana	?	?	
Pinus maximartinezii	E	E	D
Pinus morrisonicola		R	
Pinus nelsoni	R	R	
Pinus oaxacana		V	D
Pinus rigida		?	
Pinus sylvestris var. mongolica	V	V	
Pinus torreyana	I	V	
Podocarpus andinus	R	R	
Podocarpus saligna	V	V	
Pseudolarix amabilis		R	
Quercus affinis		R	
Quercus ellipsoidalis		I	
Quercus fulva		V	
Quercus pontica		R	
Rhododendron elliotii		I	
Salix magnifica	V	V	
Sinojackia xylocarpa	E	E	D
Stuartia sinensis		V	W
Taiwania cryptomerioides	I	R	W?
Taxus chinensis	?	?	
Taxus cuspidata	I	?	
Thuja koraiensis	V	R	
Tsuga dumosa	?	?	
Zelkova cretica		V	D

z. The table is not complete because there was no data for some plants for some categories.

y. IUCN ratings. Ex = Extinct; E = Endangered; V = Vulnerable; R = Rare; I =Indeterminate, belongs to E, V, or R but not enough data to say which; K = no data; ? = probably belongs to E,V,or R but not enough data to say.

x. IDS ratings. A = Absent from any collections; B = Borderline, in 0-11 collections worldwide; C = confined, occurs in 11-50 collections worldwide; D = one of the former, but not enough data to say; W = widespread, in 50 or more collections worldwide

Table 3.8 Number of rare and threatened species occurring in genera at Eastwoodhill.

GENUS	Number of species at Eastwoodhill	Number of rare or threatened species at Eastwoodhill
Pinus	60	15
Abies	33	08
Picea	24	07
Cupressus	12	06
Juniperus	22	06
Quercus	101	04
Magnolia	33	04
Araucaria	03	03
Calocedrus	03	03
Malus	35	03
Betula	37	02
Camellia	19	02
Cedrus	04	02
Podocarpus	09	02
Cephalotaxus	03	02
Cunninghamia	02	02
Taxus	03	02
Corylus	07	02
Acer	133	01
Arbutus	03	01
Fraxinus	27	01
Ilex	16	01
Carpenteria	01	01
Chamaecyparis	07	01
Davidia	01	01
Emmenopterys	01	01
Eucommia	01	01
Eucryphia	05	01
Ginkgo	01	01
Jasminium	06	01
Juglans	07	01
Keteleeria	01	01
Kolkwitzia	01	01
Lyonothamnus	01	01
Manglietia	01	01
Metasequoia	01	01
Nothofagus	11	01
Paulownia	03	01
Philadelphus	08	01
Pseudolarix	01	01
Rhododendron	244	01
Salix	11	01
Sinojackia	02	01
Stuartia	07	01
Taiwania	01	01
Thuja	03	01
Tsuga	04	01
Zelkova	03	01

No rare or threatened species in key genera *Aesculus, Alnus, Crataegus, Fagus, Populus, Prunus, Pyrus,* or *Tilia*.

3.3.2.3 Availability of species and cultivars in the Eastwoodhill collection in commercial nurseries in New Zealand.

The availability of species and cultivars at Eastwoodhill from commercial sources showed that 50% of the collection was not available from commercial sources in New Zealand and that only 7% of the collection was commonly available in trade (Table 3.9).

Table 3.9 Percentage of the current Eastwoodhill collection available in commercial trade in New Zealand.

Number of commercial sources	Species and cultivars in the current collection	
	Number	Percentage
0	1087	50
1-3	650	30
4-10	287	13
11+	143	7

Does not include *Camellia* or *Rhododendron*.

Managers of the British Plant Collection Scheme proposed that species or cultivars with three or less commercial sources were at risk because they were not widely distributed (Lowe, 1988). At Eastwoodhill 80% of species and cultivars were in this category, and by this criterion were at risk. Of the three sources Lowe (1988) suggested that one will have lost the plant, one will not have any plants left, and the third hoped to have the plant but did not. Plants with 3-10 commercial sources were currently safe but needed watching. Only plants with more than ten or more commercial sources were considered commonplace and not in danger; only 7% of the collection at Eastwoodhill was in this category.

These data showed that the Eastwoodhill collection was highly significant because 93% of the species and cultivars had ten or less commercial sources. The result must be considered, however, against some of the features of the investigation. The results were based upon a survey of woody plant growers, 73 of a possible 120 selected from the nursery register. It is likely that additional sources will be found if more nurseries were surveyed. (The British have a much more complete data set as their Plantfinder is a comprehensive listing of commercial sources (Lord, 1991).) New Zealand does not have such a record of commercial suppliers and the patterns that such data might reveal remain to be seen.

Lowe (1988) supported the notion of availability in trade as a measure of significance but suggested that the measurement had two important flaws. First, plants that were difficult to cultivate were not produced because they did not generate a good commercial return and therefore were limited in commercial supply. Second, plants that were not well known to the ordinary gardener had a lower level of demand, and therefore supply in commercial trade. Both of these features will probably apply to the pattern of commercial plant supply in New Zealand, therefore the 'availability in trade' measure should only be used as one of a suite of indicators of significance.

Even though 'availability in trade' may have some weaknesses, there are some interesting patterns. The data has been summarised in major genera groups, showing the number of sources for each genus, plus the number of species and cultivars in the current collection (Table 3.10). For comparison, the number of other species and cultivars of each genus found in the survey were also shown. For example, the fact that 74% of *Crataegus* at Eastwoodhill had no known commercial source would be of less importance if the Eastwoodhill collection was only a fraction of that present in New Zealand. However, the result showed there were few other members of that genus elsewhere and the Eastwoodhill collection represented 89% of the range found in the survey. This situation, combined with the lack of commercial supply, showed that the Eastwoodhill collection was more important than the preceding analysis might have indicated.

In contrast, 56% and 50% of *Abies* and *Picea* respectively at Eastwoodhill had no commercial source, and clearly they were more readily available than *Crataegus*. When these genera were compared to others in the survey it showed that the Eastwoodhill collection represented only 58% and 37% of those genera in New Zealand, suggesting they were less important than *Crataegus*. Similarly, the Eastwoodhill collection of *Gleditsia* represented 81% of the range found in the survey, but only 15% of these plants had no commercial source. Thus although the Eastwoodhill collection of *Gleditsia* was important it was not as precarious as *Crataegus*.

Ranking the data according to the percentage of the species and cultivars at Eastwoodhill with three or less commercial sources showed that *Berberis, Euonymus, Ilex, Syringa, Crataegus, Populus, Buddleia, Abies, Malus* and *Philadelphus* were the most important genera (Table 3.11). When the same ranking was done for species only it showed that *Berberis, Ilex, Euonymus, Syringa, Crataegus, Juniperus, Buddleia* and *Ulmus* were the most important genera (Table 3.12). It is interesting to note that some genera that ranked highly were not subsequently selected as key genera. (Note that this analysis was not available at the time of selection). These results suggest that *Berberis, Syringa, Carpinus, Ulmus, Euonymus, Buddleia, Sorbus* and *Philadelphus* should be reviewed for their importance to the collection.

Table 3.10 Summary of availability of major Eastwoodhill genera in commercial trade in New Zealand.

GENUS	Percentage of the current collection with this many commercial sources				Number of species and cultivars in the current collection	Number of other members of the genus found in the survey, that are not in the total Eastwoodhill collection. [y]
	0	1-3	4-10	11+	N=S+C [z]	
Abies	56	38	06	0	34=31+3	25
Acacia	19	25	19	37	16=15+1	19
Acer *	57	25	12	04	133=83+50	62
Aesculus *	55	25	15	05	20=15+5	2
Alnus *	52	31	07	10	26=21+5	3
Berberis	94	06	0	0	19=18+1	13
Betula *	39	50	06	05	36=33+3	10
Buddleia	35	60	05	0	20=16+4	12
Carpinus	80	10	10	0	10=8+2	1
Cedrus *	10	40	40	10	10=5+5	6
Chamaecyparis	43.5	36	13	7.5	39=7+32	139
Clematis	35	54	08	03	26=13+13	25
Cornus	23	47	23	06	17=16+1	19
Crataegus *	74	23	03	0	35=28+7	4
Cupressus *	42	31.5	26.5	0	18=13+5	33
Euonymus	63	39	0	0	19=16+3	23
Fagus *	42	35	12	12	17=7+10	5
Fraxinus *	68	16	06	10	31=27+4	4
Gleditsia	15	54	23	08	13=8+5	3
Ilex *	81	19	0	0	23=16+7	27
Juniperus *	53	34	13	0	32=23+9	143
Lonicera	47	40	13	0	15=14+1	22
Magnolia *	42	35	20	03	60=31+29	71
Malus *	79	15	06	0	62=31+31	19
Philadelphus	67	27	06	0	15=8+7	15
Picea	50	31	04	15	26=23+3	44
Pinus *	39	47	12	02	83=82+1	45
Populus *	71	25	04	0	28=10+18	11
Prunus *	55	32	10	03	106=44+62	56
Pyrus *	60	20	20	0	5=5+0	7
Quercus *	74	17	04	06	101=84+17	76
Salix	23	61	15	0	13=11+2	26
Sorbus	59	33	04	04	49=38+11	14
Syringa	84	13	02	0	45=9+36	10
Tilia *	31	44	19	06	16=15+1	4
Ulmus	72	06	17	06	18=12+6	10
Viburnum	45	32	14	09	22=19+3	25

z. Number (N) = Species (S) + Cultivars ©

y. Numbers here are additional to the 'total' Eastwoodhill collection

* Genera subsequently selected as key genera.

Table 3.11 Genera (species and cultivars) at Eastwoodhill at risk because they have three or less sources in commercial trade.

GENUS	Percentage of species and cultivars in that genus with three or less commercial sources
Berberis	100
Euonymus	100
Ilex *	100
Syringa	98
Crataegus *	97
Populus *	96
Buddleia	95
Abies	94
Malus *	94
Philadelphus	93
Sorbus	92
Quercus *	91
Carpinus	90
Betula *	89
Clematis	88
Juniperus	88
Prunus *	87
Lonicera	87
Pinus *	86
Salix	85
Fraxinus *	84
Acer *	84
Cupressus *	83
Picea	81
Alnus *	81
Aesculus *	80
Chamaecyparis	80
Pyrus *	80
Ulmus	78
Viburnum	77
Magnolia *	77
Fagus *	76
Tilia *	75
Cornus	70
Gleditsia	69
Cedrus *	50

Source: Plantfinder file

* Genera subsequently selected as key genera

Table 3.12 Genera at Eastwoodhill (species only) at risk because they have three or less sources in commercial trade

GENUS	Percentage of species at Eastwoodhill with three or less commercial sources
Berberis	100
Ilex *	100
Euonymus	100
Syringa	100
Crataegus *	100
Juniperus *	95
Buddleia	94
Ulmus	92
Lonicera	92
Clematis	92
Sorbus	92
Prunus *	91
Betula *	91
Salix	91
Populus *	90
Malus *	90
Quercus *	90
Philadelphus	88
Carpinus	88
Alnus *	86
Pinus *	85
Fraxinus *	85
Viburnum	84
Magnolia *	83
Acer *	82
Pyrus *	80
Aesculus *	80
Gleditsia	75
Abies	74
Picea	74
Tilia *	73
Chamaecyparis	71
Cupressus *	69
Cornus	69
Fagus *	57
Cedrus *	50
Acacia	44

Source: Plantfinder file

* Genera subsequently selected as key genera

Table 3.13 Genera (number of species and cultivars) at Eastwoodhill as a percentage of that genus found in the 'availability in trade' survey

GENUS	Number of species and cultivars at Eastwoodhill as a percentage of that the number of species and cultivars found in the 'availability in trade' survey
Carpinus	91
Aesculus *	91
Alnus *	90
Crataegus *	90
Fraxinus *	88
Syringa	82
Gleditsia	81
Tilia *	80
Sorbus	78
Betula *	78
Malus *	77
Fagus *	77
Populus *	72
Acer *	68
Pinus *	65
Prunus *	65
Ulmus	64
Cedrus *	63
Buddleia	63
Berberis	59
Abies	58
Quercus *	57
Clematis	51
Philadelphus	50
Cornus	47
Viburnum	47
Acacia	46
Ilex *	46
Magnolia *	46
Euonymus	45
Pyrus *	42
Lonicera	40
Picea	37
Cupressus *	35
Salix	33
Chamaecyparis	22
Juniperus *	18

Source: Plantfinder file

* Genera subsequently selected as key genera

Table 3.14 Number of species only at Eastwoodhill ranked as a percentage of the number of species of that genus found in the 'availability in trade' survey

GENUS	Number of species at Eastwoodhill as a percentage of the number of species found in the 'availability in trade' survey
Fagus *	100
Gleditsia	100
Cedrus	100
Aesculus *	94
Berberis	94
Euonymus	94
Acer *	92
Malus *	91
Sorbus	91
Fraxinus *	90
Crataegus *	90
Carpinus	89
Alnus *	88
Chamaecyparis	87
Tilia *	84
Cornus	84
Populus *	81
Ulmus	81
Prunus *	80
Magnolia *	80
Betula *	80
Buddleia	76
Cupressus *	76
Syringa	69
Pinus *	68
Lonicera	67
Viburnum	65
Ilex *	62
Juniperus *	60
Abies	57
Philadelphus	57
Salix	56
Quercus *	56
Picea	51
Pyrus *	50
Clematis	43
Acacia	40

Source: Plantfinder file

* Genera subsequently selected as key genera

These trends will alter as suppliers change their propagation patterns and Eastwoodhill takes propagation initiatives. For example, the figures for *Tilia* have changed in recent times due to the release of plant material to a commercial nurseryman. This reinforces the security of *Tilia* but stock of those species is all from one source, giving a narrow representation of that species in cultivation.

The survey data can be used for another measure of importance of each genus, by calculating the representativeness of the collection at Eastwoodhill in relation to the overall numbers found in the survey. This would establish whether or not the collection at Eastwoodhill represented a significant portion of the genus found in the survey. This measure was similar to the collection survey (Table 3.6) but differed in two key areas. First, the range of material examined was different because the collections survey examined only 17 genera, whereas the 'availability in trade' collected data about all plants in the current collection. Second, the trade survey covered material available to the general public rather than specialist collectors, and one might expect the range to be different.

The 'trade survey' showed that, for many genera, a high proportion of the material in the survey could be found at Eastwoodhill. Using this measure the genera *Carpinus, Aesculus, Alnus, Crataegus, Fraxinus, Syringa, Gleditsia* and *Tilia* were important to the Eastwoodhill collection (Table 3.13). This reinforced the result from the collection survey, with the addition of *Carpinus* and *Gleditsia* which were not considered in that exercise. Using the same measure *Juniperus, Cupressus* and *Magnolia* were the least important in the Eastwoodhill collection as they represented only a minor portion of that genus found in the 'trade' survey. If the cultivars were removed from the calculation the most important genera were *Fagus, Gleditsia, Cedrus, Aesculus, Berberis, Euonymus* and then *Acer* (Table 3.14). There were 21 genera for which Eastwoodhill contained more than 80% of the species (only) found in the 'trade' survey (Table 3.14).

3.3.3 Developing a combined ranking for significance

There was no recommended mechanism available to combine the various measurements into a single score, therefore a system for obtaining a combined ranking was developed. The eight factors used to measure significance of the collection resulted in slightly different rankings of genera (Table 3.15). These separate lists were combined in the following way. First, each genus was assigned points according to its position in the ranking, with the first placed genus getting 20 points, the second placed 19 points, third place 18 points, and so on until the 20th place received 1 point. This was done for each of the eight factors (the points relating to each place in the ranking are shown on the left hand column of Table 3.15). The sum of points for each genus was calculated. The greater number of points, the more significant the genus (Table 3.16).

Table 3.15 Summary of rankings of genera for various measurements of significance

Points assigned	1. Largest number in the current collection. (Table 3.1)	2. Largest number in the total collection. (Table 3.2).	3. Largest range compared with other collections. (Table 3.6)	4. Largest range compared to the trade survey. (Table 3.13).
20	Rhododendron	Rhododendron	Alnus	Carpinus, Aesculus
19	Camellia	Camellia	Acer	Alnus, Crataegus
18	Acer	Acer	Fagus	Fraxinus
17	Prunus	Prunus	Tilia	Syringa
16	Quercus	Quercus	Malus	Gleditsia
15	Pinus	Syringa	Fraxinus, Aesculus	Tilia
14	Malus	Pinus	Betula	Sorbus, Betula
13	Magnolia	Magnolia	Pinus	Malus, Fagus
12	Sorbus	Malus	Quercus	Populus
11	Syringa	Clematis, Chamaecyparis	Abies	Acer
10	Chamaecyparis	Sorbus	Ilex	Pinus
9	Betula	Erica	Magnolia	Prunus
8	Crataegus	Betula	Prunus, Pyrus	Ulmus
7	Abies	Juniperus, Berberis, Hydrangea	Picea	Cedrus
6	Juniperus	Crataegus, Viburnum	Juniperus	Buddleia
5	Fraxinus	Abies, Populus		Berberis
4	Populus			
3	Alnus, Picea, Clematis			
2				
1				

Columns three and six do not contain 20 genera because the study in question only considered 17.

Other columns may contain more than 20 genera because of equal placings.

Examination of Table 3.8 shows that more genera took last equal place than are shown in column eight. These were not shown in column eight because they did not feature anywhere else on this table, would have had a maximum of 13 points and would not feature in the synthesis shown in Table 3.16.

....continued

Table 3.15 continued...

Points assigned	5. Survivability. (Table 3.2 or Table 3.20).	6. Rarest in plant collections in NZ (highest % in 3 or less collections). (Table 3.6).	7. Rarest in trade (highest % available from 3 or less commercial sources). (Table 3.11).	8. Largest number of IUCN rare or endangered species. (Table 3.8).
20	Platanus	Malus	Berberis	Pinus
19	Alnus, Gleditsia	Juniperus	Syringa	Abies
18	Carpinus	Pyrus	Ilex	Picea
17	Pinus	Fraxinus	Carpinus	Cupressus, Juniperus
16	Fraxinus	Tilia	Malus	Quercus, Magnolia
15	Quercus	Ilex	Quercus	Araucaria, Calocedrus, Malus
14	Callistemon, Ulmus	Quercus	Crataegus	Camellia, Podocarpus, Cunninghamia, Corylus, Betula, Cedrus, Taxus, Cephalotaxus
13	Nothofagus	Prunus	Ulmus	Acer, Fraxinus, Ilex, Juglans, Chamaecyparis, Rhododendron, Nothofagus, Philadelphus
12	Cupressus	Magnolia	Populus	
11	Photinia	Aesculus	Fraxinus	
10	Taxus, Juglans	Acer	Philadelphus	
9	Acer, Podocarpus	Picea	Euonymus	
8	Abies, Crataegus	Betula	Pyrus	
7	Cryptomeria Fagus	Alnus	Sorbus	
6		Fagus	Acer	
5		Abies	Abies	
4		Pinus	Aesculus	
3			Prunus	
2			Juniperus	
1			Alnus	

Table 3.16 Ranking of genera for the combined rating for significance

GENUS	Combined points
Malus *	106
Quercus *	104
Acer *	104
Fraxinus *	95
Quercus *	93
Carpinus	72
Alnus *	69
Prunus *	67
Betula *	67
Magnolia *	63
Syringa	62
Abies	60
Juniperus *	57
Ilex *	56
Crataegus *	55
Rhododendron	53
Camellia *	52
Aesculus *	50
Tilia *	48
Fagus *	44
Sorbus	43
Picea	37
Gleditsia	35
Ulmus	35
Chamaecyparis	34
Pyrus *	34
Populus *	33
Berberis	32
Nothofagus	26
Taxus	24

* Genera subsequently selected as key genera.

When processed this way the five most important genera were *Malus, Quercus, Acer, Fraxinus* and *Pinus* (Table 3.16). Each of these top five genera appeared on seven lists, except *Fraxinus* which was on six lists. No genus was on all eight lists. The top thirty genera calculated by this method excluded two genera subsequently chosen as key genera (*Cedrus, Cupressus*), and included nine that were not subsequently chosen (*Carpinus, Syringa, Abies, Rhododendron, Sorbus, Picea, Gleditsia, Ulmus, Chamaecyparis, Berberis, Nothofagus, Taxus*). When key genera were selected reasons were determined for excluding *Syringa, Abies, Rhododendron, Sorbus, Picea* and *Chamaecyparis* (these deliberations are reported in Chapter 5). The others, however, may need further consideration of their status in the collection. Equally, one might question the inclusion of *Cedrus* and *Cupressus* as key genera when they did not appear on this ranking.

3.3.4 Conclusion: significance and the fabric of the Arboretum

The plant collection at the Eastwoodhill Arboretum was significant because it contained groupings which were the largest in New Zealand, plants that were not found in other collections, rare and endangered species, and the majority of the material was not available commercially. The collection focused on northern hemisphere plants with 73% of northern origin, and 41% from Asia. This pattern was consistent for both total and current collections. The important genera in the collection were: *Abies, Acer, Aesculus, Alnus, Berberis, Betula, Camellia, Carpinus, Chamaecyparis, Crataegus, Fagus, Fraxinus, Gleditsia, Ilex, Juniperus, Magnolia, Malus, Nothofagus, Picea, Pinus, Populus, Prunus, Pyrus, Quercus, Rhododendron, Sorbus, Syringa, Taxus, Tilia,* and *Ulmus*. These genera were the 'fabric' of the collection and, logically, core management decisions should focus upon them. In addition, the results show another group of genera which were present in significant numbers in the past, and which should be considered in collection planning, e.g. *Clematis* and *Viburnum*. Insufficient data on this group calls for further investigation before planning decisions are made.

The most important parks were Pear Park, Orchard Hill and the Circus as these contained the greatest portion of the 'fabric'. The least important parks in terms of 'fabric' were Corner Park, the Gardens and Cabin Park. The latter parks may be important for visual purposes, but that must be balanced against biological significance in an enterprise with limited funds.

These points highlight the relationship between significance and management. A satisfactory and continuous level of significance must be a primary aim as this underpins the role as an arboretum. At the same time a key principle of recreation planning is the capacity to attract visitors, which requires that the Arboretum has notable features for which no substitute sites are readily available.

If the site is remote and rural the travelling distance makes substitution likely (Miles and Seabrook, 1977), therefore sites such as Eastwoodhill need a unique factor that draws visitors and therefore income. The significance of the collection is the only attribute that Eastwoodhill can exploit to this end as other recreational qualities are readily available at more convenient locations. Therefore management of significance is a key management function. Having identified the 'fabric' of the Arboretum the Trust Board should select the genera and parks which will be focused upon in management activity. That selection should be derived from the processing of significance and condition, including consideration of any goals and objectives of the enterprise, (discussed in sections 3.5.1 and 3.5.2).

Meanwhile, the conclusions on significance should be considered in light of the investigation that was conducted. The comparison between Eastwoodhill and other collections showed that the selected genera were important, but it is now clear that a broader selection of genera should have been studied. The selection was made before the detailed study of collection composition was finished, and focused on genera important in the current collection, without considering genera that might have been important in the previous collection. Thus, long lived genera were examined at the expense of short and medium lived groups. This was an unfortunate omission, given the loss of short lived genera revealed in the collection study. Similarly, the general absence of short lived genera in the initial New Zealand Plant Collections Scheme (Hammett, 1993) suggests another examination of this group is required.

The results must also be considered in terms of the focus on biological value, which was a deliberate choice reflecting the role of an arboretum in general, and the nominal mission of Eastwoodhill in particular. Indeed, the absence of a significant plant collection would be a major management problem thus biological value must be examined first. Other values (recreational, visual, economic) should be examined in a second phase as anecdotal evidence suggests they are important, e.g. the absence of any regional park in the Gisborne area suggests that recreational value may be significant. Measurement of economic and recreational values is likely to be a complex exercise, but would be useful for an enterprise that receives no government funding and must continually seek its own resources. Data on other values are important because, without them, one cannot discuss value conflicts in an informed manner, and must rely upon supposition and anecdotal evidence. Other values should be quantified but the specialisation of such an exercise places it beyond the scope of this study.

In fact, this determination of significance had all the difficulties outlined in the introduction in that there are poor theoretical bases for examining biological values of created landscapes. Significance was determined using indices of rather arbitrary definition, e.g. the British definition of horticultural rarity which was intuitive and based on expertise (Lowe, 1989). The overall ranking that was attempted provided interesting discussion but did not have any tested theoretical basis. Furthermore, the result represents the collection at one point in time and both the criteria and their weightings may change over time, generating different results. These difficulties are consistent with the problems of evaluating unique biological resources (Miles and Seabrook, 1977).

Despite these problems, a major advance has been made in quantifying the significance of the plant collection at the Eastwoodhill Arboretum. The usefulness of these data is underpinned by a series of external factors which may influence the Arboretum. First, in recent years there have been changes in funding and operations of local authorities in New Zealand, with a decreasing emphasis on horticulture and placement of parks under recreation or engineering offices. With no state funded botanic garden or similar institution to safeguard important plant material, the local body changes are of concern and will underpin the importance of any independent plant collections. Second, regulations governing import of plants into New Zealand have recently been tightened, making importation of germplasm more difficult and more expensive, and increasing the importance of plant material already in the country. Much of the Eastwoodhill collection was imported before 1950, when import regulations were not stringent, and the collection may contain species that would be prohibited imports today. Third, government bodies that are involved with plant collections are experiencing pressure on funds. In recent times two government held plant collections have been disbanded due to funding cuts or restructuring (Aokautere Plant Materials Centre and Taupo Native Plant Nursery). Furthermore, although plant collections are included in science output 15 'Land and freshwater ecosystems' of the Ministry of Research Science and Technology, the funding for living collections is relatively low. To date the Ministry has not funded any field investigation of living collections or ornamental horticultural resources, although there has been one study of horticultural production species (Halloy, 1993). Thus, while official bodies support plant collections in theory, little has been done in practice to support institutions such as Eastwoodhill.

3.4 RESULTS AND DISCUSSION PART TWO: CONDITION

3.4.1 Condition

3.4.1.1 Age and stage of succession

The average age of plants in a population is a useful indicator of the condition of that population (Moll, 1988) and this could be used at Eastwoodhill to give an indication of the condition of each park (Table 3.17). Older parks are more likely to contain plants in poor condition as those plants will be further through their expected life span. Thus, in general terms, the oldest parks should have the highest priority for any renewal actions.

Table 3.17 Age of each park and its date of creation

Park	Date planted	Age in 1996
Gardens	1920	76
Corner park	1927	69
Dry ridge (Corner Park)	1933	63
Upper Cabin Park	1934/35	62
Lower Cabin Park	1938	58
Douglas Park	1945	51
Pear Park	1950	46
Orchard Hill	1955	41
Circus	1959	37
Glen Douglas	1960	36
Basinhead	1961	35
Blackwater	1961	35

Condition of the population is also shown through the successional pattern, which shows the extent of losses of plant material in each of four broad life expectancy categories (Table 3.18). High losses of short lived material, and comparatively better survival amongst long lived species is evident. The life span categories are estimations, as precise life expectancy data was not available.

3.4.1.2 Density and overcrowding

Overcrowding was, and to some degree remains, a problem within the Arboretum. Much of the Trust Board's activities from 1975 to 1985 related to rectifying this problem, with the earliest reported policies relating to removing competition from important trees (Chavasse, 1976). Trees were removed where crowding was excessive (Greenwood, 1976), and groups were thinned to produce better specimens (Chavasse, 1976). Some overcrowding could be attributed to overzealous planting, but much was due to inadequate knowledge of new material when it was first brought to this country. Many species were new to New Zealand and little was known of their potential growth. Even if species reached a certain size in Britain (from which many were supplied), similar results could not be confidently predicted in New Zealand. Many species grew much faster and to a larger size than existing knowledge suggested and, understandably, considerable overcrowding occurred.

Table 3.18 Losses of genera at Eastwoodhill within expected lifespan groups

Expected lifespan less than 30 years		Expected lifespan 50-70 years		Expected lifespan 80-100 years		Expected lifespan 100 plus years	
Genus	% lost	Genus	% lost	Genus	% lost	Genus	% lost
Erica	99	*Vaccinium*	92	*Salix*	70	*Larix*	76
Cytisus	95	*Gaultheria*	90	*Rhododendron*	66	*Chamaecyparis*	55
Protea	94	*Rosa*	88	*Styrax*	60	*Tsuga*	54
Cistus	84	*Chaenomeles*	88	*Viburnum*	54	AVERAGE LOSS [z].	
Genista	84	*Hydrangea*	82	AVERAGE LOSS [z].		*Tilia* *	53
Abutilon	75	*Pieris*	81	*Euonymus*	50	*Eucalyptus*	50
Clematis	70	*Deutzia*	79	*Pittosporum*	50	*Thuja*	45
Hebe	70	*Citrus*	75	*Cornus*	48	*Ilex* *	39
Banksia	66	*Cotoneaster*	69	*Populus* *	41	*Aesculus* *	37
Ribes	63	*Philadelphus*	68	*Camellia* *	41	*Juniperus* *	37
Nerium	61	*Escallonia*	68	*Prunus* *	39	*Sophora*	36
AVERAGE LOSS [z].		*Hypericum*	66	*Sorbus*	33	*Cupressus* *	34
Grevillea	53	*Berberis*	62	*Spiraea*	33	*Magnolia* *	34
Acacia	48	*Hamamelis*	60	*Betula* *	32	*Cedrus* *	33
Melaleuca	41	*Daphne*	59	*Malus* *	30	*Picea*	33
Callistemon	18	*Syringa*	58	*Ligustrum*	30	*Fagus* *	29
		Weigelia	57	*Crataegus* *	29	*Cryptomeria*	29
		Jasminium	56	*Juglans*	25	*Abies*	27
		AVERAGE LOSS [z].		*Photinia*	23	*Podocarpus*	26
		Buddleia	51	*Fraxinus* *	16	*Acer* *	26
		Mahonia	50	*Carpinus*	09	*Taxus*	25
		Lonicera	46	*Gleditsia*	07	*Nothofagus*	21
		Rhus	40	*Alnus* *	07	*Ulmus*	18
		Vitis	40			*Quercus* *	17
						Pinus *	10
						Platanus	0

* Genera that were subsequently selected as key genera

z. Average loss for all genera was 53% .

Overcrowding was also caused by many volunteer plants of self seeding species such as lawson cypress, cherry, pine, birch, dogwood, and acacia which are common throughout the Arboretum. These fast growing species quickly encroached upon slower growing species and caused distortion or damage to more valuable species. The solution for this problem was simply to remove the volunteer material as it was of little value to the collection. Trust Board minutes regularly contained reports of successful clearing operations and a large proportion of labour was devoted to clearing between 1976 and 1985 (Board minutes, 1976-1985).

The overcrowding problem was more difficult to solve when important species were involved. In many instances important species were crowding each other, resulting in poor individual specimens. Throughout the Arboretum it was common to find important species too close to one another, with no obvious hierarchy for removal. Some means of prioritising was required, which is an issue addressed in Chapter 6.

Table 3.19 Planting density of each park within the Eastwoodhill Arboretum

PARK	No. of plants	Area (ha)	Plants per hectare
Cabin park	1292	4.0	323
Gardens	649	2.4	270
Pear park	385	3.5	110
Corner park	839	4.9	171
Circus + IDS ridge	381+44	4.9	086
Orchard Hill	252	3.5	144
Douglas Park	1126	8.8	127
Glen Douglas	306	5.4	056
Cooks Corner	182	1.3	140

The extent of any crowding was shown by density of plants within the Arboretum, with figures from the 1989 maps showing considerable variation between parks (Table 3.19). Cabin Park and the Gardens were the most densely planted areas with around 300 plants per hectare. Other parks were considerably less dense ranging from 170 to 110 plants per hectare in Corner Park and Pear Park respectively. Previous density of these parks would have been much higher considering the number of plants that have been lost from the collection. Glen Douglas and the Circus were least dense at 56 and 86 plants per hectare. According to notes made by Douglas Cook, Glen Douglas was never finished, while the density in the Circus may well be the result of clearing.

Of course density is related to size of the trees; at a certain density large trees will be more crowded than small trees. Detailed data on tree stature was not collected, but observation suggests that both large and small stature trees are evenly spread across the Arboretum, thus the number of plants per hectare is indicative of crowding. A more precise measure of overcrowding could be obtained with a rating scale for shape and structural form of individual plants, and by measuring canopy width and overlap. Such a condition rating was not measured for this data set. The 1:200 maps of the collection partly show the degree of overcrowding as the canopies are drawn to scale and the overlap shows on the plans. A sample of the maps are found in Appendix 2, but the maps for the most crowded parts of the Arboretum were not part of the set included in the appendix.

3.4.2 Change between 'total' and 'current' collections

The pattern of change between inventories taken at different times can illustrate trends in the landscape and highlight important issues (Miller, 1988). At Eastwoodhill change in the collection over time can be observed, and decline of individual genera measured. The 87 genera (represented by 10 or more species and cultivars) were ranked according to the percentage lost between the total and current collections (Table 3.20). These data show that key genera were generally selected from successful groups that suffered lower than average losses. It is logical to select key genera from groups that are successful on the site, but the apparently unsuccessful groups may still be worthy of consideration as key genera, i.e. these data cannot separate successful short lived genera that reached the end of their lives from short lived genera that were unsuccessful. The loss of short lived genera was reinforced by the data on stage of succession (Table 3.18) suggesting that further study is needed on this group of plants in the collection.

Overall, about 53% of the 'total' collection no longer exists, and while this rate of loss seems high it can be accounted for in four main of ways. First, some genera declined because they were unsuited to the generally hot, dry environment of New Zealand's east coast. Long lived genera that declined prematurely are probably in this category; at Eastwoodhill this includes *Larix*, *Styrax*, *Chamaecyparis*, *Tsuga* and *Rhododendron* where a lifespan of 50 years or more is expected.

Second, it was known that some genera were purposely eliminated and this accounted for their marked decline from the total collection. Douglas Cook reported that *Cotoneaster* became a nuisance (through self seeding) and many were cut out (Cook, undated e). *Pyracantha* and some of the *Berberis* are likely to have suffered the same fate for similar reasons. Some *Salix* have also been purposely removed.

Table 3.20 Genera at Eastwoodhill ranked for percentage lost between 'total' and 'current' collections

Genus	Percentage of species and cultivars lost between total and current collections	*Genus*	Percentage of species and cultivars lost between total and current collections
Cytisus	94	*Acacia*	48
Protea	94	*Lonicera*	46
Erica	94	*Thuja*	45
Vaccinium	92	*Camellia* *	42
Gaultheria	90	*Cornus*	41
Rosa	88	*Melaleuca*	41
Chaenomeles	88	*Populus* *	40
Ceanothus	86	*Rhus*	40
Cistus	84	*Vitis*	40
Genista	84	*Prunus* *	39
Hydrangea	82	*Ilex* *	39
Pieris	81	*Aesculus* *	37
Deutzia	79	*Juniperus* *	37
Larix	76	*Sophora*	36
Abutilon	75	*Magnolia* *	34
Citrus	75	*Sorbus*	33
Salix	70	*Cedrus* *	33
Clematis	70	*Picea*	33
Hebe	70	*Spiraea*	33
Cotoneaster	69	*Betula* *	33
Escallonia	68	*Tilia* *	30
Philadelphus	67	*Malus* *	30
Rhododendron	66	*Ligustrum*	30
Banksia	66	*Fagus* *	29
Hypericum	66	*Cryptomeria*	29
Ribes	63	*Crataegus* *	27
Berberis	62	*Abies*	27
Nerium	61	*Podocarpus*	26
Hamamelis	60	*Acer* *	26
Styrax	60	*Juglans*	25
Daphne	59	*Taxus*	25
Syringa	58	*Photinia*	23
Weigelia	57	*Cupressus* *	22
Jasminium	56	*Nothofagus*	21
Chamaecyparis	55	*Ulmus*	18
Tsuga	54	*Callistemon*	18
Viburnum	54	*Quercus* *	17
Average loss over all genera		*Fraxinus* *	16
Grevillea	53	*Pinus* *	10
Buddleia	51	*Carpinus*	09
Mahonia	50	*Gleditsia*	07
Euonymus	50	*Alnus* *	07
Pittosporum	50	*Platanus*	0
Eucalyptus	50		

Includes the 87 genera that are represented by more than 10 species and cultivars

* Genera subsequently selected as key genera

Third, some genera, which may have otherwise survived, declined because they were sensitive to the management regime. Resource constraints meant that the main body of the Arboretum had to be grazed with sheep. Unprotected plants of genera that rejuvenate from the base, such as *Philadelphus, Chaenomeles, Deutzia, Hamamelis, Weigelia, Ribes, Nerium*, and *Syringa* would not perform well under grazing pressure.

Finally, losses of many genera can be attributed to expected length of life. Over the normal passage of time species will disappear as they reach the end of their lives, short lived species first, followed by medium lived species and so on. Thus, in the absence of a replacement programme, the collection will change as different life span categories decline. In the current data (Tables 3.18, 3.20) most genera showing high rates of decline are in the short lived category.

Although the factors above may explain the losses in the collection, they do not resolve the issues associated with that loss. Those genera (or species) that prove climatically unsuitable or which become a nuisance can be justifiably dismissed from the collection, but the loss of material over time is another matter. Managing change in the collection over time is a critical factor in maintaining the integrity of this human-made landscape in the long term, and is an issue that should be addressed in management plans (Sales, 1989,1990). The data clearly show change over time and the impact of this pattern on collection composition and development must be carefully considered.

There are three important issues. First, should short lived species (that have been lost) be replaced in the collection, and what are the management implications of that replacement? Shorter lived material needs more frequent replacement, with the associated resource implications. More resources may also be needed for daily maintenance as many of these plants are shrubs and need garden cultivation (rather than grazed paddocks) to produce good specimens. The decision to hold collections of short lived shrub genera must take these factors into account.

Second, shorter lived material was either overlooked or considered unimportant when key genera were selected (Chapter 5) and no key genus came from the shorter lived group. It may be acceptable for the Eastwoodhill collection to be based on long term genera, but it does raise the question of where and how collections of the shorter term genera are conserved. This question becomes critical if Eastwoodhill contains (or contained) a significant collection of a short lived genus. Furthermore, if those genera are removed from the collection, the fate of the remaining plants must be decided. The role of short lived material in the collection should be resolved. Additional data will be needed to properly address this issue.

Third, the demise of short lived genera highlights the medium term genera which are now reaching 30-50 years, depending on when they were planted. The phase of natural decline is approaching for genera such as *Malus*, *Crataegus*, and *Sorbus* and unless provision is made for their renewal these genera will also be lost from the collection. The results in the previous section on significance suggest that such a loss would have a huge impact on the collection and lead to a loss of 'fabric' of the Arboretum.

Each of the aforementioned issues impacts upon the future of the collection and should be considered in collection management plans. At the same time, constraints of space and resources suggests that Eastwoodhill could never contain the complete diversity of the 'total' collection in the future, therefore the collection should focus upon carefully selected plant groups. Clearly those groups should be selected from the most significant fabric of the place, which has been identified in this study. The issues that need further study are the role of short lived genera, the impending demise of medium lived genera, and genera groups that were significant in the total collection but are not so in the current collection, e.g. *Clematis*, *Viburnum*.

3.4.3 Conclusion: condition and the need for urgent action

Major changes have occurred in the collection with a marked loss of short lived material and impending loss of medium lived material in the foreseeable future (if no renewal action is taken). Long lived material is in no particular danger in the short term, although renewal plans will eventually be needed. Other changes in the collection are due to factors other than life span. A number of genera appear to be climatically unsuitable, or sensitive to the management regime and have declined much sooner than their normal lifespan would suggest.

Poor condition indicates a need for urgent action, suggesting a logical priority for action for both genera and parks. Short lived genera should be in the first phase for action, followed by medium lived genera then long lived genera. The exception is significant longer lived species in unacceptable condition, e.g. some *Abies* and *Picea* which are suffering from poor siting, or marginal climatic suitability. Action may involve propagation and transfer to more suitable locations in other collections.

In the parks the most urgent action should be in older parks or those of greatest biological significance. Age and overcrowding gives a priority for parks as follows: Cabin Park and The Gardens, Corner Park, Orchard Hill, the earlier part of Douglas Park, Pear Park, Circus, the remainder of Douglas Park, and then Glen Douglas. But the most significant parks were Pear Park, Orchard Hill and the Circus (and the least significant were Corner Park, Gardens and Cabin Park).

When significance is taken into account, Pear Park and Orchard Hill should be dealt with first as these contain more 'fabric' than some of the older parks such as Cabin Park or Corner Park. This illustrates an interaction between significance and condition; in a landscape based upon biological value, Pear Park would be higher in the hierarchy than Corner Park or the Gardens.

The interaction between condition and visual value should also be considered. The Arboretum relies upon public support for its funding, therefore it must meet minimum visual standards. These are partly derived from condition of the trees, therefore high levels of condition are needed for both biological and visual purposes. For example, Corner Park is the entrance to the Arboretum and, from a visitor viewpoint, should be in excellent condition irrespective of its significance. The same argument applies to the Gardens, justifying placing these parks higher on the priority list than those with less visitor impact.

Condition also interacts with significance in another way, because condition feeds back into significance. Take two resources of equal diversity and rarity, one in good condition and the other poor — the one in good condition will be judged of greater value. The Eastwoodhill collection is clearly significant, but there are some problems with condition. Sustaining significance requires action to ensure that condition does not decline further, thus significance and condition must be managed in tandem. Planning, therefore, should include the need for an acceptable level of condition in the future.

In this regard it is important to distinguish appearance of the Arboretum from life phase status of the population. Appearance has been dramatically improved through clearing work, thereby reducing the proportion of moribund trees and improving the population characteristics. Nevertheless, the population that remains is still ageing and must be actively managed to ensure it is perpetuated. At Eastwoodhill two types of action are necessary, (i) decisions to bring condition back up to acceptable levels (so that existing significance is not lost), and (ii) decisions to ensure that both significance and condition are sustained in the long term. Each of these categories of action will require short and long term decisions.

This investigation has provided some of the knowledge needed to develop the necessary action plans, but better data would have been obtained if a narrower focus was used in the condition study. Age, density, and change in composition are useful, but too broad to show condition in different parts of the park. More precise measurements of condition are needed, e.g. measuring the age of individual trees and aggregating the information for each park, rather than using the planting date of the majority as an average score. Unfortunately this would be difficult at Eastwoodhill as (i) age of many individuals can only be guessed, (unless resources are spent doing core samples), and (ii), a proper population flow should show those individuals which have died or been removed, but many of these are impossible to define in the Arboretum. Condition could also be measured with a series of ratings for each tree, aggregated for each park. This was not done for the whole Arboretum in the evaluation stage, but was used to develop strategies for particular parks and is discussed in Chapter 6. In general the condition study was too broad, but at the time resources were not available to obtain more precise data. In time, and as each park is studied, these data could be developed.

3.5 RESULTS AND DISCUSSION PART THREE: PROCESSING

3.5.1 Processing: relating significance and condition to mission and goals

The first processing step relates significance and condition to the mission and goals of landscape management in general, and the enterprise in particular. These comparisons will highlight the feasibility of existing goals, indicate areas where management action is necessary (Kraus and Curtis, 1990), and foreshadow development of new goals.

The overarching purpose of landscape management is to uphold the values of a landscape, which is achieved through the overarching mission of ensuring continued existence and managing human use. The (nominal) purpose and mission of Eastwoodhill is to be an arboretum (Eastwoodhill Trust Act, 1975; Williams; 1987), requiring continued existence of a significant plant collection in good condition, managed for human use. This research focuses upon the former task. How does the 'continued existence of a significant plant collection in good condition' relate to the current circumstances at Eastwoodhill and any existing goals for the collection?

An arboretum requires a significant collection, and goals should outline the nature of that collection. The management plan called for plants "exotic to New Zealand" (Williams, 1987, p 16) and "northern hemisphere and temperate zone woody plants" (Williams, 1987, p 51). The data supported these ideas as the collection had 73% northern hemisphere material. The levels of diversity and rarity showed that the Arboretum was an important resource compared with other collections in New Zealand, supporting the notion of a "notable" Arboretum.

Goals for significance should address the question of a taxonomic or conservation collection (Rae, 1993; Royal Botanic Garden Sydney, 1993), although the Trust Board had no stated view on this matter. The data supported a taxonomic/horticultural collection, and did not support a conservation collection as only a minor proportion of the collection (4%) was of world conservation importance. Development of a conservation site would be difficult as Eastwoodhill has neither the number of individuals to constitute a conservation population (Burton, 1989; Rae, 1993), nor sufficient land area to develop conservation populations. (It could be done if a narrow range of species were selected for conservation and land used at the expense of current diversity in the collection). Therefore while the idea of 'protection from loss in the natural habitat' (Williams, 1987, p 15, 51) cannot be supported, the Arboretum could be a source of germplasm for conservation collections on other sites. There will also be an educational role as a site to view examples of important conservation species (Royal Botanic Garden Sydney, 1993).

Next, significance should be related to themes in the collection; proposed themes can be verified (or not) by matching patterns within the collection with those proposals. Presence of dominant genera supported the potential to "develop the systematic botanical and horticultural collections" (Williams, 1987, p 16). Existence of loose generic patterns in the planting supported display "in a geographic or generic order" (Williams, 1987, p 51), although a more disciplined development of the physical arrangement is needed. Twenty seven of the 31 genera from the early proposals were significant, also supporting a possible generic order (Chavasse, 1976; Jackson, 1964; Skipworth 1976; Sykes 1972). Three genera from the early proposals, *Eucalyptus, Larix* and *Platanus*, were not in the final ranking for significance. The data supported some geographic groupings such as Asiatic and North American groupings. The Chilean and South American groupings were harder to support as the proportion of these groups was so small; an excellent reason would be needed for focusing on a minor group at the expensive of major aspects of the fabric of the collection. Similarly the small percentage of rare and endangered plants made it difficult to support that theme (Williams, 1987) but in its narrow form (rare conifers (Berry, 1978)), it could be justified.

In general this examination showed that Eastwoodhill contained a significant plant collection as required by the nominal mission. Thus, no major management actions are needed to bring significance up to a baseline level. If the evaluation indicated absence of a significant plant collection then major management action would be needed, because the Arboretum would not have the 'fabric' to meet its mission. There are two possible solutions to that problem: either the mission is altered to fit the significance, or the significance is altered to fit the mission. Both alternatives involve major shifts in management emphasis and require considerable planning input. Thankfully neither of these options is required at Eastwoodhill at present, although any major loss of significance (due to loss of more material through ageing) would foreshadow such a scenario.

Next, the collection should be in good condition as an arboretum requires plants and populations in excellent condition for both biological and visual purposes. Discrepancies between actual and required condition indicate the need for management action. In this regard there were several problems at Eastwoodhill (ageing, overcrowding, loss of material and the need for renewal), indicating a need for plans to manage condition. That need to manage condition is reinforced by the feedback of condition into significance; if condition is not suitably managed then significance may decline as plants deteriorate and die. Thus, although the collection is currently significant and has the potential to achieve the purpose of an arboretum, that purpose may not be realised unless condition is well managed.

Management of significance and condition will be expressed in preservation goals, and possibly improvement goals for any new developments. The management plan contained two relevant preservation goals: "to preserve the property as an arboretum" (Williams, 1987, p 16), and "to conserve and restore the plant collections" (Williams, 1987, p 16). The goal "to develop the systematic botanical and horticultural collections, integrating them into the Arboretum's landscape character" (Williams, 1987, p 16) suggests some form of improvement or development. These goals are in keeping with the current significance and condition of the collection, and clearly relate to the overall goals of landscape management, but they are at an overview level and could predispose a variety of outcomes depending on how they were applied to the physical resource. For example, how should the idea to "conserve and restore the plant collections" be applied to the trees on the site? Which collections, in which order, in what manner? Similarly, how does one convert the valid principle of preserving the property as an arboretum into an action plan? The goals in the management plan provide a valid overview for the collection, but they were too broad for planning at a detailed level. The evaluation data in this research can be used to propose more detailed actions and priorities.

3.5.2 Processing: probable goals and priorities

Long range goals, which describe the future characteristics of the collection, are a key management tool as they influence all collection management decisions. Decisions about which goals are pursued at Eastwoodhill are the responsibility of the Trust Board, nevertheless this evaluation indicates the most likely approaches. Assuming that the nominal mission in the Act (Eastwoodhill Trust Act, 1975) is valid and that the Trust Board wishes to fulfill the role of an arboretum, proposals for managing the collection can be outlined. These were generated by examining the current situation, comparing it with the required future situation, and describing the changes needed to achieve the future situation.

Significance

Eastwoodhill has a significant plant collection based upon a fabric of northern hemisphere plants, particularly those of Asian origin, and the following genera: *Abies, Acer, Aesculus, Alnus, Berberis, Betula, Camellia, Carpinus, Chamaecyparis, Crataegus, Fagus, Fraxinus, Gleditsia, Ilex, Juniperus, Magnolia, Malus, Nothofagus, Picea, Pinus, Populus, Prunus, Pyrus, Quercus, Rhododendron, Sorbus, Syringa, Taxus, Tilia* and *Ulmus*. Some parks were more significant than others. Current significance matched the nominal mission and the broad goals in the management plan, and supported most of the proposed collection development themes. If no action is taken the collection will gradually lose significance as genera groups die out according to their life spans. Significance will also be lost if plants in poor condition are not dealt with in the near future.

The required future significance is unknown because the Trust Board has not yet defined it beyond a general level. Previous proposals offered a range of possibilities, but there was no consensus on any particular direction. Without a more detailed position from the Trust Board, it will be assumed that future significance should build upon the strengths of the collection, developing a significant taxonomic/horticultural collection around existing features. The future will therefore focus upon:

(i) The most significant parks.

(i) Plant groups for which the Arboretum already holds a significant collection.

(ii) Plant groups for which the Arboretum can successfully develop a significant collection, and which are not currently held elsewhere.

Those groups that relate to (i) have already been outlined in the results. Groups that might relate to (ii) can only be identified through a combined examination of the previous collection and other plant collections in New Zealand. It is the Trust Board's responsibility to define the future picture, confirming that all/some of the current fabric is required, then selecting any other relevant groups.

Attaining the selected future significance requires various goals and plans, mostly relating to preservation. The following activities will be relevant: (i) definition of the fabric that makes the collection significant, (ii) heightened acquisition of targeted groups, (iii) non replacement of lowest priority groups, (iv) long term plans to achieve any shifts in composition (fabric), and (v) short and long term plans to sustain the existing fabric, including any links to management of condition. Ranking of goals may be needed as the 'correct' action often depends upon the hierarchy of goals. For example, the present low level of world conservation species is of little moment if a conservation collection is a low priority, whereas major management action would be needed if it was a high priority.

Condition

It has already been shown that current condition involves some problems, meanwhile, the required future is a plant collection in excellent condition. Plants must be kept viable to support significance, while simultaneously influencing visual value which is essential for visitors.

Achieving the required future condition involves transforming a significant collection in decline (and facing increasing competition) into a significant collection in excellent condition. Any further deterioration should be halted, then plans for renewal developed. This involves preservation and improvement actions which are described below

Immediate decisions should address the worst aspects of condition, particularly where significant elements of the collection are involved. The purpose of these decisions is to halt the decline, including immediate maintenance to prolong the life of important species until they can be propagated, propagation of moribund species, and development of renewal plans to save groups that are in danger. Priorities should be as follows:

(i) Most significant genera needing most urgent action, i.e. *Sorbus, Malus, Crataegus, Prunus, Berberis* and *Syringa* because they are significant but approaching the end of their life span. Also significant plants that are normally long lived but are presently in poor condition (probably due to marginal climatic suitability) such as some *Abies* and *Picea*.

(ii) Most significant parks needing most urgent action, i.e. Pear Park, Circus, Orchard Hill, because they contain the greatest concentrations of the 'fabric', and Corner Park and the Gardens because of their interaction with visual values.

(iii) Significant genera in moderate condition, i.e. *Fraxinus* because it is in the next age band, and *Juniperus* because it has been poorly sited.

(iv) Significant parks needing next most urgent action, i.e. Cabin Park because, although it has relatively low significance, its age and overcrowding need action and because it is in the centre of the Arboretum it is highly visible to visitors. Next are Douglas Park, Glen Douglas which are the youngest and therefore have the least need for action for condition.

Next, plans are needed to manage condition in the long term so that the same problem does not occur in the future. This is a separate (although related) step from the need to restore some collection elements that have fallen below a baseline level of condition. Both long and short term decisions will be needed to sustain both significance and condition of the collection for the long term. Although significance and condition should be managed in tandem there will still be a hierarchy in the development of the long term plans in which attention will be given to:

(i) Most significant genera which can ensure future significance.

(ii) Most significant parks which can ensure future significance.

(iii) Developing long and short term decisions to get the 'fabric' of collection into good condition.

(iv) Developing long and short term decisions to get the rest of the collection into good condition.

A major planning effort, with considerable detail, is needed to achieve the principles outlined above for the whole Arboretum. Furthermore, although the evaluation leads to likely goals and priorities, plans cannot be developed without the input of the Trust Board. As 'senior managers', it is the Trust Board's role to either select goals in keeping with the above proposals, or develop and implement another series of defensible goals. This involves developing sufficient detail to connect the broad ideas of the goals with the specific tasks of daily operations, otherwise daily operations will not progress towards the desired goals. These issues are the subject of Chapters 4 to 6.

3.6 RESULTS AND DISCUSSION PART FOUR: OVERALL DISCUSSION

3.6.1 Managing significance and condition: proposal for 'landscape category'

There are clearly interactions between significance and condition, which require the two factors to be managed in tandem. 'Landscape category' is a concept which I have developed after considering those interactions and their management implications. Measuring a landscape for significance and condition takes place at a single point in time, but the two factors continuously interact resulting in different possible combinations over time. When those combinations are considered four landscape categories can be distinguished (Figure 3.6).

Consider the categories in relation to an arboretum. To achieve its purpose an arboretum should have a significant living plant collection in good condition. That plant collection should not be a random set of plants, but a focused and planned composition comprising generic, geographic, or horticultural groupings. Condition of the plants must be sufficient to ensure that important plants are kept healthy and then replaced at an appropriate time. This is a category one landscape; both significance and condition are high.

This evaluation, however, has shown that Eastwoodhill is a category two landscape. It is highly significant but individual trees are not in good health, and the population characteristics show ageing and loss of material. In the long term condition of the collection must be improved if significance is to be sustained and the purpose of an arboretum achieved.

1. Significance: high. Condition: good

Immediate action: None, maintenance mode only

Long term action: Engage planning mode

Likelihood of funding: Good

2. Significance: high. Condition: poor

Immediate action:

- Stabilise aspects that cause poor condition.
- Bring condition back up to minimum acceptable level, as much as possible through maintenance, e.g. pruning, fertilising, thinning.
- Eliminate aspects of condition that fall below baseline level. The implications of these actions for significance must be considered; should these elements be replaced or eliminated?

Long term action:

- Engage planning mode to ensure continuation of significance, i.e. fabric remains significant.
- Engage long term maintenance mode to ensure continuation of acceptable condition.

Likelihood of funding: Moderate

Notes:

(i) Eastwoodhill is in this category at the moment.

(ii) If condition is too far gone then there are several possibilities:

- Another aspect of significance is developed and the enterprise stays in category two.
- The original significance is abandoned and the landscape is managed in maintenance mode only, landscape moves into group three.
- Landscape disassembled and moves into group four.

3. Significance: low. Condition: good

Immediate action: Maintenance mode only

Long term action:

- None unless circumstances change and a level of significance is developed. Alternatively, long term planning for biological replacement, no composition constraint.

Likelihood of funding: For biological lifetime only, unless significance changes.

Notes: This is a common landscape type, well maintained but of no importance in terms of visual (design) or composition (biological) value.

4. Significance: low. Condition: poor

Immediate action: None

Long term action: None, redevelopment

Likelihood of funding: Poor

Notes: Category four is the only one where the notion of action = redevelopment (and thus reverting into a development mode) is justified.

Figure 3.6 Proposal for 'landscape category' for describing the interactions between significance and condition

A category three landscape would develop at Eastwoodhill if the collection was well maintained, and trees replaced at the end of their lives, but with common species. The result would be a site containing healthy and well maintained trees, with no particular significance. Many public parks are in this category, but Eastwoodhill's mission calls for it to be an arboretum, not a park, therefore category three is not an acceptable outcome. If Eastwoodhill ended up with a healthy population of common plants, it could not achieve its purpose as it would lack the significant collection needed at an arboretum.

A category four landscape would develop at Eastwoodhill if the Trust Board was unable to take action on material that is in poor condition because, in time, important groups would be lost and overall significance would decline. If condition remained poor the landscape would ultimately become moribund. At this point it would be a major task to restore both significance and condition to acceptable levels and redevelopment may be required.

Ideally, landscapes should be in categories one or three where condition is good. Enterprises with a focused mission, such as botanic gardens, historic gardens, or recreation sites, should be in category one (where significance is also good) as the significance acts as a drawcard for the site. Category three, however, seems to be a default category; a well maintained landscape with no significance. This appears to equate with the "maintain it till it dies" scenario (FRCC, 1988) which does not look beyond the current growth cycle. Unfortunately this short term time frame is common, predisposing landscapes towards category three. Furthermore, developing a category three landscape could not be a valid management goal; how could one justify a city park which does not have any significance for the values relevant to a city park? Thus *aiming* for category three is poor management, on the other hand, landscapes frequently end up in this category due to various management difficulties.

Categories two and four are the landscapes which develop when either management is poor or funding is constrained. Inadequate management skills or poor understanding of landscapes may generate poor decisions, which leads to landscape categories two and four. Inadequate funding constrains the management activities needed to avoid categories two and four. Inadequate management is often associated with poor funding, but (up to a point) funding should not be a reason for being in these categories. Ideally the manager should identify the 'fabric' and make best use of resources to focus on improving the site.

Landscapes move between categories as biological and management processes act upon the landscape. Natural ageing will reduce the condition of plant material and, if no action is taken, a landscape in categories 1 or 3 (good condition) will move into categories 2 or 4 (poor condition) respectively. In contrast, maintenance, planting and renewal programmes will improve the condition characteristics of a landscape. Constrained management might result in a landscape changing category, e.g. loss of significance in a botanic garden. Conversely, a collection development plan could change a landscape from insignificant to significant. Managers should identify the required category for the landscape, and understand the processes that are needed to keep it there. If the landscape is not in the appropriate category, then significance or condition (or both) should be managed so that the category changes accordingly.

Landscape category is a useful concept for understanding the interaction between significance and condition in the landscape. The categories help define 'required' and 'actual' characteristics of the landscape, plus broad management actions needed to stay in (or get to) the correct category. The concept allows an existing landscape to be described in theoretical terms and allows theoretical future positions to be examined. This comparison helps clarify future choices, e.g. a landscape that fails on biological significance could be revived visually and used for other purposes for the remainder of its biological lifetime.

Conversely, landscape category is limited because, although it describes the interaction between significance and condition, it only considers one value and excludes interactions with other values. Indeed, there could be a landscape category for each value that applies to a site, e.g. a landscape category to describe biological significance and condition, and another one to describe human significance and condition (particularly visual value). Biological significance and condition has already been discussed, showing that composition (diversity, rarity, representativeness) and condition of individuals and populations are important factors. Visual significance will be determined by layout (design) and appearance (maintenance) rather than any particular species of plants. Visual condition is determined by plant health and maturity as these influence visual preference. For example, the value of the garden at Blenheim Palace is based upon a significant design with mature vegetation which is immaculately presented (Cobham, 1985).

When two sets of significance and condition factors exist in a landscape there will be an interaction between them. For example, poor biological condition might be masked by good visual condition. This interplay exists at Eastwoodhill. In recent years appearance of the Arboretum has improved dramatically, but examination of biological condition reveals losses in the collection. Understanding the interplay between different sets of significance and condition is needed if the whole range of values of the landscape is to be successfully managed (not just the primary set). This leads to the proposal for the biological and visual management paradigms, which give guidelines for managing two sets of significance and condition factors in two different configurations.

3.6.2 Proposal for biological and visual management paradigms

Biological and human values are present in all landscapes, but one value or group of values is often in a primary role with others in a secondary role (Kirby, 1986). It is useful to describe the relationship between the primary value (and its management) and the secondary value (and its management). The paradigms describe two hierarchies which define the factors that management activity should focus upon when (i) biological values are superior or (ii) visual values are superior.

If the primary value is biological then long term management focuses upon keeping biological parameters within acceptable limits. Therefore the biological management paradigm focuses on botanical composition and condition factors such as plant health, age and the need for replacement. This paradigm usually has a long term time frame, associated with the long life of living systems. Landscapes with biological value in the primary position include botanic gardens and plant collections as these must meet minimum biological value to achieve their purpose.

Visual factors are present in a secondary role in the biological management paradigm. Visual quality is important in (biological value) landscapes that involve human participation, such as botanic gardens where visual quality is needed to attract visitors. Visual factors may be employed in varying degrees, e.g. in plant collections good appearance may be sufficient without any particular design, but in public botanic gardens good layout (design) may also be needed. The only biological value landscape which does not have visual management in the secondary role is natural landscape where layout and appearance are driven by natural processes. At the same time however, natural landscape that has organised visitation will be subject to visual management, e.g. national parks are 'designed and maintained' around entrances, visitor centres, and car parks.

The management hierarchy in the biological management paradigm is:

- (i) Long term management of significance, focusing on composition (diversity and rarity), themes, and biological layout.
- (ii) Long term management of condition, focusing on health and replacement of individual plants, and condition and cycling of the whole population.
- (iii) Interaction with visual factors:
  - (i) The need for consistent appearance to attract visitors; maturity of vegetation, avoidance of neglect and repair cycles of appearance, recycling area by area to avoid sharp drops in visual value over the whole site.
  - (ii) Organising layout in relation to biological values:
    - (i) Visual layout must accommodate the biological layout.
    - (ii) Visual layout of species should take account of life cycle patterns of species, e.g. long lived plants as backbone, short lived as fillers.

If visual value is in the primary position, then management will focus upon keeping visual parameters within acceptable limits. These parameters are associated with human use of the landscape and focus upon the visible physical attributes of the landscape that generate positive response from the user. (These have already been outlined in section 3.1.3, but include neatness, order, pattern, visual composition, and mature vegetation). Therefore the visual management paradigm focuses on layout and appearance factors such as good maintenance, garden design, and plant display. Landscapes with visual value in the primary position include designed gardens, public parks, urban plantings and gardens for aesthetic display. Management under the visual management paradigm is apparent in historic designed gardens; the literature frequently reports gardens of this type that are overgrown and neglected (category two; significant but poor condition) that are being restored.

Biological factors are present in a secondary role in the visual management paradigm. Biological composition is not particularly important in these landscapes, as visual elements such as 'tall green hedge' can be made from any one of a number of plant species. (The exception is some historic gardens where the plant species also has historic significance). Biological condition does have an important role in the visual management paradigm as plant health contributes to visual quality of the landscape.

The management hierarchy in the visual management paradigm is:

(i) Long term management of layout (design) of the site.

(ii) Long term management of appearance of the site (neatness, maturity, maintenance).

(iii) Interaction with biological factors:

  (i) Acceptable appearance of vegetation is derived from good management of condition; healthy plant gives good appearance. Similarly achievement of mature vegetation is derived from management of life cycle.

  (ii) In the majority of these landscapes botanical composition is not important. Generally it is the appearance of the plant, not the species which is important, thus any number of species could be substituted for the same visual effect. The exception is historic landscapes where plant species <u>and</u> appearance may contribute to significance.

Landscape design is part of the visual management paradigm as it creates the physical characteristics that generate good response. Unless large trees are involved, visual characteristics of a landscape can be achieved relatively quickly, indeed much of the landscape design industry is based on this short time frame. Jackman (1986) criticised the landscape industry for being superficial and operating at the cosmetic level, which could be explained by undue emphasis on notions associated with the visual management paradigm. The reactive manager is also likely to focus upon the visual management paradigm as reactive management, which operates at a daily level, tends to focus on the immediate cosmetic (visual) aspects of the landscape. Matthews (1989) warned against this approach which leads to neglect and repair cycles of maintenance, while the 'fabric' of the landscape declines. This is not suggesting that the visual management paradigm is invalid, in fact it is crucial as it is derived from fundamental human response to landscapes. The manager, however, must understand it, know when to use it, realise that it often has a short term time frame, and that it may not deal well with long term biological values.

The paradigms can be used as a conceptual framework when managing the balance between different groups of values on a site. Decisions that relate to the primary or secondary value can be given an appropriate weighting according to their placement in the paradigm. Thus the biological management paradigm shows that overemphasis on appearance of an arboretum, without a composition plan, is an inappropriate balance. In a designed garden the hierarchy is the other way around as the visual management paradigm directs the balance.

3.6.3 Proposal for an evaluation methodology

As a result of this research a methodology is proposed for evaluation of a single site for management purposes (Figure 3.7). This method draws various ideas in the literature into a coherent process. The method identifies steps to be taken, but allows the manager to define which values should be measured, and how that measurement should be done. Using this framework, the role of each value component should be identifiable. Furthermore, a clear distinction can be made between measurement and processing steps.

Data are; an important prerequisite for this process, thus an inventory is needed to give a basic understanding of the site. Next, significance and condition of the landscape are determined using a range of suitable attributes. Assessment of significance requires a thorough understanding of landscapes, landscape values and their measurement. Similarly, the condition step requires a thorough understanding of landscapes and the biological indicators used to measure individual plants and populations.

In the processing step information is synthesised to determine goals and priorities. This step has received little attention, with no proposed methods for synthesising significance and condition against the mission and goals of the enterprise. The method that I have proposed (and used) can be used to define landscape category and take cognisance of the landscape management paradigms.

The latter two concepts help define the management actions that are needed to achieve the mission of the enterprise and manage its values.

The landscape as represented by its inventory

Identification and measurement of the factors which influence goals and priorities

- Significance (Intrinsic biological values, and ascribed human values)
    - Select the values to be measured
    - Determine the context in which they will be measured
    - Measure
    - Interpret results and make preliminary conclusions
- Condition (of individuals and populations)
    - Select the parameters to be measured
    - Determine the context in which they will be measured
    - Measure
    - Interpret results and make preliminary conclusions

A set of results

Processing of the results including:

- Synthesis of actual significance and condition against required significance and condition, as defined by the mission and goals of the enterprise.
- Definition of current landscape category and required landscape category, discrepancy indicates the actions needed.
- Landscape management paradigms indicate the interaction between primary and secondary value.

Proposed goals and priorities for management action

Figure 3.7 Proposed process for evaluation of a single site

What is missing from these concepts is detail on how to translate them into an operating strategy. For example, how should the requirement for a category one landscape, based on biological value, be related to daily management? Clearly the ideas in the management paradigms must be extended so that the detail needed for daily operations can be developed. Some of these issues are considered in Chapters 5 and 6.

The evaluation process described here could be applied to any type of landscape as long as the operator has certain skills. Ability to operate the process is dependent upon a thorough knowledge of landscapes, landscape values and their measurement, and an understanding of the relationships between significance and condition. Knowledge of the landscape and its purpose will lead to identification of the relevant values. An understanding of values leads to identification of the attributes that should be measured and methods to make the measurements. The processing approaches used in this research could be applied to any significance and condition data, the principles are not exclusive to an arboretum. Thus the overall process has general application, even though specialised knowledge will be needed for particular applications. Much of that specialised knowledge already exists, the advance made by this research is the framework for its structured use in an evaluation process.

3.7 CONCLUSION

The evaluation stage of the management process is an *analytical* step where data are synthesised to reveal important patterns. It involves two steps: identification and measurement of values, and processing of the information to foreshadow goals and priorities. It may involve both inventory data and other information specific to this step. Given the paucity of suitable evaluation processes in the literature, a method has been proposed and developed in this project.

Evaluation should be done from a sound philosophical platform. There are an important series of concepts that should be applied to an evaluation including:

(i) The role of the mission of the enterprise in indicating which value is primary, and the desired landscape category. The mission must be regularly applied to the data, in order to come up with the decisions needed for *this* enterprise. A different mission applied to the same data would give a different set of priorities and subsequent actions.

(ii) Identification of relevant landscape values to give a framework for the evaluation.

(iii) Significance and condition should be separated in the measurement process. Significance is based upon measurement of values, but some of these are not well understood and measurement techniques are not well developed. Biological values in created landscapes are not well described. Condition of populations can be difficult to measure, again because biological indices for created landscapes need more development. Any management factors should be considered separately.

(iv) The processing step involves interpretation of the measurement results against the mission and goals of the enterprise, and proposal of possible goals and priorities.

(v) The landscape category concept can be used in the processing step. It indicates the current status of the landscape. This is compared with the desired category, and therefore indicates the subsequent management actions.

(vi) The landscape management paradigms can be used as a framework for managing the balance between biological and human values in a landscape, and can be configured for either value in the superior position.

These concepts underpin the conduct of the evaluation step itself, but evaluation also fits into a wider conceptual framework associated with the whole management process. Because evaluation measures and interprets values, which underpin the fundamental purpose of landscape management, it creates a link throughout the management process. The mission indicates which values are required in the landscape, an evaluation establishes whether or not those values are present. Any form of mis-match indicates a management problem, perhaps a poorly selected mission or a landscape in the wrong category. Thus mission focuses evaluation and, in return, evaluation supports or otherwise the validity of the mission.

A second link connects evaluation with daily operations. The evaluation will have shown that certain values, and therefore certain fabric of the site, are crucial to the mission. Subsequent goals, priorities, operational plans and daily operations should focus upon that fabric and values. Thus the evaluation is the driving force for latter steps; again a mis-match indicates a management problem. For example, a botanic garden that does not have a composition plan is failing to manage critical fabric of the site.

These links are crucial as they help connect long term and short term management. They also require the manager to continually focus on the fundamental purpose of managing values, as it applies to the site in question. This continual focusing could be seen as a series of questions. Which values are required by this mission, why, and in what hierarchy are they to be managed? Which values does the site actually have, are they the same as those required by the mission, what should be changed if they are not? What goals are needed to sustain or enhance those values? What type of operational plans and daily operations are needed to support the values of the site, do these exist, what should be changed if they do not? In some respects these questions seem obvious, nevertheless they are rarely articulated in the literature that has been available for this research. This suggests that the aforementioned conceptual links are either taken as read, or not appreciated. In either case landscape management would benefit from a more explicit statement of the conceptual thinking underlying the management process.

Returning to Eastwoodhill, the evaluation in this research showed that Eastwoodhill was significant and had the potential to meet the nominal mission and most existing goals. At the same time condition measurement indicated some difficulties, and if no management action is taken significance may be lost, which is an unacceptable outcome for the Arboretum. Finally, Eastwoodhill was found to be a category 2 landscape when it should be a category one landscape.

The Trust Board should take a number of steps to alter the landscape category of the Arboretum. They could either adopt the approaches proposed in this chapter, or develop and implement another approach. Whichever alternative is taken, a set of long range collection goals is needed, condition should be stabilised, and plans developed to manage future significance and condition. These plans should incorporate an understanding of the action of time on biological systems, the consequence of a loss of significance, and the need to manage condition of populations, as distinct from appearance.

Given the significance of the collection, it is unacceptable to do nothing otherwise normal biological change will result in deterioration of both significance and condition and the Arboretum may lapse into category four. When resources are constrained it can be difficult to achieve action quickly but it is important that some action is initiated to address the current problem. This should be done in stages as resources allow.

A method is needed to develop plans for management and renewal of the collection. The plans must be detailed enough to translate broad goals into specific activities at daily operations level. Furthermore, visual value must also be managed, therefore plans will ultimately be needed for layout (design), and appearance, as well as biological significance (collection composition) and condition. This project focuses upon the latter and its relationship to the primary biological value. Chapter 4 addresses the question of a planning method, Chapter 5 illustrates the use of that planning method to develop goals, and Chapter 6 shows the development of plans for particular genera and parks.

Chapter 4

A planning and decision making mechanism: the workshops

Rhododendron 'Winsome', Blackwater, October 1988

4.1 INTRODUCTION AND REVIEW

Development of long and short term goals, objectives, and strategies for management of an arboretum requires a sound planning and decision making mechanism which includes a philosophical position, data, organisational structure, and suitable processes and expertise. This chapter focuses upon development of such a mechanism for the Eastwoodhill collection, known as 'the workshop', which was used to assess the collection and to develop long range goals and short range plans. This chapter focuses upon the workshop as a management tool, Chapters 5 and 6 examine the use of the workshop to develop collection management outcomes. To set the scene for the development of the workshop, three broad ideas must be considered: planning as a management function, decision making as a management function, and planning and decision making in relation to the Eastwoodhill collection.

4.1.1 Planning

Planning is the central management function. Moreover, it is a prerequisite for all other management functions because each depends upon thinking in advance of the actual activity (Bromley, 1990; Massie, 1979; Miller, 1988; Stoner et al., 1985). Miller (1988) proposed that the purpose of planning in landscape management was to ensure continuation of a resource. The need for conscious management action to perpetuate human-made landscapes has already been introduced in sections 1.2.1 and 1.4.6 and is considered in more detail in 6.1.1.

Planning is a systematic and formalised effort to establish the mission, goals and strategies for an enterprise, and then to develop detailed plans to achieve the same (Johnston et al., 1991; Rue and Byars, 1992). Plans give clear direction and purpose to an enterprise, and are used to guide activities towards the desired outcomes (Stoner et al., 1985). Actions, therefore, are based upon method or logic rather than hunch, and the plan minimises chances of mistakes and unpleasant surprises because activities have been subject to careful prior scrutiny (Stoner et al., 1985).

Planning involves thinking out a course of action in anticipation of the future and searching for problems that might occur (Christiansen, 1977; Massie, 1979; Miller, 1988; Stoner et al., 1985). The mental exercise involved in thinking in a future-oriented manner provides knowledge and experience that gives great advantage over static thinkers (Rue and Byars, 1992). In this regard, plans help managers anticipate problems and deal with them before they arise (Stoner et al., 1985). Anticipating the future can be difficult, but those who do not plan face difficulties because many current problems result from failure to plan in the past (Miller, 1988).

When planning is absent crisis management will prevail, where managers react to daily events rather than working to long term goals (Miller, 1988). Crisis managers complete tasks on a daily basis, but are unlikely to reach long term goals (Miller, 1988). It is easy to get into crisis mode as unexpected problems are demanding, immediate and time consuming (Miller, 1988). Predominance of crisis management, and the associated lack of plans, can be caused by a variety of factors. Lack of resources is a key problem (e.g. funding, information or expertise (Griffin, 1990)) which constrain managers' capacity to develop plans. Resistance to planning can also be a problem, particularly in small organisations where managers often question its usefulness (Stoner et al., 1985). Resistance takes three main forms. First, managers are often reluctant to establish goals and make plans to achieve them (Griffin, 1990; Stoner et al., 1985). Such reluctance is usually caused by lack of knowledge or ability, fear of failure, and unwillingness to forego alternate goals (Griffin, 1990; Stoner et al., 1985). Second, reluctance to accept change is an important factor as implementing a plan usually means change, and personnel often resist planning to avoid that change (Griffin, 1990; Stoner et al., 1985). Third, plans are often resisted if they conflict with the personal interests of staff, e.g. plans control work activity and require workers to focus on needed activity, which may not equate with preferred activity (Stoner et al., 1985).

In spite of these difficulties the systematic manager understands that planning helps reduce future uncertainty, and improves the capacity to deal with change. Developing a planning function in an enterprise requires a series of inputs, plus reduction of any barriers to planning. Inputs required include data, planning skills, funding, and expertise relating to the enterprise. Potential barriers to planning can be overcome with four main tactics (Griffin, 1990). First, senior managers should set the mission and grand strategy which provides the framework for all other activities in the enterprise. Second, plans should be communicated to everyone in the enterprise. Third, planning is more effective if those who are affected by a plan are involved in its development. Fourth, the limits of planning should be recognised, in that it will not solve all the problems of an enterprise (other management functions may also need attention). Plans are dynamic, not static, and will need regular revision, updating and adjustment over the course of their use. Massie (1979) called this 'navigational change', i.e. taking advantage of unexpected but immediate opportunities while still pursuing the long term goal. Massie (1979) described management as a paradox because it demands a rigorous and identifiable framework, yet at the same time strives to break out of that framework to be flexible in the face of change and opportunity.

Different types of enterprise show different planning characteristics. Smaller organisations are less likely to plan and generally do not use formal procedures to monitor, evaluate, forecast and control (Stoner et al., 1985). In these organisations the information needed for planning is often unavailable and/or unreliable and most managers are not trained in planning procedures (Stoner et al., 1985). Stoner et al. (1985) proposed that in small organisations "...strategy should be formulated by the top management team at the conference table. Judgement, experience, intuition and well guided discussions are the key to success..." Indeed, intuitive decisions are often used by landscape managers when suitable data is lacking (Miles and Seabrook, 1977). Nevertheless, it is these very characteristics that leaves landscape managers open to the criticism that they make too many subjective judgements and use too little quantification.

Stoner et al. (1985) also described non-profit organisations, which often provide intangible services (such as many of the benefits of landscapes). In these organisations planning is often absent and they are managed in a short term framework only, often focusing upon short term budget cycles and personal goals rather than mission or corporate goals (Stoner et al., 1985). Sales (1990) argued against this approach for landscapes, suggesting that if landscapes were not managed according to mission they would become a personal expression of the manager, which was unacceptable in his view. The planning characteristics of small and non-profit organisations do not bode well for landscape enterprises which are small businesses, which need a long term time frame, and which must use conscious management action to sustain those landscapes.

4.1.1.1 The mission and goals of an enterprise

Planning focuses upon development and achievement of the mission and goals of an enterprise, so these two concepts will be considered in more detail. The mission of an enterprise is a statement of its fundamental purpose, which sets it apart from other enterprises of its type, and identifies its scope in product and market terms (Griffin, 1990). Mission statements establish the philosophical position of an enterprise and provide mutual agreement about the primary task, thereby giving direction to its activities (Eloff, 1989; Kraus and Curtis, 1990; Massie, 1979; Stoner et al., 1985). If an enterprise lacks a philosophical position, or regularly changes it, it will be difficult to establish any basis for management activities and the enterprise "is like a ship without a rudder, subject to every passing breeze or current" (Kraus and Curtis, 1990).

Development of a mission statement requires rigorous and conscious deliberation, considering where the enterprise is going and what one is trying to achieve. The customers should be considered: who they are, what product they are looking for, and what features they look for in that product (Hitchmough, 1994; Rue and Byars, 1992). Enterprises usually have one primary orientation in their mission statement, but may also have secondary approaches (Kraus and Curtis, 1990), such as the science and recreation mix commonly found in botanic gardens. It is important that the mission is re-examined at regular intervals, to ensure that it still meets the needs of the enterprise (Rue and Byars, 1992).

Goals are derived from the mission statement and are a target state or condition that the managers wish to achieve (Griffin, 1990). Goals are a critical management tool as they outline what must be achieved to reach the mission. Goals have four important purposes: (i) to give direction to the organisation, (ii) to facilitate planning, (iii) to motivate employees, and (iv) to act as an evaluation and control mechanism (Griffin, 1990). An enterprise will have different types of goals relating to different time frames (e.g. long, medium, short), functions of the enterprise (e.g. quality, marketing, production), and level in the enterprise (e.g. strategic goals, specific objectives) (Griffin, 1990).

Development of goals should be based upon a thorough understanding of the enterprise and its purpose (Miller, 1988). The process of setting goals must be managed as there are several potential pitfalls to overcome. Selection is influenced by the personal values of the managers, e.g. profit, aesthetics (Stoner et al., 1985), and managers should be aware of those influences. Goals that are clearly unattainable, inappropriate, or not consistent with the mission should be avoided (Griffin, 1990). A mix of quantitative and qualitative goals should be developed, without undue emphasis on either type (Griffin, 1990). The overall set of goals of an organisation must mesh together through the different levels (e.g. Board of Directors, versus single division, versus factory floor) and aspects of that organisation (e.g. marketing goals should be consistent with production goals (Griffin, 1990; Rue and Byars, 1992). To achieve this consistency Rue and Byars (1992) suggested that goals should be developed in a precise order starting with mission, and then followed by long range organisational goals, short range performance objectives, then objectives for each division of the business. This method ensures that daily activities of the organisation relate to the mission.

4.1.1.2 Planning processes and types of plans

Planning takes place in two forms in an enterprise: strategic and operational. At the strategic level the purpose is to analyse the enterprise and develop the mission and long range goals, which give overall direction to the enterprise and provide a framework for all other activities (Johnston et al., 1991; Miller, 1988). This application of planning at the overview level of an enterprise is known as strategic management, which is a common practice in the business world (Griffin, 1990; Rue and Byars, 1992). Strategic management is expanded on in section 4.1.1.3.

The planning that takes place within the strategic framework is called operational or tactical planning, where shorter term plans are developed that contain the detail needed to achieve the strategic plan (Johnston et al., 1991). This type of planning takes place within the philosophical position and criteria set by the mission and long range goals, and activities focus upon steps to achieve those goals. Operational plans are often divided into different time frames. Some business managers distinguish tactical, operational and annual plans, each with a shorter time frame and tighter focus than the one before (Griffin, 1990; Rue and Byars, 1992). Shorter term plans are derived by breaking the long range goals into steps, with each increment contributing to long term goals (Miller, 1988). Annual plans deal with daily management activities and should involve a planned system of activities, such as scheduled and prioritised work activities, equipment maintenance, supervision, reporting, and action plans to deal with crisis situations (Miller, 1988).

Operational plans can be also divided into functional plans for each aspect of the enterprise such as financial, marketing, personnel, or production plans (Johnston et al., 1991). Organisational planning involves determining roles for people within the organisation and then operating those roles. Financial planning involves revenue forecasting, budgetary control and financial allocation. Stoner et al. (1985) suggested that many managers assume financial planning is the only type required and overlook other types.

Different types of plans can be illustrated using a street tree example. Suppose the mission of a city Parks Department is to create a quality city environment. This will be achieved through the overall goal of maintaining healthy and mature tree populations in parks, streets and public places. Within this context an operational plan for the street tree population would be developed, with long term goals such as full stocking of diverse species and ages, adequate maintenance through scheduled services, and prompt removal and replacement of problem trees (Miller, 1988). Achieving those goals would require a prioritised planting plan, a prioritised maintenance plan, a replacement policy, and a plan for diversity of species and age structure (Miller, 1988). Contingency plans might be developed to deal with storm damage or pest and disease outbreaks. At the same time the manager should have a series of functional plans such as a budget, a staffing plan and a public relations plan.

Development of an operational plan has five main stages. First, setting of goals, which are derived from the framework provided by the strategic plan. In the example above, the goal of an operational plan for maintenance would be adequate maintenance through scheduled services, which is necessary to achieve the healthy population required. Next, data must be obtained, otherwise it will be impossible to make the necessary decisions. Thus, the street tree manager should collect information such as number of trees, condition of each tree, work required for each tree, and urgency of that work. The third step is development of objectives to translate goals into operational terms (Stoner et al., 1985). This step usually begins with a review of current objectives (Stoner et al., 1985). At the objectives level street tree manager's might aim to inspect each tree once per year, prune each street every two years, and replant ten percent of streets each year. Next, detailed plans are developed to achieve the objectives. In non-profit enterprises it is common to find that objectives are well known, but there is no explicit strategy in place to achieve them (Stoner et al., 1985).

The fourth step is implementation where the manager organises resources to achieve the prescribed activities. Effective implementation is essential because making a plan and not using it is as ineffective as not making one in the first place (Stoner et al., 1985). The key barrier to implementation is lack of understanding or acceptance on the part of the manager who must implement the plan (Stoner et al., 1985). Sometimes a plan is seen as too complex, unchangeable, or is simply ignored by the manager (Stoner et al., 1985). Implementation may also be inhibited by poor organisational structure, e.g. uncertain hierarchy, or unclear responsibilities (Matthews, 1989; Stoner et al., 1985).

In the final step, control, progress is checked to ascertain that the plan is being achieved (Christiansen, 1977; Johnston et al., 1991; Massie 1979). Without this step the result may be much activity, but little actual achievement of goals (Massie, 1979). Control involves comparing actual performance with planned performance, identifying any discrepancies, then making necessary adjustments to ensure that the goals of the plan are achieved (Kraus and Curtis, 1990; Stoner et al., 1985). This comparison is useful for the manager's 'future sense' and improves their ability to predict the next round of future problems (Massie, 1979). The control function emphasises the use of plans as a continuous management tool rather than simply a development tool (Christiansen, 1977).

4.1.1.3 Strategic management

Business managers define strategic management as the application of planning at an overview level of the enterprise. Strategic management sets the overall position and direction of an enterprise and might include the following elements: mission statement, goals, scope of the enterprise, overall strategies, distinctive competence (a feature that distinguishes this enterprise from its competitors), broad resource deployment, key assumptions about the external environment and competitors, and information about internal and external constraints (Griffin, 1990; Johnston et al., 1991). Thus the strategic plan describes the philosophical position of the enterprise and sets broad and long range goals that it must meet.

Strategic management involves four broad steps: analysis of the enterprise, development of strategy, implementation of the strategy, and finally control. The detail of the steps varies between different authors, but the general pattern of analysis, development and implementation is common. First, the enterprise and the environment in which it operates is analysed (environment in the business sense). This includes an examination of current status, identification of any existing mission, goals, or strategies, and measurement of past performance (Rue and Byars, 1992; Stoner et al., 1985). This internal analysis determines the strengths and weaknesses of the enterprise in terms of human, physical and information resources, and market position (Griffin, 1990; Rue and Byars, 1992). At the same time, an analysis of the business environment identifies threats to, and opportunities for, the enterprise (Griffin, 1990; Rue and Byars, 1992).

The second broad step in strategic management is development of the strategy itself, where the future course is set and the enterprise is matched to its business environment, thereby minimising threats and weaknesses and taking best advantage of strengths and opportunities (Griffin, 1990). This step includes the mission statement and goals which form the framework for subsequent plans. Business managers also include the notion of 'grand strategy' as a component of strategic management. Three types of grand strategies are identified: growth, retrenchment and stability (Griffin, 1990; Rue and Byars, 1992) which describe the general direction an enterprise might take.

The third step in strategic management is implementation of the strategy which is done by developing shorter range objectives and tactical and operational plans, which contribute to strategic goals. Tactical and operational plans have shorter time frames, more detail and narrower focus in order to address the specific actions that are needed to achieve strategic goals (Johnston et al., 1991). Some consider tactical and operational planning to be synonymous (Johnston et al., 1991; Rue and Byars 1992), while others separate them with tactical planning at a higher level (Griffin, 1990). This separation relates to very large organisations that might be involved in multiple businesses, each with several divisions. The whole organisation has a strategic plan, each business has a tactical plan, and each division has an operational plan. In smaller organisations separate tactical and operational plans may not be needed. Finally, as with any plan, the strategic plan must be subject to control which has already been outlined in the previous section.

The similarity between strategic management and planning in general is quite apparent, but there are two key differences. First, the strategic process begins with an analytical step, where the purpose is to determine strategic goals. This is in direct contrast to operational planning where strategic goals are already known, and the operational process begins within a framework of goals which have been taken from the strategic plan. Clearly an enterprise that does not have a strategic plan will not have any framework for operational planning and must develop a strategic position before any useful operational planning can take place. The second difference is the broad nature of strategic planning in that its purpose is to take an overview of the enterprise and then effectively position it in the business environment, which contrasts with the detailed, focused features of operational planning. This broad nature of strategic planning places it in the domain of senior managers and calls upon their abilities at conceptual, diagnostic and analytical thinking (Griffin, 1990).

4.1.2 Collection planning at Eastwoodhill

Eastwoodhill is a small non-profit organisation. Therefore it might be expected that a long term framework and a planning function would not be found in this enterprise. In general this was correct, with only a few planning activities and documents being generated.

As a private individual, Douglas Cook did not produce formal written plans but he did make strong statements of intent in various written articles (Cook, 1948, 1949, 1950a, 1963). These have already been presented in Chapter 1 and showed that Douglas Cook wanted to develop an arboretum that contained a wide range of exotic woody plants. When the Trust Board took over the property in 1975 it might be expected that either planning, or the basis for planning, was developed.

Indeed, at an early stage Mr Williams commissioned Mr Thorp to engage a suitable person who would advise on maintenance, development and management of the Arboretum (Thorp, 1971). Thorp (1971a) was of the view that there was insufficient expertise locally for the task, therefore outside experts were consulted. The need for planning was supported by a variety of experts who advised the Trust Board (Advisory, 1979, 1980, 1981, 1982, 1983, 1985, 1986; Chavasse, 1976, 1978; Greenwood, 1976; Skipworth, 1976; Taylor, 1980). This view was reinforced by those involved locally (Overbye, 1984; Way, 1978; Weatherall D, 1982, 1985) who believed that the Arboretum would decline if action was not taken (Berry, 1978; Weatherall K, 1985; Williams, 1987, p 50). Although the need for planning was recognised, a management plan was not commissioned until 1984 (Board minutes 21.6.84). Until that time planning was seen as too expensive (Advisory, 1983; Board minutes 9.8.78; Board minutes 12.8.82), and the Board gave priority to structural elements of the property such as water supply, workshops, and repairs to the homestead (Board minutes 3.7.79; Board minutes 15.10.85).

While the outside observer might question why planning was not initiated sooner, it is important to note that the Trust Board took over a property that was in poor condition, and had to operate under a marked financial constraint. Only one labour unit was possible for the 65ha Arboretum, until 1988 when a second person was employed; even two labour units on a property of that size still represents a severe constraint. Therefore the Trust Board operated in very difficult conditions, nevertheless they achieved significant progress over the first ten years from 1975 to 1985. Major improvements were made to, (i) property infrastructure such as fencing, new driveway, tracks, water supply, improved levels of equipment, and development of a major new water supply (Board minutes, 4.9.79; Board minutes, 20.11.84; Board minutes 8.12.87), (ii) labour and housing such as improving the homestead, provision of a second house, and employment of a second person (Board minutes, 3.8.88; Manager, 1985), (iii) visitor facilities such as a visitors pavilion, improved tracks, signs, noticeboards, labelling, and brochures (Board minutes 8.8.78; Board minutes, 2.8.83; Board minutes 15.10.85; Manager, Dec 1985; Manager, April 1986), and (iv) administration such as the formation of the Friends association, and employment of a qualified curator.

Another reason for a delayed start to planning was the condition of the property. Even after ten years of clearing work by private owners, the Arboretum was in poor condition when the Trust Board took over, being choked with volunteer plants and weed species which made it almost impenetrable in places. From 1975 to 1985 the Board focused on a clearing strategy with an estimated half million superfeet (13,500 cubic metres) of timber removed from the property including dead trees, weed species, damaged shrubs, duplicated species, shelter trees, and trees at the end of their life (Williams, 1987, p 50). The Arboretum was cleared park by park and advisors regularly noted the improvements (Advisory, 1978, 1979; Taylor, 1980; Advisory, 1980, 1981, 1983). Clearing was completed in the Gardens and Corner Park (Manager, Sept 1983, March 1984, Dec 1985, April 1986, April 1988), Orchard Hill (Board minutes, 29.7.81; Manager, Dec 1985), Cabin Park (Manager, March 1984, April 1984; Board minutes, 2.12.85; Manager, Dec 1985, Feb 1988), Theatre and Cedar Garden (Manager, March 1986), Circus (Manager, Oct 1986), various parts of Douglas Park (Manager, July 1984, Jan 1987), and Glen Douglas (Manager, April 1984).

Although the emphasis had been on clearing and infrastructure improvement, there were some activities relating to planning for the collection. A significant advance was the inventory of the collection (Berry, 1976, 1980, 1982) which was an essential basis for planning, and some planning documents were developed from that information. In 1980 a committee was formed and asked to formulate plans for replanting (Board minutes, 25.11.80). A planting plan was produced (Berry, 1980a) and observation suggests that most of the recommendations were followed, although there is no supporting documentation. In 1985 an executive committee comprising R.J.Berry and T.L.C.Williams was formed with the purpose "to inspect progress to date and to determine priorities for future works" (Board minutes 12.3.85). The committee met once and wrote a report; again observation suggests that most of the recommendations were followed. In 1987 another planting committee was formed which met twice and produced a report; most of those recommendations were also followed. Thus, although there were several planning initiatives, they were fragmented activities that did not continue in the long term. The level of implementation varied and there was no evidence of monitoring. Unfortunately no long term plans were generated, or any long term overview of the collection. The short-lived nature of the initiatives probably stems from two causes, lack of information and a weak planning process.

A review of planning for the Arboretum should include the 1987 management plan (Williams, 1987). This document was a major advance at the time as it was the first official plan relating to the future of the Arboretum. Its purpose was to "provide a deliberate assessment of the resource" (Williams, 1987) and was a comprehensive document giving broad coverage to the enterprise. It considered the Arboretum under four categories, setting out objectives and policy for each category, including notes of explanation and implementation. The four categories were:

(i) administration and management: the Board, management roles, labour, the garden group, and the Friends Association.

(ii) finance: publicity, finance.

(iii) use of the Arboretum: types of uses, facilities and buildings, interpretation, signs.

(iv) resource protection and development: the collection policy, protection, future planting, records, propagation, maintenance, equipment, the farm, the development strategies.

This research focuses on the collection management aspects of the plan and will not comment on other aspects.

Although it was a major advance at the time, the 1987 management plan had insufficient detail or data to be a long term planning document for the collection, thereby being restricted to a general discussion of collection management. (This has already been partly demonstrated in Chapter 3 where the plan was examined with respect to evaluation of the collection.) The objectives for "resource protection and development" were (Williams, 1987, p 50):

- "To preserve the property as an arboretum."
- "To conserve and restore the plant collections as well as the landscape and historical features."
- "To develop the systematic botanical and horticultural collections integrating them into the arboretums landscape character."

These statements are in keeping with the overall goals of landscape management, and the need to ensure the continued existence of the Arboretum. Unfortunately, the plant collections, landscape and historical features, and botanical and horticultural collections were not described, therefore these goals could lead to a variety of outcomes depending upon how they were implemented. The collection policy also involved broad statements, in that the Arboretum should contain "mainly northern hemisphere and temperate zone woody plants" which are "geographically and taxonomically related to those plants established to date" (Williams, 1987, p 51). The same ideas were restated in the priorities for future planting, with the addition of expansion of the taxonomic range from the northern hemisphere (Williams, 1987, p 56). Again these ideas are in keeping with the evaluation results, but their general nature could foreshadow a number of possible outcomes. Although Williams did not provide further detail he recognised that future development must be targeted with firm decisions on acquisition of plant material (Williams, 1987, p 55).

The management plan was limited to a general discussion because, with respect to collection planning, there was limited examination of inventory or evaluation data. Evaluation involved identifying eighteen genera with "notable numbers" and a brief discussion on significance which proposed several values for the collection (Williams, 1987, p 14), but there was no assessment or validation of those values. Without such analysis, the management plan was based on anecdotal knowledge of the time and constituted logical, but unsubstantiated, proposals. Thus the management plan was a useful philosophical guideline which could be built upon if supporting data and processes could be established. Some proposals in the management plan have been supported by this research and, in relation to collection planning, the management plan should be rewritten with the benefit of newly generated data and other new developments.

Turning to another issue, the Trust Board appeared to show some reluctance to plan. Once the management plan was adopted by the Trust Board it was seldom mentioned in Board minutes and there was little documented evidence of it being used as a planning or monitoring device. This suggests either reluctance to plan, or some difficulty in using the plan as a management tool. Two records from 1988, however, suggested that the Board was reluctant to plan. First, the Board queried the relevance of a planning project that was about to be initiated for the remainder of the property by Jackman (Board minutes 30.3.88) and, second, in 1988 the advisory committee was still urging the Board to plan ahead for planting (Advisory, 1988).

This apparent difficulty must be related to weak definition of mission, goals and objectives. It has already been stated that there was no formal mission statement and, although the Act implied a clear primary purpose, the records suggested that the question of primary purpose was not resolved. Importantly, the matter of the target audience was subject to debate. In 1978 the Board expressed the view that the Arboretum was for scientific, botanical and educational purposes and that the public were not to be encouraged as the casual visitor was not beneficial (Way, 1978). Chavasse (1976), however, had already pointed out that the collection was not in a suitable configuration for the aforementioned scientific purpose, and outlined a proposed redevelopment (Chavasse, 1976a). Way (1978a) disputed the idea suggesting that "a public botanical garden" was *not* the intended role (my emphasis). The difficulty of resolving goals and objectives was illustrated by a discussion which suggested that, although the Trust Board were 'senior managers' of the Arboretum, they did not perceive that their role was to set objectives for the collection.

> "From time to time discussion took place as to the future of the collection of trees and shrubs and the policy of the Board for the development of the Arboretum.....These discussions could said to have been brought to a head at the meeting of the advisory committee on 9.2.78. On that occasion Mr Chavasse, on behalf of his fellow members, stated that the advice of the advisory committee depended largely on the policy which the

> Board wished to pursue for the future of the Arboretum. To this, Mr Williams as chairman quite properly replied that the future policy of the Board would be guided by the advice of the advisory committee." (Way, 1978).

Having expressed this point of view, the Board did not accept the plan proposed by Chavasse (1976a), and an alternative was proposed (Berry, 1978). Berry (1978) pointed out that the Board could carry on without a plan, which would "be something of a laissez-faire approach relying on past performance and just maintaining things more or less as is". He warned however, that there was no room for complacency or Eastwoodhill would lose its leading position in the future (Berry, 1978). As previously discussed, the 'no planning' approach is not viable for landscapes with important biological values that must be maintained over the long term.

In adopting the management plan (Williams, 1987) the Board adopted a role for the Arboretum "to promote and develop the function of the Arboretum in that it has scientific, conservation, educational and recreational uses" (Williams, 1987, p 39). The initial statement of objectives promoted the same idea of "scientific, conservation, educational and recreational uses" (Williams, 1987, p 16). It might be suggested that the previous debate over the role of the Arboretum was still not resolved, as the aforementioned resolution allowed for all possibilities. Unfortunately, the management plan was contradictory; the aforementioned statements are at the start of relevant sections, but different views are put forward in the text - in several sections the primary function was given as science and education only (Williams, 1987, pp 35,39,40). The statement that "there must be constant debate over the question of public against primary function; i.e. science and education value, balanced against attracting funding without having the place too widely known and used" (Williams, 1987, p 35), suggested that the important question of primary role was not resolved, and/or any mechanism for prioritising roles and managing within a hierarchy was not operating. The variety of views in the management plan left the Board with no firm guideline for choosing between activities with a scientific versus recreational outcome.

A similar debate on long range collection goals was also apparent when Trust Board records were examined, showing that the Board did not come to a consensus on characteristics of the collection. After initial discussions and meeting with the advisory committee (Advisory, 1978) the Board adopted a geographic layout for future development (Board minutes, 9.2.78). In response to this resolution Chavasse (1976a) produced a development proposal which, after discussion, was rejected by the Board which stated that it preferred the main body of the Arboretum to remain as it was, which they described as "haphazard or higgledy-piggledy" (Board minutes 12.12.78). This position was justified on the basis that it was more appealing to the average visitor; but it was considered acceptable to plant *some* areas on a geographical basis (Board minutes 12.12.78). In 1979 the advisory committee suggested that a framework for future planting be developed (Advisory, 1979) to which the Board replied that it did not wish to develop such a framework and wished to continue in the (then) present haphazard manner as the average person was not interested in organised plantings (Board minutes 6.11.79). This position would have been reasonable, if the primary role of the Arboretum was for visual display for recreational purposes, but it did not equate with the more organised collection needed for a primary role of science and education. These seemingly inappropriate choices suggested an unresolved purpose, or inappropriate mechanisms for operating under a hierarchy of goals.

Without background data or an agreed role for the collection it was impossible to either select or defend any particular themes for the collection. The management plan addressed this issue and with its adoption the Board accepted "display in a generic or geographic setting" (Williams, 1987). Nevertheless, after the draft plan was put out for comment in 1984 (and in direct reply to a question on generic and geographic themes (Advisory, 1985)) the Board stated that it preferred a mixed approach (Advisory, 1985). The critical observer might conclude that these events illustrated an unresolved approach to collection development.

Concomitant with the aforementioned situation it was not surprising to find that there was no long term planting plan for the collection. Various advisors and associates had stressed the need for a planting plan (Advisory, 1979, 1980, 1982, 1988; Greenwood, 1976; Weatherall, D. 1982, 1985; Weatherall, K. 1985). In 1986 the advisory committee felt that the Arboretum had "an uncoordinated approach to planting" (Advisory, 1986) but the Board replied that it had a planting policy; the mixed species approach (Board minutes, 20.9.86). Clearly the Board had not distinguished between a planting policy and a planting plan. Williams (1987) proposed that planting decisions should be made with reference to the original concept; "to grow every worthwhile tree and shrub against possible loss in the northern hemisphere" (Williams, 1987, p 51). He called for deliberate acquisition of plant material following a predetermined priority list which was: northern temperate material, plants related to material already in the collection, replacement of those lost or declining, and expansion of the taxonomic range from the northern hemisphere (Williams, 1987, p 56). These views are too broad to be realistically applied to a total collection of 621 genera and 5647 taxa, and should be re-examined against inventory and evaluation data and a more detailed focus developed. In fact Williams subsequently stated that Douglas Cook's 'grow everything' policy was no longer feasible and that future planting decisions should be made to fit the available resources (Williams, 1987, p 56). Williams did not consider planting any further and did not address the issue of a planting plan.

Thus, the Board was in a position where it had developed basic documentation but had not developed an agreed philosophical position, a formal mission statement, a consensus on long range goals for the collection, or any operational plans for planting, maintenance, or collection development. The difficulty in developing plans must have been related to the unresolved primary purpose for the collection, insufficient data, insufficient processing of data that was available, and underdeveloped goals and objectives. The use of the management plan as a management device might be questioned as it was infrequently referred to in Board business, and contradictory views were expressed. Development of new management approaches could overcome some of these difficulties, and, when combined with the results of the evaluation in Chapter 3, new planning methods for the collection would be a logical development.

4.1.3 Decision making

Decision making is a key management function as it is a component of all other management functions. A decision is a course of action consciously chosen from available alternatives and for the purpose of achieving a particular result (Massie, 1979). An important part of the manager's role is identifying decisions that need to be made and examining their likely outcomes (Bromley, 1990; Kraus and Curtis, 1990). Decision making is underpinned by three important ideas: the notion of choice, mental processes at the conscious level, and the idea of deliberate purpose (Massie, 1979), indeed, the process of making the decision is as important as the decision itself (Bromley, 1990).

There are three main types of decisions. First, crisis decisions which are used in an emergency (Bromley, 1990) and clearly relate to short term management, e.g. repair after storm damage. Second, organisational decisions which are made within predetermined guidelines, e.g. standard procedure for dealing with customer complaints, or rules for use of equipment (Bromley, 1990). Third, planned decisions are those which the manager foresees, and specifically allocates time to approach in a systematic way, e.g. next year's planting plan (Bromley, 1990). Unfortunately many decisions are only taken when symptoms of the problem become obvious, i.e. crisis management, where one runs the risk of curing the symptom and not the problem (Bromley, 1990). For example, a large number of declining trees in a population may require a large time and cost input from the removal crew. The crisis manager may see the problem as insufficient resources for the removal crew, who cannot keep up with the workload. The systematic manager would uncover the real problem, a poor age distribution in the population caused by poor planting policies in the past. The solution is to develop a planting programme which adjusts the age distribution of the population and ultimately creates a consistent workload for the removal crew. The immediate problem of an overworked removal crew must still be dealt with, but by taking the long term view the systematic manager ensures that the problem does not occur again. This scenario underlines the importance of recognising what type of decision to use and when to use it, as important decisions taken on the spur of the moment are rarely effective (Kraus and Curtis, 1990).

Decision making has several steps which focus upon understanding the situation, developing and selecting the best solution, then implementing that solution. Rue and Byars (1992) suggested that the process starts with 'intelligence' where one searches for conditions that require a solution. Then a solution is developed using steps such as the following:

(i) Understanding the situation (Massie, 1979). A number of factors will provide a context for the current decision, such as past actions and decisions, relevant information, and any predetermined objectives (Massie, 1979).

(ii) Problem definition. This is the most important step as a clear understanding of the issue is critical. Often the symptoms are obvious, but the underlying cause is not (Bromley, 1990) and managers are mislead by symptoms and assume the obvious (Johnston et al., 1991). Fact must be separated from opinion (Johnston et al., 1991). Limiting factors should be identified (Massie, 1979).

(iii) Search for and analysis of alternatives. All data related to the problem and the alternative solutions must be gathered, such as hard data, opinion, and assessment of constraints (Bromley, 1990). Next, alternative solutions are developed. Complex problems may need creativity in developing solutions; group decision making is useful in this regard (Johnston et al., 1991). An analytical stage is next, where the consequences of each solution is examined (Bromley, 1990). Logic is the key to these steps (Massie, 1979).

Massie (1979) described the process for examining alternative solutions, which focused on the premise as the basic unit of decision making. The premise is a statement of relationship between cause and consequence, i.e. if one does A then B will result. B's can be categorised into desirable and undesirable, giving a framework against which each premise can be measured. Developing and analysing alternatives involves developing a series of premises that are used to select the best solution, but in practice there are complicating factors. First, no framework can include all possible premises, in fact people can deal with a maximum of about seven (Massie, 1979). Thus any framework will tend towards certain conclusions, emphasising the need to understand the problem properly in the first place and formulate the right types of premises to measure the decision against.

Second, factual and value premises should be separated. Factual premises are observable and measurable, while value premises can only be asserted to be valid and may contain bias (Massie, 1979). 'Bounded rationality' will influence the selection of alternatives and managers may 'satisfice' rather than optimise (Johnston et al., 1991). (These concepts are explained below). Concealed premises must also be considered, i.e. premises that hide other value judgements or assumptions (Massie, 1979).

(v) Selection of the solution. Ranked goals are needed at this point to rank preferences which in turn determine the selection (Massie, 1979). Massie (1979) suggested that the 'best' solution is often only slightly better than the 'satisfactory' ones. Selection of the solution will be influenced by the values of the managers, e.g. profit versus social values, and an alternative that is viable for one person may be unacceptable to another (Rue and Byars, 1992).

(vi) Implementation of the decision. This step may have many substages as the decision makers may not be the decision implementors (Bromley, 1990). Implementation is more successful if those responsible for implementation are involved in making the decision (Bromley, 1990). Acceptance of the decision is the key notion at this stage, because action will not occur if the solution is not accepted (Massie, 1979).

(vii) Monitoring effectiveness of the decision. This fills the same role as control, which was described in section 4.1.1.2.

Business managers call the decision making process outlined above the rational, classical, scientific or optimising approach (Griffin, 1990; Rue and Byars, 1992). The approach is based upon the assumption that people behave rationally and makes four main assumptions: (i) that people have clear criteria and weightings are stable, (ii) that people have full knowledge, (iii) that people have the ability to evaluate alternatives and rate each one logically and rationally, and (iv) that people have the self-discipline not to manipulate the system (Griffin, 1990; Rue and Byars, 1992).

Management experts believe that, in reality, the assumptions do not hold true and decision making is actually done by the approach in the administrative model (Griffin, 1990; Rue and Byars, 1992). In this model decision makers 'satisfice', i.e. select the first alternative that meets a minimum set of requirements, and do not continue searching for an optimum solution. This occurs because, in reality, knowledge is limited and people act on the basis of a simplified view of the world that is influenced by personal perceptions and biases (Griffin, 1990; Rue and Byars, 1992). This is called 'bounded rationality' where decision makers are 'bounded' by their values and unconscious reflexes and habits (Griffin, 1990). The characteristics of the administrative model mean a manager's decisions may not be in the best interests of the organisation (Griffin, 1990). Griffin (1990) proposed that both models contained useful lessons; the rational model shows how to improve the logic and rationality of the approach, whereas the administrative model can be used to understand the inherent limitations in decision making.

The decision making process described above highlights two important issues for an enterprise: expertise and data. The ability to understand the situation, identify the problem, and formulate alternative solutions assumes that decision makers have sufficient background in the subject in question. A minimum level of knowledge is needed to recognise important issues and data that should be used in the decision otherwise the decision is unlikely to be the best one. Development of premises and alternatives depends upon relevant data, satisfactory decisions will be hard to achieve if data is lacking. Kraus and Curtis (1990) proposed that competent decision makers must have technical expertise, (but not necessarily in every aspect of the enterprise), be able to recognise when action is necessary, and know when to employ suitable consultants with in-depth knowledge.

There are also important behavioural ingredients in decision making (Griffin, 1990). The first of these is politics where groups of people try to achieve a particular solution. Political influences can be positive and help keep an enterprise on track, or negative and strangle well conceived strategies. Second is intuition, which is an innate belief about something without conscious consideration (Griffin, 1990). Sometimes intuition can be valid, but inexperienced managers must be careful about using it and not overlook rationality and logic (Griffin, 1990). The third behavioural component is escalation of commitment where one holds to a decision even when it is clearly wrong; an enterprise may collapse if managers refuse to consider other options (Griffin, 1990).

Decision making roles vary depending upon position in the enterprise. At the top of the hierarchy are senior managers who are responsible for the whole enterprise and who develop long range planning decisions associated with the strategic plan (Griffin, 1990; Kraus and Curtis, 1990; Rue and Byars, 1992). At the other end of the spectrum are front-line managers who are responsible for daily operations. Such managers spend most of their time on decisions relating to supervising short term and daily tasks (Kraus and Curtis, 1990).

Decision making may be done by groups rather than by individuals, and this approach has several advantages. Groups bring together a range of expertise and points of view, and can generate a wide range of alternatives, and creative or innovative solutions (Griffin, 1990; Massie, 1979; Quinn et al., 1990; Rue and Byars, 1992). Groups can be used to negotiate between conflicting positions, or to support a point of view (Massie, 1979). Groups may be used to avoid the appearance of arbitrary decisions, or to avoid giving too much authority to one person (Massey University, 1993). Groups facilitate acceptance of decisions, when those affected by the decision were part of the group that made the decision (Griffin, 1990; Quinn et al., 1990).

There are also disadvantages in the group approach (Griffin, 1990; Massey University, 1993; Massie, 1979; Quinn et al., 1990; Rue and Byars, 1992). First, it is expensive and a group can take longer to reach a decision. Second, groups will not be effective if they do not have the expertise for the decisions at hand. Third, one person may dominate the group, or competition may develop so that 'winning' becomes more important the issue at hand. Fourth, group action may result in compromise rather than consensus. In a similar fashion social pressures may inhibit members from putting forward non-conformist views. Griffin (1990) described 'groupthink' where the desire to avoid conflict overwhelms the need to reach the best decision, resulting in poor decisions. Fifth, the group structure means no one person is responsible for the decision which may lead to poor accountability. On the other hand, groups often make more risky decisions because individuals feel less responsible for those decisions.

A group approach can be useful for planning because several viewpoints can be incorporated into a single solution (Massie, 1979). Similarly, decisions requiring the input of a range of specialists are suited to a group approach (Massie, 1979). The conclusions of such a group are often advisory, the actual decision being taken by a senior manager (Massie, 1979). Implementation, on the other hand, is better done by a single executive as groups are weak mechanisms where immediate and forceful action is needed (Massie, 1979).

4.1.4 Organising a decision making group

An enterprise should be logically organised as poor structure will hamper performance at every level (Kraus and Curtis, 1990). Structure includes both formal and informal elements (Kraus and Curtis, 1990). Formal structure is comprised of stated rules, policies, and work procedures that are devised by management (Kraus and Curtis, 1990). Informal structure relates to the interpersonal behaviour and decision making of individuals (Kraus and Curtis, 1990).

A decision making group is part of the structure of an enterprise, and it should be organised to focus attention on solving problems and achieving goals (Massey University, 1993; Quinn et al., 1990). Massie (1979) suggested that much of the criticism levelled at committees is not caused by the group concept, but the way it is applied. Too often groups are not used to make decisions, but to ratify decisions that have already been made, therefore negating the advantages of group interactions (Massie, 1979). An effective group operates within the organisation of 'the meeting' which has two essential elements, participants and organisation (Massey University, 1993).

4.1.4.1 Participants in decision making groups

A decision making group should be small, not more than about 12 people, and the following criteria should be used to select members of the group (Massey University, 1993):

(i) Knowledge of the subject area involved in the problem. The group must have sufficient expertise to develop a valid solution to the problem.

(ii) Commitment to solving the problem.

(iii) Members must have time to participate.

(iv) Diversity of viewpoint.

(v) Expressiveness, i.e. the capacity to express an opinion on the subject and participate in discussion.

(vi) Open mindedness. Members should be prepared to change their minds when presented with compelling arguments, allowing the best solution to be reached.

4.1.4.2 Organising a decision making group: the meeting

Preparation for a meeting starts by setting goals for the forthcoming session, then developing and distributing an explicit agenda in advance of the meeting (Bromley, 1990; Massey University, 1993; Massie, 1979; Quinn et al., 1990). Ideally, agenda items should be prioritised and the meeting planned with set times for each item (Massey University, 1993), although there should still be flexibility to discuss any important issues that arise. The agenda may be a brief document for the participants, but those managing the meeting should have detail on time allocation, techniques and data to be used, and equipment needed (Massey University, 1993). The data should be identified, acquired and analysed in advance of the meeting. It should be complete and accurate if it is to be useful in generating alternatives and making decisions (Massey University, 1993).

The meeting should take place on neutral ground and with a designated time, place, and timetable (Massey University, 1993; Massie, 1979; Quinn et al., 1990). It begins with a review of the agenda, making any necessary adjustments at the start (Quinn et al., 1990). Ground rules for conduct of the meeting should be made at this point (Massey University, 1993). Operation of the meeting is managed by the chairperson who makes sure that the agenda is completed, time is kept, and everybody participates. When the meeting is in session emphasis should be on interactive discussion, with participants facing each other (Massey University, 1993). Group discussion should generate alternative approaches to the problem, with discussion continuing until a consensus solution is formed. Consensus does not necessarily mean unanimity, but should result in individuals accepting the group decision on the basis of logic and feasibility (Massey University, 1993). If action is based on a minority view then the group has failed to do its job (Massie, 1979). The meeting should conclude with a restatement of any decisions reached or tasks assigned (Quinn et al., 1990). Minutes should be taken throughout the meeting and later distributed to all participants (Quinn et al., 1990).

4.1.4.3 Organising a decision making group: roles

Successful groups depend upon well organised structure and properly managed meetings, requiring that some members take certain roles such as researcher, chairperson, or group manager (Bromley, 1990; Massey University, 1993).

The group manager's task is to organise meetings before and after the event. This person plans the structure of each session, defines problems to be addressed, and formulates and circulates the agenda. Any necessary data must be researched, processed and presented in a form suitable for the meeting. Protocols for the meeting should be determined, which the chairperson uses to manage the meeting at the actual event. The planning stage is crucial as the decision making process begins at this stage; in defining the agenda, the data needed, and the issues for discussion, the manager is making a preliminary definition of both the problem and the related situation.

This illustrates the critical role of a group manager. This person must be able to recognise problems, define the right problem, understand what is relevant to understanding the problem, recognise what type of data will be needed, research and process that data, and plan a suitable discussion session. These requirements underline key roles of managers, including the ability to recognise decisions that need to be made (Bromley, 1990), and to use the right type of decision (Kraus and Curtis, 1990). At the same time, the manager must have the discipline and self-awareness to avoid bias (as much as possible) and similar mis-uses of their position.

The chairperson's role focuses upon the meeting itself. Their task is to control and guide the operation of the meeting by focusing the group, keeping them on course, and ensuring that the agenda is completed (Massey University, 1993; Orsburn et al., 1990). First, they introduce the topic and outline objectives for the session, then initiate action (Massey University, 1993). The chairperson uses the agenda to keep discussion on the topic and maintain an appropriate pace, but at the same time stimulating discussion, facilitating conflict resolution, and bringing out differences of opinion (Massey University, 1993; Orsburn et al., 1990). The chairperson also oversees the interpersonal interactions of the meeting (Massey University, 1993). They monitor participation, facilitate feedback amongst members, and ensure that the group deals openly with conflict and individual feelings (Bromley, 1990; Massey University, 1993). As the discussion develops the chairperson summarises the proceedings and tests the feeling of the group on forthcoming decisions. Finally, the chairperson ensures that action plans are developed before the session closes and finishes each session with a summary (Massey University, 1993; Orsburn et al., 1990).

4.1.5 Decision making for collection management at Eastwoodhill

The decision making authority at Eastwoodhill is the Trust Board, which has already been described in section 1.1.2 and whose role is to manage the Arboretum (Eastwoodhill Trust Act, 1975; Williams, 1987). The Trust Board is ultimately responsible for all decisions, but their primary focus should be on the mission, long range goals and planning. Daily decision making is the responsibility of the employees; the curator and his assistant (Williams, 1987). In an indirect link is the supervisor, who is not an employee, and who liaises between Board and employees and assists the curator by facilitating activities and providing advice.

The 1975 Eastwoodhill Act also included a scientific advisory committee, which was obliged to meet once per year and report to the Trust Board. It contained three members from national scientific institutions, namely Massey University, the former Forest Research Institute and the former Department of Scientific and Industrial Research. The 1994 amendment to the Act eliminated the advisory committee, removing any legal obligation by the aforementioned institutions to provide advice. The Board retained the power to co-opt and to create other committees as appropriate (Eastwoodhill Trust Act, 1975).

The Trust Board meets approximately every 1-2 months with its deliberations recorded as minutes. Meetings were usually attended by the curator, the supervisor, and occasionally retired Board members who attended depending upon the business at hand. Minutes were circulated to Board members and, prior to 1994, also to members of the Advisory Committee. Obviously one cannot comment directly on previous methods of decision making, but the commentary in section 4.1.2 suggests that some new approaches to decision making for collection management might be beneficial. A number of observations suggest that the prerequisite conditions for effective collection management decisions were not as strong as they might have been .

First, as previous discussions have illustrated, the Board did not have the data necessary to support decision making for collection management. Although there was an inventory there was no documented evidence that this data was evaluated, and no other data was developed. The absence of detailed data would make it difficult to define problems, develop alternatives, or select the best solution; indeed, the entire decision making process relies upon data, and in its absence the process will be weakened. It could be argued that a detailed anecdotal knowledge of the collection could substitute for recorded data, and a sound knowledge of the Arboretum could have been used as a informal basis for decision making. The curator is well placed to develop such knowledge, but its usefulness is likely to be reduced by other aspects of the decision making process (next paragraph). Of the Board members, Mr Berry developed this level of knowledge through his studies of the collection, but other members of the Board did not visit the Arboretum frequently enough to reach a similar level. Overall, the Trust Board was an infrequent visitor to the Arboretum. During the period 1975 to September 1983 the Board held 33 meetings, but only three of those were at the Arboretum, indeed, the Board were criticised for not visiting more frequently (Weatherall, K. 1985). From October 1983 to the end of 1988 ten out of twenty six meetings were held at the Arboretum, the change in frequency being stimulated by a new curator who sought greater participation by the Trust Board at the Arboretum. As infrequent visitors to the Arboretum the

Trust Board would find it difficult to develop a suitable level of knowledge, assimilate the requirements of daily operations, or usefully contribute to those operations.

The second problem is the relationship between long and short term management and the influence this has on decision making. Short term (daily operations) management takes place within the context of long term goals and should contribute cumulatively to those goals. Confidence in the nature and direction of short term management is generated from the knowledge that those operations sit comfortably with, and contribute to, the 'bigger picture'. The Trust Board are more likely to be assured of the appropriateness of daily decisions, and more likely to delegate those decisions when the links between short and long term management are clear. This was likely to be a problem at Eastwoodhill as the long term goals were not clear, thus the framework that should have underpinned daily management, and assured the Board of its suitability, was uncertain. There are two likely responses to this situation.

Although daily decision making may apparently be delegated to the curator, uncertainty about the long term framework may mean it was not a true delegation (with the associated acceptance of decisions), and those decisions may be revisited when the Board met. Thus, although the Board had limited participation in daily operations it would comment on the results, and outcomes of operational decisions might be debated after the fact, rather than reaching a consensus before the event. Under this scenario it is inevitable that individual members, whose opinions varied, would conclude that some decisions were 'incorrect' after an operation had been implemented. This would be an untenable position for the curator who had to make daily decisions in the absence of the Board or a long term plan, but then had to defend the decision to a group which had no consensus on relevant issues. Obviously this would create conflict, and one notes the appreciation of the curator when the Board accompanied him on a park tour where decisions were reached jointly (Manager, Sept 1983). The curator was "able to proceed confident that my actions and instructions are certain of approval by the Board." (Manager, Sept 1983). The appointment of a supervisor to liaise between the Board and the employees was a step towards reducing these types of problems.

The other possibility was that the Board might not delegate (actually or apparently) and would operate daily decision making themselves and become involved in planting and removal decisions. This would be useful; providing they developed a long term framework and had sufficient expertise to make the decisions.

Therein lies the third key problem, the expertise needed for decision making was not readily available amongst the Trust Board. Although Board members were selected for their interest in trees, they did not have the depth of botanical expertise needed to manage the range of varied and unusual species in the collection. The exception was Mr Berry who is a plantsman of international renown and who was involved in all aspects relating to the collection; his documents have been referred to throughout this thesis. Mr Berry is now retired from the Board and has no official rights therein. The other Board members were (and are) all business people and farmers with limited expert knowledge in plants. None of the members are qualified in arboriculture, botany, or landscape planning, design, or management. One member is qualified in ornamental and production horticulture and nursery production (Paul Pollock), and these skills have been used to the benefit of the Arboretum. Other members are qualified agriculturalists or local body administrators. The present curator (Garry Clapperton) is qualified in botany and is the first curator to have any horticultural expertise, while his assistant has no horticultural qualifications.

One could argue that the comparative lack of specialist expertise on the Board could be overcome by having a curator with the right skills. Unfortunately that solution was unlikely to work because the curator would still be faced with an apparently weak decision making process, with no long term framework, and would still find himself defending decisions after the fact. In a planned management system it should be possible for a curator to be the main decision maker and coordinate a wide range of activities, but the role would be one of facilitation rather than decision making. The size and breadth of the collection management task, and the range of skills and knowledge needed make it unlikely that a single individual would have sufficient expertise. The situation lends itself to a group approach where several people provide knowledge and skills, with some type of system to organise their activities.

The Trust Board should have been a group decision maker in which the group made decisions rather than individuals, but the factors described above reduced their effectiveness. There must be enough people present to ensure that interaction is achieved (Massie, 1979), but the Board had only five members, (six since the 1994 amendment to the Act) and not all attended or participated regularly, making group interaction hard to achieve. The variety of opinions and knowledge amongst the Board should have been used to develop consensus before the fact, and avoid making individual evaluations of completed tasks. The group should work to explicitly stated goals (Massie, 1979), which were unclear at Eastwoodhill. The lack of data and long term framework, and limited specialist expertise, reduced the Trust Board's potential to make effective collection management decisions.

In adopting the management plan the Board accepted the idea of a committee who would decide on future plantings and removals (Williams, 1987, p 51). Since 1980 the Trust Board had appointed three committees to look at future plantings but none held more than two meetings. Each produced a report which was mostly implemented, but none developed a long term time frame. Thus, the Trust Board had some of the ingredients needed for good decision making: a certain level of expertise amongst themselves and the curator, commitment to the Arboretum, willingness to participate in committees, and the notion of the use of a group. They lacked the framework, data and specialist expertise needed and if a long term plan was to be developed for the Arboretum a more effective decision making method was needed.

Goal

To develop a planning and decision making mechanism that could be used in collection management at Eastwoodhill. Characteristics should include data and expertise to be used in decision making and planning, and an organisational structure that facilitated decision making and development of plans for the collection.

4.2 METHOD

Eastwoodhill was a category two landscape (highly significant but not in good condition) when it should have been a category one landscape (highly significant and in excellent condition) (Chapter 3). Achieving the transition between categories, and the subsequent perpetuation of the collection, required a long term planning framework was which was not in place at the Arboretum. A planning and decision making method was needed which could establish long range goals, and create shorter term plans needed to manage the collection. The method had to provide the features that were previously weak or absent: landscape management expertise, data, and good decision making and planning methods. The method should include the following characteristics:

- A group approach to obtain the benefits of that method of decision making.
- Participants with the appropriate type and level of knowledge to deal with the issues.
- Participants with knowledge of, and interest in, the Arboretum.
- Provision of data needed for the decisions.
- A clear procedure for using data to make each decision.
- Emphasis on development of factual premises and reduction of subjective judgements.
- Structured approach for group meetings, with clear manager and chairperson roles.
- Clear statement of agenda and goals for each session.
- Use of structured method for completing each session at the meeting.
- Use of chaired discussion sessions as a means of reaching consensus.
- Completion of each session through submission of a report to the Trust Board.

Furthermore, when operational, the mechanism should result in either plans or the basis for plans. Thus the method should have the following characteristics:

- Use a long term time frame in plans that were developed.
- Operate at a level detailed enough to drive daily operations.
- Include enough detail by which plans can be monitored.
- Outcomes should be recorded in a written document and presented to the Trust Board.

Following discussions with the curator in 1988 it was proposed to the Trust Board that a group be formed. The required people and processes were brought together in a management mechanism known as 'the workshop'. The group met three times, in June 1989, April 1990 and March 1991, and considered a range of strategic and operational issues. Each workshop was held over a weekend with business being conducted all day Saturday and Sunday until mid afternoon.

The planning and operation of the workshops had to meet two broad goals: for this research the overall goal was to develop and examine a method for planning and decision making for the collection, while the Trust Board's goal was to achieve some useful outcomes for collection management. This research focuses on the method as well as the outcomes whereas the Trust Board will focus more on the outcomes. The combined purposes are reflected in the objectives that were stated for each workshop, noting that if the method works, the two sets of goals will coincide. The workshop method had three main components: participants, organisation of the meetings, and the decision making method that was used.

4.2.1 Formation of the workshop: participants and expertise

A decision making group was used for the workshops as this would overcome a key problem at the Arboretum, the need for specialised botanical expertise. A group could provide that expertise, stimulate creative thinking, and give support to daily operations by ensuring these were driven by agreed goals and action plans.

The decision making group was selected from Arboretum representatives and outside experts who had botanical expertise and familiarity with the Arboretum. A range of botanical expertise was sought including management of arboreta or parks, ornamental horticulture, propagation, and taxonomy. The Arboretum was represented by the curator, the supervisor and two Trust Board members. Each member of the workshop group had to participate in each on-site workshop and to the botanical and aesthetic ratings of plants made before each workshop session. The members were as follows:

Berry RJ: Skilled plantsperson, former member of the Arboretum Trust Board, owner and developer of Hackfalls Arboretum, world expert on Quercus. Farm forester.

Bush S: Plantsperson, Arboretum supervisor.

Cave P: Skilled plantsperson. Nurseryman. Propagator. Expert on Magnolia.

Chalmers D.J. (Chairperson):
Plantsperson. Professor of Horticultural Science, manager of science and research.

Clapperton G.W:
Curator. Skilled plantsperson. In charge of daily operations of the Arboretum.

Collier G: Skilled plantsperson. Horticultural consultant and landscape designer. National president of the International Dendrology Society. Board member of Pukeiti Rhododendron Trust.

Faulkner R: Plantsperson, Arboretum Trust Board. Farm forester.

Gordon R: Skilled plantsperson. Board member of Pukeiti Rhododendron Trust.

Hudson M: Skilled plantsperson. Owner and developer of Gwavas Arboretum. Board member of Pukeiti Rhododendron Trust. Expert on Magnolia.

Jellyman A: Skilled plantsperson. Director of New Plymouth District Community Services (formerly Parks and Reserves Department). Board member of Pukeiti Rhododendron Trust.

MacKay M. (Manager):
Skilled plantsperson. Horticultural scientist. Developer of management method.

McKean I: Skilled plantsperson. Owner and developer of private Arboretum. Expert on coniferous material.

Pollock P: Plantsperson, Arboretum Trust Board. Nurseryman, propagator.

Sykes W: Skilled plantsperson. Professional taxonomist.

A summary of expertise was as follows:

Management of horticultural enterprises: Chalmers, Jellyman

Science, research: Chalmers, MacKay, Sykes

Expert plant knowledge: Berry, Cave, Clapperton, Collier, Gordon, Hudson, Jellyman, McKean, MacKay, Sykes

Detailed knowledge of the Eastwoodhill collection: Berry, Clapperton, MacKay

Taxonomy: Sykes

Propagation: Cave, Pollock

Arboretum Trust Board: Bush, Clapperton, Faulkner, Pollock

Trust Boards of other arboreta: Collier, Gordon, Hudson, Jellyman

Development of other collections/arboreta: Berry, Collier, Hudson, Jellyman, McKean

Landscape design skills: Collier, MacKay

4.2.2 Organisation of the workshop

(i) Roles

To ensure that the goals of the workshop were met, operation of the group had to be organised. The group was divided into members, chairperson, and manager.

Manager: MacKay M.

The workshop manager had responsibility for planning and operating each workshop, providing data, monitoring and recording business as it was conducted, completing a report of the session, and reporting the results to the Trust Board. This involved ensuring that workshops were properly planned, supported, executed, and reported. Details of how this was done are described below.

Chairperson: Chalmers D.J.

The chairperson's job was to chair each workshop session, guide the progress of the group through each exercise or issue, and ensure that exercises were conducted according to the criteria set. The chairperson had to be impartial and act as a moderator and facilitator of the workshop process, not a decision driver. The group process would not work if the chairperson influenced (purposely or inadvertently) the outcome of an exercise, therefore it was desirable that the chairperson was not a member of Arboretum staff or Trust Board.

Members

The responsibility of each member was to provide their expertise into the workshop process. This involved participating in workshop sessions and contributing to plant assessments beforehand.

(ii) Operation

The workshops were planned and executed using a consistent and logical process (Figure 4.1). The process began with the workshop manager and chairperson determining the overall goals for the forthcoming session. Those goals were driven by the need to achieve good planning outcomes for the Arboretum, but at the same time to develop the method itself. The goals for Workshops One and Two were determined by the workshop manager and chairperson, and for Workshop Three by the workshop manager, chairperson, and curator. The goals for each workshop were as follows:

Workshop One:

(i) To develop a managerial system for decision making on plants and plant management.

(ii) To provide factual information on the merit of the collection, to be used as a basis for planning.

(iii) To provide data which could be used in problem solving.

(iv) To highlight collection management problems in the collection, e.g. important plants in poor areas.

(v) To prioritise propagation activities by highlighting important plants in danger.

(vi) To use expert opinion to evaluate the collection, recorded as quantitative data. (adapted from MacKay, 1989c).

Workshop manager

- Overall goals for the workshop identified (with chairperson and curator).
- Exercises identified and goals for each exercise set.
- Method for each exercise determined including identification of outcomes and data needed.
- Cover sheet written.
- Background data gathered, including pre-session plant ratings by participants.
- Method for conduct of the exercise determined.
- Background information book sent to members.

Workshop group

- Chairperson operated the meeting with the workshop manager recording.
- Each exercise conducted according to the plan on the cover sheet, and any predetermined method.
- Each workshop finished with a summary, and discussion of outcomes of that workshop.

Workshop manager

- Workshop written up as a report (Appendices 5, 6, 7).
- Report presented to the Trust Board.

Figure 4.1 Basic process for planning and operating a workshop

Workshop Two

General goals

(i), (ii), (iii), as before

(iv) To develop methodologies for solving collection management problems.

Specific to the second workshop

(i) To develop a park planning method, which incorporated the tree assessment method and a plan of action for the park.

(ii) To use the collection evaluation data from Workshop One to continue to discuss collection development.

(iii) To discuss issues that have arisen from the workshops.

(iv) To develop a decision making and information processing method that ultimately becomes a botanical management method (adapted from MacKay, 1990b).

Workshop Three

(i) To discuss the interface between the public and the Arboretum, and management of public areas.

(ii) To use the methods established to date to consider other genera and parks.

(iii) To discuss development of the other 65 hectares of land owned by the Trust Board.

(iv) To refine the decision making process (adapted from MacKay, 1990b).

These goals emphasised the need to develop collection management methods, the use of quantitative data in those methods, and problem solving and planning. Once the goals for each workshop were established, about 3-4 individual exercises were identified for each workshop. Workshop One had two exercises on long range issues (assessment of the collection, role of the Arboretum) and two on establishing operational plans for the collection (preliminary planning exercises on Pear Park, and *Abies* and *Picea*). Workshop Two contained one long range exercise (key genera), and two exercises on operational plans (a genus plan for *Magnolia*, and a park plan for Pear Park). Workshop Three had one long range exercise (development of the remaining land), and three operational planning exercises (a genus plan for *Acer*, a park plan for Orchard Hill, and a preliminary exercise for Basinhead).

Each exercise was planned and a cover sheet developed (Figure 4.2, and also Figures 6.2 and 6.3) which outlined the organisation and operation of the exercise including its goal, information needed, method of execution, and the nature of the expected output. The cover sheets were used to direct the preparation of the exercise, (e.g. preparation of data, development of answer sheets) and subsequently to manage the operation of each exercise when the group was in session. At this point the background data needed for the exercise was obtained, including pre-session plant ratings by the members (botanical or aesthetic ratings of the plants to be studied; the particular method for ratings is not relevant here, but is described in Chapter 5). A 'Background information' booklet was formed which contained an agenda, plus the coversheets and data for each exercise. This was sent to each member (prior to the workshop) to ensure they were informed about what would be happening when the workshop was in session (MacKay, 1989c, 1990b, 1991a).

Once a workshop was in session the operation was controlled by the chairperson. He led the group through each exercise, calling upon the workshop manager to explain the exercise and review background information. He then chaired the activity or discussion, usually prompting the group

SECTION THREE: New developments, the new area. Saturday 3.00-5.00pm (Workshop Three)

Aim

1. Development of philosophy, objectives and task for action for the new area.
2. Provision of the above to a person skilled in landscape development in order to formulate a layout plan for the area.

Background information

Table 3.1	Information on the objectives for Eastwoodhill, taken from the writing of W.D.Cook.
Table 3.2	The future objectives for Eastwoodhill as proposed in Workshop One.
Table 3.3	List of suggested factors that contribute to the Arboretum character at present.
Table 3.4	Description of the elements on the borders between the present Arboretum and the new area.
Table 3.5	Analysis of existing key genera for proportion represented at Eastwoodhill, and possible extensions of these genera.
Plan 3.1	Map of new area and boundaries.

Action

1. Define overall objective for development of the new area.
2. Consider and identify the elements of the current Arboretum that contribute to its style and character.
3. Site inspection.
4. Identify those elements that need to be incorporated into the new area to ensure that its character is compatible with the overall Arboretum.
5. Identify detail and/or particular elements that should be included in the new area.
6. Suggest plant groups that might be included in various ways in the new area.
7. Identify tasks that need to be done to initiate development of the new area.

Conclusion

1. Defined list of objectives for new area.
2. List of character elements that should form the structure of the area.
3. List of suggested detail that might be included in the new area.
4. List of immediate tasks to be done.
5. Provision of items 1,2,3 to a landscape advisor to be used in formulating a proposed layout into which desired elements should be incorporated.

Figure 4.2 Example of a coversheet for a workshop exercise with predetermined discussion points, while the workshop manager recorded proceedings. The chairman also ensured that each participant received equal chance to contribute and that all relevant points were addressed. He then ensured that each exercise was completed according to the criteria set, and that the expected goal was reached, e.g. a statement of criteria for park development, or a list of species to be obtained.

When the meeting was completed the workshop manager recorded the outcome as a report. A draft was sent to all members for comment, to ensure that the report was an accurate record of the meeting. The final report was presented to the Trust Board with each workshop recommendation being officially put to the Board; noting that the recommendations were only advisory and would not become official decisions or policy until accepted by the Board.

4.2.3 Decision making

Sound decision making processes should be used in a group forum, otherwise the value of participation by the group is reduced. Such processes should make effective use of data to support problem definition and development of solutions, and take advantage of the range of views in a group to develop creative solutions. These factors push decision making towards the more rigorous rational model rather than the administrative model.

The basic decision making process used for workshop exercises reflected the rational model and attempted to make full use of data and objective judgements by the group (Figure 4.3). An overview is presented here as detailed application of the process for collection management is discussed in Chapters 5 and 6, with the specialised versions that were used for particular problems. The decision making method and the overall workshop method are closely interwoven, as they should be if sound collection management outcomes are to be achieved from the workshops.

The decision making process started when the workshop manager identified the exercises to be considered in each workshop, equating to Rue and Byars (1992) 'intelligence' where one searches for problems that must be addressed. In planning the exercises the workshop manager was developing a preliminary understanding of the situation and definition of the problem. Preparation for the decision continued with the cover sheet, identification and collection of data, and preparation of the 'Background information' booklet. Until this point preparation for the decision was done by the workshop manager, in consultation with the chairperson and the curator. Clearly the workshop manager needed excellent decision making skills to make a full and unbiased preparation of the exercises, recognising what type of decision to use (Kraus and Curtis, 1990) and which data would be needed.

Workshop manager

- Use of 'intelligence' to identify workshop exercises.
- Preliminary 'understanding of the situation'.
- Preliminary 'problem definition' including identification of data needed in the decision.
- Prepare for 'development of alternatives' and 'selection of a solution' by:
    - Determining method for making that decision and writing up as a cover sheet.
    - Gathering background data, including botanical and aesthetic ratings by the members.
    - Using quantitative data where possible (summaries of collection features, rating scales).
    - Sending cover sheets and background data to members.

Workshop group

- 'Understanding the situation' and 'development of alternatives' through:
    - Introductory discussion and examination of background data.
    - Quantitative assessment of plants in the field, using rating scales.
    - Quantitative processing of field data using agreed trigger points for action.
    - Group discussion of all data.
- 'Selection of a solution' through group discussion, then formulation of recommendations.
- Decisions recorded by the workshop manager in a report.

Trust Board

- 'Acceptance' of workshop recommendations.
- 'Implementation' of recommendations.
- 'Monitoring' of decision outcomes.

Figure 4.3 Basic process for decision making for workshop exercises

When the workshop was in session the decision making process was taken over by the group. First, they reviewed the background data and discussed the situation relating to the problem. i.e. with the data at hand the group moved through 'understanding the situation' and 'problem identification.' Next the group went into the field to examine the problem and gather field data. Four rating scales were used to quantify plant characteristics in the field inspection, therefore increasing the objectivity of the data and the rationality of the decision making approach. The group then used the full set of data as a basis for discussion and to devise a solution for the exercise. That solution was recorded and reported to the Trust Board.

The final phase of the decision making process passed to the Trust Board. When the workshop recommendations were put to the Board it was their role to accept and then implement those recommendations. The workshop group had no mandate for implementation or monitoring, these being the responsibility of the Trust Board.

4.3 RESULTS AND DISCUSSION

The overall result of the workshops was three reports (MacKay, 1989d, 1990c, 1991b) which were published as technical reports for the Trust Board, and which are found in Appendices 5, 6, and 7. Each document contains a full account of the exercises conducted and the discussions held, plus the decisions and recommendations generated using the method described above. Discussion in this chapter will focus on the results as they relate to the workshop method and its capacity to deliver planning and management outcomes. The details of those outcomes and their relevance to collection management are the subject of Chapter 5 (long range goals) and Chapter 6 (plans for parks and genera).

Long range issues were the focus of the first workshop, with some further development of these in the second and third workshops. In the first workshop a quantitative assessment of the whole collection was made which resulted in statements on the role of the Arboretum, a proposed focus for the collection and selection of 'key' genera, and some broad management goals for the collection. In Workshop Two the key genera list was refined. In the third workshop broad principles for development of the remaining 65 hectares were developed. Details of these results and their implications for collection management are discussed in Chapter 5.

The workshops also resulted in two types of operational plans for tree management: park plans and genus plans. In the first workshop preliminary exercises of each type were done and plans developed for a segment of Pear Park and for *Abies* and *Picea* on Orchard Hill. In the second workshop a genus plan was developed for *Magnolia* and a park plan for Pear Park. In the third workshop *Acer* and Orchard Hill were considered, resulting in development plans for each. A preliminary exercise was conducted on Basinhead which resulted in guidelines for that area. Genus and park methods are discussed in detail in Chapter 6.

The workshops were successful in that all of the recommendations made in the reports were formally accepted by the Trust Board and the stated goals for the workshops were achieved. Within that overall result however, there are a number of important individual results and issues.

There were three broad issues relating to use of the workshops which must be considered in this discussion, (i) structure including use of the group, participants in the group, and roles taken by the participants, (ii) operation of the group including planning and operation of each workshop, the programme, decision making, and implementation, and (iii) an overview of the workshops as a planning and management strategy. Each of these issues is interrelated, but the detailed points will be discussed first, leading to consideration of the workshops as an overall strategy, which in turn leads to conclusions about their use.

4.3.1 Workshop structure

The group structure provided expertise for collection management by bringing together people with a breadth of knowledge and viewpoints (Griffin, 1990; Massie, 1979; Rue and Byars, 1992). This gave weight to the decisions (Massie, 1979) and reassurance to both curator and Trust Board that the suggested actions were soundly based. The curator was involved in each decision, and therefore did not have to take sole responsibility for decisions (Massie, 1979), or defend an individual decision to the Trust Board. The main disadvantages were the expense and time involved in operating the group.

4.3.1.1 Participants

The participants were crucial to success of the workshop as they provided the necessary expertise (Griffin, 1990). There were two issues relating to participants: the first relates to management of volunteers, the second to the mix of people in the group.

The workshop participants were volunteers who were providing a free consultancy service to the Trust Board. (Nine participants were not already associated with the Arboretum, six gave their professional time as they were primarily employed as landscape or horticultural professionals. The remaining three were farmers, but each owned and managed an arboretum on their farm property). A volunteer has a different 'contract' to a paid consultant and this has implications for the management of the workshops. A paid consultant exchanges money for work; the payment carries an obligation for the consultant to complete the work and allows the manager to set 'rules' for the job. Volunteers have no such obligations, therefore the workshops had to strike a balance between the interests of the participants and the Arboretum.

On one hand, the workshops had to achieve specific collection management outcomes for the Arboretum, so participants contributions had to meet certain criteria. They had to be prepared to take part in structured and rigorous decision making and focus upon the goals and exercises for each workshop. Therefore, participants had to be focused on the objectives of the workshop, underlining the importance of well planned meetings with clear objectives that were effectively communicated to the group.

On the other hand, the workshops had to be organised so that the participants were motivated to make a voluntary contribution in exchange for non-monetary values such as interest, stimulation, or to support Eastwoodhill. Thus the programme had to contain a variety of activities, that were pitched at the right level for the members, and were not too mathematically or conceptually difficult.

It was necessary to strike the right balance between the volunteers and the Arboretum. If it was too far towards the Arboretum then the participants may lose interest, conversely if it was too far towards the volunteers then the decision making method may lose rigour and fail. In this workshop series the Arboretum needs were addressed through the planning and execution of the workshops. Satisfaction of the participants was hard to judge, but there were two relevant points. First, the participants completed all three workshops, suggesting that they found the experience worthwhile. Conversely, there were some weak points in decision making (discussed in section 4.4.2.3) that reduced the level of interest, but those problems were largely eliminated by revising the method for conducting the exercises. Management of volunteers adds another dimension to planning and operating the workshops, but if the Board cannot afford to pay consultants then it is the only viable option.

The second issue about participants was whether or not the right mix of people were selected for the group. In retrospect there should have been greater involvement by the Trust Board, particularly when long range goals were being considered. (That is, involvement of the whole Board, not just Mr Faulkner and Mr Pollock). This conclusion relates to the decision making process. As 'executive manager' the Board is responsible for all decisions, but particularly the strategic issues (assessment of the collection, role of the Arboretum, key genera) (Griffin, 1990; Kraus and Curtis, 1990; Rue and Byars, 1992). Even if they did not have the same level of expertise as other participants, involvement in those discussions would have given them greater understanding of the issues (Stoner et al., 1985), and greater ownership of workshop proposals. In turn this makes informal acceptance more likely (Stoner et al., 1985) and increases motivation for implementation. Some of the proposals involved changes in approach, or new allocation of resources; important decisions like these were more likely to be implemented if the Trust Board had been involved in their development (Bromley, 1990).

Returning to participants, two other changes are worth considering for the future. Input from a professional arborist would have been useful to give expert views on the safety of trees and any structural problems. Landscape architectural input would have been useful on some issues, e.g. development of the remaining land which was considered in the third workshop, and in future the design skills of a landscape architect will be needed to address the upcoming issues of site layout.

Such a person will need specialist knowledge of trees, and specific skills in design of arboreta, which has not always been well considered by design professionals (Byrd, 1989; Lighty, 1989; Posner, 1989).

4.3.1.2 Roles

If the workshops are to function in the intended manner, some participants must take certain roles. Roles were clearly defined in these workshops, which kept time inputs of volunteer participants to a minimum. The chairperson and participants had minimal time requirements other than the actual meeting, on the other hand, the workshop manager had a major time input to plan and operate the workshops in the required manner. The workshops conducted for this research were completed using the resources of Massey University, which raises the issue of how future workshops should be staffed, particularly with respect to the critical roles of chairperson and workshop manager.

This issue reflects the initial problem at the Arboretum, of insufficient management inputs (time and landscape management expertise) which were a barrier to planning (Griffin, 1990). The Trust Board does not currently have the human resources to fill the roles of chairperson and workshop manager because the employees do not have time to do the necessary work. In part this reflects the Trust Board's poor financial situation, on the other hand, it reflects the issues associated with long term goals. If the Board does not agree about the importance of long term planning, it is unlikely to make corporate decisions which assign resources to such tasks. Such a response can be related to the previous lack of data on the collection, including the knowledge that might have come from an evaluation of the type conducted in Chapter 3.

If the Trust Board did have resources to allocate to the chairperson and workshop manager roles, who would fill them? A chairperson needs basic plant knowledge but should be independent, and ideally that role should not be filled by a member of the Trust Board. The workshop manager must have sufficient expertise to plan and operate the workshops (Kraus and Curtis, 1990). That person needs good management skills and understanding of landscapes to recognise issues that need to be addressed, plan workshop sessions, define problems, and operate the decision making process. The workshop manager must be capable of identifying, obtaining and processing data in a rigorous way as effective plans depend upon appropriate use of data (Bromley, 1990; Griffin, 1990; Massey University, 1993; Quinn et al., 1990). The workshop manager's role could be filled by the curator, as long as issues relating to expertise and conflict of interest are resolved.

A potential conflict exists between the curator's roles as a decision maker (group member/manager) and person in charge of implementation, i.e. the curator may have to implement decisions that go against personal preference. In theory, if consensus discussion is working this should not happen because 'discussion continues until agreement is reached', conversely, the curator may find it difficult to act as an impartial participant in group discussions. This relates to the difficulty of being closest to the on-the-ground situation, and being able to separate personal preference from consensus views.

A second potential conflict of interest exists between the curator's roles as future workshop manager and curator. A workshop manager has to develop and present impartial background data to the group, requiring careful separation of their individual view from their role as workshop manager. The curator has the closest on-the-ground knowledge of any issue, and a valid opinion on each topic which should be contributed to the group, but they (and each other member of the group) should avoid presenting their personal perception of a problem as data for consideration. The potential conflict of interest lies between the curator's individual view derived from detailed daily familiarity with the Arboretum, and the role of workshop manager which has to be as impartial as possible. Inexperienced managers might inadvertently make decisions prior to the meeting and use the group to ratify those decisions (Massie, 1979); leading to poor decisions and defeating the purpose of the group. This potential pitfall exists in any workshop manager, it should be minimised by ensuring that the workshop manager has sufficient management expertise for the task. At Eastwoodhill the Trust Board could facilitate the curator's successful transition to workshop manager by ensuring that he is fully conversant with the decision making process and its application. In addition, a protocol could be established wherein the chairperson (and any other appropriate person) moderated the workshop planning process, thereby minimising any potential difficulties in the preparation of exercises.

4.3.2 Operation of the workshops

4.3.2.1 Planning the workshops

A key feature of the workshops was the careful attention given to planning and operating each one (Massey University, 1993). The structure, objectives and exercises were set several months in advance of each workshop, allowing time for data collection and preparation of background material (Massey University, 1993). Each workshop was operated using a series of structured activities with set objectives and a planned discussion that gave attention to relevant issues. Each session was chaired according to the objectives set for that session (Massey University, 1993), but still allowed for flexibility in discussion. A structured decision making method used quantitative techniques and factual data (Griffin, 1990; Massie, 1979; Rue and Byars, 1992). Each session was completed according to the criteria in its agenda and the results were presented as a written report (Massey University, 1993; Quinn et al., 1990).

Apart from the factors mentioned elsewhere in this discussion (which impinge indirectly on planning and operation of the workshops) major changes to planning and operation were not needed. The exception was the overview issue (sections 4.3.3.2, 4.3.3.3) that related to overall usage of the workshops. That is, in retrospect, more data should have been developed sooner, and more focus given to strategic issues. Those two issues, however, relate more to content and would have little impact on the method of preparation and execution.

4.3.2.2 Programme

The programme contained exercises that addressed a mixture of strategic and operational issues. Each exercise related, in some form, to management of the fabric of the Arboretum. The sequence of park and genus exercises allowed for development and refinement of the methods for formulating operational plans. There were no design issues introduced, which was appropriate given the focus of the workshops and the skills of the participants. Design issues will, in time, become relevant to the group and changes in approach should be made as appropriate.

The main issue about the programme was its planning. For these workshops the content and approach for each workshop were primarily decided by the author as workshop manager, although the chairperson and curator were involved. Thus, the author, as workshop manager, was making 'executive' decisions about the overall approach to the workshops. The appropriateness of this method must be considered.

It could be argued that the author as workshop manager did not have the prerogative to make such executive decisions which would normally be the responsibility of the Trust Board or its employees. Likewise, workshop participants might also have had a valid contribution to those decisions. Those arguments can be countered in several ways. First, although those decisions fall within the role of the Board, they had not yet resolved collection planning issues or developed any long term plans. Second, the participants were given the opportunity to identify issues that should be addressed in subsequent workshops (Two and Three), through a discussion item at the end of each agenda. Third, it would have been quite counterproductive to wait until the group was in session before identifying the issues to be addressed on each occasion. The careful preparation of the workshops was one of their strengths, and a certain amount of 'understanding the situation' and 'problem definition' is inherent in such preparation. Without that preparation the workshops would become an anecdotal 'firefighting' unit, an approach which ignores the need to develop a long term management function at the Arboretum. Fourth, the workshops also had to meet the goals of this research, placing some boundaries on the approaches used, and giving the author some prerogative over decisions.

In future workshops the Trust Board, the curator and participants should have a greater role in planning the programme. To do so they should ensure that they are equipped with the conceptual, diagnostic and analytical skills needed for the 'intelligence, understanding, and problem definition' stages that were involved (Rue and Byars, 1992). An intimate knowledge of the Arboretum is needed. Sufficient landscape management knowledge is required to recognise the changes occurring in the collection and realise the implications for its future. The group should develop skills in planning and executing the workshops, addressing both strategic and operational issues, in both long and short term time frames. A suitable staff development programme could be used to ensure that each of the needed skills is available within the group.

4.3.2.3 Decision making and data

Decision making followed sound management practice and resulted in defensible decisions for the collection. Detailed data was used (Griffin, 1990; Rue and Byars, 1992), including rating scales to quantify plant features, which reduced subjective judgements (Massie, 1979). Knowledgable decision makers were used, who could understand the data and therefore the situation (Massey University, 1993). The decisions were recorded in detailed reports which contained objectives, data, the decision making method, a record of the discussion and its outcomes, and the recommendations. The reports could also be used as a standard against which progress could be monitored.

The reports contained strategic, long term, and short term decisions, e.g. park and genera plans contained both immediate actions and longer term guidelines for development. The short term decisions solved existing and immediate problems, and could be immediately inserted into daily operations. Other decisions had a longer time frame, no immediate impact, and could not be inserted into daily operations. Most longer term decisions required further management activity before they could be implemented, e.g. a recommendation to replant the *Prunus* and *Malus* on Orchard Hill needed further research and development for a replanting scheme. Finally, the strategic decisions, such as key genera and Arboretum roles, had little immediate impact, but will drive the long term outcomes via detailed strategy development.

A weakness of decision making was that different stages of the process were done by different groups of people. Planning was done by the workshop manager, including preliminary problem definition. The process then passed to the workshop group who developed the solution, then to the Trust Board for implementation. Although there were people in common at the different stages, this progression left several opportunities for poor or ineffective decisions, unless each person/group fully understood the deliberations of the others. Ideally the whole decision making process should be done by the same people, but for these workshops the resource constraints did not allow that to occur.

A second weakness was that some decisions were not prioritised, e.g. recommendations on the role of the Arboretum were not ranked. This was an unfortunate omission as it left the situation no further ahead with respect to primary purpose, conversely, one might argue that as 'chief executive', that decision rested with the Trust Board. Thus the workshop reports cannot be implemented until the Trust Board completes its job as final arbiter. This illustrates the next disadvantage; the results were only advisory (Massie, 1979). The group had no mandate for official adoption or implementation of the recommendations, therefore decisions could be rendered ineffective at those stages (Bromley, 1990; Massie, 1979).

The final disadvantage was the time needed for decision making (Griffin, 1990; Massey University, 1993), particularly for assigning a rating to each plant, which was time consuming in both field and processing time. The scales were used to ensure rigour, and to support the rational approach to decision making by attempting to provide clear criteria, stable weightings, and a logical way to evaluate alternatives (Griffin, 1990; Rue and Byars, 1992). Unfortunately, however, the opportunity to brainstorm in the field was restricted, limiting the creativity of solutions (which is a key advantage of groups) (Johnston et al., 1991). A revised balance of activity was needed. The rating scales should be retained to keep the method rigorous, but the scales should be reviewed (Chapter 6) and the exercises arranged to provide more time for field discussion.

4.3.2.4 Implementation of workshop outcomes

Responsibility for implementing workshop recommendations lay with the Trust Board and there were several issues relating to this step. First, the Trust Board needs to accept any decision to be motivated about its implementation. The recommendations were formally accepted at Board meetings, but motivation to implement also requires informal acceptance (Kraus and Curtis, 1990; Massie, 1979), thus individual members must have suitable attitudes towards the recommendations before they will initiate implementation (Griffin, 1990; Stoner et al., 1985). This is partly driven by the personal values and motivations of the individual, which is well beyond the scope of this discussion. It is also related to participation of Board members in the workshops; if they do not feel they have been sufficiently involved their enthusiasm for implementation may be reduced (Griffin, 1990; Stoner et al., 1985).

Implementation also requires resources and there are two relevant issues, short term actions and long term actions. Some workshop decisions could be implemented immediately, requiring enough labour to do the immediate physical work. As the Trust Board only has two employees it may not be possible to implement all of the immediate recommendations and work should be prioritised to suit the labour pool. Other decisions (generally longer term decisions) cannot be physically implemented straight away, and may need more research or documentation. These decisions do not demand immediate attention in the manner of the short range decisions, and can easily be put aside. If the Trust Board wishes to ensure the long term viability of the collection it must not overlook the resourcing of those long range decisions. Clearly this is difficult when resources are constrained, but an appropriate balance between short and long term decisions must be achieved.

The final issue relating to implementation was that of monitoring and control. The workshop group made recommendations, but was not in charge of implementation and therefore had no mandate to monitor or control. The workshop group had the skills to execute the control function, and could make a yearly review of progress which would act as a form of control. (The group visits too infrequently to execute any more detailed control.) The group could not, however, take any control function unless the Trust Board were to give it the appropriate mandate. Alternatively, the Trust Board could execute the monitoring and control function, having equipped itself with suitable guidelines and processes.

The control function raises another conflict of interest for the curator. It might be suggested that he could execute the control function as he had the highest level of botanical skills amongst local participants. But that would be difficult if he was also responsible for implementation as he could not realistically be expected to monitor himself. When combined with the previous discussion on conflict of interest, one concludes that the role of curator must be carefully defined to avoid those conflicts. If the Trust Board continues to operate with constrained resources, where the curator is involved in planning, implementation, and potentially control, those conflicts should be recognised and managed. Ideally the conflicting roles should be separated, or at least managed to minimise the impact. This could be done through a careful description of responsibilities, monitoring potential conflict situations, or allocating some tasks to other people.

4.3.3 The workshops as a management strategy

As a management strategy the workshops achieved some significant results for the Arboretum. They resulted in quantitative data on the collection, assessment of the collection, broad principles for its management, plus a series of specific plans for certain parks and genera in the collection. The workshops focused on the collection and its management in a way that had not been done before at the Arboretum, and were a significant advance in collection management. The overall approach used careful planning, a rigorous decision making method, knowledgeable decision makers, a structured meeting method, and included a mix of strategic and operational issues

(Griffin, 1990; Kraus and Curtis, 1990; Massey University, 1993; Massie, 1979; Rue and Byars, 1992; Stoner et al., 1985).

At the same time, there were several strengths and weaknesses associated with the workshops. The main strengths were the capacity of the workshops to fill the planning role that was needed at the Arboretum, and the timeliness of workshops in terms of changes occurring in the business environment of the Arboretum, (and which underpin the need for a planning mechanism). The two main weaknesses that should be overcome to make the workshop more effective relate to the preparation of data and the focus on strategic issues.

4.3.3.1 Strengths: a possible framework for collection management

The strength of the 'workshop' was that it could be the linchpin of a potential systematic management framework for the collection (Figure 4.4). To explain this idea one must consider the components of systematic management and how the workshops relate to those components.

Strategic management: The Trust Board and The Workshop

Philosophical position (Purpose, scope, key assumptions)

Mission

Long range goals

|

Operational planning: The Workshop

Long range planning decisions which achieve the goals

Medium and short term plans that drive daily operations

|

Daily operations: Employees

Short term decisions

Implementation of short and medium term plans

Facilitation of long range plans.

Figure 4.4 The workshop in a systematic management framework

Systematic management is a combination of long term and short term management (Bromley, 1990; Miller, 1988). The purpose of long term management is to ensure continuation of the resource by developing a philosophical standpoint and long term goals that are associated with a strategic position, and which indicate the future shape of the enterprise (Griffin, 1990; Miller, 1988). In isolation long term management is insufficient to manage an enterprise because it does not include the detail, focus, data or technical information needed in daily tasks, yet its philosophical position is the main driving force behind daily operations.

The purpose of short term management is twofold: to achieve the daily operations that contribute to long term goals, and to make short term 'firefighting' decisions that deal with unexpected or immediate problems that arise in the normal course of events. Short term management must be driven by long range goals, otherwise those goals will not be achieved. If long range goals are absent then the enterprise will progress towards 'nowhere in particular'. In isolation, short term management is insufficient to manage an enterprise because it does not have the long term view that gives direction to its activities.

Therefore, if the managers of an enterprise wish to achieve long range goals, and avoid ending up 'nowhere in particular', there must be a continuous interaction between long term and short term management as each is insufficient on its own. That interaction is driven by the common purpose of achieving the goals of the enterprise, which are usually expressed in various types of plans. Thus, goals and plans are the glue that hold long and short term management together (and on the same path). Plans connect long range goals with daily operations by requiring senior managers to explain their intentions for the enterprise and outline their position; and by requiring first-line managers to account for their activities and justify long term outcomes. The key, therefore, to systematic management is a mechanism for planning and development of goals. That mechanism must be capable of turning long term goals into a form that can be used and understood at daily operations level, and directing operations as appropriate. Conversely, it must be capable of communicating the issues, outcomes, and problems of daily operations to those developing strategic or operational plans.

The workshops could be used at Eastwoodhill to fill the connecting role, developing goals and plans needed to connect the long term future of the Arboretum to daily activities. In effect, the workshop group would be the Arboretum planner and would operate on three fronts. First, they would expect the Trust Board to develop and confirm a strategic position (which they could also critique) that would give a framework for the workshop to operate within. That responsibility lies with the Board as senior managers, but the discussion in sections 4.1.2. and 4.1.4 have shown that some development is needed in this area. In part the workshop has improved the situation by deliberating on roles of the Arboretum, and the group could assist the Board on any further examination of relevant issues. The Board, in their role as senior managers, must still select and confirm a strategic position which forms part of the management framework (Griffin, 1990; Rue and Byars, 1992).

Second, the workshop group could develop operational plans needed to achieve the long term goals for the collection, such as the park and genus plans developed in this research. The structure and operation (as per this project) of the group is suitable for this work where the expertise of the participants is targeted at tree management problems that suit their skills. To fill this second role the group should be organised and operated according to sound planning practice, as they were in this project. The group and its operation could be modified to address different types of plans, e.g. site layout plans needing the input of a landscape architect.

The third role of the group would be to examine short term management and determine its effectiveness in achieving long term goals. This is a planning aspect of short term management, i.e. 'what do you intend to do and how will it achieve long term goals'. (This is not the same as the control function which is retrospective and asks, 'what happened and was it on track'. It has already been pointed out the that group cannot readily fill the control function.)

If it achieved the three roles above the workshop would be central to the systematic management framework. It could not be used in a higher role as that is the job of the Board. It could not take a short term management role as that is the job of the employees (and simply not feasible). But it could operate effectively in the middle and contribute the necessary planning elements. The key is positioning and operating the workshop so that it fills the connecting role. If the group became too philosophical it would be ineffective in directing daily decisions; problem solving would be a statement of what 'might' be true because there would be no information to make decisions. If the group concentrated on short range decisions it would lose the long range view and would not contribute to long term goals; problem solving would be an ad hoc assemblage of visible and immediate information combined with the on-the-spot thoughts of the participants.

When correctly positioned the workshop would integrate strategic goals and daily events, with an appropriate combination of plans and decisions. The workshop would be driven by strategic goals for collection management, and in turn would drive daily operations towards those goals. Workshop decisions would stimulate changes in daily operations when necessary. On the other hand, in feedback mode, the workshop would influence goals for the collection, making sure that collection management focuses on long term planning and management.

The workshop could be used at Eastwoodhill as described above, provided four criteria are met. First, the Board should develop a strategic position to create the framework for operational planning (Griffin, 1990; Johnston et al., 1991; Rue and Byars, 1992). Some components of such a position were developed in the first workshop, but the issues need to be revisited in light of new knowledge and a strategic position debated and finally selected. A workshop specifically for the Board could be used for this purpose, with the workshop group participating if appropriate. Second, the workshop must be appropriately organised, including the role of manager (Bromley, 1990; Massey University, 1993).

Third, data should be used appropriately (Bromley, 1990; Griffin, 1990), to turn long term philosophical goals into plans that can be executed at a daily level. Data provide the background facts, and are the basis for the decisions derived from those facts. At the same time, data are the basis of the control mechanism which measures progress and ensures that daily operations move towards goals. Data are used to test feasibility of any short term decision against the long term plan. Data are the means with which the daily manager argues for 'navigational change' in the plan when difficulties arise (Massie, 1979).

The fourth factor is adequate resourcing of the workshops, which is a key barrier to planning (Griffin, 1990). There was a major time input on the part of the workshop manager, which will be an expense for the Trust Board if they continue with the method. Any decision not to resource the workshop manager's role will have a major impact on the long term planning functions of the workshops, as these require most preparation. It is recognised that resources are a difficult problem for the Trust Board, nevertheless any further deterioration of the collection is also a difficult problem. Anecdotal appraisals of immediate problems will not be sufficient to deal with long term issues therefore future planning, and the necessary resources, should be addressed at some point. This research has demonstrated that significance and condition of the Eastwoodhill collection are such that long term decisions and planning for the future cannot be disregarded. If the Trust Board takes the view that resourcing the long term planning function is too difficult or expensive, then it should make that decision in full knowledge of the consequences.

4.3.3.2 Weaknesses

There were also weaknesses in the workshop approach and the first of these related to data. The sequence of events in this project was such that the workshops were initiated after the inventory phase, but before much of the evaluation work had been done. Therefore the group operated without the benefit of some of the knowledge in Chapter 3 and clearly this might have limited decision making. (Information on the previous collection and the comparison with other collections was available; information on rare and endangered plants, availability in trade, analysis of significance and all condition factors had not been developed). In hindsight a better foundation of data should have been established for the workshops because good quality decisions depend upon data (Bromley, 1990; Griffin, 1990; Rue and Byars, 1992).

The second point was the handling of strategic versus operational issues. Both were considered, with strategic issues concentrated towards the start of the workshop sequence, but at the time that selection was largely intuitive and not based upon knowledge of management processes. In hindsight, the strategic issues might have been better defined, and discussion more focused upon a strategic position. One of those strategic issues was the problem of a nominal mission (rather than an actual mission) and the influence of this upon the workshops. This meant that part of the framework within which the workshops should have operated was missing, and although the problem is obvious now, at the time it was not recognised. Perhaps the Trust Board should have been asked to clarify the strategic position before the workshops started, but they were in no better position to do so then than in the past, and still lacked data and landscape management expertise needed to make any strategic analysis.

4.3.3.3 Modifications

Completion of this workshop series led to increased skills and knowledge on the author's part, giving a different perspective on the workshops in hindsight. If another series of workshops was being started for another enterprise, current knowledge shows that one would, (i) recognise the nature and importance of strategic issues, and identify such issues and focus initial discussions accordingly, and (ii) complete a preliminary analysis of both the resource and its management before any workshop began so that a better set of data was available.

With current levels of knowledge a workshop could be conducted for Eastwoodhill that was sequenced before Workshop One and which focused on the strategic planning level. It would involve all of the Trust Board (as senior decision makers) plus the other members of the workshop group (Griffin, 1990; Rue and Byars, 1992). Data such as that in Chapter 3 would be available, plus the review of previous management (Miller, 1988). Issues relating to mission, role, scope, market position, grand strategy and long range goals would be discussed (Griffin, 1990; Johnston et al., 1991). This approach would focus attention on the strategic position and give a better framework for subsequent workshops. At the time that this current project commenced, the sequence of events for the workshops occurred because, in political terms, it was timely to start the workshops at that point. Given the level of data available and the author's expertise at the time, it is unlikely that the workshops could have been much improved under those circumstances.

Indeed, a greater level of knowledge on the author's part might not have had much benefit at the time because one must also take the participants into account. To develop a sound mission and strategic position one has to understand the concepts themselves, appreciate the difference between strategic and operational planning, and understand how strategic planning should be applied to an arboretum. One has to know Eastwoodhill (in particular) well enough to apply those concepts to that resource. Similarly, problem definition and development of solutions depends upon the decision maker's knowledge of both collection and problem; an unfamiliar decision maker may make relatively unskilled decisions. The participants in the workshops were plant experts but not necessarily skilled in management, who knew the Arboretum but not intimately, and who were not familiar with the workshop process. The participants, therefore, had to go through a learning curve which probably took 1-2 workshops. Over time the sophistication of their decisions would increase as they become more familiar with the Arboretum, its problems, and the workshop method. Therefore, even if the workshop manager had greater knowledge, provided better data, and crystallised the strategic issues in the first workshop, the result would only have been as good as the collective level of understanding of the participants at that time. Indeed, it may have been counterproductive to increase the level of complexity in the first workshop because people were only just coming to grips with the situation and may have been overwhelmed if more complex problems were put to them.

In an ideal world the workshop sequence would be started with participants who had the same (in depth) knowledge of the Arboretum, and management processes. (That is, skilled managers will make more progress, sooner, than inexperienced managers.) In the real world that is not the case and even amongst these participants (who were the best who could be found in New Zealand for the task at the time) levels of skills and knowledge varied. All of the above discussion illustrates that, to be effective at a more sophisticated level, the workshop approach needs to be used in more than one planning cycle.

This illustrates an important characteristic of planning; it is usually cyclical and involves feedback loops. For example, one suspects that the collection is important and designs an investigation accordingly. The results confirm the general principle but the detail shows unexpected features revealing that, in hindsight, the first investigation was incomplete, and extra features should be included in the next cycle. This catch-22 exists within the overall workshop strategy, e.g. an assessment of the collection reveals its broad characteristics, and identifies attributes to be measured in the next assessment. Similarly, workshops should really be held within the context of the mission, but the Board was not well placed to develop one without having gone through a workshop.

This cyclical characteristic applies to the activities and organisation of the workshops, the development of the participants, and management of both. Thus there is a relationship between the usefulness of the workshops and the developing skills of the participants, including the skills of the workshop manager. In the initial stages workshop outcomes will be limited by the collective level of knowledge of the participants, and will then become more sophisticated as management skills improve. If the skills of the participants need developing, or the workshop method needs developing, then more than one cycle will be needed. In a second cycle issues can be revisited in light of new data, or new issues that were not previously apparent can be considered. At Eastwoodhill a new cycle should be started with a workshop that refocuses on strategic position in light of new knowledge. The aim of such a session should be to debate and clarify the strategic position, and then review previous workshop decisions and adjust if necessary.

In conclusion, the workshops were a valid management strategy because they produced useful collection management outcomes, they were run in a rigorous way, and because they were a suitable method for more than one planning cycle if needed. For the given level of skills of the participants in this series, the series would have been improved by: (i) better data earlier, (ii) a slightly different focus in Workshop One that concentrated more on primary purpose and resolved (if at least in a preliminary way) the issue of mission, (iii) participation of all the Trust Board in the workshops, (iv) more discussion time.

4.3.3.4 Workshops needed because of changes in the enterprise

The primary rationale for the workshop was the need to develop plans to manage biological values of the collection, particularly biological change and the need for restoration and future planning. At the same time, other issues reinforce the need for a planning mechanism. Over the period that the Arboretum has been managed by the Trust Board three important changes in focus can be observed: change in main strategy from clearing to development, change from a private garden to public park, and change from private funding to public funding.

Each of these reinforces the need for a well considered strategic position and associated plans. For example, when the Trust Board first took over the Arboretum poor condition of the property necessitated a clearing strategy which the Board pursued from 1975 to about 1985-87. Any progress on planting or new development was constrained until the vast quantities of dead and redundant material was removed. It was not until this phase was over that future plantings of any volume could be considered, or the need for restoration be highlighted through examination of the condition of the remaining collection.

Concomitant with the formation of the Trust Board was the change from private to public ownership, with the associated change in funding source. If the Trust Board is to seek funds from the public purse (not necessarily government) then it must also expect to be held accountable for those funds. This underlines a distinct change in accountability compared with the owners of private gardens who are responsible only to themselves. In contrast, the Trust Board may not act with impunity if it is financed by donations. When this circumstance is combined with the fact that the collection is the most significant of its type, it can be argued that the Trust Board operates within the realm of the public good, rather than in the manner of a private individual. Charged with this responsibility the Trust Board must take every possible step to ensure the long term viability of such an important resource, including long term planning, design and management mechanisms. At the same time, if the Arboretum is the most significant of its type, then one can also argue strongly for a larger donation from the public purse.

The change from private garden to public arboretum is also relevant. A private person can organise their garden or plant collection in whichever manner they see fit and has no responsibility to anyone else to ensure that the garden remains viable over time, or has any particular visual characteristics. If the garden/collection is lost it is of no consequence (notwithstanding the inherent biological interest of the material). Again the situation is different for those who act in the public good, especially when they manage an important resource. The difference is emphasised if the property relies on visitors as a source of funds because, to attract visitors on a continuous basis the property must be managed for maximum visitor interest. In physical terms this means maintaining and displaying the property in ways that generate positive response in visitors, such as well maintained mature trees in designed arrangements. Thus the Trust Board must plan the long term vegetation resource so that it focuses on mature trees rather than newly planted or senescent specimens. A long term plan for recycling of vegetation will be needed.

Concomitant with the internal changes described above, a series of external changes also underpin the need for a planning and management mechanism such as the workshop. Recent data shows that 'competition' from other plant collections is increasing in that newly developed collections have eclipsed Eastwoodhill in certain genera, e.g. the *Magnolia* collections at the Auckland Regional Authority botanical gardens and collection 129 (Hammett, 1993; MacKay, 1993). Collections like those, which are closer to large population bases, will invariably substitute for Eastwoodhill and reduce its potential visitor attraction (Miles and Seabrook, 1977). Furthermore, it is apparent that more private plant collections being developed (Hammett, 1993; MacKay, 1993). In fifty years time those collections will be in the young vigorous stage, while Eastwoodhill will be senescent in many genera. If the Arboretum is to maintain its leading position the Trust Board must deal with the biological changes that are evident in the collection, underpinning the need for a long term planning method.

4.4.3.5 Groups or individual decision makers

An underlying premise in this work was that group decision making was an appropriate approach at Eastwoodhill. A group would confer the advantages of that approach; a greater pool of knowledge than a single individual, enhanced capacity to develop alternative solutions, capacity to develop more accurate decisions, and greater levels of acceptance of decisions (Griffin, 1990; Rue and Byars, 1992). These advantages would outweigh the disadvantages of time and expense. Carefully operated meetings would overcome any tendency for domination or competition among members.

Despite the advantages of a group approach, no single decision making style suits all situations (Rue and Byars, 1992) and it is reasonable to consider whether or not a single individual could have operated effectively in place of the group. Both groups and individuals may 'satisfice' and accept the first positive solution that appears, rather than continuing until the optimum solution is reached (Rue and Byars, 1992). Thus there is no distinction between approaches. Rue and Byars (1992) proposed that a key factor in selecting the approach was the need to achieve acceptance in the people who were to execute the decision. Acceptance is more likely if relevant people are involved in making the decision, supporting a group approach rather than single executive. This is an important feature for the Trust Board, who may not have the expertise to make all the necessary decisions, but through their participation can be assured that appropriate decisions are being reached.

A key use of the group in the workshops was as an expert panel to provide data via the rating scales, and this aspect of the group approach would be hard for an individual to achieve. The botanical rating, with a 'rarity' interpretation, could be replaced by quantified data on species occurrence in New Zealand (although that data requires time and expense to obtain). An individual could do the field ratings, but they would need extensive plant knowledge to do so, and a single observation is more difficult to support than a series of observations. The latter reduces the possibility of arbitrary or incorrect decisions by the individual (Massey University, 1993), and use of as an expert panel to provide data via the rating scales will assure the Trust Board that the data is robust and that no one person is having undue influence on decisions. Any point of view that is at variance with the majority will stimulate discussion and may highlight issues that may not have been raised by one person. The use of as an expert panel to provide a consensus of opinion is as an accepted business practice (Griffin, 1990) and has been used to determine rarity of plants (Sanecki, 1986), to determine significance of heritage sites (Davis, 1988) and to examine husbandry practice at an arboretum (Percival and Morton, 1995).

It may be possible to find an individual who has the knowledge to make comprehensive collection planning decisions at Eastwoodhill, but two important criteria must be met. First, that person will need a comprehensive range of skills in planning, design and management of arboreta such as discussed throughout this thesis. Such knowledge should be combined with an in-depth knowledge of Eastwoodhill and exotic trees, which is a specialised combination that may not be available from one person. Second, that person must be accepted by the Trust Board and given the authority to make the necessary decisions. If the Board do not have faith in the abilities of that person, or feel uncomfortable about providing decision making authority, then they are unlikely to informally accept any resulting plans and decisions. Selection of an individual collection planning expert is problematic for a Trust Board that is not well placed to judge the landscape management abilities of potential applicants. There are two possible solutions to this problem. One is to use the group approach, obtain a breadth of abilities and the other advantages of a group, and avoid reliance upon a single person. The other possibility is for the Board to develop suitable skills so that they may select an individual collection manager. This could be done by staff development within the Board, or by new addition of suitable people.

4.4 CONCLUSION

Eastwoodhill Arboretum needs a sound planning and management mechanism that can be used to develop long and short term plans, and which can connect the strategic position with daily operations. This is necessary to systematically manage normal biological change in a highly significant human-made landscape; change which is causing deterioration of the plant collection. Eighteen years ago Berry (1978) pointed out that the Board could carry on without a plan, which would "be something of a laissez-faire approach relying on past performance and just maintaining things more or less as is", but warned that there was no room for complacency or Eastwoodhill would lose its leading position in the future. Eighteen years of biological change, plus the rise of new plant collections elsewhere in New Zealand, foreshadows the truth of Berry's words. The Trust Board has had to operate under difficult circumstances, but if the value of the collection is to be sustained they should initiate development of plans for both strategic position and operational management. These must be focused on the need to identify and manage the 'fabric' of the Arboretum, and to manage the change inherent in the living system.

The 'workshop' approach could be used to develop collection management plans in a rigorous, deliberate and focused manner; provided it is appropriately planned and operated. Particular attention must be paid to decision making method and preparation and use of data. In this project the workshop was used to develop long and short range plans, and decisions that related to the strategic position for collection management. Some modifications are necessary to the workshop method originally attempted, particularly with respect to greater involvement by the Board, earlier provision of data, better focus on strategic position, and ranking of decisions. The interface with the Trust Board must be carefully managed, in that the workshop group is not in charge of implementation, monitoring and control, and those steps contain a variety of ways in which plans made by the workshop might be rendered ineffective.

Use of the workshop mechanism raises important philosophical questions about allocation of resources at the Arboretum and the Trust Board's position on long term planning. To be effective, the workshop must be properly resourced, otherwise it will revert to a short term unit, but resource allocation requires a deliberate decision by a Trust Board which faces severe resource limitations. The decision to resource the workshop requires the Board to develop a new focus and confirm its belief in the need for long range planning, then initiate development of appropriate plans.

This chapter has examined the workshop as a planning and management mechanism, focusing on how the mechanism worked. The following two Chapters (5 and 6) consider the collection management outcomes that were achieved using the workshop.

Chapter 5

Using the workshop for collection management Part One: Long range goals

Sorbus caloneura, Cooks Corner, April 1994

5.1 INTRODUCTION

This chapter considers the use of the workshop to develop long range goals for the collection and focuses on collection management outcomes developed from the workshops. No further review will be included as relevant topics have already been reviewed in Chapter 4.

Long range goals are a key management tool for driving the activities of an enterprise towards its mission. Business managers use the term strategic planning to describe development of those goals and any associated strategic position (Griffin, 1990; Rue and Byars, 1992). How should strategic management be applied to botanic gardens and arboreta? The mission statement should indicate the primary purpose, and may identify the customers and indicate the priority order for science, education and recreation. Long range goals should define collection type (taxonomic or conservation (Rae, 1993)) and collection organisation (geographic, generic, taxonomic, habitat (Byrd, 1989; Lighty, 1989; Sales, 1988; Simmons, 1986)). Statements on the type of flora to be collected, plus broad accession policies should occur at this level. A plan for botanical layout might be expected, plus an associated design plan.

Unfortunately, many landscape enterprises, including botanic gardens and arboreta, do not engage in systematic management. Botanic Gardens Conservation International asserted that botanic gardens and arboreta could play a useful role in management of plant resources, but they needed more effective and coherent organisation, including development of mission statements and more professional standards of management (WWF and IUCN, 1989). Documentation and verification of plants should be improved and gardens should develop purposeful, focused accessions policies that take account of plants in other gardens (WWF and IUCN, 1989). Major management reforms are needed in many botanic gardens, indeed, each year some gardens become moribund and close (WWF and IUCN, 1989). The review in Chapter 4 showed that new management methods would be beneficial at Eastwoodhill and the workshop mechanism could be used to achieve some of those outcomes.

Strategic decisions are normally made by senior or executive managers, but this was a problem at Eastwoodhill because the Trust Board did not have the necessary data or landscape management expertise. Data were supplied by this research, and the workshop group supplied the expertise and developed recommendations, although final decisions and their implementation were still the responsibility of the Board.

Goal

To use the workshop group to assess the collection and propose long range goals for collection development at Eastwoodhill.

5.2 METHOD

Issues relating to long range goals were addressed in each workshop, but the greatest emphasis was in Workshop One. Three activities in that workshop related to long term goals: assessment of the collection and selection of key genera; a review of the role of the Arboretum; and development of goals for management of the collection. In Workshop Two the key genera were revised, and in Workshop Three guidelines for development of the remaining land were formulated.

5.2.1 Assessment of the collection (first and second workshops)

The *raison d'etre* of an arboretum is the living collection which is the 'fabric' of the place, with its biological value underpinning the purpose of an arboretum. Management, therefore, focuses upon that living collection and its utilisation to achieve the mission of the arboretum. An assessment of the Eastwoodhill collection and its characteristics would focus the workshop group upon management of the 'fabric' of this arboretum. The assessment itself was done at the first workshop, discussion relating to the assessment was held at both first and second workshops.

Prior to the first workshop participants were sent a customised copy of the Arboretum catalogue and asked to assess the importance of each genus in the collection using two ratings, botanical and aesthetic, each with a six point scale (shown below). Participants were instructed that half scores (e.g. 2.5, 3.5) could be used. The purpose of the ratings was to generate quantitative data on each genus in the collection, thereby developing a rational basis for future decision making (Griffin, 1990; Rue and Byars, 1992). This method was similar to the derivation of the 'Pink Sheet' plants in Britain where a list of important ornamental plants was derived by expert opinion (Sanecki, 1986). The scales used by the participants for this project were as follows:

(i) Botanical importance

0 No interest
1 Little interest
2 Ordinary
3 Interesting
4 Very interesting
5 Excellent

(ii) Aesthetic importance

Participants were told to use a six point scale but no actual description was given.

Two ratings were used to separate botanical value from visual value, e.g. a species with high botanical merit, which is important to the botanical goals, may have no aesthetic merit and therefore no useful visual contribution. Conversely, a species may have high aesthetic merit but little botanical value. Both ratings were used to give a rounded indication of the importance of a genus (ratings were also applied to species in other exercises). Scoring was done without reference to any particular specimen as the objective was to assess fundamental importance of each genus, not the quality of a particular specimen. (The score should be the same irrespective of age or condition of any specific individual.) Ratings were made without reference to any individual plant, so the participants had to have sufficient knowledge of species and cultivars to score them off-site.

The botanical or aesthetic score for any genus was the mean of ratings given by the participants. Some genera were not rated by all participants, therefore some botanical and aesthetic scores were the mean of only 2-3 observations (sometimes only one observation) whereas other scores were the mean of 8-9 observations. About 7.6% of scores were based on 1-3 observations out of a possible maximum of nine observations. Average score for a genus was the mean of botanical and aesthetic score for that genus. The ratings were given as a number between 0-5, which was doubled and the score expressed on a scale of 1-10 (1 being the lowest, 10 the highest score).

At the first workshop the data were used in two stages. First, a general discussion was held on the botanical, aesthetic and average scores for all of the current collection, and then the scores for trees, shrubs, and New Zealand native material were discussed. The group also identified a minimum score above which plants of a genus should be actively sought. In the second part of the discussion, data were used to focus discussion on critical features of the collection. A brainstorm session (at the first workshop) resulted in a consensus on the significant genera in the collection (key genera).

At the second workshop further discussion was held on key genera. By then the assessment data had been processed and genera ranked for botanical score, aesthetic score, average score, and number of species and cultivars in the collection. Also available at the second workshop were lists of species and cultivars in the current and previous collections, and additional species and cultivars in other collections. A weighted score was developed which showed the comparative volume of each genus; a genus with a high score but represented by only one species will give less volume than another genus with a high score that is represented by fifty species. Weighted score was calculated by multiplying average score by number of species and cultivars of that genus at Eastwoodhill, the latter expressed as a percentage of the total number of species and cultivars in the current collection. For example, there are 134 *Acer* in the current collection, which is 6.3 % of the species and cultivars in the current collection. The average score for *Acer* was 9.19 (Appendix 8). Hence, the weighted score for *Acer* was $9.19 \times 6.3 = 57.89$. Such new information highlighted several genera that had not been considered as key genera at the first workshop, therefore the original list was re-examined and several changes were made at the second workshop.

5.2.2 Role of the Arboretum and development of the collection (first workshop)

Following the discussion above a number of predetermined issues were addressed at the first workshop. These were:

(i) The role of the Arboretum
  (i) Social, scientific, tourism roles.
  (ii) Significance of the Arboretum to New Zealand.
  (iii) Long term objective.
  (iv) National focus and international liaison.
  (v) Links to other organisations.

(ii) The collection
  (i) What type of plants should be collected?
  (ii) Cultivars versus species.
  (iii) Native plants.
  (iv) Geographical origin of species in the collection.
  (v) Following the pattern of Douglas Cook.

(iii) Future prospects
  (i) Where should the collection go from here?
  (ii) Important issues to ensure sound decision making in terms of the composition of the collection.
  (iii) Further assessment, comparison with the national collection (MacKay, 1989c).

Each issue was put to the group in light of the assessment of the collection and, after discussion, a consensus was reached on each issue.

5.2.3 Development of the remaining 65 hectares of the property (third workshop)

The final exercise relating to long range goals was a session on development of the remaining 65 hectares of land which, at that time, was unplanted and grazed by sheep and cattle (Figures 5.1, 5.2). This issue was addressed at the third workshop and the stated aims were:

- "Development of philosophy, objectives and tasks for action for the new area".
- "Provision of the above to a person skilled in landscape development in order to formulate a layout plan for the area".

Background information was prepared on Douglas Cook's goals for the Arboretum, goals for the Arboretum as proposed in the first workshop, and a map of the area and its boundaries. Elements that contributed to the visual character of the present Arboretum were identified, along with notable

Figure 5.1 Photograph showing part of the remaining area of land. A view from the end of Orchard Hill onto Johnson's, Top Dan's and Bottom Dan's, April 1993.

Figure 5.2 Photograph showing part of the remaining 65 hectares of land. A view over Little Flat and Wee Flat, June 1990.

features on the interface between the current Arboretum and new area. Finally, a table was prepared which showed the proportion of each key genus present at Eastwoodhill, thereby identifying opportunities for collecting more members of those genera.

When the group was in session the background material was reviewed, the site inspected, and a discussion held. The group was asked to define objectives for the area, list character elements that would form the structure of the area, identify any detail elements that should be included, and list immediate tasks needed to initiate development of the area.

5.3 RESULTS AND DISCUSSION

5.3.1 Establishing the present status of the collection

Management of the collection should focus upon the need to sustain the fabric of the collection (Marquis-Kyle et al., 1992; Moggridge, 1986; Sales, 1989,1990), beginning by establishing the characteristics that Douglas Cook developed in the collection . The workshop group stressed the historical value of the collection as a reflection of Douglas Cook's work and restated the well known northern temperate theme. In discussing the assessment of the collection, they identified specific features of the collection including key genera.

5.3.1.1 Assessment of the collection

The collection assessment exercise resulted in data on Botanical, Aesthetic and Average scores for each genus in the current collection (Appendix 8). This satisfied two objectives for the first workshop: factual data on merit of the collection, and a consensus on the collection, both recorded as quantitative data.

The mean of Average score for all genera in the current collection was 6.88, with sixty genera scoring 8 or more and fourteen below 5 (highest possible score was 10). The mean of Average score for different segments of the collection was 7.24 for trees, 6.59 for shrubs, 6.94 for climbers, and 5.98 for New Zealand native genera. The workshop group decided that 6 was the minimum score for inclusion in the collection and any genus scoring below the minimum should be given lowest priority, and that no further members of those genera should be acquired. They also decided that any genus scoring 8 or more should be actively sought for the collection. Genera scoring between the previous two levels should be sought but as a secondary priority.

Sixty genera (from a total of 410 genera) scored 8 or more; collectively these genera accounted for 33% of species and cultivars in the current collection. Those genera can be divided into two groups: those above a certain number (represented by 10 or more species and cultivars), and those below that number (represented by less than 10 species and cultivars). The first group (high score, high number) were: *Abies, Acer, Aesculus, Betula, Cornus, Fagus, Ilex, Magnolia, Malus, Photinia, Pinus, Prunus, Quercus, Sorbus, Tilia* and *Viburnum*. The genera in this first group alone accounted for 30% of species and cultivars in the current collection. The genera in the second group (high score, low number) were: *Calodendrum, Cercidiphyllum, Cercis, Colquhounia, X Crataegomespilus, X Crataemespilus, Davidia, Dipelta, Disanthus, Ehertia, Emmenopterys, Euschaphus, Fothergilla, Freylinia, Ginkgo, Glyptostrobus, Heteromorpha, Itea, Keteleeria, Lardizabala, Mallotus, Manglietia, Metasequoia, Michelia, Neolitsea, Nyssa, Oxydendron, Parasyringa, Paulownia, Picrasma, Pistachia, Platycarya, Sassafras, Schizophragma, Schima, Sinojackia, X Sorbopyrus, Staphylea, Stuartia, Styrax, Taiwania, Talauma, Tecomanthe,* and *Tetracentron.*

The aforementioned minimum level of 6 resulted in lowest priority being given to the following genera: *Abelia, Alectryon, Aucuba, Baeckia, Banksia, Buxus, Cassia, Ceanothus, Celastrus, Cestrum, Choisya, Cistus, Coprosma, Cordyline, Cotoneaster, Cyphomandra, Cytisus, Duranta, Eccremocarpus, Elaeagnus, Elaeocarpus, Erythrina, Exochorda, Fatsia, Feijoa, Ficus, Helichrysum, Hibiscus, Hoheria, Hypericum, Kerria, Lagunaria, Lantana, Laurus, Lavandula, Ligustrum, Macadamia, Maytenus, Melia, Myoporum, Myrsine, Nandina, Nerium, Nestigis, Olea, Olearia, Pennantia, Phoenix, Phormium, Pomaderris, Poncirus, Prostanthera, Protea, Pseudopanax, Pyracantha, Raphiolepis, Robinia, Rosa, Rosmarinus, Salvia, Sambucus, Senecio, Solanum, Tamarix, Teucrium,* and *Trachycarpus.*

The 66 genera below the minimum score accounted for only 6% of species and cultivars in the current collection. Fourteen were New Zealand native genera, and about two thirds were shrub genera (which is disproportionately high given that the current collection is about 50% shrub genera). Those genera below the minimum were all represented by less than ten species and cultivars, with the exception of *Cotoneaster*. One could argue against the exclusion of *Cotoneaster, Exochorda, Kerria, Pyracantha, Raphiolepis* and *Rosa* because the rose family rates highly in the overall collection, noting however, that Douglas Cook began removing *Cotoneaster* and *Pyracantha* as they were self-seeding and getting out of control (Cook, undated e). A similar case could be made for *Ligustrum* as Oleaceae is also a high ranking family, but some *Ligustrum* are considered weeds in this region therefore that genus would have to be considered carefully.

Ranking the genera for Average score showed that the six most important genera were *Magnolia, Tetracentron, Acer, Quercus, Prunus*, and *Talauma*. Ranking the genera for number of species and cultivars in the collection showed that *Acer, Prunus, Quercus, Malus, Magnolia* and *Pinus* were the most important genera (using figures available at that time). The top five genera as measured by weighted score were *Acer, Prunus, Quercus, Magnolia, Malus* and *Pinus*. A weighted score for families showed that the most important families were Rosaceae, Aceraceae, Pinaceae, Fagaceae, and Oleaceae.

These data were used in discussions at the first and second workshops, resulting in proposals for key genera and the role of the Arboretum. The exercise focused participants on quantitative values and placed the discussion on a more objective level than it would have been without the assessment. In retrospect however, it is clear that there was limited consistency between the scoring and subsequent selection of key genera. The group decided to give priority to genera with an Average score of 8 or more, but their selection of key genera was more closely aligned with Botanical score than Average score. Fourteen key genera scored 8 or more for Botanical score, but only 11 scored at that level for Average score. Their instinctive selection apparently focused upon biological value, with aesthetic value being given less weight.

With limited consistency between rating scale results and selection of key genera, the scales and their operation should be questioned. The intent of the Botanical and Aesthetic ratings was to measure significance, which could be done by experts irrespective of any individual plant, but it is clear that some modifications were necessary. Rarity, desirability of plants in the collection, and botanical interest are not necessarily synonymous. It became apparent, after the fact, that lack of clarity on these ideas led to different interpretations of the scales by different people. Some used them to indicate rarity and others to give an opinion on desirability of that species in the Arboretum. One person consistently rated cultivars lower than species believing that cultivars did not belong in the Arboretum. This disparity could be overcome with clearer instructions, and by holding a discussion to reach a communal understanding before the scales were applied. Use of a scale to determine importance of the genera was reasonable, but subsequent study of rating scales showed that the Botanical and Aesthetic scales were not well enough defined nor the instructions explicit enough to allow consistent application.

Use of the rating scales illustrated an issue of preference and value, and personal and professional views. For these workshops the scales were supposed to be a measure of professional opinion (not personal preference), therefore participants should have tried to give an impartial rating to plants they would not select personally. In reality, participants' ability to make an impartial rating depends upon developing the right mind-set in the group, reinforcing the need for a briefing as a prerequisite to satisfactory application of the scales.

The ability to express professional judgement was also needed in the workshop manager, who had to set the 'rules' for applying scales (e.g. measuring rarity, cultivars allowed), while avoiding any influence on the ratings. Even if the workshop manager suspected a certain outcome, any workshop briefing had to be impartial as the value of the exercise would be negated if it was conducted as a foregone conclusion. It is the unexpected conclusion which often gives important insights into problems and solutions, or foreshadows an unanticipated future problem. Managers should consider all possibilities, not just the obvious ones, and try to think outside parameters that define the current situation. This capacity underlies the skill of lateral thinking, which often leads to creative solutions to problems.

Returning to the assessment, there were two other problems with the exercise. It was regrettable that *Rhododendron* and *Camellia* were omitted from the assessment exercise, reflecting an unfortunate decision by the workshop manager. There is no record of the reasoning at the time and one can only surmise that initial, intuitive, but incorrect conclusions about the collection were responsible for the decision. When the studies for Chapter 3 were completed it was clear that both genera were important to the collection and should have been studied more carefully. This reinforces the point about impartial preparation for the workshops as assumptions or premature judgements can cause such omissions.

The other difficulty involved rating some of the very rare species. Some were so unusual that few members, even in this expert group, could give them a rating. Thus Botanical and Aesthetic scores for some genera were the average of only 1-2 observations compared with up to 9 for other genera. For example, only one person rated *Peltaphorum* in the collection assessment, whereas nine people rated *Quercus*. It would be difficult to correct this problem within New Zealand as the workshop participants were drawn from the most knowledgeable people in the country; one solution is to seek help from suitable people overseas.

5.3.1.2 Key genera

A major outcome of the first workshop was the proposal for 'key' genera. This was the group's consensus on the genera which formed the 'fabric' of the current collection. It was refined at the second workshop and was subsequently an important focus for future goals for the collection. The key genera proposed at the first workshop were:

> *Abies, Acer, Aesculus, Alnus, Betula, Conifers (all), Fagus, Ilex, Juniperus, Malus, Magnolia, Picea, Pinus, Prunus, Pyrus, Quercus, Tilia.*

This list was a consensus decision following discussion and informal examination of the assessment data. After the second workshop it was decided that *Camellia, Crataegus, Fraxinus* and *Populus (species)* should be included in the key genera list. *Syringa* and *Sorbus* were also considered but rejected on the basis of poor climatic suitability. Changes were also made to the coniferous genera on the list, which originally included all 37 coniferous genera, many of them represented by small groups. At the second workshop the six largest genera were considered (*Abies, Chamaecyparis, Cupressus, Juniperus, Pinus, Picea*) and, after discussion, *Cedrus, Juniperus* and *Pinus* were included as key genera. *Abies* and *Picea* were removed, and *Chamaecyparis* not assigned, because the group felt those genera were not climatically suitable (generally needing cooler, more humid climates, e.g. central North Island). At the close of the second workshop the key genus list had been modified to include:

> *Acer, Aesculus, Alnus, Betula, Camellia, Cedrus, Crataegus, Cupressus, Fagus, Fraxinus, Ilex, Juniperus, Malus, Magnolia, Pinus, Populus (species), Prunus, Pyrus, Quercus, Tilia.*

The final selection of key genera was made using expertise and limited data. It is interesting, therefore, to compare the key genera list with the significant genera list developed in Chapter 3. All key genera but one were represented by ten or more species and cultivars in the collection. The exception was *Pyrus*, which was justified because of its relationship to *Malus* and *Crataegus*. Each key genus was supported by the Chapter 3 evaluation, except *Cedrus* and *Cupressus*. *Cedrus* was not botanically significant and had a relatively small representation, but was included for aesthetic value as it was an important visual element. *Cupressus* had only a moderate representation in the collection and subsequent data showed that the Eastwoodhill collection was not significant (MacKay, 1993). It cannot be justified by the present evaluation but the workshop group supported it because of climatic suitability, identifying it as a potentially important genus in the future.

Chapter 3 also showed that *Berberis, Carpinus, Gleditsia, Nothofagus, Rhododendron, Taxus* and *Ulmus* were significant genera. They were not considered during the workshops and should be placed on the agenda for subsequent workshops. *Abies, Chamaecyparis, Picea, Sorbus,* and *Syringa* were also supported by the evaluation but were rejected as key genera for this site because the workshop group believed they were poorly suited climatically. In making this comparison between key genera and significant genera, one must remember that the evaluation in Chapter 3 examined a certain range of genera (long lived genera with a high number of species and cultivars in the current collection). If a modified set of genera had been evaluated (including short lived genera and other genera from the previous collection) then different conclusions may have been reached.

Selection of key genera can also be examined against the results of the assessment exercise, showing that the key genera list had limited support from the assessment results. The following key genera scored 8/10 or more for botanical score: *Acer*, *Aesculus*, *Betula*, *Crataegus*, *Fagus*, *Fraxinus*, *Ilex*, *Juniperus*, *Magnolia*, *Malus*, *Pinus*, *Prunus*, *Quercus*, and *Tilia*. *Alnus*, *Cedrus*, *Cupressus*, *Populus*, and *Pyrus* were in the 7.0-7.9 band. *Cedrus* and *Cupressus* were in the lower band, which was consistent with their poor support in Chapter 3. The presence of *Alnus* in the lower band was an anomaly as it rated well in Chapter 3 (Table 3.16). If the scores were valid then *Carpinus*, *Cornus*, *Photinia* and *Viburnum* should be reconsidered as these were high volume genera that scored 8 or more in the assessment (The group decided that genera scoring 8 or more should be actively acquired). *Abies*, *Picea* and *Sorbus* were also in this category but were discounted for climatic suitability.

When considered in terms of Average score (the mean of Botanical and Aesthetic score), *Crataegus*, *Fraxinus* and *Juniperus* dropped out of the first priority band (score 8 or more) and into the 7.0-7.9 band. *Cedrus* and *Populus* remained in the 7.0-7.9 band, but *Alnus* dropped into the 6.0-6.9 band with *Cupressus*. Thus presence of the Aesthetic score (within the Average score) demoted *Crataegus*, *Fraxinus*, *Juniperus*, and *Alnus*. The Average scores supported the reconsideration of *Abies*, *Cornus*, *Photinia*, *Sorbus* and *Viburnum* as these scored more than 8, but not *Carpinus*. Overall, botanical score gave a much better match with key genera than did Average score, which seems logical given that it is botanical value that underpins the purpose of an arboretum. The possible weaknesses of the scoring exercise have already been discussed and, with a different system, the ratings should prove a useful tool. As more data become available the key genera list should be re-examined and genera should be consciously considered for inclusion or exclusion.

When combined, the results in Chapter 3 and the assessment exercise suggested that *Abies*, *Berberis*, *Carpinus*, *Cornus*, *Gleditsia*, *Nothofagus*, *Photinia*, *Picea*, *Rhododendron*, *Sorbus*, *Syringa*, *Taxus*, *Ulmus* and *Viburnum* should be reconsidered for inclusion in the key genera. At the same time *Alnus*, *Cedrus*, *Cupressus*, *Populus* and *Pyrus* should be reconsidered for exclusion from the key genera as they are not well supported by the analyses to date (bearing in mind possible weaknesses in Chapter 3 results). Of the genera for possible inclusion, *Photinia* should be considered because it is in the rose family and could be justified on the same basis as *Pyrus*. *Abies*, *Chamaecyparis*, *Picea*, *Sorbus* and *Syringa* were discounted because of climatic suitability; this is reasonable, as long as the conclusion is valid and the problem is not one of natural ageing or poor siting. This particularly relates to *Sorbus* as inspection shows this group to be in poor condition, and many are senescent or have died (although many are planted on the most difficult soil in the Arboretum). Although *Sorbus* is generally a colder climate genus, it would be unfortunate to conclude that none are suited when better siting might eliminate some of the problem.

Selection of key genera shows that the workshop group intuitively considered both significance and condition, as illustrated by their rejection of some groups on the basis of climatic unsuitability. Key genera can be broken down into three categories:

(i) Those found to be significant (Chapter 3):

Selected by the group

Acer, Aesculus, Alnus, Betula, Camellia, Crataegus, Fagus, Fraxinus, Ilex, Juniperus, Malus, Magnolia, Pinus, Populus (species), Prunus, Pyrus, Quercus, Tilia.

Not selected by the group

Berberis, Carpinus, Cornus, Gleditsia, Nothofagus, Photinia, Taxus, Ulmus and *Viburnum*

(ii) Those found to be significant (Chapter 3), but rejected because of poor condition (assumed to be climatically unsuitable):

Considered but rejected by the group

Abies, Picea, Sorbus, Syringa

(iii) Those not significant, according to these analyses:

Selected by the group

Cedrus, Cupressus,

Different management actions will be needed for each category. Those that were significant but which were not selected should be reconsidered at a subsequent workshop. Those that were not significant, but were selected, should also be reviewed to ensure that there was a valid reason for their inclusion, e.g. the visual importance of *Cedrus*. Those rejected as climatically unsuitable must also be reconsidered, but in terms of their future at the Arboretum. Should the more successful members be retained, and under what circumstances (e.g. some of the *Abies* are successful even though there are problems with the group as a whole). What should happen to the germplasm of collections that are climatically unsuited? It would be inappropriate for those collections to disappear, raising issues of when, how and to whom the species should be dispersed?

The development of key genera illustrated several collection management principles. First, the key genera represented a consensus on the fabric of the collection (Marquis-Kyle et al., 1992; Sales, 1989, 1990) which is important in understanding the original concept, and carrying that concept forward into future management. Second, key genera are the basis of a focused accessions policy (Heywood, 1987; WWF and IUCN, 1989). Third, knowledge of the range and distribution of key genera in other collections and commercial trade underpins the principle of managing a collection with knowledge of the content of other collections (WWF and IUCN, 1989). For example, *Fraxinus* was not selected as a key genus in the first workshop, but was added at the second workshop because new data showed it was an important collection in New Zealand. Similarly *Carpinus, Euonymus*, and *Gleditsia* did not score highly in the botanical assessment, nor were they considered to be important to the character of the collection, yet other data showed that the Eastwoodhill collections were the most important in New Zealand (MacKay, 1993).

In conclusion, selection of key genera was an important way of focusing on the characteristics of the collection, and giving a sound basis for collection development decisions. The selection reported here, however, was an analysis of the current collection and cannot be expected to remain static. The future pattern of key genera will depend upon decisions defining the future shape of the collection. Key genera in the future are discussed under goals for the collection in section 5.3.3.2.

5.3.2 The role of the Arboretum

After consideration of the Arboretum, the collection, and the assessment of the collection at the first workshop, the group proposed that the roles of the Arboretum should be to:

(i) Maintain and further the collection of Douglas Cook.
(ii) Encourage visitors of a scientific and public nature.
(iii) Act as an educational resource.
(iv) Conserve plant material.
(v) Be proactive in the area of land management and (soil) conservation planting.
(vi) Act as an international liaison point for botanical matters in New Zealand.

The first role was in keeping with a key principle of landscape management; ensuring that the resource continues to exist (section 1.2.4). This basic purpose must be achieved if values are to be obtained from the landscape. Furthermore any utility functions (recreation, education) depend upon the existence of the resource in the first instance. Thus one would expect to find a statement of this kind (the first role) somewhere within the overview planning levels of an arboretum. For example, at the Centre for Plant Conservation in America they will "develop and maintain the national collection" (Anon., 1991c). The Australian National Botanic Gardens will "maintain and develop integrated living and herbarium collections" (ANPWS, 1993).

The first role was also in keeping with the management of historic landscapes (Sales, 1988) where one manages according to the intentions of the original creator of the place. The group concluded that it was important to continue Douglas Cook's work. He developed certain visual and botanical patterns in the Arboretum (Chapter 3) and it is logical that the Arboretum reflects those patterns in future. The group also proposed extending the collection theme into its warm temperate component. This would strengthen the uniqueness of the collection by introducing plants such as warm temperate relatives of existing Magnoliaceae and Fagaceae that are not present in other collections in New Zealand.

The second role was in keeping with the functions of an arboretum (Morley, 1993; WWF and IUCN, 1989). The group discussed scientific versus public visitors and recognised the need for visitors to sustain the Arboretum, but they also stressed that the unique character of the collection should not be compromised. That is, although the Arboretum should be a memorable experience for visitors, the recreational use must be controlled to protect the Arboretum. The group also recognised that, if the Arboretum was to attract scientific visitors, it had to develop unique features and identified the warm temperate material in this light Although these conclusions implicitly recognised botanical scientific merit as superior to recreational uses, this issue was not addressed directly by the group and the conclusion was not explicit.

The third role (education) was in keeping with the functions of an arboretum (Eloff, 1987; Given, 1986; WWF and IUCN, 1989), and the statutory obligations of the Trust Board which require that the Arboretum is available for public education (Eastwoodhill Trust Act, 1975).

The fourth role (conservation) is valid with respect to a taxonomic collection of ornamental flora (Rae, 1993). Conversely, a conservation collection in the scientific sense would be hard to achieve because of the number of individuals needed (Rae, 1993). One could however, consider the conservation approach taken by the Sydney Botanic Gardens, where ex-situ collections were divided into three categories (Royal Botanic Gardens Sydney, 1993). It has already been pointed out that a class one collection (scientifically managed for genetic conservation) is unlikely to be achievable at Eastwoodhill. A class two collection (collections for specific research projects, which do not have to meet genetic criteria), might be possible. Class three collections (ex-situ material for educational purposes, not survival purposes, therefore genetic integrity is not critical) would be suitable for Eastwoodhill, indeed the current collection seems to fit this category already.

The fifth role will be difficult to meet for two reasons. Eastwoodhill does not have any leading edge in New Zealand with respect to plant material for soil conservation purposes. This is already met in New Zealand at LandCare New Zealand Ltd, a specialist government research centre. Eastwoodhill has been used to trial their material on erosion prone land, but does not have the expertise or resources to take new scientific initiatives. The fifth role is, however, valid in the local area where Eastwoodhill could be a demonstration site for soil conservation plantings and also fulfill an educational role. However, such plantings are common on general farmland throughout the East Coast and Eastwoodhill should concentrate on factors which emphasise its uniqueness.

The sixth role is ambitious and impractical for a low income enterprise such as Eastwoodhill. Eastwoodhill is the leading plant collection of its type in New Zealand, but the Trust Board has neither the time nor the expertise to be a substantive research centre. The latter requires national planning and administration, scientific skills, and the ability to gather and process large amounts of data. In addition, the task of national plant collections planning has already been initiated by the Royal New Zealand Institute of Horticulture (Hammett, 1993; RNZIH, 1990). The Arboretum could, however, make new contacts by joining BGCI and other relevant international groups, and the workshop group agreed that this should be done.

Of the six proposed roles, four seem appropriate. While no explicit priorities were developed for those roles, there was an implicit priority in the first workshop where the group decided that "the unique character of the place as a special botanical collection must never be compromised", but at the same time "public are the sustaining base of visitors to the Arboretum and therefore must be catered for". These statements implicitly place biological value of a unique collection over visual value in the management hierarchy.

To achieve the proposed roles, collection management should be focused on the two main tasks of landscape management: (i) perpetuation and development of the collection made by Douglas Cook and, (ii) managed utilisation of that collection for whatever purposes are selected, e.g. science or education. The tasks are interwoven as the latter will not be possible without the former, and the quality of the collection influences its usefulness for any given purpose. Therefore those two tasks promulgate very clear foci for collection management. First, a high quality collection (significant and in good condition) must be developed and sustained. This involves planning, designing and managing a collection that focuses on the characteristics developed by Douglas Cook, and then developing whatever extensions of that collection are logical under the long term goals of the collection. Next, the Trust Board must plan and manage the utilisation of that collection for their chosen science, education, or recreation roles. On one hand, managing the utilisation of the collection is the business of the Trust Board and is not relevant to this project. On the other hand, the utility roles depend, in part, on the management of the collection, as suitable plants must be present for those roles. Indeed, the workshop group recognised that usefulness of the collection would be governed by plants that were in the collection. Thus the proposed utilisation of the collection (science, education, recreation) must be a factor in collection management.

5.3.3 Goals for development of the collection

Once the group understood the features of the current collection, goals for the future of the collection could be proposed. These were reported under six categories.

(i) Future direction (Workshop One)

The group was unanimous that themes developed by Douglas Cook should be continued and extended, a view that had already been expressed under the roles of the Arboretum and which is in keeping with the general goal of preservation. The future direction should focus on the current temperate flora based upon key genera, but extended into its warm temperate component, also based upon key genera and their logical extensions. The warm temperate flora that related to existing themes, e.g. Magnoliaceae and Fagaceae, was seen as supporting uniqueness of the collection (Miles and Seabrook, 1977). The autumn colour and spring flower displays of those groups was seen as an important additional attraction for visitors.

(ii) The range of plants (Workshop One)

The workshop group discussed the range of plants that should be included in the collection and concluded that three sets of plants were relevant. First, they believed that appropriate South American flora should be included in the collection. These were supported on the basis of climatic suitability, providing an evergreen element, and because the group believed those plants were in keeping with the character of the Arboretum. *Nothofagus* was specifically identified because of its relationship to the strong oak collection in the Arboretum. In terms of theme development, South American relatives of key genera can be supported, but any broader South American range would not be in keeping with the patterns of the previous collection. South American flora is only 2% of the current collection, and was only 3% of the total collection, therefore it would be counter to the overall theme to emphasise it past its logical relationship with the key genera.

Second, the workshop group favoured inclusion of plant material that demonstrated the climatic range that can be grown in the East Coast area, e.g. warm climate *Lithocarpus* and *Quercus*. They also supported the idea of Eastwoodhill being used to demonstrate plants that were suitable for dry areas (such as the East Coast), anticipating the range of plants that could be used in a drier warmer New Zealand if climate change is a reality. In part, demonstration of climatically suitable plants happens by default because plants that are not climatically suited will not survive. Logically a climatic theme should be subordinate to key genera, unless a conscious decision is taken to change the main collection focus.

The third important set of plants emphasised was those for soil conservation purposes. This is particularly relevant to the Gisborne region as many soils in the region are strongly susceptible to erosion and there are serious erosion problems on much of the steeper farming land. New species with soil conservation uses will be of much local interest. Clearly this plant group relates to the proposed land management role for the Arboretum, which was previously discounted. There is an opportunity to demonstrate new plant material at the Arboretum, such as Mexican oaks, and to work with the scientists from LandCare New Zealand Ltd in developing joint initiatives. It would not be possible to initiate any solely Arboretum based scientific activities unless the Trust Board could obtain sufficient scientific expertise for that task.

These proposals on the range of plants to be included in the collection show the importance of an explicit hierarchy for collection development. It was implicit that the 'range of plants' was subordinate to 'future direction' and that the range of plants developed in the collection should meet both goals, i.e. plants that are key genera or their relatives *and* of South American origin are easier to justify than South American groups that are unrelated to key genera. It was unfortunate that this was not explicitly stated at the workshops as it would have confirmed the key genera focus and given a conscious hierarchy on which to judge subsequent decisions. It also removes any confusion about the extent to which other goals should be developed, e.g. the climate advantage goal would be clearly subordinate to the key genera goal and should not take first priority, unless a conscious decision was made to alter the overall collection focus. The principle of developing a focus and a hierarchy is particularly important when resources are in short supply as that principle is used to direct limited resources toward the most important tasks.

(iii) Cultivars (Workshop One)

The workshop group considered the role of cultivars and concluded that selected cultivars were acceptable in the collection. This included cultivars of species and first order hybrids. This decision allowed most cultivars of genera such as *Magnolia* and *Malus*, whose ornamental representatives include many taxa of cultivar rank. On the other hand the decision is potentially ambiguous as it would allow *Malus* 'Simcoe' (*baccata x niedwetzkyana*) but not *Malus* 'Veitch's Scarlet' ('Red Pippins' x *robusta* 'Red Siberian'). This decision was not tested against the catalogue, therefore its practicalities are difficult to estimate. The likely intention was to avoid plants with gaudy variegations or highly artificial forms and concentrate on taxa closer to the natural types. In reality however, there are already variegated plants, dwarf forms, and highly contrived cultivars (especially *Camellia* and *Rhododendron*) in the collection. This issue should be re-examined in future workshops to clarify exactly what was intended by this decision.

(iv) Native plants (Workshop One)

At the first workshop the group decided that the Bush area of the Arboretum should be modified to incorporate it into the surrounding areas (it was previously fenced off and separate). The group felt that native plants should be demonstrated either as part of a functioning remnant, or as part of a collection which shows a range of species. The Bush area was neither of these and was incongruous in both visual and collection terms. It was decided that the Bush Area should be transformed into an area that showed the link between native and exotic genera, using genera such as *Nothofagus*, *Podocarpus* and *Libocedrus* to establish the link. These genera would link to the strong Fagaceae and conifer elements already present in the collection, and form the basis for any potential Gondwana theme in the future collection. This was an important decision as it dealt with a previously incongruous element and developed a goal to merge it into the overall pattern of the collection.

(v) International profile (Workshop One)

The group recognised that the international reputation of the Arboretum was an important issue in its future development and that this was closely related to the uniqueness of the collection. The development into the warm temperate theme was seen as the key factor here, because the group believed that New Zealand's climate would allow a combination of temperate and warm temperate that would be difficult to achieve in northern hemisphere arboreta.

(vi) Operational goals (Workshops One and Two)

As a result of the first two workshops the following broad collection management goals were developed:

(i) That a more detailed assessment of the collection should be carried out.

(ii) The tree evaluation system (use of rating scales) should be continued as a mechanism to aid tree management decisions.

(iii) The acquisition policy for key genera should, in the absence of a specific genus plan, be the acquisition of all species possible. If a species does not succeed at Eastwoodhill then an herbarium sample should be held.

(iv) The acquisition for non key genera groups should be that of selective acquisition based on climatic suitability, followed by other selection factors.

(v) Site suitability is the first criterion for location of planting sites, other factors such as geographical association, aesthetic merit, and seasonal factors, should be of secondary consideration.

These goals supported the need for continued planning input through further assessment of the collection and tree management decisions. They also contained broad accession policies for both key genera and other genera, as would be expected at this management level. At the same time however, a number of unresolved issues remained. The practicality of the acquisition policy for key genera is unknown; how many taxa are involved and does the Arboretum physically have room to accommodate all of the plants that might be collected under this goal? Similarly, how does goal (v) relate to goals (iii) and (iv). While these goals are reasonable principles, they clearly cannot be implemented without further operational planning, e.g. feasibility of the acquisition and planting goals have not been tested. In addition, the overarching goals of preservation, protection and improvement were not discussed directly and, while they are inherent in the goals discussed above, a more explicit discussion would have been useful.

These goals also highlight the issue of physical layout. This issue was not addressed in the workshops, but physical layout planning will be needed to implement the above goals. A coherent physical layout is necessary for the scientific utility of an arboretum; new material should be planted in logical groupings, not an ad hoc arrangement. In particular, how should the key genera principle be transformed from an idea into a physical planting layout? The existing layout foreshadows a generic backbone but it is presently only concentrations of genera rather than coherent groupings; further planning is needed to convert the present pattern into a generic layout. Such a layout would not preclude areas with other themes, however the generic pattern should dominate if biological value is the primary value and a generic layout has been selected by the Trust Board.

In addition, any biological layout must be successfully merged with a satisfactory visual layout. This is a difficult issue as the biological framework imposes a constraint upon visual composition, and this merging of visual and biological factors in design has not been widely considered by landscape professionals (Byrd, 1989; Lighty, 1989; Posner, 1989; Robertson et al., 1989). Eastwoodhill does not have a plan for visual effects, but Jackman (1990) developed a plan for broad spatial and circulatory layout. Thus, there is an unresolved planning issue involved in converting collection management goals into a physical layout, e.g. will all the key genera fit into the physical space, how should key genera be arranged physically in relation to site microclimates, what visual development should be used? The problem of physical layout for the collection should be considered in future workshops, in association with suitable landscape design professionals.

5.3.3.1 Development of the remaining 65 hectares

At the third workshop the question of the remaining (unplanted) land area of the Arboretum was addressed. The present Arboretum is 65ha, the unplanted area is also 65ha, representing a major portion of the potential future Arboretum. To perpetuate the original concept and visual character of the place, any development of the remaining land should include biological and physical characteristics that link it to the present Arboretum. At the third workshop the group concluded that principles for physical development were:

(i) The principle of key genera should be continued in any development of the new area. Guidelines for treatment of each key genus were outlined in the third workshop report (Appendix 7).

(ii) The new area should have a character compatible to the present Arboretum, incorporating elements such as repeated evergreen elements, conifer backdrops with deciduous highlights, conifers on ridge tops, a backbone of red oaks and cedar, 'forests' of a single species, genera plantings, high impact plantings around lakes, areas to demonstrate plant material for various uses (e.g. shelter), occasional symmetrical elements for contrast, vistas and open spaces, lookout points, and tracks which follow the contour.

(iii) A method for planning the detail of site development should be formulated.

If these guidelines were followed the visual and conceptual characters of the existing collection should be carried into the remaining land as it is developed. The guidelines do not specify which species should be used, or in what arrangement, therefore considerable planning and design remains to be done. These guidelines simply set a conceptual framework so that future development will be consistent with existing features.

5.3.3.2 Key genera in the future

Selection of key genera was an important collection management focus, but that selection is unlikely to remain static. The key genera represented the collection as it was at the time, but other genera might also be developed as key genera in the future. Current key genera are:

> *Acer, Aesculus, Alnus, Betula, Camellia, Cedrus, Crataegus, Cupressus, Fagus, Fraxinus, Ilex, Juniperus, Malus, Magnolia, Pinus, Populus (species), Prunus, Pyrus, Quercus, Tilia.*

Future key genera are those which might be purposely developed into a significant collection; they may or may not exist in the current collection. Key genera selected for the future should either strengthen the existing significance of the collection, or develop new significance that is related to the existing collection. Completely new aspects of significance should be considered carefully. These could be supported if they support the uniqueness of the collection and are not being collected elsewhere. New genera that will not be significant, or have strong 'competition' in other collections should assume low priority in any acquisition policy.

Four broadleaf genera and three families were proposed as future key groups: *Castanopsis, Celtis, Lithocarpus* and *Nothofagus*, and Theaceae, Magnoliaceae and Ulmaceae. *Castanopsis* and *Lithocarpus* can be justified by the warm temperate theme and the Fagaceae theme, and anecdotal evidence suggests that they are not being collected in other collections. The 'availability in trade' data also supported *Castanopsis* and *Lithocarpus* as future key genera. *Nothofagus* can also be justified by the warm temperate and Fagaceae themes, and is a component of any potential Gondwana theme. This genus was 29th of the 30 currently significant genera identified in Chapter

3, but is a weaker selection because there is strong competition from other collections. There were eighteen taxa in other collections; the largest collection had 11 while Eastwoodhill had 8 (MacKay, 1993), showing that although Eastwoodhill could establish a collection of *Nothofagus*, it would take comparatively more effort to make it significant.

Celtis and Ulmaceae were proposed on the basis of developing a collection of Ulmaceae trees in light of the recent arrival of Dutch Elm Disease in New Zealand. Both were justifiable selections. *Ulmus* was one of the significant genera identified in Chapter 3 and its inclusion as a key genus could be justified on that basis. *Celtis* was not studied in Chapter 3 so its true status is unknown. At the time of the workshops Dutch Elm Disease had been found in New Zealand and it was feared that the elms would ultimately be lost, therefore *Celtis* was favoured over *Ulmus* at the time. If the disease is eliminated then both genera should be considered for future key genera.

The evaluation results and the collection assessment supported Magnoliaceae but there was insufficient data to judge Theaceae. The workshop group did not identify Betulaceae, but it could be argued that it should also be identified as a key family group, as *Alnus* and *Betula* were selected as key genera and *Carpinus* was identified as a significant genus. The collection assessment also showed that Rosaceae, Aceraceae, and Oleaceae were important families when measured by weighted score (Appendix 6). The workshop group did not identify these families either, so each should be reconsidered for collection development at a subsequent workshop.

Discussion also took place on possible future key genus rank for a number of coniferous genera and one family including *Athrotaxus, Callitris, Keteleeria, Podocarpus, Taiwania*, and Taxodiaceae. The Taxodiaceae group and *Keteleeria* were proposed for the warm temperate theme, *Callitris* for climatic suitability and *Podocarpus* for a Gondwana collection. No New Zealand collection data were available for any of those groups except *Podocarpus*. At present Eastwoodhill does not have a significant collection for that genus, ranking only seventh and having 11 species when 35 species are needed for a significant collection (MacKay, 1993). Likewise, *Callitris* is already being collected on another site therefore any Eastwoodhill collection would not be unique. Collecting *Athrotaxus* and *Keteleeria* might be worthwhile as these are poorly represented in the 'availability in trade' data. The assessment exercise supported Taxodiaceae as an important family, which particularly lends itself as its members scored well in the assessment exercise and it contains several rare species.

The key genera which define the future shape of the collection will be drawn from existing significant genera, new groups that will be developed into significant groups, genera that were present in the collection in the past and which are re-introduced, and genera that are significant for visual reasons. Genera fall into these four categories as follows:

1. Existing genera that are significant.

(i) First priority (Supported by Chapter 3, botanical score 8.0 or more).

Selected: *Acer, Aesculus, Betula, Crataegus, Fagus, Fraxinus, Ilex, Juniperus, Magnolia, Malus, Pinus, Prunus, Quercus, Tilia.*

Not selected: *Carpinus*

(ii) Second priority (Supported by Chapter 3, botanical score 7.0-7.9).

Selected: *Alnus, Camellia, Populus (species), Pyrus*

Not selected: *Gleditsia, Nothofagus, Taxus, Ulmus*

(iii)Third priority (Supported by Chapter 3, botanical score 6.0-6.9).

Not selected: *Berberis*

(iv) Evaluation (Chapter 3) or assessment (Chapter 5) results support reconsideration of these as key genera.

Not selected: *Cornus, Photinia, Rhododendron, Viburnum*

2. Existing genera, not botanically significant, but contribute to visual character.

Cedrus

3. Genera to be developed, not presently significant, compatible with the goals set for collection development.

(i) Current data suggest these are likely to contribute botanical significance.

Athrotaxus, Castanopsis, Celtis, Lithocarpus, Keteleeria

(ii) Current data suggest these may not contribute botanical significance.

Callitris, Podocarpus

(iii)Climatically suitable.

Cupressus

4. Genera present in significant numbers in the past, and which should be considered again.

Clematis, Philadelphus, Viburnum

The genera marked 'not selected' are those which were shown to be important in Chapter 3 but which were not chosen by the workshop group. Data should be developed on each genus and then each one reconsidered. Likewise, genera in categories three and four need further study before defensible decisions can be made. Decisions on future key genera should not be made until adequate data on relevant genera have been collected and evaluated. It would be an error to shape the future of the collection on genera that could not strengthen the significance of the Arboretum; justifiable selections depend upon knowledge of those plant groups in other collections (WWF and IUCN, 1989) therefore the need for good background data cannot be overemphasised.

The need for rigorous decision making is illustrated by changes in the patterns of other collections between 1990 and 1993 (MacKay, 1990a; MacKay, 1993). These changes showed that Eastwoodhill lost ground in the coniferous genera and some broadleaf genera, particularly *Magnolia*. Moreover, those data showed that the Arboretum contained significant genera which had not been recognised, e.g. *Carpinus* and *Gleditsia*. This suggested that the collection focus at Eastwoodhill was not as well clear as it might have been, and therefore its uniqueness was not being used to full advantage.

The process of selecting key genera depends upon use of data, thus the collection manager must continuously seek data on those genera. This discussion illustrates the point; the anecdotal key genera list was defensible, but it was not until data were available that other important genera were revealed and the list was revised. A defensible result also depends upon proper processing of that data, e.g. *Cedrus* appeared on the key genus list because the workshop group did not distinguish between biological and visual value. Better planning of the discussion and clearer definition of issues would have clarified that point.

If the Eastwoodhill collection is to remain nationally significant the Trust Board *must* consciously and rigorously manage the focus of the collection. The designation of key genera and future key genera must be made with a disciplined decision making process. Key genus rank must be assigned through rational consideration of long range goals and their priorities, current significance of the collection, and knowledge of plant material in other collections. The key genus list should be used as a basis to rigorously manage the collection, but the list should not be static; it should be regularly reviewed and modified as new data becomes available or if circumstances change. The workshop group recognised this principle and stated that issues such as criteria for key genera, objectives for expansion of key genera, and closer examination of conifer groups should be investigated. Thus, the key genera concept must be continually managed as a component of the systematic management system for the Arboretum.

5.3.4 Critique of the method

This research has made significant progress in developing long range goals for collection planning and management at Eastwoodhill. The role of the Arboretum was explicitly considered, and a series of roles proposed. The overarching theme of the collection was selected (northern temperate to warm temperate) along with key genera and types of flora within that theme. The future shape of the collection was considered and likely future key genera identified. Goals for future development of the collection were proposed. Important principles were proposed for development of the remaining land, and acquisition of plant material. Each of the decisions was well supported by data, expertise and planning and decision making processes. The critique of those outcomes, contained in the discussion above, shows that most recommendations were defensible, but some need further clarification or re-evaluation. Several observations can be made about the development of long range goals.

Collection management outcomes were influenced, in part, by the overall effectiveness of the workshop approach, therefore the discussion in Chapter 4 is also relevant to this discussion. As already stated in Chapter 4, more data (as per Chapter 3) should have been available at the workshops. More robust rating scales, with better instructions, would have lead to better selection of key genera, and reduced the need to re-evaluate issues when new data was developed. Better recognition of strategic issues would have been useful. Acceptance of a nominal mission left several issues unresolved namely no consensus on customers; hierarchy (or indeed relationship between) science, education and recreation; definition of core business or key result areas for the Arboretum; selection of collection type; and selection of layout for the collection. These factors were not addressed directly by the workshops and it is now clear that one or more workshop(s) focusing on these issues is needed.

The workshops should also be seen within the broader picture that relates to both collection and enterprise management, i.e. the scope of collection management issues that were addressed in the workshops. The workshops concentrated on the plant management aspects of collection management, and did not address issues of physical layout or take any overview of the parks and their features. It is now obvious that physical layout is intimately related to feasibility of collection management goals and, in due course, a layout type must be selected and concepts for its development should be formulated.

The second aspect of scope was consideration of parks. Chapter 3 showed that the parks had different significance and condition characteristics, and these features will have an important bearing on collection management decisions, e.g. the management of *Crataegus* will be closely associated with management of Pear Park as many of that genus are in that park. Parks in general were not considered in overview at the workshops, and clearly the integration between key genera and parks is an issue that must be addressed at subsequent sessions. Although parks, physical layout and collection arrangement are integral parts of the whole picture, it would have been impossible to adequately address all of those topics unless the workshops were longer. Moreover, it would have been unreasonable to ask for a longer time commitment from volunteer participants. Even if time had been available the extra topics may not have been successful; they are complex and require a good grasp of the Arboretum and its features, and are better suited to a second workshop series.

Finally, at some point the deliberations of the workshops must be integrated with other aspects of the enterprise, e.g. financial planning, maintenance planning, design planning. Some of these issues (e.g. financial planning) are beyond the scope of the workshops or this project. Others impinge upon operation of the workshops and implementation of the recommendations. The workshop group needs to be aware of those factors and their relationship to collection management, so that they can comment as appropriate.

5.3.5 Development of a strategic position

The outcomes of Chapter 5 were a series of long range goals and some associated philosophical ideas that are important components of a strategic position for the Arboretum. These have already been described in section 5.3.4. These results were an important advance for managing the collection, but in retrospect, constituted only part of the strategic position that might have been developed.

Consider the likely components of a strategic position (Griffin, 1990; Rue and Byars, 1992). A consciously chosen and rigorously developed mission is needed which identifies the customers and the product they are looking for. These topics were not discussed at the workshops therefore the primary purpose (and the previously uncertain position of the Trust Board) was not resolved. The mission is a subject that must be addressed in future. Associated with the mission was the question of scope. What 'businesses' should the Arboretum be involved with (science, education, recreation), to what extent, and how do these influence the collection? What key assumptions were, or were not, being made about business and scope? Broad resource deployment was not considered, when this is an extremely important issue for an enterprise with very limited resources. No clear distinction was made between the two key tasks of landscape management (section 1.2.4): ensuring the resource continues to exist, and managing its use. The latter cannot occur without the former, therefore the clear separation of these two management tasks should have been important in strategic level priorities.

At a more detailed collection level, there was no conscious selection of a taxonomic or conservation collection, and the difficulty of conservation in the scientific sense was never addressed. Nor was there any deliberate selection of a biological layout for the collection (generic or geographic). A generic arrangement was implicit within the notion of key genera, but it was not explicitly stated and was never debated against the other alternatives. Physical layout of the collection was not addressed either and, although that topic was not within the scope of the workshop, it should have been highlighted as an important associated issue.

It could be argued that many components of the strategic position were the prerogative of the Trust Board rather than the workshop group, and that the Trust Board should develop the strategic position that forms the framework that the workshops operate within. Theoretically this is correct, nevertheless the Trust Board has not yet developed the components of a strategic position (Chapter 4). It makes sense to use the expertise of the workshop group (or a modified workshop group), together with the Trust Board, to develop that strategic position.

5.4 CONCLUSION

The workshop group and the workshop method were used at Eastwoodhill to develop an overview of the collection and a series of long range goals for the collection. These are important components of a strategic position, but did not constitute a comprehensive strategic position as several major issues were not addressed in the workshops. As a result of this project, however, the principles and processes needed to manage a workshop session for the purpose of developing a strategic position are now apparent. Such a workshop could be conducted and the outcomes could be used in the long range component of a systematic management framework for the Arboretum.

The long range goals that have been developed are a component of the systematic management framework and should be used to drive the development of shorter range goals and operational plans. Each park and key genus should be managed within the context of the goals that have been set. Operational plans for parks and genera are the subject of the next chapter.

Chapter 6

Using the workshop for collection management Part Two: Plans for genus and park management

Acer rubrum 'Brilliant', Pear Park, April 1994.

6.1 INTRODUCTION AND REVIEW

Previous discussion showed that Eastwoodhill Arboretum was a category two landscape (according to the system outlined in Chapter 3), characterised by loss of short lived material and the impending loss of medium lived material including key genera such as *Crataegus*, *Malus* and *Prunus*. Plans should be developed to transform the Arboretum into a category one landscape and to ensure timely renewal of important collection components as they reach the end of their natural lives. At the same time, good quality appearance must be maintained to attract visitors. These outcomes can only be achieved through deliberate management plans because the vegetation array within the Arboretum is human-made and cannot renew itself. This chapter outlines how the workshop was used to develop plans for parks and genera in the Arboretum. Planning has already been reviewed in Chapter 4, but two particular aspects are developed in this chapter: the need for deliberate management of vegetation in human-made landscapes, and the planned approaches that might be used including use of rating scales to measure plant attributes.

6.1.1 The need for deliberate management action to sustain vegetation in human-made landscapes

Vegetation in human-made landscapes is an imposed form, being a conglomerate of disjunctive plants that would not normally be found together, and which are kept in a designated state by human intervention (Owen, 1991; Sales, 1990). Such vegetation is a contrived plant diversity, and although biological processes occur (e.g. biomass store, energy exchange) there is no self-sustaining ecosystem (Hall, 1981; Owen, 1991). This vegetation is the 'fabric' of many human-made landscapes and is the basis of many important values; if it declines or disappears the value of those landscapes diminish (Beckett and Dempster, 1989; Egerton-Smith, 1987). But vegetation continually changes as individual plants and whole populations move through life phases (Miller, 1988; Neilsen, 1993; Ramsay, 1992; Sales, 1988, 1989, 1990; Taylor, 1990). Change and eventual death of plant material is inevitable (Anthony, 1975; Bourke, 1983; Green, 1984).

Ageing vegetation is a common problem in human-made landscapes with trees in poor condition, and insufficient young trees for replacement (Cobham, 1985; Green, 1984; Moll, 1988; Paris and Munro, 1989; Reeder and Gerhold, 1993; Rogers, 1983; Sales, 1975). Plants in even-aged populations will decline simultaneously, creating massive visual disruption in the landscape when they die (Lewis, 1990; Sales, 1975). Vegetation decline is reported in urban forests, countryside landscapes, and parks (Anon., 1994b; Beckett and Dempster, 1989; Davis, 1987; Johnson, 1996; Lewis, 1991; Loeb, 1993; Profous and Loeb, 1986; Spencer and Kirby, 1992). Loeb (1993) noted a 59% reduction in the number of species in Central Park due to tree deaths. Similar reductions in countryside trees were noted in Britain (Allison and Peterken, 1985; Davis, 1987; Towler, 1986a).

Shifts in composition occur as short lived material dies out (Dawson and Khawaja, 1985; Paris and Munro, 1989).

Environmental, human and visual benefits of urban trees are maximised by a population with an optimum number of healthy trees in the mature phase. Unfortunately, declining urban tree populations are frequently reported with over-mature trees in poor condition (Barnett, 1993; James, 1985; Jim, 1986b; Lewis, 1991; Lohmann, 1988; Moll, 1988; Moore, 1993; Paris and Munro, 1989; Rollinson, 1987; Rubens, 1978; Schoon, 1993; Stevens and Richards, 1986). The problem is exacerbated by insufficient replacement planting (Dolwin and Goss, 1993; James, 1985; Lewis, 1991; Moore, 1993). Endress (1990) noted that only one tree was planted for every four removed in America, and Moll (1988) reported only one tree planted for every eight removed in a third of American cities surveyed.

Similar problems occur in historic gardens which focus on specific arrangements and species of plant material, e.g. the genius of Blenheim Palace lies in the precise placement of trees of particular maturity (Moggridge, 1983). Without appropriate renewal strategies these gardens become overgrown and deteriorate and visual features are lost (Anthony, 1975; Banks, 1988; Davis, 1986; Keen, 1985; McGuire, 1981; Sales, 1987). Replacements in historic gardens must be carefully planned to maintain both visual and biological integrity. For example, Neilsen (1993) distinguished between layout and specific plants. Plants that are fashionable or available must be used with caution, as these may reduce the historic integrity of the garden, and replacements should reflect the original intent of the creator, not the personal tastes of the manager (Bourke, 1983; McGuire, 1981; Sales, 1975, 1987; Workman, 1982). McGuire (1981) noted that it can be difficult to maintain essential qualities when gardens, that were created by an individual, come under institutional management.

Botanic gardens and arboreta face similar problems of vegetation decline. Many are over-planted, leading to overcrowding, competition, and suppression of rare species (Beach, 1985; Wright, 1982). Although replanting is needed, it is often avoided because establishment is more expensive than maintenance and the expense is a considerable barrier for arboreta with financial constraints (Hall, 1974). But age and deterioration place important plants in danger, and collections may be damaged (Beach, 1985; Davis, 1986; Hall, 1974). For example, Davis (1986) reported that failure to replace a shelter planting at Trebah in Britain caused damage to the collection. Where deterioration has occurred a considerable period of clearance may be needed to reveal the collection and set the stage for renewal (Beach, 1985; Davis, 1986).

Renewal in botanic gardens and arboreta focuses upon sustaining vegetation of a particular composition as this underpins their purpose. The composition factor places particular constraints on any renewal plan as the biological composition of the collection must be maintained. The replacement species cannot be chosen at random, but must meet the criteria for that arboretum, e.g. if one is protecting *Davidia involucrata spp. vilmorini*, then it cannot be replaced with anything but *D. involucrata ssp. vilmorini.*

Visual criteria are also important in arboreta (Johnson, J. 1989; Lighty, 1989; Posner, 1989; Robertson et al., 1989), but complicate the replacement issue for both designer and manager. Botanic gardens are a unique design problem because the medium of the design is also the primary purpose of the landscape (Robertson et al., 1989). Therefore the designer cannot arrange plant material solely according to visual values as there must also be a rational biological connection. The problem of vegetation renewal in botanic gardens and arboreta is twofold. First, biological renewal is prescribed by collection management objectives that focus on precise groups of plant material. Second, biological renewal must be overlaid with visual renewal to maintain human values. This scenario reflects the biological management paradigm outlined in Chapter 3, where actions were primarily focused upon maintaining biological value but visual value was merged within those actions at the same time. Plans for managing and renewing vegetation in arboreta are likely to be complex if they are to successfully balance the factors in the biological management paradigm.

These examples illustrate that vegetation in human-made landscapes must be deliberately managed and designed, usually according to precise criteria and with constant input to ensure that it is renewed at an appropriate stage (Miller, 1988). (This is in contrast to natural landscapes where cycles of growth and renewal are generated and controlled automatically by the ecosystem and managers do not (usually) need to manage renewal.) A system is needed to sustain vegetation in human-made landscapes through constant manipulation and renewal (Amir and Misgav, 1990; Sales, 1988). A population is needed that is consistent, in optimum health, with the right type and number of trees in the right growth phases, and enough planting to counteract losses (Lewis, 1991; Lobel, 1983; McGuire, 1981). As reactive, short term management is not rigorous enough for such a system (Lobel, 1983) an organised management programme and long term time frame must be used (Herbert, 1991; Impens and Paul, 1985; Kelsey and Hootman, 1988; Lewis, 1990; Lobel, 1983; Weinstein, 1984).

Unfortunately many managers operate in crisis mode and do not work in a long term time frame or plan for vegetation renewal (Cobham, 1990 p 223; FRCC, 1988; Lewis, 1991; Lobel, 1983; Rubens, 1978). Green (1984) suggested that managers did not consider population turnover until vegetation was declining, and the response was often a short term solution. A British research committee (FRCC, 1988) identified tree replacement as a major problem and suggested that most managers simply 'replace it when it dies'. Reactive responses are often related to poor funding, and this problem has been reported for urban forests, arboreta, and parks (Burton and Matthews, 1989; Goodchild, 1984; Hall, 1974; Lewis, 1990; Matthews, 1989; Moll, 1988). Many parks and gardens were created when labour was cheaper than it is today, and as costs rise new methods must be developed to achieve quality landscapes at less cost (Boisset, 1980; Miller, 1988). Rigorous systematic management, including vegetation management, is essential when funds are limited.

Systematic vegetation management should be considered from two angles. Background knowledge is needed about plants, populations and human-made landscapes and how these relate to vegetation management issues. A systematic approach to vegetation management is also needed.

6.1.2 Knowledge needed in vegetation management

6.1.2.1 Understanding the life phases of a plant

Effective management of plants in the landscape requires an understanding of plant growth and development. For example, pruning and fertilising should be done in association with growth flushes (Clark et al., 1990), and trees in public places should be removed before they become senescent and potentially dangerous. Such understanding begins with knowledge of the physiological stages of a tree. This is distinct from chronological age, e.g. one species may grow, mature and die within thirty years, while another remains in the juvenile stage for more than thirty years. Both trees are the same chronological age, but have completely different physiological patterns. Physiological stages of tree growth have been discussed by Clark (1983), Clark and Matheny (1991) and O'Callaghan (1989) and these are outlined below.

The first physiological phase is the juvenile phase, characterised by rapid vegetative growth. This phase occurs in all plants but the length varies. Juvenility is often distinguished from later phases by differences in leaf morphology, shoot orientation, seasonal leaf retention, thorns, phyllotaxy, or differential disease resistance. O'Callaghan (1989) proposed that young trees were characterised by surplus energy, with a matter:energy ratio of 1:100, which changed over time to 1:50, 1:25 and 1:1 at maturity. Clark (1983) suggested that the juvenile phase was an investment in structure, which was used to support the tree in later stages.

Maturity occurs when the plant moves from vegetative to reproductive growth. A mature tree is close to maximum height, with reduced shoot elongation, and a rounded rather than pointed crown. Mature trees generally have sound structure, although they may contain many compartments. The onset of maturation is related to the size of the plant, hormone levels, and resource availability at the apex. Only the meristem changes, so there may be juvenile and adult stages on the same plant. Sometimes an adult plant can revert to juvenile form, e.g. hard pruning some *Acacia* ssp. stimulates pinnate leaf growth rather than phyllodes.

As trees age a number of changes take place. Old trees are larger and more structurally complex than young trees, and there is a loss of vigour associated with that complexity. Shoot elongation usually declines, as does the number of shoot flushes in any growing season. There is decreased net assimilation rate, decreased growth in all organs, and changes in photosynthesis and respiration patterns. Resource allocation patterns change within the tree, with photoassimilate preferentially allocated to the stem in older trees compared to the leaves and roots of young trees. Ageing trees are more susceptible to pest, disease, and stress.

In the final stage of life the tree becomes senescent. These trees have slow or non-existent growth. The crown is typically stag-headed and may dieback and reduce in size. Foliage is reduced in size and density, retention may be poor, discolouration may occur, and autumn colouration may be premature (Clark and Matheny, 1991; Ling et al., 1993). Epicormic shoots at the base are typical. Wound healing, compartmentalisation response and stress response is reduced. Once a tree moves into the senescent phase it has a limited life span, and the decline is generally irreversible (Clark and Matheny, 1991; Green, 1984).

Clark and Matheny (1991) proposed that tree longevity was based on principles of defence and growth. Defence is the tree's capacity to resist pest, disease, or other stress whereas growth relates to maintenance of wood strength and retention of structural integrity. Differences between species in their use of growth and defence results in two longevity types. Longevity in fast growing trees is usually based on the growth principle. Such trees maintain themselves through rapid growth rates, but once the growth rate slows they cannot grow fast enough to replace damaged tissue and they decline. This group includes deciduous early succession pioneers such as *Alnus, Salix* and *Liriodendron*. Longevity in slow growing trees is usually based on defence, thus when growth slows down they are still able to protect themselves. This group includes conifers and shade tolerant late succession broadleaves such as *Quercus*. Tree longevity could be supported by providing cultural conditions which reinforced the aforementioned scenarios, i.e. management of fertility, moisture, and environmental stress to minimise decay and its influence on structure. The prerequisite for such support is knowledge of the category of any particular species, its life history and potential lifespan, underlining the need for good biological information.

The manager's goals are (usually) to reach the mature phase as rapidly as possible (thereby securing visual value that people associate with mature trees), keep trees in the mature phase for as long as possible, and then delay the transition from maturity to senescence for as long as possible. Deliberate management of the life phases of a tree requires knowledge of how particular species will behave and the factors that trigger the changes. In turn this requires reliable methods to judge the status of a tree, rating scales provide one such method.

6.1.2.2 Measuring plant status - rating scales

Rating scales are an important component of vegetation management as they can be used to judge the status of a tree and determine when actions should be taken. Rigorous use of scales gives decisions a more rational basis and reduces their subjectivity (Barrell, 1993; Griffin, 1990; Rue and Byars, 1992). Although there is no universal definition of rating scales, there are several widely used methods. The METRIA group in America used a standardised method to assess cultivars (Gerhold, 1985). The Council for Tree and Landscape Appraisal scales are generally accepted in America and in Britain the Helliwell system is used for tree valuation (Coombes, 1994; Dolwin and Goss, 1993). The Royal New Zealand Institute of Horticulture tree valuation method, which is based on the Helliwell system, has been proposed as the New Zealand standard (RNZIH, 1988). Each of these methods uses a range of scales that are combined in some way to produce a final score.

There is also considerable variation in both style and definition of rating scales. The scale range varies and although five point scales are common, three, four or six point scales are also encountered. There is no consistent orientation to the scales; some have zero as the best score, others use it as the worst score. Campbell (1985) used 1 as the best score and 5 as the worst score, except for negative factors which were the other way around. There is no standard numerical type with many scales using whole numbers (with the intention of adding or averaging), while others use percentages (with the intention of multiplication).

Definition of each point on the scale must also accurately describe the factor being measured. For example, the condition scale reported by Richards (1979) actually measured growth phase. The description of each point should have some physiological basis, e.g. if a scale uses the term 'mature' it should refer to a tree that is physiologically mature. This characteristic of a scale will be referred to as its reliability.

Each point on the scale should be accurately defined to ensure that the scale can be applied without confusion or ambiguity, and used consistently over time and between different operators. Variation in application of scales should be minimised (Lohmann, 1988), otherwise appraisals may be subjective (Webster, 1978). Gerhold and Sacksteder (1982) speculated that a variable set of performance data was caused by different applications of rating scales between operators. Suitable definition of a scale to achieve consistent application will be referred to as its repeatability.

Ideally scales should only measure one factor, e.g. the SULE scale described by Barrell (1993) contains a mixture of life expectancy predictions and management actions. Such a scale pre-judges the situation and mixes significance, condition and management action (Margules et al., 1991; Marquis Kyle et al., 1992). Unless all possible combinations of the three factors are included the scale may be difficult to apply.

The assessment of a tree might involve several scales which are combined in some way. Some methods combine separate scores into an aggregate score which is then interpreted (Coombes, 1994; Dolwin and Goss, 1993; Flook, 1996; Franks and Reeves, 1988; Hickman et al., 1989; RNZIH, 1988). Jim (1994) combined scores for species, size, structure, condition, location and special features. Other methods generate a dollar value by combining a basic dollar value with the rating scale scores, e.g. Miller (1988, p 72) combined basic value with species score, condition score and location score. The combined scores may be processed by addition, multiplication or ranking although (Campbell, 1985) argued that multiplication caused distortion in the results and that ranking was a preferable method.

There are a wide range of scales for different attributes. It is not possible to include every scale in this review, therefore selected examples will be used to illustrate different scales and their use. Scales that measure size, health, example of species, growth phase, life expectancy, contribution to scene, and aesthetic value will be considered.

(i) Size measurements.

These factors are absolute measures taken from physical characteristics of the tree and have minimum subjectivity. Measurements such as height, diameter at breast height (dbh), and crown diameter can be made (Jim, 1994; Rhoads et al., 1981). Jim (1994) used 'relative height' which was height expressed as a percentage of the expected height of the species. In the revised Helliwell system height is multiplied by crown diameter to give crown area in square metres (Coombes, 1994). Seiler et al. (1992) used a photographic method for rapid estimation of crown size, but it only worked if the crown could be distinguished from adjacent trees.

(ii) Condition/Health

This is an assessed factor which is subjective, but the subjectivity can be minimised if scales are well defined. There are various scales that relate to condition, usually measuring the state of crown and foliage. Ling et al. (1993) proposed that several attributes should be measured to give an adequate description; they used crown thinness, crown architecture and crown chlorosis. The American group that tests trees for street usage had two health related scales (Gerhold, 1985). Some health ratings focus on the amount of damage, others on the amount of growth. Both will be appropriate in different circumstances, the former more useful for hazard and safety assessment, the latter more suitable for performance and longevity assessment. The scales below demonstrate the variation in points, orientation and degree of description.

The scales from Ling et al. (1993), Gerhold (1985), Nowak (1993b) and Webster (1978) illustrate quantified scales, noting that Ling's crown thinness assumes the assessor is familiar with normal density. The condition measure used by Rhoads et al. (1981) is an example of an ill-defined rating that would be hard to apply consistently (i.e. its repeatability is poor).

Condition (Rhoads et al., 1981):

1 excellent, 2 good, 3 fair, 4 poor

Foliage and branch health (Gerhold, 1985):

1 65-100% injury or damage.
2 45-60% injury or damage.
3 25-40% injury or damage.
4 5-20% injury or damage.
5 no injury or damage.

Condition (Council for Tree and Landscape appraisers, from Nowak, 1993b):

0.9 Full healthy crown.
0.75 5-25% of crown with dieback or distortion.
0.5 25-50% of crown with dieback or distortion.
0.25 50-75% of crown with dieback or distortion.
0 75-100% of crown with dieback or distortion.

Crown thinness (Ling et al., 1993):

0 0-10% reduction in density.
1 11-25% reduction in density.
2 26-60% reduction in density.
3 greater than 60% reduction in density.

Growth rate (Webster, 1978):

3 Growth more than six inches.
2 Growth 2-6 inches.
1 Growth less than 2 inches.

Crown architecture (Ling et al., 1993):

0	vigorously growing.
1	reduced apical and lateral growth.
2	reduced apical and lateral growth.
3	greatly reduced growth and vitality.

Crown development (Webster, 1978):

5	Dense leafy crown, well balanced.
4	Dense leafy crown, but slightly unbalanced.
3	Either thin crown or severe imbalance.
2	Slight imbalance with thin crown.
1	Thin crown and severe imbalance.

Lohmann's (1988) rating combined assessment with management decisions in the same rating. This is undesirable as it makes assumptions about the action to be taken.

Health (Lohmann, 1988):

1	Full foliage, strong shoot extension and good form of bole and crown.
2	Not seriously impaired, but has damage which calls for treatment to allow it to reach full size and form.
3	Damage requiring major surgery, or signs of dieback.
4	Severely damaged, will not reach good size and form even if attended to promptly. Many of these would be listed for removal.
5	Dying or dead. Should be removed.

(iii) Form/ example of species.

The Helliwell system used factor six 'form of tree' to measure this characteristic, describing it as 'factors which might affect the amenity form of a tree including structure, coarse or tight branching, crown balance etc' (Dolwin and Goss, 1993). The factor can be rated as poor, fair, good, especially good (Dolwin and Goss, 1993), but no criteria were given for assigning a tree to a particular category. In the revised Helliwell (Coombes, 1994) descriptors were added (3 = trees of good form) but they still involve the vague concept of 'good' and are only a marginal improvement on the previous system. Other ratings consider the structural integrity of the tree. The rating for trunk health by Gerhold (1985) would be hard to apply because of poor definition. Webster's scales are better described.

Trunk health (Gerhold, 1985):

1	dead.

2 severe injury or decay.

3 moderate injury or decay.

4 slight injury or decay.

5 no injury or decay.

Structure (Webster, 1978):

5 No major limbs missing or dead. No bad angles, good radial distribution.

4 Good major limbs and radial distribution. One bad angle.

3 Major limb dead or missing or broken. Therefore poor radial structure.

2 Bad angles on 2-3 limbs, at least one broken limb.

1 Two or more major limbs broken, several bad angles.

Trunk factor (Webster, 1978):

5 Sound and solid, no visible deterioration, no visible damage to bark or cambium.

4 Minor damage to cambium, otherwise as above.

3 Early signs of decay, or bark/cambium damage.

2 Extensive decay, hollow, bark/cambium damage, cross section still circular.

1 extensive decay, bark missing, trunk hollow, cross section not circular.

(iv) Growth phase

Growth phase ratings should record the current life phase of a tree. It is important to distinguish between growth phase (a record of the current status of the tree) and life expectancy (a prediction on the future life span of the tree). Many ratings do not separate the two concepts, which is unfortunate because life expectancy ratings are generally unreliable as there is usually no sound basis for the predictions. Life expectancy is discussed in the next section. Growth phase is more reliable as it only requires the operator to record current status, and does not include any management actions or predictions. Determining growth phase is important for managed renewal (which is discussed below). Both Richards (1979) and Lohmann (1988) used four categories to describe the phase of each tree.

Age ranks (Lohmann, 1988):

N Newly planted trees, those with stakes still attached.

Y Young trees. Those no longer dependent on the stake, past the establishment stage, but not yet mature.

M Trees with size and form commonly associated with the mature form of the species. Or, weak or undersized specimens showing mature features.

O Over mature. Fully grown structure receding, extensive surgery will not arrest the decline.

Condition (Richards, 1979):

Developing
Stable
Declining
Deteriorated

Green (1984) used seven classes. The portion of the population in each category indicated the state of the population at that time and the rate at which replacement actions needed to be taken. Note, however that classes three, four and five include either longevity predictions or management actions. Classes six and seven infer management actions by indicating possible planting sites. Kelsey and Hootman (1988) used a modification of Green's method which is a less robust scale because it contains more predictions and management actions. Collection of data about a tree should be separated from management decisions about that tree.

Condition (Green, 1984):

1. Young tree, seedling, sapling or recently planted; apparently healthy and not yet near final height and shape.
2. Developing tree; no major visible defects; well established; indicating ultimate height and shape.
3. Mature tree; may show some defects; mature shape and height, life expectancy beyond 20 years.
4. Declining tree; exhibiting major defects, life expectancy less than 20 years.
5. Deteriorating tree, exhibiting such serious defects that immediate removal is warranted.
6. Stump; location of previously inventoried tree, now removed.
7. Location for future tree.

Kelsey and Hootman (1988):

1. Newly planted; not established but expected to live a long time
2. Established tree that is not of mature size, but expected to live a long time.
3. Mature tree expected to live at least 15 years.
4. Mature tree that has such a severe limiting factor that death is expected within 15 years regardless of treatment. Treatment may be warranted to prolong life.
5. Mature tree that is dead or nearly dead and is considered hazardous. Immediate removal is recommended.
6. Newly planted, but has a severe limiting factor such that treatment may be needed to avoid premature death.

7. Established tree, not of mature size, that has severe limiting factor and needs treatment to avoid premature death.
8. Mature tree that has limiting factor which requires treatment to prolong life more than 15 years.
9. Mature tree that is so near death that treatment is not recommended and is a poor allocation of time and money. Immediate removal recommended.

Growth phase ratings have two important roles in renewal plans. First, they are used to determine when a tree has become senescent and should be replaced (Lobel, 1983). Therefore they should be able to separate mature and stable trees from mature but declining trees. The latter needs to be replaced, the former does not. Second, growth phase ratings are one of the components that indicate plant performance. Comparing 'actual age for growth phase' with 'expected age for growth phase' gives some indication of the impact of site conditions on performance. For example, progress through life phases may be accelerated by poor conditions and the tree dies sooner than expected. Conversely, favourable conditions may inhibit decline.

It is important to distinguish growth phase from condition as the two are related and this can lead to ambiguity. Consider two trees in different growth phases: an immature tree may be in poor condition because it has been suppressed or suffered disease attack while a mature tree can be in poor condition for the same reason. Both are in poor condition, but they are not in the same growth phase. Poor condition over a population primarily indicates poor cultural and maintenance practices. If the causal factors are not mitigated the trees may become pressurised to the point where they become senescent. Over time, therefore, continued poor condition may result in a change in growth phase. 'Condition' can be ambiguous because it may indicate poor maintenance practices, even though the growth phase profile of the population is acceptable. 'Condition' should preferably be used as 'quality/quantity of growth' or 'presence/force of pest and disease factors' because when it is used as 'signs of impending death' it will be confused with growth phase.

(v) Life expectancy

Life expectancy ratings are used to predict the longevity of a tree, which is an important factor in a planned replacement strategy (Barrell, 1993). Barrell (1993) proposed a rating for Safe Useful Life Expectancy (SULE), suggesting that it was based on the potential in the local area. At the same time he conceded that there was not enough quantitative data on which to base the predictions. His assessment considered health and vitality, obvious past influences, estimated age in relation to expected age, structural defects, and remedial work that would allow the tree to be retained.

SULE (Barrell, 1993):

Long SULE	Will last another 40 years. Structurally sound and with room to grow. Could be made sound with surgery. Historic etc trees that warrant extra effort to retain.
Med SULE	Will last 15-40 years. Tree will only last 15-40 years. Trees that will last that long but should be removed in favour of others. Trees that might live that long but remove because of nuisance factors. Damaged tree that will last that long if repaired.
Short SULE	Will last 5-15 years. Will only live that long. Trees that will last that long but should be removed in favour of others. Trees that might live that long but remove because of nuisance factors. Damaged tree that will last that long if repaired.
Remove	Need removing within five years. Dead. Dying, suppressed, declining through poor conditions. Dangerous through structural defects. Damaged and can't retain. Dangerous through instability or loss of adjacent trees.

Even though it looks detailed, this rating system is not a good predictor of life expectancy. There is no way to determine which category a tree will fall into; how does one tell whether or not the tree will last 5-15-40 years - the rating gives no guidelines. Furthermore, it mixes management decisions in with the attempted physiological measure, e.g. the decision to remove a tree because of nuisance factors is not influenced by its physiological potential for longevity.

Dolwin and Goss (1993) used the Helliwell system which measures 'useful life expectancy' using four categories: 10-20 years, 20-40 years, 40-100 years, and 100+ years. These categories give more scope for longer lived trees than those used by Barrell (1993), but neither specifies how a tree is assigned to a particular category. Webster (1978) used a five point scale for life expectancy which covered five years through to more than thirty years, but there were no criteria for putting a tree into the categories, and Webster (1978) conceded that the judgement was subjective.

Clearly there is a difficulty with life expectancy ratings in that they have no rational basis for their predictions. Predictive parameters are rarely reliable over a wide range of circumstances unless they have a strong predictive function (Marquis-Kyle et al., 1992). Theoretically that function would be synthesised from performance and longevity data (Barrell, 1993; Richards, 1979). Although there is a great deal of anecdotal knowledge on this subject, there is little quantified data which can be used to develop a sound predictive function for life expectancy for a variety of trees over a variety of circumstances. Richards (1979) suggested that future senescence could be predicted using dbh distribution and condition data. This assumes, however, that one knows how long a species will live, and what dbh pattern will be typical over that time. As Good (1977) pointed out, whereas the forester has tables containing this information, the landscape manager does not.

In this regard the life expectancy factor in the revised Helliwell system is interesting (Coombes, 1994). The basic premise is as follows:

Raw life expectancy (expected age - actual age) - reducing factors = life expectancy.

This is in keeping with the points made above, but consider the difficulties of its application. There is insufficient data available on the expected age of the wide range of landscape tree species to calculate the raw expectancy component. The reducing factors include structural defects, likelihood of damage, environmental changes, and position of the tree (Coombes, 1994). Each of these is logical, but there is insufficient data actually attribute a percentage reduction to those factors. Outlining a logical method is useful, but the data needed to operate such a method (e.g. growth rates, life expectancies, age-class distributions) is not readily available. Only when more information becomes available on survival then will it be possible to make better predictions of longevity (Barrell, 1993).

Without suitable data there is no sound basis for predictions, and life expectancy ratings will remain subjective. It makes more sense to use a growth phase rating which records the growth phase at that point in time. Monitoring over time will indicate when the tree begins to deteriorate, and will help build up the data needed to develop a reliable life expectancy predictor.

(vi) Landscape impact, contribution to scene

In the Helliwell system Factor Five is 'relation of species to setting', which Dolwin and Goss (1993) described as difficult to define, and no criteria were given for assigning the categories. Factor four rates 'presence of other trees' which described the portion of the tree which was hidden by other trees (Dolwin and Goss, 1993). Specific criteria were given:

Many	More than 20% of visual surface area covered by trees and at least 10 trees in total.
Some	More than 10% of visual surface area covered by trees and at least four trees in total.
Few	10% minus of visual surface area covered by trees and at least one other tree present.
None	No other trees present in the area under consideration.

Factor three of the Helliwell system described 'importance of position in landscape' (Dolwin and Goss, 1993):

Little importance	Most trees in woodland, back gardens or groups.
Some importance	Individual roadside trees or in public parks.
Considerable importance	Prominent individual trees such as town centres etc.
Great importance	Principal features of public place.

(vii) Aesthetic value

No ratings for aesthetic value have been found in the available literature.

Some broad observations can be made about the rating scales illustrated above. First, many lack sufficient description to make them repeatable. Descriptions such as 'good' could mean a variety of different things depending upon the circumstances and the operator. Some factors in the Helliwell are weak in this regard, but in the revised Helliwell (Coombes, 1994) many of these weaknesses have been addressed. Second, many scales have more than one attribute in the same scale, e.g. mixes of condition and management action. Invariably a combination will be found that has not been catered for, therefore it is better to separate attributes into different scales. In fact, as discussed in Chapter 3, mixing of attributes signals a poor recognition of the difference between significance, condition, and management factors (Roome, 1984; Roper-Lindsay, 1986). Overall, rating scales are a potentially useful tool, but a lack of strong principles for design, definition and use results in weaknesses in their application.

6.1.2.3 Understanding plant populations in human-made landscapes

Individual plants in a human-made landscape combine to form a population with the overall 'behaviour' of that population derived from the combined life phase and performance of individual plants in the population, and management interventions made to that population. The population as a whole will have a pattern of growth and decay which must be managed if the values of the landscape are to be maintained. Description of populations in human-made landscapes has already been addressed in Chapter 3 where indicators such as diversity (composition, dominance), density, and condition were considered.

6.1.2.4 Managing plant populations in human-made landscapes

(i) Managing diversity of the population.

The composition and dominance of plant populations in human-made landscapes should be driven by the enterprise and its goals. For example, the aim of the replacement programme in Central Park, New York, was to increase the species range and to plant more conifers for visual purposes

(Weinstein, 1984). Schmidt et al. (1989) intended to manage diversity so that any one species did not constitute more than ten percent of individuals in the population. Once the specification for diversity has been derived, plans should be made to achieve and sustain that diversity over an appropriate time frame.

(ii) Managing life phases of the population

Plant populations in human-made landscapes are a series of overlapping life cycles with each species having its own pattern of growth, development and senescence (Dolwin, 1993; Herbert, 1991; Sales, 1975; Sales, 1990). Those life cycles must be anticipated through a succession of continuous replanting, i.e. phased replacement (Herbert, 1991; Sales, 1975; Nowak, 1993a; Wright, 1982; p 138). The first step in managing the population is to understand its characteristics, as already described in Chapter 3. Subsequently there are two issues relating to development of a replacement system: replacement cycle and replacement method.

Replacement cycle

Vegetation management plans should have a long term time frame (Herbert, 1991; Impens and Paul, 1985; Lobel, 1983). Plans should cover the life span of the trees, potentially up to 200 years (Boisset, 1980; Lobel, 1983; Miller, 1988; Workman, 1982), and with operating intervals of 10-20 years (Boisset, 1980; Miller, 1988). Banks (1988) used a three tier structure with long (150-200 years), medium (20-100 years) and short (1-20 years) term categories. Lobel (1983) used three 75 year intervals for Golden Gate Park. Intervals will vary with different conditions, the more difficult the situation the shorter the cycle. Excellent maintenance regimes may extend the cycle by extending the life of the trees and therefore the population. Street tree rotations may be as short as ten years (Foster and Blain, 1978, Miller, 1988), or up to 40 years (Miller, 1988), while park trees may live close to expected life span if not abused (Foster and Blain, 1978).

Within each interval a portion of the population should be replaced, e.g. with a 200 year cycle, 1/200 of the trees must be replaced each year (Workman, 1974). Moll (1988) divided average tree life into total tree count to determine how many trees should be replaced each year. Logic suggests that removal rate would indicate the number of trees that should be replaced each interval, but Richards (1979) concluded that removal rate was not a good indicator for replacement rate. Removal rate underestimated replanting needs because it did not account for establishment losses and other losses that were unrelated to the normal life cycle of the tree, e.g. pest or disease (Richards, 1979). Removal rate was only a good indicator if early losses were low and most trees reached maturity (Richards, 1979).

Replacement method

Clear felling and select felling are the two basic replacement methods (Moggridge, 1983; Neilsen, 1993; Peterken, 1981). Select felling methods will be favoured in landscapes with high visual values as there is less disruption than with clear felling. Both strategies were used at Blenheim Palace. Continuous select felling and replanting was used within blocks thereby retaining overall mass, avoiding visual disruption, and also developing an uneven-age structure. Clear felling was used for blocks which were too small for select felling (Moggridge, 1983). Flemer (1981) used select felling to achieve continuous cover and high visual value in a street tree population by phasing short and long lived species. Short lived but quick growing trees gave a vegetated appearance in the short term. These were alternated with slower, long lived trees which took over after ten years, then the short lived ones were removed. Wright (1982, p 91) however, argued against select felling and interplanting for renewal. He suggested that, unless the new trees were tolerant of competition from mature trees, the new trees would produce weak, deformed specimens.

Select felling is associated with the forestry principle of un-even age stands (Cobham, 1990; Endress, 1990; Lobel, 1983) where only a portion of the population is senescent at any one time. The uneven character is produced through phased and continual replacement of some of the population, and can be established within blocks or between blocks (Lobel, 1983). Continuous vegetation cover can be achieved with this method (Barnett, 1993; Lobel, 1983) and visual values are consistent because the landscape always looks vegetated (Barnett, 1993; Cobham, 1990; Helliwell, 1988). The uneven-age principle can be used to improve the age structure of street tree populations, and avoid simultaneous decline (Barnett, 1993).

The uneven-age principle in forestry works with particular population characteristics, i.e. one species, one life span, for a definite time period. The tree is harvested before it becomes senescent so there is no need to predict when a species will fail on that site. Furthermore, the forester has detailed data on growth phase behaviour. In contrast, applying the uneven-age principle to landscape populations is more complex as one is managing multiple species and life spans, unknown growth behaviours, and an indefinite time period. Sometimes the additional factor of precise layouts for designed landscapes must also be added, further complicating the programme. For example, woodlands have comparatively few visual and location constraints, while designed gardens or particular visual compositions (e.g. avenues) are the most difficult to replace without visual disruption (Workman, 1982).

6.1.3 A systematic approach to vegetation management

Systematic approaches to vegetation management involve planning, and this has been recognised by some landscape managers. Street tree managers must achieve continuous cover in circumstances very difficult for plant growth (e.g. pollution, poor soil) and many have recognised the need to manage the whole population on a long term basis (Herbert, 1991; Miller, 1988). Managers of the British National Trust have also realised the need for deliberate vegetation plans to sustain historic landscapes (Sales, 1988). Otherwise, there is limited discussion of planned vegetation management as a general tool to maintain landscape values. Consider the broad principles of planning in relation to vegetation management.

Goals

Clearly defined goals are essential (Sales, 1988) as different goals will result in different vegetation structure (Nowak, 1993a). Goals for vegetation management plans will be derived from the need to perpetuate vegetation, and uphold the values of that landscape (e.g. visual values for designed gardens, biological values for botanic gardens). The distinction between management of vegetation for biological versus visual values has not been made, nor have notions such as the biological or visual management paradigms been proposed (section 3.6.2).

Data

Effective planning requires data and three broad categories are needed in vegetation management. First, managed renewal requires knowledge of individual species and their performance in human-made landscapes, which has been discussed in section 6.1.3.1. Second, rating scales and their use is an integral part of understanding plant performance as scales are used to measure the current status of a plant and predict future outcomes. Use of scales underpin any method for determining when replacement is needed, and ideally should have some predictive capability to avoid the 'replace it when it dies' approach. Rating scales and their use has been discussed in section 6.1.3.2. Third, data is needed to describe and manage populations in human-made landscapes. The descriptive aspect has been discussed in Chapter 3 (section 3.1.5), with management of populations discussed in section 6.1.3.4.

Defining the actions to be taken

The need for continuous recycling of vegetation, through phased renewal over a long term time frame, has been identified (Cobham, 1985; Nowak, 1993a; Wright, 1982, p 138). The aim is to keep the population in an acceptable state with consistent cover (Nowak, 1993a). Any strategy should control the effect of change (Nowak, 1993a; Sales, 1990), and direct change along lines that will preserve the integrity of the garden (Sales, 1990). The general replacement strategies of clear felling or select felling are well known, as is the uneven-age principle (Peterken, 1981) and sustained yield (Herbert, 1991; Lobel, 1983), and removal and replacement rates have been proposed for street trees (Moll, 1988; Richards, 1979). These ideas could be used to manage landscape populations, but there is limited discussion on applying these to the multi-species, multi-lifespan populations that exist in many human-made landscapes and which relate to a wide range of values.

Outcomes

The completed vegetation management plan should describe how vegetation is to be managed over the long term time frame. Outcomes might include plans for diversity of species and age structure to ensure continuous cover (Miller, 1988), a prioritised planting plan (McGuire, 1981; Miller, 1988), a list of removals (McGuire, 1988), a replacement policy (Miller, 1988), long range replacement plans (Impens and Paul, 1985), a list of replacements (McGuire, 1988) and a design plan (McGuire, 1988).

Although ideas from the literature can be categorised under the topic headings that relate to planning, there are weak conceptual links between the mechanics of measuring and manipulating populations and the management of landscapes. For example, how should the precise layout and maturity required in an historic garden, or a particular species composition of a botanic garden be managed? How should the approaches described above be integrated with the need to sustain significance and condition, and retain the landscape in the appropriate category? What relationship should there be between vegetation management plans and the biological and visual management paradigms? Clearly such plans will influence significance, condition, landscape category and the operation of the paradigms, but the linkage between these ideas is yet to be determined.

Management of vegetation in human-made landscapes will be a deliberate combining of the principles and mechanics of vegetation renewal, the principles of planning, and the goals of the enterprise. This should take place within the conceptual framework created by the biological and visual management paradigms which outlines the balance for managing different sets of values relating to a site. The notion of deliberate vegetation management using planning processes can be applied to the plant collection at the Eastwoodhill Arboretum.

6.1.4 Eastwoodhill Arboretum

Long term management of the plant collection at Eastwoodhill would benefit from development of plans for composition of the collection, programmed maintenance, planting or renewal. When this project commenced such a process had not been developed for the collection. In Chapter 5 some long range goals for collection management were determined, giving a framework within which detailed plans for relevant parks and genera could be developed. The workshop group and the workshop method could contribute to development of those plans.

Goal

To develop vegetation management plans for parks and genera in the collection.

6.2 METHOD

6.2.1 Developing vegetation management plans

The 'workshop' method was used to develop vegetation management plans for selected genera and parks at Eastwoodhill. The basic method has already been outlined and discussed in Chapter 4, whereas in this chapter it is considered in a more specialised form for park and genus plans. The three key features of that specialised use of the workshop were: the rating scales used within both methods, the park method, and the genus method. The park method was applied to two parks within the Arboretum (Pear Park and Orchard Hill), and the genus method to two key genera (*Acer* and *Magnolia*).

6.2.2 Rating scales to measure tree attributes

A series of seven rating scales was used to measure various plant attributes. Botanical and aesthetic ratings have already been described in Chapter 4 but will be repeated here for easier integration. Significance of individual trees was measured with (i) botanical importance and (ii) aesthetic importance. Condition of individual trees was measured by (iii) health, (iv) example of species, and (v) growth phase. Height and (vi) height index of individual trees were used in some exercises. In some exercises the relationship between individual trees was of interest and the visual importance was measured by (vii) contribution to scene. Finally, in the park exercises (viii) the division between permanent and transitory species was used to categorise species according to expected life span. The scales are explained as follows:

(i) Botanical importance

Botanical and aesthetic importance measured the intrinsic value (significance) of the species, which was not related to the condition of any particular individual. The scale was as follows:

0	No interest
1	Little interest
2	Ordinary
3	Interesting
4	Very interesting
5	Excellent

(ii) Aesthetic importance

Participants were told to use a six point scale but no actual description was given.

(iii) Health

This rating measured quantity and quality of growth of the tree, and separated this from other attributes. Many trees at Eastwoodhill are misshapen and malformed, but are otherwise healthy and in no apparent danger of dying. Although these trees are not pristine examples of the species, they do not need urgent action for rescue or renewal. Conversely, other trees that look unsightly are also unhealthy and do need urgent action. It would be important to separate those that were healthy from those that were not, regardless of their appearance because each will have a different priority for action. The following rating scale was used to assess health:

1	Unlikely to survive.
2	Alive, poorly furnished, signs of stress, dying back.
3	Fully furnished, signs of stress, not growing.
4	Well furnished, healthy, no stress signs, growing slowly.
5	Well furnished, healthy, no stress signs, growing vigorously.

(iv) Example of species

This rating measured quality of an individual as representative of its species. For example, *Abies concolor* 'Candicans' would be expected to have a central leader form with evenly spaced branches and the classic triangular shape of the *Abies* group. It should have a full complement of vivid blue-grey foliage. One would not expect an *Abies concolor* 'Candicans' to be multi-trunked or to have lost its leader, to have an asymmetrical outline, to have heavy branches on one side and thin on the other, or to have gaps in the foliage. Such a poorly formed tree might be quite healthy, but is not representative of the species. The ratings for health and example of species were intended to separate these two trees. One is more desirable in the Arboretum than the other, but neither needs urgent action if their health is acceptable.

The example of species rating required the assessors to consider four factors: health (which was measured first); form in terms of shape or silhouette; form in terms of branching and structure; and a factor called association with other trees. The latter was intended to judge any detrimental effect of overcrowding or overshading. Each of the four factors was considered and then the tree given a rating, depending on how many factors were acceptable, using the following rating scale:

1 Not representative of the species, all factors unsatisfactory.
2 Poor example of the species, three factors unsatisfactory.
3 Identifiable example of the species, two factors unsatisfactory.
4 Good example of the species, only one factor unsatisfactory.
5 Excellent example of the species, all factors good.

(v) Growth phase

The purpose of the growth phase rating was to establish the life stage of the tree. The rating would indicate the urgency for action, e.g. a growth phase of 1 indicated that urgent action was needed as the tree was senescent. It would also indicate what action might be required, e.g. propagules might be taken from a senescent, a tree that was slow in moving out of the establishment phase might require improved maintenance. Growth phase was assessed using the following rating scale:

1 Senescent - not growing, declining canopy.
2 Mature - adult features, growth regenerative.
3 Mature vigorous - adult features, growth vigorous.
4 Juvenile vigorous - established, in rapid growth, juvenile features.
5 Establishment - still establishing, not yet growing.

(vi) Height index

Height index was used in some exercises. The intention was to compare actual height of the tree with expected height for the species. Height index was calculated by measuring the actual height of an individual and expressing this as a percentage of the expected height. The rating used 'about' within the descriptions as different books gave different views on the expected height of many species. The scale below was used to determine height index:

1 Has made about 20% of expected height.
2 Has made about 60% of expected height.
3 Is in expected height range.
4 Has grown 50% more than expected height.
5 Has grown 100% or more than expected height.

(vii) Contribution to scene

The previous four ratings were used to examine the qualities of individual trees. They did not give any account of the relationship between a tree and its neighbours, or the visual impact of an individual tree. Where combinations of trees were considered, 'contribution to scene' determined the relative weighting of one tree against its neighbours in terms of visual importance. For example, a tree may be botanically important and aesthetically striking, but make a small contribution to the visual scene because it is small or located out of the main view. Contribution to scene was determined with the following scale:

1 Insignificant tree in this scene.
2 Noticeable tree but part of the general canopy.
3 Average visual impact, tree stands out as an individual.
4 Major contribution to this area.
5 Dominant feature of the area.

(viii) Permanent or transitory element

The permanent or transitory element categories were used in the park plans to separate longer lived species from those that would need more regular replacement. Trees within a park were divided into 'permanent' which were those that would normally be expected to live for 150 years or more, and 'transitory' which would live for less than 150 years. These divisions were made on the basis of the expected performance of the species, and did not refer to any particular specimen. For example, *Crataegus* are generally short lived and may survive for 60-80 years whereas *Quercus* are generally long lived and may live for 200-300 years.

'Permanent' and 'transitory' could be used in two ways. First, the normal life cycle length gives an indication of priority for that plant, e.g. a short lived plant must be replaced earlier than a long lived plant. Second, the categories help with sensible biological arrangement within the visual layout. If an area contained mostly short lived species it would suffer (comparatively) regular visual disruption as the species died out and were replaced. Conversely, an area that had a backbone of long lived species would not suffer the same regular disruption as the long lived visual structure would remain even though shorter lived elements had to be replaced. Arranging the plantings so that long lived species form the main structural members of the visual layout will make the physical recycling easier, and smooth the visual changes when felling and replacement must be done.

6.2.3 Application of the rating scales

The ratings scales were used in two ways. First, botanical and aesthetic ratings were done by the participants prior to each workshop and were part of the background data for each exercise. These ratings were intended to measure intrinsic value (Jim, 1994), and did not refer to any particular specimen. Botanical and aesthetic ratings gave a profile of the plants being studied, before any physical inspection was made. For example, ratings for the Orchard Hill exercise showed that

Picea obovata, Picea koyami and *Acer henryi* were considered the most important plants in botanical terms, and immediately established a priority for the field inspection. If any of those plants had been in poor condition then urgent action would be needed. In contrast, *Pseudotsuga menziesii* was considered one of the least important plants in that area and would not warrant urgent action if it was found to be in poor condition. It was essential that species were sorted for significance before any area was viewed in the field, and botanical and aesthetic ratings were used for that task.

Second, the remaining scales were used to determine the status of an individual tree in the field. The score given to any tree was the average of the ratings given by the participants. When combined with botanical and aesthetic ratings the field ratings indicated the type of action that should be taken and the degree of urgency. For example, consider the *Magnolia* exercise in the second workshop. If field inspection showed that *Magnolia delavayi* and *Talauma hodgesonii* were both in poor condition, action should be taken first on the *Talauma* because it had a botanical rating of 8.8 and was more important than the *Magnolia* which only had a rating of 7. The type of action that might be taken was also indicated by the scales. A plant in poor health, but not senescent, needs different action from one that is in poor health and senescent. If it was an unimportant plant it might be removed, but if it was an important plant it might be propagated or repaired.

An important aspect of use of the scales was that the workshop group set particular trigger points for action. The precise trigger varied with the exercises, e.g. a health rating of 3 triggered 'action', and 2 triggered 'urgent action'. These trigger points immediately set priorities for implementation of the resultant plan.

6.2.4 Genus and park plans

Genus and park plans were developed with the basic workshop method outlined in Chapter 4, plus the rating scales to quantify plant attributes. These plans were part of the overall goals of the workshops which was to develop a management system for "decision making on plants and plant matters", for "planning park management over time", and for "a botanical management method". Each workshop had at least one park exercise and one genus exercise.

6.2.4.1 Tree management exercises at the first workshop: a forerunner to the park and genus plans

Examination of the workshop reports shows that there was a marked change between the tree management exercises in the first workshop and the park and genus exercises in the subsequent workshops. The park and genus methods were developed after reflection upon the preliminary consideration of *Abies* and *Picea* on Orchard Hill and a segment of Pear Park (both of which were held in the first workshop). The general method in the first workshop was followed in subsequent workshops (review of background information, field exercise, discussion and conclusion), albeit in a simpler form. Those first exercises were interesting, however, because they showed the evolution of the rating scales. At that time the full series of rating scales was not developed and a scale called 'site ranking' was tried which was intended to assess the features of the plant on site. This was a five point scale, from poor to excellent, but was discarded after the first exercise (Pear Park) because it was apparent that 'site ranking' was unworkable as it did not distinguish the different attributes of each tree. When the *Abies* and *Picea* exercise was conducted the rating method had been modified and the following two scales were tried:

Health		Desirability of the individual	
0-1	Will not survive.	0	Certain removal.
2	Will just survive.	1	Probably remove.
3	Survive and grow.	2	Neutral, stay or go.
4	Healthy, good.	3	Neutral, stay or go.
5	Optimum, excellent.	4	Good, important to keep.
		5	Excellent, essential to keep.

These scales separated the health aspects of a plant from its representativeness. It is quite apparent however, that neither scale is particularly repeatable or reliable as there are no criteria for placing a plant in any particular category. The 'desirability' scale also mixes ratings with management actions. Between the first and second workshops the scales were studied and modified into the 'health', 'example of species', and 'growth phase' scales that are described in section 6.2.2. Over the same period the tree management exercises in Workshop One had also been re-considered and the method refined into that which is described below.

6.2.4.2 Genus plans

The refined method for genus plans was used in the second and third workshops (Figure 6.1). The manager and chairperson selected the genus to be studied, namely *Magnolia* at the second workshop and *Acer* at the third workshop. The exercise was set out on a cover sheet under four categories: aim, background information, action, and conclusion (Figure 6.2). The cover sheet and background information were sent to all participants prior to the workshop (as described in Chapter 4). The goal (aim) for both genus exercises was to consider the status of the genus at Eastwoodhill and formulate a development plan for that genus. The action for each exercise fell into two broad categories: identifying and preparing background information (completed by the workshop manager), and using that information when the workshop was in session.

Goal (workshop manager)

- Goal set for the exercise

Action: preparation for the workshop (workshop manager)

- Prepare cover sheet and plan exercise
- Identify and prepare background information
- Cover sheet and background information sent to participants in 'Background Information' booklet

Action: in session (workshop group)

- Preliminary discussion
- Field inspection: plants assessed for health, example of species, and growth phase
- Status of each plant determined, agreed trigger points for action.
- All data used in discussion
- Action plan developed showing action and time frames

Conclusion (workshop manager)

- Results written up as a report

Figure 6.1 Method for developing genus or park plans

Background information for genus plans included the following:

- Tables of botanical, aesthetic and average scores for species in the genus.
- Tables showing rankings for each of botanical, aesthetic and average scores.
- List of current and previous species and cultivars at Eastwoodhill.
- List of species and cultivars found in other collections in New Zealand.
- A diagram of the botanical subgroups within the genus (*Acer* only).
- Information showing what portion of each genus was apparently in New Zealand and therefore the potential for expanding the genus at Eastwoodhill (*Magnolia* only).
- List of suggested acquisitions for Eastwoodhill (*Magnolia* only).

The workshop sessions were conducted in the manner described in Chapter 4. The chairperson explained the goal of the exercise and how it would be conducted. The workshop manager reviewed the background information and the group discussed that data. By the end of the preliminary discussion the problem had been reviewed and defined, the field exercise explained, and the most significant plants had been identified from botanical and aesthetic ratings (usually using the score of 8/10 as a cut-off point). Field inspection followed where individual plants were rated for 'health', 'example of species', and 'growth phase'. Scores were processed in time for the final discussion so that an overall rating for each plant could be discussed.

SECTION TWO: Key genus study - *Acer*. Saturday 10.30am-2.30pm(Workshop Two)

Aim

To consider the status of the genus *Acer* at Eastwoodhill and formulate a development plan for the genus.

Background information

Table 2.1	Botanical, aesthetic and average scores for the genus *Acer*.
Table 2.2	Ranking of *Acer* for average score.
Table 2.3	Ranking of *Acer* for botanical score.
Table 2.4	Ranking of *Acer* for aesthetic score.
Table 2.5	List of current species and cultivars at Eastwoodhill, with height records.
Table 2.6	List of *Acer* previously held at Eastwoodhill.
Table 2.7	List of other species and cultivars of *Acer* held in other collections.
Table 2.8	Botanical review table of *Acer*, showing breakdown of genus into sections.
Table 2.9	Results sheet for field exercise.

Action

1. Review background information, tables 2.1.-2.8.
2. Outline field exercise.
3. Field assessment of important species, assess using rating scales.
4. Highlight outstanding examples and those in need of attention.
5. Outline any action required for the examples examined in the field.
6. Determine the status of the genus at Eastwoodhill.
7. Outline those species that should be acquired.
8. Outline how the genus should be developed at Eastwoodhill.

Conclusion

Development plan for the genus *Acer*.

Figure 6.2 Cover sheet for a genus plan

The final discussion used all available data and focused upon determining future actions for each plant and the overall genus. For example, excellent and poor species were highlighted from field ratings and an appropriate action plan was developed. Any plants which fell below a certain score were targeted for action, e.g. maintenance, removal, replanting. Action for those plants was stated and a time span attached. Overall condition of the genus was discussed. Composition of the genus, now and in the future, was discussed and future acquisitions identified.

The expected conclusion for each exercise was stated on the cover sheet, in this case a development plan for the genus. Results were written up as a section of the workshop report and included background information and key discussion points; results of the field exercise including actions for removals, replanting and maintenance; an acquisition list; an acquisition policy and criteria for acquisition; and policy on expansion of the genus. These documents were combined into a section of the report which was presented to the Trust Board (Appendices 6 and 7).

6.2.4.3 Park plans

The park method was essentially the same as the genus method but altered to suit a park study (Figures 6.1, 6.3). It was applied to Pear Park (Figures 6.4 - 6.7) in the second workshop and Orchard Hill (Figures 6.8, 6.9) in the third workshop.

The goal for the park exercises was to "formulate a strategy for managing the park over time" which would be "presented as a development plan" and "development of a management strategy for Orchard Hill". The 'action' followed the same basic pattern as the genus exercises. Background information for park plans included:

- Any information on Douglas Cook's objectives for the park.
- Lists of current and previous plants in the park.
- Botanic, aesthetic and average scores for each species in the park.
- Ranking of the species for botanical, aesthetic and average scores.
- Highlighting of key genera in the park.
- Other genera important in this park.
- Actual height of trees, and expected height of trees.
- Base plan showing all plantings, key genera, permanent elements, and any other factors relevant to that park (conifers on Orchard Hill, rose family in Pear Park).

SECTION FOUR: Development of a management plan for Orchard Hill.
Sunday 8.30-12.30 (Workshop Three)

Aim
Development of a management strategy for Orchard Hill

Background information

Table 4.1	Known information of Cook's objectives for Orchard Hill.
Table 4.2	Botanical, aesthetic, average scores for plants on Orchard Hill.
Table 4.3	Ranking of plants on Orchard Hill for average score.
Table 4.4	Ranking of plants on Orchard Hill for botanical score.
Table 4.5	Ranking of plants on Orchard Hill for aesthetic score.
Table 4.6	Arboretum key genera on Orchard Hill.
Table 4.7	Park key genera for Orchard Hill.
Table 4.8	List of plants previously existing on Orchard Hill.
Table 4.9	Genera mix on Orchard Hill, taking into account previous plantings.
Table 4.10	Actual heights, expected heights, and height index for plants on Orchard Hill.
Plan 4.1	Base plan showing all plantings, key genera, permanent elements, conifers, heigh index.
Plan 4.2	Reduced size plan for field exercise.

Action
1. Define objectives for future of Orchard Hill. Describe any themes.
2. Examine plant assessments and ranking tables.
3. Examine plant composition on Orchard Hill.
4. Examine general layout for Orchard Hill. Define permanent and transitional elements.
5. Field exercise. Ratings for health, example, contribution to scene, for selected trees.
6. Discuss present condition of plantings on Orchard Hill in relation to stated objectives
7 Formulate list of actions required.

Conclusion
Development plan for Orchard Hill, including objectives, themes, long term plan, actions required.

Figure 6.3 Cover sheet for a park plan

Figure 6.4 Photograph of Pear Park, lower Linden Green, July 1989.

Figure 6.5 Photograph of Pear Park, Cottage Course, April 1994.

Figure 6.6 Photograph of Pear Park, lower Linden Green, October 1990.

Figure 6.7 Photograph of Pear Park, below the Cottage, April 1994.

Figure 6.8 Photograph of Orchard Hill, April 1993.

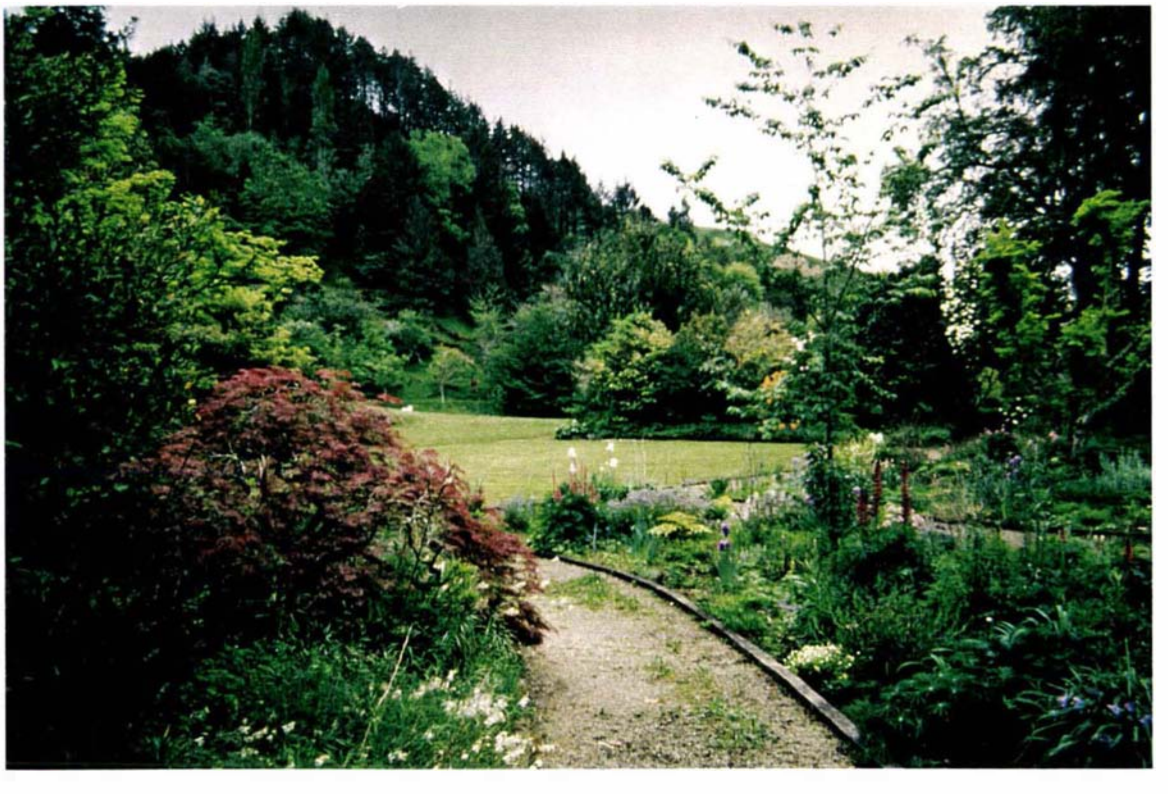


Figure 6.9 Photograph looking onto Orchard Hill from the Gardens, October 1989.

When the workshop group was in session the exercise was conducted in the same manner as for the genus exercises. The preliminary discussion included consideration of the objectives for that park, starting with a review of Douglas Cook's objectives (if known), then determining whether to retain or modify those objectives. The composition and layout of the parks was considered and any particular themes identified. Plants were classified into permanent or transitory elements and these were marked on the base plan. Once the preliminary discussions were completed the problem had been reviewed and defined, the field exercise explained, and the most significant plants were identified. The field inspection, ratings, processing and discussions were conducted in the same way as the genus plans. The discussion and decisions were formulated into a series of output documents. Actions such as maintenance, removals, propagation, and replanting were listed with a time frame for each one. A map for each section of the park was included, with trees needing action highlighted.

6.3 RESULTS

The results were two genus plans (*Magnolia* and *Acer*), two park plans (Pear Park and Orchard Hill) and one preliminary park exercise on Basinhead which each outlined a series of specific actions that were prioritised and placed into time frames. These plans are found in the reports of the second and third workshops (Appendices 6 and 7).

6.3.1 Park plans

Each park exercise resulted in a development plan (section 4 of Appendix 6, sections 4 and 5 of Appendix 7). The aim of the exercise was stated first, followed by a description of the park including a brief history, current and previous composition, a list of plants, height of each plant, and a map of the park. Objectives and theme of that park were then reported, including any information about Douglas Cook's objectives and the discussion and conclusions of the workshop group about the objectives for the park. The method for examining the park was described including the background information and the field exercise. Results of the exercise were reported and included maps of each area examined, tables recording scores given to each plant and the action category for that plant, detailed lists of actions needed for each area including time frame, and general comments on the management of each area. The actions included propagation, maintenance, removal and replanting. The final aspect of the plan was the summary discussion. In the Pear Park exercise this was very brief. In the Orchard Hill exercise this covered composition factors, visual qualities, maintenance needs and physical arrangement of the plantings.

An important part of the results was the workshop group's consensus on use of certain trigger points for actions. In the Pear Park exercise the three field scores were added (possible total 30). Plants scoring less than 14 were put in an urgent action category, scores of 14-18 resulted in action but it was not urgent, scores of 19-23 and the plant was designated as 'okay' and no action needed, 24 or more was designated as excellent with no action needed. In the Orchard Hill exercise the three field scores were averaged (highest possible average 5). An average less than 2 put the plant in the urgent action category, less than 3 then action required in 0-5 years, between 3 and 4 then the plant was okay and no immediate action was needed, 4 or more then the tree was excellent and no action was required.

Specification of certain time frames for action was also important. In both park exercises the time frames were 'urgent', 0-5 years and 5-10 years, then general categories of 10-20 years and 20-30 years. Each action was listed under one of those categories. These time frames were similar to Reid (1981) who used immediate, five years, ten years, and long range.

6.3.2 Genus plans

Each genus exercise also resulted in a development plan (section 3 of Appendix 6, section 2 of Appendix 7). The aim of the exercise was stated first and background information reported, including information on the composition of the genus, the results of the botanical and aesthetic scoring, and the range of that genus found in other collections. The field exercise was then explained. The results section of the plan contained a table which outlined all scores for the plants, including the field scores and the action category for each plant. In the *Acer* exercise action categories were based upon field scores. A health score below 3.5, or an example of species score below 3 was unacceptable and triggered action. In the *Magnolia* exercise the trigger levels were 3 for action and 2 for urgent action. Recommendations from the field exercise were reported next, including the workshop group's conclusions about each plant and the actions relating to each one.

The discussion section of each plan contained recommendations on the current collection, general problems, acquisition, siting, and expansion of the genus. Acquisition recommendations indicated taxa that might be acquired, the number of each, and criteria for selecting any further members of the genus (e.g. climatic range, form). In the *Magnolia* exercise expansion of the genus was considered with other genera in the family being identified. The need for more information on these groups was recognised and several investigations recommended, e.g. investigation of other Magnoliaceae species in New Zealand.

6.4 DISCUSSION

6.4.1 Methodology for park and genus plans

General methodology of the workshops has already been discussed in Chapter 4, but there are other discussion points relevant to the park and genus plans in particular. The general workshop methodology ensured that plans were developed using a sound method, suitable expertise, and with careful attention to development and use of data. Reports were detailed and specific, giving clear instructions on management of each park/genus, and identifying the research needed to conduct the next planning round. At the same time details of implementation were left to the discretion of the curator giving him the flexibility to manage daily operations as necessary.

An important feature of the plans was the detailed level at which the park or genus was considered. Operational plans should link strategic goals with daily operations and that link will only be achieved if the plan contains enough detail to relate it to daily activities. These genus and park plans included specific operations for particular plants, as well as specific instructions for future decisions, e.g. obtaining herbarium samples of species that would not grow at the Arboretum. Although working at a detailed level, park and genus plans also linked back to strategic decisions, i.e. key genera and significant parks were considered rather than any other groups.

Another important feature of the plans was the use of rating scales to quantify plant attributes, thereby making decisions more objective (Griffin, 1990; Rue and Byars, 1992) and establishing a priority for action (Hickman et al., 1989). Scales were used to separate significance from condition, immediately establishing a priority for the field inspections by focusing on the most significant plants. Separating significance from condition also established a priority for any action, e.g. significant plants in poor condition would be dealt with before insignificant plants in poor condition. The scales could also separate different values of plants (biological value from visual value), thereby signalling a priority among plants that related to biological or visual functions of the collection.

It is important to note that the scales were not used to predict future outcomes. Without a reliable predictive function, which does not exist for most landscape species, any attempt to use scales for prediction is simply speculation. Instead, the consensus discussion was used to determine what action was necessary to sustain each tree. These scales could be used as a basis for informal predictions, which is discussed in section 6.4.2.1, but development of a true predictive function needs much more data so that standard growth curves can be made for each species (Good, 1977).

The rationale for using the scales was to provide an objective indicator of plant status by giving repeatable and reliable measurements of tree attributes, but the scales used in this study could be improved for both factors. Repeatability depends upon the descriptor for each point being accurate enough that the scale can be applied consistently by different people at different times. Reliability depends upon the accuracy with which the descriptor for each point describes the physiological events in the tree. The botanical scale was open to several interpretations (e.g. rarity versus desirability in the collection) and needed better definition. Rarity could be measured by expert opinion as done in this research and by Sanecki (1986), or by quantification as also done in this research and by Jim (1994). 'Desirability in the collection' would be a matter of judgement in relation to the strategic position of the Arboretum, and this could be done by an expert panel.

The health and growth phase scales need better description of each point to make them reliable. Neither scale could cope with a tree that had been suppressed but was subsequently recovering, or plants that had a mixture of poor health symptoms and strong regrowth. The scales describe a plant which makes a standard progression through life phases, or degrees of health, but they did not allow for cycles of regression and progression on the plant at the same time. None of the scales described in section 6.1.2.2 have this capacity either. The nearest example is the notion of 'vigorous poor' which describes a young tree that is damaged but still growing (Talarchek, 1987; Welch, 1994). A mature tree that has been suppressed but is recovering has not been described in any scale found to date. At Eastwoodhill, where many plants have been suppressed, a scale that includes the recovering plant would be useful. At the same time the physiological basis of each point on the scales could be tightened.

Methodology could also be improved in two other ways. First, more attention should be given to future composition of each park. Future composition must achieve the objectives for the park, but it cannot be assumed that today's composition plus the agreed additions will achieve the necessary future composition. Ideally, composition should be controlled by projecting the future requirement backwards (Ackoff, 1986), and not by assuming that the current composition will develop into the required result. Second, the time span of the plans needed to be expanded. While 20 years was a reasonable operational planning interval (Boisset, 1980; Workman, 1974), the plans developed did not take account of longer term views for either parks or genera, instead focusing on current problems, i.e. restoration issues and the need to bring the collection back up to a minimum baseline. The plans did not look far enough forward to address the next round of recycling, which is more complex because it must be done in tandem with recycling of the physical layout.

Upon further reflection it is clear that a series of related issues should be considered as part of an overall vegetation management approach. The question of physical arrangement and replacement was not considered in the park or genus plans, nor was the relationship between physical layout and landscape design addressed. Because the time frame of the park and genus plans was too short, the issue of anticipating future replacements was not considered. This in turn, raises the topic of plant performance as a component of vegetation management. Despite many of these issues being outside the scope of a first series of workshops, analysis of workshop outcomes makes it possible to describe a future framework for vegetation management that should include those issues. This framework will be discussed under two headings: understanding and concepts, and a process for vegetation management.

6.4.2 A vegetation management framework: understanding and concepts

A vegetation management framework should be underpinned by an appreciation of precisely what is being managed. Superficially, it is the vegetation itself but more precisely it is the values generated by that vegetation. In this regard any framework for vegetation management is linked with the biological and visual management paradigms and therefore back to the mission of the enterprise. If the enterprise is a botanic garden then biological value is in the superior position, and composition and condition of vegetation are the primary factors. Visual factors (appearance and layout) are present in the secondary position. If one is working under the visual management paradigm then appearance and layout will be superior and composition and condition are in the secondary position. Thus the management paradigms establish a priority for vegetation management and indicate which factors of vegetation should be managed in which order.

It is also necessary to appreciate when vegetation management takes place. There are three broad application points in the life of an individual plant or population: establishment, maintenance and renewal (Miller, 1988; Talarchek, 1987). Although each application point is important, renewal is the crucial one for human-made landscapes which cannot sustain themselves. Renewal is complex and the issues of replacement cycle and replacement method have already been raised in the introduction to this chapter.

Three other issues are important in this regard: which plants should be given priority for renewal, when renewal actions should be made, and where the replacement plants should be sited. The first issue has been addressed in this research. The concepts of mission and goals, significance and condition, and the management paradigms are used to establish hierarchies for decisions and identifying the 'which' element of renewal. The second issue is complex. The 'when' of renewal decisions is based upon an understanding of plant performance and the relationship between this and renewal. If one is to avoid the 'replace it when it dies' scenario (FRCC, 1988) a method is needed to anticipate the demise of plants, which can be used in a planned replacement schedule.

The 'when' of renewal is discussed in section 6.4.2.1. Finally the 'where' of renewal decisions requires an appreciation of the interaction between renewal and physical issues including landscape design. This is discussed in section 6.4.2.2.

6.4.2.1 'When': vegetation management and plant performance

Planned vegetation renewal involves anticipating when a plant will become senescent and planning ahead for its replacement. These actions require knowledge of the 'normal' growth phase behaviour of a species and what may influence that pattern in the landscape, and a way to predict the timing for renewal.

'Normal' growth phase behaviour and its modification in landscape situations

Each species has a 'normal' life span and pattern of progression through the life phases (section 6.1.3.1) but that pattern can vary between species. Growth and deterioration rates vary (Rhoads et al., 1981; Wray and Mize, 1985), e.g. sugar maple deteriorated from the mature phase faster than silver maple (Richards, 1979). Some species must produce more seedlings than others to produce the same number of adult trees (Good, 1977).

As the 'normal' pattern for a species may change when the plant is used in the landscape (Clark and Kjelgren, 1989; Whitlow and Bassuk, 1988), replacement time is also likely to change. Progression through life phases is influenced by genetic make-up of the individual, the site conditions in which it is planted, and the management interventions applied (Clark and Matheny, 1991; Close et al., 1996a; Close et al., 1996b; Struve et al., 1995). It is likely that there is a relationship between natural habitat of the species and its performance in the landscape, but use of this relationship is constrained by lack of information on many species. Furthermore, such matching (e.g. swamp habitat to damp landscape conditions, dry habitat to dry landscape conditions), may not reveal the capacity of a species to adapt to new circumstances.

Consider species that are 'best suited' compared to 'best tolerant' of their native niche. A species which is found in a particular niche because it best suits those circumstances is likely to grow best in similar circumstances in the landscape, it may or may not have genetic potential for adaption to other landscape situations. In contrast, a species found in a niche because it is the only one that could survive there may have best fit potential that relates to other niches and may adapt well to a variety of situations. Distinguishing 'best suited' from 'best tolerant' may be difficult, although the provenance range of a species may give an indication, as will ecological studies of the species. Therefore knowledge of habitat is useful, but limited in application as a species may or may not be adaptable to circumstances other than its habitat range. It may be adaptable over a wide or narrow range of factors and levels of factors, e.g. one species may be adaptable over a range of soils, but have specific temperature requirements while another may grow in a range of temperatures, soils, and moisture.

The potential variability in translation of growth patterns from natural habitat to the landscape, plus the added influence of cultural and managerial factors, complicates the prediction of renewal time. Yet the critical nature of the decisions based on the knowledge of growth pattern and response to different situations reinforces the need to understand the basis of growth and performance of plants in the physical landscape.

Predicting plant renewal

Trees should be renewed when they become senescent because once this physiological stage is reached, they are incapable of being rejuvenated and removal is inevitable. Determining the right time for replacement is essential for an effective renewal programme, and that depends upon suitable data and predictive functions. Unfortunately, there is insufficient information on the performance of many species in the landscape (Clark and Kjelgren, 1989; Endress, 1990; Gerhold, 1978; Gerhold, 1985; Gerhold and Sacksteder, 1982: Impens and Paul, 1985; Karnosky et al., 1982; Murgas, 1981; Richards, 1993). Descriptive information is readily available but performance data is not (Gerhold and Sacksteder, 1982; Rhoads et al., 1981). Ideally one would have growth curves for individual trees and populations which showed the typical pattern for the species, plus additional curves to show the influence of different soils and sites (Good, 1977). This type of information is typically contained within production tables which foresters use to plan and manage their crops (Good, 1977), but is rarely developed for landscape trees. Gerhold and Sacksteder (1982) suggested that the performance data that is available is flawed because it is often contradictory, incomplete, with no indication of how the results will translate into the field. In addition they suggested that information was deficient because it was not sufficiently detailed to define adaption to specific sites, not standardised and not suitable for comparative purposes, and was not precise enough to discriminate between cultivars.

The necessary information is difficult to obtain as it is not available from any one source, or necessarily found in books (Clark et al., 1990). Gerhold and Sacksteder (1982) proposed two main ways of obtaining the necessary information. First, current information should be used more effectively. Published information and personal experience should be collated into a standard format that outlines relevant characteristics (Endress, 1990; Gerhold and Sacksteder, 1982). For example,. Clark et al. (1990) developed a species profile for use in street tree selection which had 96 pieces of information in five categories: name and plant group, growth and development, reproductive development, culture and management, and landscape values. Similarly, Murgas

(1981) created the Tree Information Planning System which recorded eight site factors and 13 visual factors for each species.

Data should also be obtained from field tests (Clark and Kjelgren, 1989; Gerhold and Sacksteder, 1982; Santamour et al., 1980), e.g. Gerhold and McElroy (1994) tested cultivars of *Pyrus calleryana* for suitability as street trees. A major programme is being undertaken in the United States of America by the Metropolitan Tree Improvement Alliance (METRIA) to test the potential of cultivars in street plantings (Gerhold, 1978; Gerhold, 1985; Gerhold and Sacksteder, 1982). A standardised method measured nine factors to describe the success of a cultivar in the street situation; it could be used to rate either new plantings or existing trees (Gerhold, 1985; Gerhold and Sacksteder, 1982). In time a large data set would be developed which showed which cultivars were adapted to which regions and sites (Gerhold and Sacksteder, 1982).

Performance of cultivars is relatively easy to measure as they are generally uniform (Gerhold, 1985), whereas seed grown material is more difficult as it is more variable. Gerhold and Sacksteder (1982) speculated that a variable set of performance observations was caused by variable adaptability of different seed sources. The hidden genetic potential for adaptability that exists within seed grown material is usually measured by experimenting with species in different landscape situations and recording the outcome. For example, Santamour et al. (1980) found there was sufficient variation within twelve species of oaks to select for higher survival and growth rate. Better genotypes, with better landscape performance, could be selected through species testing (Karnosky et al., 1982; Percival and Hitchmough, 1995; Ware, 1994; Whitlow and Bassuk, 1988). For example, Bresnan et al. (1996) tested different provenances of *Fraxinus pensylvanica*, and Townsend and Douglass (1994) tested different provenances of *Alnus glutinosa*. Good (1977) also studied species performance and developed production tables and growth curves for seven important landscape species in Britain showing performance of individual trees and populations on different sites and soils. Trees could be classified by age, life expectancy, performance and growth rate.

If comprehensive data on performance of a species are not available then renewal actions could be partially planned from informal interpretation of rating scale observations. Reflecting upon the rating scales used in this research, a possible method is as follows. A synthesis of health, growth phase, actual age against expected age, and actual height against expected height, can be used to make a judgement about the performance of a species at that point in time. For example, many *Sorbus* in Glen Douglas are in poor health and verging upon senescence, suggesting that they are at the end of their lives, yet they are smaller than expected and declining before their expected life span is completed. These trees have performed below their norm, apparently constrained by very poor soils, wind and too hot a climate. Consider a second example. Many *Crataegus* in Pear Park are in poor health and are verging upon senescence, but most have reached expected height and life span. These trees have performed to expectation, and are declining after a normal life span. This process shows that the *Sorbus* needed replacing sooner than expected, but the *Crataegus* did not need any action until the normal life span was completed.

Perhaps the example above appears obvious because *Sorbus* are cold climate trees and will not do well in the hot dry climate of the East Coast, but consider the adaptability factor. The specimen of *Acer saccharum ssp. leucoderme* is only 13 years old at Eastwoodhill and has already exceeded its expected height. The current health status of this tree and its mature vigorous growth phase suggests that it will continue to increase in height. It has outperformed expectations and the final outcome is as yet unknown. *Betula papyrifera var. kenaica* is about 20 years old at Eastwoodhill and has also outperformed expectations; it is from Alaska and Canada and might not be expected to do well at Eastwoodhill. In contrast *Abies procera* (from NW North America) is well below expected height, is in poor condition and is in a mature growth phase. The *Betula* apparently had the potential to adapt to Eastwoodhill while the *Abies* did not.

If these analyses were repeated for the same species on different sites, a predictive function could ultimately be developed. In the meantime, the aforementioned method can be used to give an estimate. One observes the health and growth phase of the tree, then actual height against expected height, and actual age against expected age. These measurements indicate whether or not the tree is still growing (growth phase), its condition, its height to date, all against the expected age and height. If the pattern seems unusual, compare growing conditions against normal habitat for either an explanation for poor performance, (i.e. growing conditions well out of normal habitat range), or an indication of adaptability, (i.e. good performance while well out of normal habitat range). Maintenance actions (or lack of) may also account for the observed performance of the tree. This method could be used to measure performance and propose likely replacement dates for the park and genus exercises in this research.

6.4.2.2 'Where': vegetation management and physical layout

Physical replacement planning

Park plans developed in the workshops would have been of greater use if they had been accompanied by a projected physical layout for the park. While this was not an objective for the workshops it has been attempted subsequently for segments of Pear Park . Working concurrently with physical layout revealed renewal issues that were not apparent from the written plan, e.g. a scale drawing showed that there was insufficient room in Pear Park to replace all the plants therefore some low priority plants must be removed. Another issue is the need to find suitable replacement sites for some plants, which limits the sites available for other plants.

Planning the future physical layout can be done using the following method. First, assume that a 200 year planning cycle is used. The future layout is worked through on a plan of the park with the following steps:

1. Rank the plants for significance so that highest and lowest priority plants can be identified. High priority plants must be kept. Lowest priority plants are candidates for removal if space is lacking.
2. Mark (on the plan) the long lived plants that will still be present at the end of the cycle; remove the long lived plants that are damaged or poor quality. Then, replace long lived plants that are selected for replacement, placing them to form a long lived structural backbone in the park.
3. Remove (on the plan) the medium and short lived plants that are moribund. Replace those which are selected for replacement to form a physical layout around the long lived backbone and which follows good design principles. Repeat this step as many times as necessary to sustain the short lived plants through the 200 year cycle.
4. If space is insufficient to accommodate the high priority plants; select the lowest priority plants for removal, use those spaces to replace high priority plants.

Decisions on *which* plants are kept or removed depends upon significance and condition of each plant in relation to the objectives for the park and Arboretum. Decisions on *when* to replace them should be based upon an assessment of the performance of each plant and a best estimate of when it will decline. The above method can be used to decide *where* to put the plants.

Landscape design

At some point biological layout should be integrated with landscape design for the Arboretum. To appreciate how this might be done, consider the ordering mechanisms that are used when developing a landscape design. In the geometric ordering mechanism, geometric patterns are used to link different areas and functions of the site (Motloch, 1991). This device is commonly used for residential sites and urban areas and suits the generally geometric forms of those areas. It is not usually dominant in parks or rural sites although it frequently occurs around rural houses as a transition into the softer shapes of the surrounding countryside. In the circulatory ordering mechanism, the layout is driven by the need to progress around the site (Motloch, 1991). This ordering mechanism manipulates mass and space, viewing points and views, hidden vistas, focality, enclosure, light and shade, and ease and difficulty of locomotion, thereby moving people around the site in the desired pattern. Circulatory ordering can be used in either rural or urban landscapes; when used in rural landscapes it is characterised by informal lines and natural forms. The third ordering mechanism is the visual arts mechanism (Motloch, 1991). Here one manipulates art components (line, form, colour and texture) using art principles (repetition, rhythm, balance, etc) to create visually satisfying scenes (Motloch, 1991). This device is commonly used in large rural gardens and parks, and can be used to create either formal or informal effects. Both circulatory and visual arts mechanisms manipulate masses and spaces first, then the visual effects within the masses, i.e. the plants.

The key issue is overlaying the biological requirement of an arboretum with the ordering mechanism used to design the site. The biological requirement can be viewed as a fourth ordering mechanism that is manipulated along with the others being used. For sites such as Eastwoodhill the primary ordering mechanism will probably be circulatory. Thus the designer will manipulate mass and space, viewing points and views, hidden vistas, focality, enclosure, light and shade, ease and difficulty of locomotion, and physical and implied pathways to develop a preliminary proposal for the physical layout of the site. Next, a biological layout should be developed where the various genera and other collections are fitted to the spatial layout previously developed. Adjustments to both spatial and biological layout should be made until the finished layout satisfies both the design mechanism and the biological requirement. Finally, specific visual effects should be organised within the plant masses and collections. This process is the same as any design process, with an additional step where the biological layout is merged into the design layout.

This process follows accepted design thinking; function is organised first, aesthetics second. Function is organised on two levels: people (circulatory ordering mechanism), and arboretum (biological layout). The beautification of the site (aesthetic component) is applied only after the functional use is satisfied. On a large site such as Eastwoodhill this process will be complex, but it could be done using a sound process and precise data. A design process of this type will be needed at Eastwoodhill as the remaining land area should be developed using a professionally developed layout plan. Similarly, recycling of the present Arboretum will also need physical layout plans that can accommodate biological and visual factors.

6.4.3 A framework for vegetation management: process

A vegetation management system is needed to stop landscapes deteriorating, reverting to a stereotype of the period, being manipulated by circumstance, falling prey to short term expediency, or being influenced by the preferences of those in charge (Sales, 1988). There is no widely accepted methodology for planned vegetation management in human-made landscapes, yet there would be considerable benefit in having a framework for planning long term outcomes. The basic ingredients already exist, e.g. the phased replacement principle and replacement methods (Cobham, 1985; Sales, 1988,1990), but these have not been formulated into a coherent planning mechanism. Existing ideas can be combined with basic planning processes to develop a comprehensive vegetation management framework. My proposed method has 15 steps which can be used to manage vegetation renewal in created landscapes. The steps fall into three main categories: understanding the landscape, understanding the vegetation management issue, and developing vegetation management plans.

Understand the landscape

First, one must understand the landscape in question by considering three aspects: existing mission and goals, the original concept, and the site itself based on inventory and evaluation. This step is needed for any type of landscape strategy in either planning, design or management, (e.g. vegetation management, landscape design, or recreation and tourism planning). The steps in this first category are:

1. Understand the strategic position of the enterprise: its purpose and mission, goals and objectives, management priorities (Workman, 1982).
2. Understand the original concept underlying the site (Moggridge, 1986; Sales, 1988, 1989, 1990) as perpetuation of the landscape requires understanding of the character and tradition of the place (Anthony, 1975; Bourke, 1983; McGuire, 1981; Miles, 1991; Sales, 1987, 1989, 1990). Specific knowledge may be necessary, such as visual composition and design for sites where particular visual effects are involved (Sales, 1975). Summarise the character of the place and the current trend of development, including season of display, etc, (Sales, 1989).
3. Identify the values that underpin the landscape.
4. Identify which landscape category the landscape should be in, and which management paradigm will apply.
5. Understand the site through examination of the inventory and evaluation data (Miller, 1988; Nowak, 1993b; Sales, 1989, 1990; Weinstein, 1983), including history (Boisset, 1980), factors of change, and previous management (Miller, 1988).
6. Understand the current status of the landscape by examining current significance, condition and landscape category.
7. Using the strategic position of the enterprise, define the desired future characteristics of the vegetation. This will include, collection type, goals for collection development, physical layout to be used. At a more detailed level, and as necessary, define future characteristics of specific collections or areas within the Arboretum.

Define the vegetation management issue

Next, focus on vegetation management in particular, developing an understanding of the issue in relation to the goals of the enterprise. Examine present significance and condition of the vegetation, and compare this with the goals, thereby highlighting any discrepancy between actual and desired vegetation and indicating where action must be taken.

8. Understand the present state of the vegetation. Develop profiles and look for patterns in composition, condition, ages, life phases, size, distribution, and visual effects (Boisset, 1980; Cobham, 1990, p 223; Dolwin, 1993; Miller, 1988; Weinstein, 1983; Sales, 1990). Make additional inventory if required, use rating scales where appropriate.
9. Summarise the current status of the vegetation, using population and individual plant indicators. Relate the current state of the vegetation to the mission and goals, landscape category and the relevant management paradigm (as described in sections 3.6.1 and 3.6.2). Identify strengths and weaknesses of current vegetation.

Develop vegetation management strategies

The first step of the solution is defining future requirements for vegetation, with goals for composition, condition, appearance and layout. Next, strategies must be developed to achieve those goals. The aim is to ensure the population remains in an acceptable state with consistent cover through recycling (Nowak, 1993a). The strategy should control the impact of change (Nowak, 1993a; Sales, 1990), and direct change along lines that will preserve the integrity of the landscape (Sales, 1990).

10. Describe the required future state of the vegetation in terms of composition, condition, appearance, layout. Use the management paradigms (section 3.6.2) to select the appropriate hierarchy for the four factors.
11. Adopt a long term time frame (Boisset, 1980; Dolwin, 1993; Herbert, 1991; Impens and Paul, 1985).
12. Set goals for composition, condition, appearance and layout. For an arboretum composition and condition will be decided first, then appearance and layout.
13. Determine actions needed to achieve those goals.
    (i) Manage composition with plans for future composition (Miller, 1988), acquisition, prioritised planting plan (McGuire, 1981; Miller, 1988), a replacement policy (Miller, 1988) and list of replacements (McGuire, 1981).
    (ii) Manage condition of individuals with plans for maintenance. Manage condition of the population with plans for maintenance, planting and replacement (McGuire,

1981; Miller, 1988), and diversity of age structure to ensure continuous cover (Miller, 1988).

(iii) Manage appearance with plans for maintenance.

(iv) Manage layout with plans for biological layout, visual layout (McGuire, 1981), and physical plans for replacement which deal with structural problems first (Sales, 1987).

14. Develop a replacement plan. Set the rotation cycle for whole landscape e.g. 200 years, and select operating intervals, e.g. 20 years. Group trees into longevity groups, long medium, short etc. Plan the replacement using the method described in 6.4.2.2.

Output

Plans should outline how to manipulate vegetation to achieve the composition, condition, appearance and layout goals. Plans could be developed focusing upon the four factors of vegetation with the intervention points for vegetation management (selection, maintenance, renewal) managed within each plan. Conversely, plans could focus upon selection, maintenance and renewal, with the four factors of vegetation managed within each one.

15. Express 10-14 as (park or genus) plans. This will include a report outlining all of the above, and plans for each of future composition (written), acquisition (written), biological layout (written and drawn), visual layout (drawn), planting (written and drawn), maintenance (written), removal (written), replacement with phased recycling strategy (drawn in phases).

To my knowledge a model such as this has not been proposed in the literature, although some of the component parts are regularly discussed. The need for a long term time frame is recognised, although this is not always linked to the need for planned renewal of human-made populations. Conceptual links between the mission, goals and values of the enterprise, and then through to vegetation management are not widely discussed. Concepts such as the landscape management paradigms, and their links to vegetation management via the four factors of vegetation, have not previously been proposed in the literature. The use of rating scales to measure plant attributes is common, although many scales are not particularly repeatable or reliable. The use of ecological or forestry concepts to measure the state of human-made tree populations is a relatively recent idea, and although the measurement component is regularly reported, any interpretation of the management implications of that data is not as common. This is related to the lack of integrated planning and management methodologies, lack of information for determining plant performance, and poor capacity to predict future outcomes for plants in the landscape. Methodology for renewal also needs more work; the un-even age principle is a useful concept for landscape populations, but there is little discussion on applying it to the multi-species, multi-lifespan situation in landscapes. Similarly, the theoretical basis of landscape design needed to merge biological and visual layout in an arboretum is not widely recognised.

6.5 CONCLUSION

Vegetation management is complex because it involves multiple concepts. First, composition, condition, appearance and layout need to be managed simultaneously, but in a definite hierarchy determined from the management paradigms, which in turn, are determined from the mission of the enterprise. Second, the four factors of vegetation need to be integrated with the three intervention points (selection, maintenance and renewal). Third, a managed renewal system is needed for human-made landscapes. This requires a systematic approach and long term time frame which can be used to predict and manage vegetation renewal at least one cycle ahead.

Although aspects of vegetation management in human-made landscapes are frequently reported in the literature, integrated frameworks or models are seldom proposed, thus the concepts proposed in this research could prove a useful contribution to vegetation management. Understanding of the landscape and landscape values leads to definition of the management paradigm, which indicates the factors that will influence vegetation management. Four factors of vegetation allows separation of those aspects of vegetation that relate to different values. Considering biological layout as a fourth design ordering mechanism gives a method to merge biological and visual layout in an objective way. The overall process for vegetation management proposed here provides a mechanism to draw all those ideas together. This method provides a way to develop a long term view of vegetation in the human-made landscape and distinguishes vegetation management from short term maintenance activities.

A vegetation management framework is applicable at the Eastwoodhill Arboretum. The biological management paradigm applies to the Arboretum, with composition and condition being the primary vegetation factors, and appearance and layout controlling the visual factors in the paradigm. A long term time frame should be adopted to manage the important vegetation in this human-made landscape. Daily maintenance activities should contribute to long term goals via a systematic vegetation management framework.

The park and genus plans developed for Eastwoodhill were useful contributions to vegetation management at the Arboretum. The plans included actions for composition, acquisition, maintenance, propagation, and removals. The notion of a long lived structural backbone was included in the park plans. Conversely, the plans did not include all of the factors subsequently described in the vegetation management model. The time frame was not long enough, and layout issues were not considered. A comprehensive vegetation management system would include physical layout (both biological and visual), and the physical planning for renewal (as per 6.4.2.2). These tasks are complex and require excellent conceptual skills, biological and visual layout skills, and skills in physical planning for renewal. It is unlikely that these tasks could have been addressed in this series of workshops as the proposed system is complex, but the workshop group could contribute knowledge on various issues (e.g. biological layout, future composition, park objectives).

A comprehensive vegetation management system for Eastwoodhill would be part of the overall systematic management framework and would have the following characteristics and stages:

(i) Understanding the landscape through the knowledge in Chapters 2 and 3.

(ii) Defining vegetation management issues through the knowledge in Chapters 3 and 5.

(iii) Developing vegetation strategies including plans for composition, condition, appearance and layout.

(iv) Developing a recycling strategy using the method in 6.4.2.2.

Applying and implementing this process at Eastwoodhill will provide a series of developmental challenges for the Trust Board. A composition plan could be developed using the expertise of the workshop group. Condition should be managed through long and short term maintenance plans and replacement plans, which could be developed with the assistance of the workshop group. Appearance should be managed through short term maintenance plans. The integrated issue of biological and visual layout should be addressed, with underpinning concepts being developed for each, and then merged into an overall layout, using the method described in section 6.4.2.2. Future composition could be expressed on that layout plan, and a planting plan extracted from it. Layout planning requires specific expertise in spatial and visual composition which is not available in the present workshop group. The services of a suitably skilled person(s) should be obtained for this job, possibly a suitable landscape architect in combination with the workshop group or curator.

The overall conclusion for this chapter is similar to that of Chapter 5. Management of human-made landscapes requires systematic approaches, which would be an approach that the Eastwoodhill Trust Board could adopt in the future. A series of plans and management concepts have been developed in this research which could be used at the Arboretum as part of a systematic framework, recognising however that some further development of those plans and concepts is needed. Their application at Eastwoodhill however, is dependent upon the Trust Board confirming the systematic approach and initiating the next stage of development.

Chapter 7

General discussion

Magnolia veitchii, Orchard Hill, August 1989.

7.1 INTRODUCTION

The components of an arboretum or botanic garden are the living plant collection, the library and the herbarium. These components are managed to achieve the functions of the arboretum, which are science, recreation and education. The critical component is the living collection because this is the fabric of the arboretum, and is fundamental to the utility of the arboretum. Thus managers of arboreta have two main tasks: developing and sustaining a suitable plant collection; and managing the utilisation of that collection for the selected mix of science, education and recreation. This project has focused upon the former task, of developing management methods that could be used to ensure that an appropriate plant collection exists, and continues to exist, at the Eastwoodhill Arboretum. These studies have led to a proposal for a model for managing a plant collection which is discussed in section 7.2. Application of the model to other landscapes is covered in section 7.2.4. The outcomes and issues relating directly to the Arboretum are discussed in section 7.3.

7.2 MANAGING A PLANT COLLECTION: A MODEL

Results of this research can be synthesised into a model for managing a plant collection. This model could be applied to any plant collection, and also has relevance to other landscapes. It draws upon principles of planning and management, which are well known and not exclusive to landscape management, but adapts those basic processes for application in a particular context. This is a specialised task and combines knowledge of both the principles and the context. Those principles and their applications are discussed in the landscape context, incorporating a series of new concepts that relate to landscape management in particular. These principles and concepts have been developed into a landscape management model which has three main components: 'understanding management concepts', 'strategic management' and 'operational management'. There are two main pathways in the model, depending upon presence or absence of a strategic position (Figure 7.1).

Both pathways are underpinned by six areas of understanding: knowledge of human-made landscapes; landscape values and their management; broad mission and goals of landscape management; basic management processes; understanding of the mission and strategic position and its role in influencing management; and the influence of the organisation of an enterprise on its management. This understanding is crucial as it gives the manager the knowledge to comprehend how subsequent steps work, and facilitates adaption of the process to new circumstances and landscapes other than plant collections. This component is explained in detail in section 7.2.1.

In subsequent steps the model takes one of two forms, depending upon presence or absence of a strategic position. When these are absent, unclear or under review, the model includes both strategic and operational management (components B and C in Figure 7.1) and has the following steps:

(i) Understand the broad purpose of the enterprise and make preliminary identification of likely values.

(ii) Develop an inventory using methodology suitable to that type of enterprise (in this case a plant collection).

(iii) Undertake an evaluation suitable to that type of enterprise. Single sites can use the method proposed in this programme. Significance and condition, landscape category and the landscape management paradigms can be used in the evaluation.

(iv) Strategic analysis, leading to development of a strategic position including definition of scope, identification of distinctive competence, identification of key assumptions, and development of a mission statement.

(v) Understand the framework for operational management from the known mission statement, strategic position and long range goals.

(vi) Develop any additional inventory data as needed for operational management.

(vii) Undertake any further evaluation as needed for operational management.

(viii) Develop operational goals.

(ix) Develop vegetation management strategies, using the method proposed in this research.

(x) Implementation.

(xi) Monitoring and control.

When the strategic position are known, or not under review, the model involves only the understanding and operational management steps (v) to (xi) (components A and C in Figure 7.1). The pathway where the strategic position is absent is discussed in detail in section 7.2.2. The pathway where the strategic position is present is discussed in section 7.2.3.

In addition to the two main pathways in the model (Figure 7.1), there are several feed-back loops. If an existing strategic position is being reviewed or updated, then a feed-back loop directs one back to the strategic management component where such a position can be developed. Other feed-back loops (dashed lines) apply when circumstances change, new data is obtained, or operational management is reviewed. There are also internal feed-back loops within the strategic and operational components. For example, an evaluation may indicate that more inventory data are needed, or monitoring may indicate that different vegetation management strategies are needed.

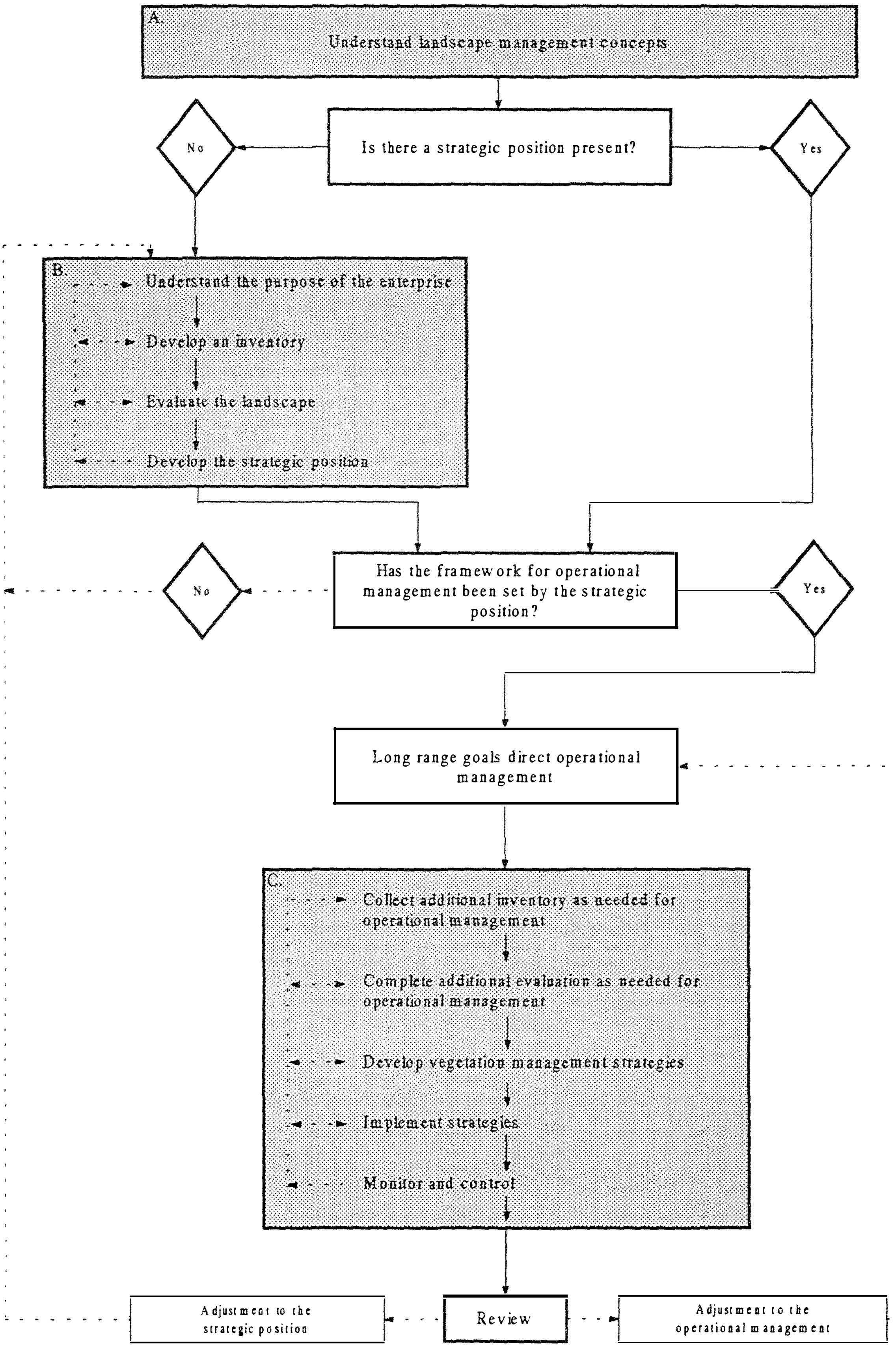


Figure 7.1 Management model for a plant collection.

7.2.1 Understanding management concepts

Both pathways in the model are underpinned by an understanding of a series of landscape management concepts. These form component A in the model.

A: MANAGEMENT CONCEPTS
An understanding of landscapes and landscape values is needed.
The broad mission and goals of landscape management should be understood
Sound management principles should be used including: good planning and decision making processes, use of suitable expertise, and use of data in plans and decisions.
Appreciate the importance of the management framework formed by the mission and strategic position
Suitable organisational structure will be needed

Understanding landscapes

Effective management depends upon an understanding of what one is managing, therefore knowledge of landscapes and their functioning is needed. This research focused upon a human-made landscape, which has particular management implications. Inevitable change and decline is coupled with an absence of any self-renewing capacity, therefore sustaining human-made landscapes and their values can only be achieved by deliberate management action over a long time frame. In turn this requires two elements of understanding. First, the nature of change must be appreciated, requiring an understanding of individual plants and whole populations in human-made landscapes. Second, methods are needed to manage that change so that values of the landscape are upheld. In addition, value of some landscapes is associated with the original concept that underpinned their creation (Moggridge, 1986; Sales, 1990), requiring a thorough understanding of those underlying principles to manage change in those landscapes. All these elements must be put into a long term context, requiring a comprehensive planning and management framework.

In this programme the general notion of understanding landscapes was applied to an arboretum, recognising the components, functions and values of an arboretum which are relevant. The importance of the living collection is well known, as are the functions of arboreta for science, education and recreation (Ashton, 1989b; Heywood, 1987; 1989b). The 'botanic garden management problem' (section 1.4.6), where the biological purpose of arboreta must be reconciled with the need for good visual values to attract visitors, is also recognised (Morley, 1993; Robertson et al., 1989). The recognition that a key role of arboreta is to preserve plant material yet they are not self-renewing, was highlighted in this research; but the basic idea already existed in heritage garden management, particularly stressed by Sales (1988, 1989, 1990) who outlined the need for planned renewal in human-made landscapes. Thus while deliberate management action is needed for all plant collections, the process will be different for conservation collections managed for genetic integrity, compared to taxonomic or horticultural collections where genetic integrity is not a key issue.

Understanding landscape values

An important component of understanding landscapes is an appreciation of the values associated with a site, e.g. arboreta usually have both biological and human values but biological value underpins the primary purpose. At one level it is the components of landscapes that are managed (landform, water, vegetation, human elements) with the general aim of producing a high quality landscape. At the same time, however, it is the biological and human values derived from the landscape that are being managed; therefore at an arboretum the plant collection is managed to generate recreational, scientific, educational, and visual benefits. The realisation that the benefits are a key outcome, as well as the landscape itself, adds an extra dimension to the management task.

Understanding values begins with appreciation of different individual values, the basis of each one, the likely interactions and conflicts with other values, and how to measure each one. The topic of values is well described in the literature, and common conflicts have already been identified, thus this research operates within a context of current knowledge of individual values. Values should also be considered in overview, where the interactions of a series of values relate to a particular site. Indeed, most sites have multiple values, and different sites will have different primary values, requiring conscious management of the balance of values and the interactions between them.

Development of the landscape management paradigms which outline a framework for managing the balance between different sets of values, is a further contribution to research on this subject. Although individual values are frequently discussed, the need to manage suites of values is seldom considered (with the exception of Jackman, 1986; Kirby, 1986). The landscape management paradigms can be used to manage the balance between biological and visual values of an arboretum and are therefore a useful development on previous work. The role of the paradigms in establishing a link between mission, evaluation, goals and vegetation management is a significant framework for connecting values to management, and for connecting steps in the management process. Thus the long term and short term management of a site is linked through by the paradigms. A concept such as the paradigms has not previously been reported in the literature.

The demonstration of that link between values and management is an important outcome of this research. Links in the management process have been made more explicit, where each step of the process is influenced by the need to manage values of the site, e.g. the mission indicates which values might be measured in inventory and evaluation. In return, an evaluation indicates the likelihood of achieving the mission.

Mission and goals of landscape management

In broadest terms the purpose of landscape management is to obtain optimum values from the landscape, making landscape values pivotal to both 'understanding' and 'management' of the landscape. This realisation supports the two aspects of the overall mission, (i) development (if necessary) of the landscape and then management to ensure its continued existence, and (ii) managed utilisation of the landscape for human use, e.g. recreation. If these tasks are achieved then the landscape will 'provide' the relevant values. This broad mission is achieved through the general goals of preservation, protection, improvement, provision for human use, and development of sustainable landscapes. This connection between the underpinning values and the purpose of landscape management cannot be overemphasised. At one level it is a key rationale for the existence of the profession, at another level that same linkage between values and management practice is the driving force behind management of individual sites.

Understanding basic management methods

The final factor is an understanding of basic management practice as it is this knowledge, in combination with the knowledge above, that is adapted to generate processes for managing landscapes. First, an understanding of the functions of management is needed, particularly planning and decision making and how these are used in problem solving methods or planning frameworks. Second, an understanding is required of the inputs needed in management (data, expertise, process), and the skills needed in different types of managers. Finally, the influence of management structure on planning and decision making (e.g. roles) should be understood. This knowledge is well described in management literature (Griffin, 1990; Rue and Byars, 1992; Stoner et al., 1985) and in recent times is beginning to appear in landscape literature (Hitchmough, 1994; Miller, 1988; Kraus and Curtis, 1990). The landscape manager needs to understand how these basic methods might apply to the landscape, e.g. what sort of data is needed, what sort of broad goals are likely, what is the nature of the business environment, what are typical constraints?

Some of these elements are considered more frequently than other by landscape managers. For example the inventory stage is regularly discussed. Conversely, the five broad goals of landscape management (preservation, protection, improvement, provision for human use, and sustainability) may appear self-evident, but explicit discussion of them is limited (e.g. Sidaway (1990)). The general notion of planning is supported by many landscape managers, but the distinction between operational and strategic planning is generally not made. Business management ideas on strategic planning seem logical, giving overview of the enterprise and its overarching issues, but explicit application of these ideas to landscapes is uncommon. Some managers of arboreta and botanical gardens use these practices (Eloff, 1989; Leadlay, 1994) but they are infrequently reported in the literature in terms of frameworks for managing the landscape, suggesting that such practices are either taken as read, or not fully explored. Indeed, Leadlay (1994) surveyed three hundred botanic gardens and received a mission statement and corporate strategy from only forty. Therefore, there is a useful contribution to be made by considering business management principles and applying them to arboreta.

The mission and strategic position of the enterprise and its role in management

The mission statement and its associated strategic position are important management tools which set the framework under which a landscape is managed. Strategic management considers the overarching issues including purpose of the enterprise, distinctive competence, scope, its position in the business environment, competitors, key assumptions, and the customers and what product they are looking for (Griffin, 1990; Hitchmough, 1994; Rue and Byars, 1992; Stoner et al., 1985). A strategic position is developed from a comprehensive understanding of the landscape including the data from an inventory and evaluation. Once selected, the mission and strategic position provide agreement about the primary task and give direction to the activities of the enterprise (Kraus and Curtis, 1990; Massie, 1979; Stoner et al., 1985). The mission statement of an arboretum will reflect the science, education and recreation roles associated with living collections and their utility.

The importance of the mission statement has been recognised by world authorities on botanic garden management (Leadlay, 1994; WWF and IUCN, 1989) and the need for better management highlighted by several authors (Eloff, 1989; Given, 1986). The other components of strategic management for botanic gardens and arboreta, or the links referred to above, have generally not been reported in the literature. This research has shown how the management framework can operate in the landscape context, because the mission also indicates likely values, (and therefore the factors that might be measured in inventory and evaluation), landscape category, and the management paradigm with its hierarchy of values. Through the management paradigms the mission determines the hierarchy of values in the management framework and influences the development of operational plans and daily activities. The mission indicates priorities for choosing between decisions with different outcomes. Thus the mission statement is not simply a sentence at the start of a plan, but it is a key idea that establishes an infrastructure for subsequent management steps. Managers should appreciate those links and realise that selecting a mission and strategic position will have important implications for subsequent management.

The organisation of an enterprise and its influence on management

The functions of management in an organisation are interrelated, and the operation of the management process will be influenced by the organisational structure as it relates to planning and decision making. Expertise, data and good processes are needed for good planning and the organisational structure should supply these. In this research those inputs were supplied by a group of experts, as discussed in Chapter 4, but in other circumstances a single expert may be equally appropriate. The important factor is provision of suitable inputs for good planning and decision making, the source and number of people should be selected to suit the circumstances of the particular enterprise.

7.2.2 The management process: strategic position absent or under review

When the mission and strategic position are absent or under review there is no (or an uncertain) framework for management. In this situation both strategic and operational management components of the model are used (components B and C).

B: STRATEGIC MANAGEMENT

Identify the likely purpose and values
Identify the likely landscape management paradigm and landscape category

INVENTORY
Provides data for subsequent decisions
Use standard methods to make a suitable inventory

EVALUATION
To understand the values of the site and relate this to the mission
Measurement of significance and condition, and processing of that data.
Actual landscape category determined

DEVELOP, CHANGE OR CONFIRM MISSION AND STRATEGIC POSITION
To determine overall purpose and set the framework for subsequent management
Identify strategic goals for preservation, protection, improvement, human use
Select collection type and themes, and biological layout
Identify required landscape category and management paradigm

The strategic component begins with general knowledge of the purpose of the enterprise and the values that are likely to apply. Thus examination of any botanic garden, arboretum, or plant collection draws upon the 'understanding' described in section 7.2.1 and the manager will know (i) the general purpose and functions of a botanic garden, arboretum or plant collection, (ii) the distinction between taxonomic and conservation collections and management thereof, (iii) the various ways in which a collection could be arranged, (iv) the role of biological and visual values in arboreta, (v) the use of landscape category and the landscape management paradigms. Armed with this general knowledge, the manager proceeds by completing an inventory and evaluation and using the data to discover how these principles apply to the particular landscape being examined.

Development of an inventory is a critical step, as data are a fundamental requirement for describing and understanding the landscape, and form the basis for subsequent plans and decisions (Miller, 1988). An inventory is essential for any strategic cycle, and may be a major exercise if none previously existed or the available data were out-of-date. Developing a complete inventory may be time consuming for large sites, but the process is relatively straightforward using the well researched methods for record keeping, database development and managing an inventory that are currently available. Existing conventions for making a plant collection inventory were followed in this research, and a complete inventory with maps, catalogue, archival documents, herbarium, and records or previous management was made (Cross, 1990; Lowe, 1991; McBride and Nowak, 1989; Miller, 1988; Sales, 1988; Smiley and Baker, 1988; Stungo, 1982). Although no new steps or processes were proposed in this project, future inventories of plant collections should take advantage of new technology (e.g. GIS and GPS systems, (Goodwin, 1996; Sorvig, 1995)) to make a more sophisticated inventory than was possible at Eastwoodhill. Potential application of this model to landscapes other than plant collections does not raise any issues at the inventory stage, as methods are well developed, and simply requires selection of appropriate inventory type, components, factors and permanent record.

An inventory describes the landscape, but its information is static and does not constitute plans or decisions (Annett, 1990; Miller, 1988). Understanding of the site and its values requires an evaluation. The purpose of this step is to find out the importance of a landscape, in relation to certain values, and relate this to management of the site. The principle is logical but its application is complex.

Knowledge of landscape values is an essential foundation for an evaluation. This topic has been discussed in Chapter 3 and will not be repeated here, but the following aspects must be understood:

- Biological values such as life support and environmental improvement values and how these might apply to the landscape in question (Folke, 1992; Grey and Deneke, 1978; Groombridge, 1992; McNeely, 1988; Miller, 1988).
- Human values of landscapes including historic value (Marquis-Kyle et al., 1992), visual value (Kaplan, 1985; Ulrich, 1983), cultural and social values (Relf, 1992, 1992b) and how these might apply to the landscape in question.
- The relationship between landscape values and economics (Folke and Kaberger, 1992; Groombridge, 1992; McNeely, 1988) and the implications landscape management.

- The difference between direct and indirect values (Groombridge, 1992; McNeely, 1988; Pearsall, 1984) and the implications for landscape management.
- The difficulties associated with measuring many landscape values (Church, 1990).
- The potential conflicts between different values, how they arise and how they might be managed (Lemons, 1987).

This knowledge is readily accessible in the literature, (although it must be drawn together from a variety of sources), and is combined with evaluation methodology to conduct an evaluation. In this research, a new process for evaluation was developed because although a variety of methodologies exist for evaluation (such as broad scale planning, impact assessment), the scale and focus of these methods made them unsuitable for a single site human-made landscape such as an arboretum. Furthermore, the literature is dominated by discussion of individual values and their measurement, while discussion of interactions and processing was limited, indeed insufficient, therefore the processing step of evaluation needed to be developed

Both measurement and processing steps of the proposed evaluation method have been described in Chapter 3, so this discussion will focus upon the underlying concepts. The concepts of significance and condition, and the interaction between them, were important features of the method. The concept of significance already existed in historic landscape management (Goulty, 1993; Marquis-Kyle et al., 1992). Significance describes the importance of the landscape according to certain values, and there is a vast literature on landscape values and their measurement. This research focused upon determining biological significance of a human-made landscape, of which there were no examples in the literature relating to plant collections. The indicators diversity, rarity and representativeness are commonly used for managing natural landscapes, and have been applied by some authors to the artificial populations in human-made landscapes (Chacalo et al., 1994; Loeb, 1993; McPherson and Rowntree, 1989; Profous and Rowntree, 1993; Welch, 1994), but again there were no examples relating to plant collections.

The concept of condition is relatively common in landscape management where indicators such as maturity, dbh, and health are used to measure the condition of human-made landscapes. This research employed current knowledge on measurement of condition and did not make any advance in this area. Any future applications of the proposed model should make more extensive use of existing condition techniques than were used in the Eastwoodhill Arboretum study. This research has illustrated the combined use of significance and condition for a plant collection, and foreshadows a standard method for evaluating collections.

An advance made in this research was the conceptual development of the processing step of evaluation. Although a number of authors proposed the need to interpret the results of the measurement step (Jackman, 1980), few discussed how that processing might be done. The notion of discrepancy analysis was used to process the measurement information, and the interaction between significance and condition stimulated development of 'landscape category' and the landscape management paradigms. Each of these was a processing mechanism that was not previously found in the literature.

In the first processing step the actual values of the site were compared with the (likely) required values, as suggested by the mission and existing goals. This was an application of discrepancy analysis where the actual state of the enterprise is compared with the desired state of the enterprise (Kraus and Curtis, 1990). The results of that comparison established whether or not the site had the potential to achieve the existing mission and goals. The results also identified significant aspects of the site that had been overlooked, significant aspects of the site that might be lost due to poor condition, and highlighted goals that were difficult or impossible to achieve because the site lacked suitable features.

The interplay between significance and condition was a key idea in the 'landscape category' concept that was use in the processing stage of the evaluation. The notion of an interaction between factors came from by Roome (1984) who proposed that different factors would have different influences on subsequent management. This was a key idea, as most other literature considered a value or values in isolation, and did not consider processing or implications for management. Reflection upon Roome's idea, and the need to process significance and condition data in some way, led to the new concept for 'landscape category'.

Landscape category described the current interplay between significance and condition and outlined broad management actions for each category. Using the discrepancy analysis idea, it was possible to identify the actual category and the required category, and the actions needed to change category. Thus, a significant landscape in poor condition could be distinguished from a significant landscape in good condition and different management actions identified for each one. Not only did landscape category provide a framework for managing the interaction between significance and condition, it also gave a conceptual link back to the mission and strategic position — the mission indicates the category the landscape should be in, which is compared with the actual category, thereby foreshadowing subsequent action. Establishing these conceptual links throughout the management process is one of the key features of the process that has been developed in this research. Landscape category was limited, however, because it only considered the interplay between significance and condition for one main value set (biological or human).

The landscape management paradigms extended the interaction idea further by describing the interaction between more than one set of significance and condition factors. The paradigms described the interaction between biological and human values on a site, therefore giving a hierarchy for management of those values. The idea of managing multiple values had been previously expressed (Jackman, 1986; Kirby, 1986), and problems caused by common conflicts are often reported (Jim, 1986a; Lemons, 1987), but a method to devise and manage a hierarchy had not been described. The landscape management paradigms give a framework to that hierarchy and are a potentially powerful technique for organising plans and decisions that involve more than one value of a site.

Once the knowledge from inventory and evaluation has been developed and understood, it can be used to make any necessary strategic decisions. If the mission and strategic position were entirely absent, then the data can be used to propose what they might be. If they were unclear or under review the discrepancy analysis aspect of the evaluation would show whether or not the existing ideas were feasible. That information would be used to decide whether or not the existing ideas should be kept or modified. At this level of decision making for an arboretum one would expect to find decisions on the following:

- broad purpose: the choice between a role as an arboretum or a park.
- landscape values and their management in a hierarchy: identification of the values of the site and selection of the appropriate management paradigm for an arboretum.
- broad goals: consideration of preservation, protection, improvement and provision for human use as they apply to the site.
- broad goals: relate the broad goals to the 'existence' and 'human use' aspects of management.
- decisions about the mix of science, recreation, education or other functions to be attained (scope), and therefore identification of the desired customers.
- definition of the features that will make the arboretum distinctive from other arboreta and botanic gardens (distinctive competence).
- selection of taxonomic or conservation collection, or suitable mix of the two.
- selection of the type of flora to be collected (e.g. endangered native flora, rare exotic flora) and any component themes (e.g. certain genera or families).
- selection of the physical layout type (e.g. geographic, generic).

Definition of each of these factors will describe, at an overview level, the purpose and direction of the arboretum or botanic garden. The decisions involved should be summarised as a strategic position document and key ideas would be expressed in the mission statement. Once the purpose and direction have been defined, more specific goals can be developed to attain the desired outcomes. At this point this pathway moves into the operational management stage (component C).

C: OPERATIONAL MANAGEMENT

OPERATIONAL GOALS Statements of intent which direct subsequent operations Derived from the strategic position and long range goals Determined from the discrepancy between actual and required significance and condition
INVENTORY AND EVALUATION As needed for operational planning
VEGETATION MANAGEMENT STRATEGIES A type of operational plan Connected to the mission via the management paradigm Manipulate significance and condition by managing the four factors of vegetation. Plans developed for each of composition, condition, appearance and layout
IMPLEMENTATION AT DAILY OPERATIONS LEVEL MONITORING AND CONTROL

If the strategic component has been completed in a rigorous way, then operational management should be relatively straightforward. The evaluation will have shown whether or not there is a mis-match between actual and required values, and the current features and those required by the mission. Landscape category will have shown if there was any problem with the configuration between significance and condition. The management paradigms will have shown which set of values will be placed first in a hierarchy. Long range goals will focus upon preservation, protection, and improvement of the collection (ensuring its continued existence), and management of whichever human uses are selected. Priorities for management of the plant collection in an arboretum will logically focus upon:

(i) Sustaining the significance of the collection by sustaining its 'fabric'.

(ii) Achieving (i) will involve sustaining the condition of the collection.

(iii) In some landscapes (those in landscape category 2 or 4 (section 3.6.1)) that may involve restoring significant elements back to acceptable condition.

(iv) Developing long term plans to manage vegetation in human-made landscapes.

Operational management may require further inventory and evaluation data, depending upon the issues being addressed. For example, in the Eastwoodhill study it was clear that extra data on tree condition was needed for operational planning, in addition to that which had been collected for the evaluation. When sufficient data is available, the next step is development of specific plans (also called strategies or programmes) to achieve the goals. The purpose of these plans is to link the broad ideas of mission and goals with the specific actions of daily operations by setting out actions at a level sufficiently detailed to relate to daily operations. At this level of management it is important to make the connection between the values of the landscape (and the overall purpose of management) and daily management practice. In this model, the connection was made with the four factors of vegetation (composition, condition, appearance and layout), which each influenced significance and condition and therefore values. Configuration of the four factors is directed by the management paradigms. Actions that will be needed are shown by landscape category. Strategy development, which manages the four factors, is complex and is described in Chapter 5. The system developed in Chapter 5 is proposed as a general method for developing vegetation management strategies.

Implementation is the next step. The implementation and monitoring stages were not within the scope of this thesis, but some observations can be made. Implementation requires acceptance, both formal and informal and by both senior and front line managers. Without acceptance there may not be any motivation for implementation and the plan or decision will fail. This is an important step as making a plan and not using it is as ineffective as not making one in the first place (Stoner et al., 1985). The technical skills that relate to implementing a vegetation management plan are not the subject of this thesis and will not be considered here.

The final step is monitoring and control. This also involves discrepancy analysis where actual outcomes are compared with planned outcomes (Kraus and Curtis, 1990). It may involve further inventory and evaluation cycles to determine whether or not the plan is being achieved. This also requires a minimum level of expertise.

7.2.3 The management process: strategic position present

When the mission and strategic position are present and not under review, the management process is less complex as the overview ideas that provide the framework for operational management are already present. (Components A and C only). Inventory and evaluation may not be needed if the necessary data is already available, or those steps may take place in a less complex form to gather the additional data needed. Strategic goals will already be in place, thus the goals for operational management will be relatively easy to define. Each operational goal should relate to the strategic position and should contribute to it in some way. The operational steps (strategies, implementation, monitoring) are as described above. It was this form of the model that was first described by

MacKay and Chalmers (1996), with subsequent study revealing the importance of the context created by the strategic position and resulting in modification of the model.

7.2.4 Application to other landscapes

The way in which this landscape management model has been constructed means that the general principle could be applied to any landscape. As previously stated, the background understanding and knowledge of how each step works gives an "understanding of 'why' the process works, and gives the manager the flexibility and background to elevate their management practice above the 'how' of 'following a recipe' and adapt the process to changing circumstances and different landscapes". For example, consider a bush remnant that is near a town, which contains an unusual plant or plant association, and which is used for recreation. A manager skilled in my management process would propose that the primary value was biological, that the biological management paradigm is likely to apply and that a category one landscape is required. They would employ inventory and evaluation techniques suited to natural areas. Goals and strategies will focus upon sustaining composition and condition of the vegetation association. In contrast, consider a city on the coast with a beach-side park development (e.g. Marine Parade in Napier or The Strand in Tauranga). The manager would propose that the main values were likely to be visual and recreational and that the visual management paradigm would apply. Inventory and evaluation would, in addition to recording the landscape itself, include records of user behaviour, and preferences. A visual analysis of the site might be used, with biological analysis taking the secondary position. Vegetation management strategies will emphasise layout and appearance as composition is less important in the visual management paradigm.

These potential adaptions are readily apparent when one understands how the model works, although not all managers will have the skills to operate the model in every possible configuration. For example, the spatial and visual analyses needed for an evaluation of visual value are a specialised skill. Experienced managers will, however, recognise the variety of configurations and if they cannot do the necessary analyses themselves, will readily identify the skills needed in a suitable consultant.

The process can be readily applied to landscapes other than plant collections as long as the operator develops the appropriate knowledge. Recognition of likely values, landscape category and management paradigm are dependent upon suitable knowledge of landscapes and their values. Inventory techniques are relatively straightforward in principle, although modern technologies such as GIS and GPS require specialist skills. Selection and measurement of values for other landscapes such as a street tree population, an historic landscape or designed garden will be no more problematic than a plant collection, as long as the manager understands the site, its values and their measurement. The same problems will be encountered on other sites if they are human-made vegetation arrays in human-made landscapes. Evaluation for natural landscapes will not be difficult (in principle) if the functioning of those landscapes is understood in the first instance.

Strategic goals for any landscape are likely to follow the framework of preservation, protection, improvement, sustainability and provision for human use, although these will be adapted to suit particular circumstances. The general principles inherent in those strategic goals will be made more specific for the shorter range goals and those applying to particular aspects of the landscape, e.g. a specific landscape design goal relating to the overall improvement goal. Vegetation management strategies will vary, depending upon the paradigm and the hierarchy of composition, condition, appearance and layout; but an understanding of how those four factors relate to the values of the landscape will give the background needed to organise them accordingly. In conclusion, I believe the proposed landscape management model can be applied to other landscapes and other circumstances, although further work may be needed to develop the detail of such applications.

7.2.5 Further developments

Completion of this thesis raises a series of issues that require further study.

- Development of the evaluation method to remove some of its weaknesses.
- Application of the evaluation method to other landscapes to test the robustness of significance, condition and the processing method.
- Testing of the visual management paradigm for its application to other landscapes.
- Testing of the framework of the four factors of vegetation on other landscapes.
- Further development of the proposed methods for integrating biological and visual layout of the arboretum, and for physical recycling.
- Refinements to the workshop method.
- Improvements to the rating scales to improve both reliability and repeatability.
- Investigation of the use of the rating scales, including methods to make that use more robust statistically.
- Investigation of the use of group versus individual decision makers.
- More detailed investigation of the principles of management and their application to landscapes.
- More detailed consideration of the two main tasks of landscape management; i.e. 'continued existence of the landscape' versus 'human use' aspects of management.
- More explicit consideration of the goals of landscape management in relation to a variety of landscape types.

7.3 EASTWOODHILL ARBORETUM AND THE FUTURE OF ITS PLANT COLLECTION

7.3.1 Preview

When this research started the Eastwoodhill Trust Board had, under very constrained circumstances, developed some important foundations for management of the plant collection. They had developed a catalogue of the collection (Berry, 1982) and some parks within the Arboretum had been recorded in simple grid square plots. A management plan concerning the whole enterprise had been developed, and this document included some goals for the collection (Williams, 1987), even though those ideas were not supported by analysis. Thus the Trust Board had reached the point where collection management plans were needed, but they were not well placed to develop those plans due to limited resources. This research has advanced the cause of collection management at Eastwoodhill by developing plans that can be applied directly to collection management at the Arboretum, and methods that can be used to generate other plans in the future. In *toto* the research resulted in a proposed model for collection management that could be applied to Eastwoodhill and other collections. The specific outcomes that relate to Eastwoodhill and its future are summarised in Table 7.1 and are discussed below.

7.3.2 Outcomes of this research

The first major result was a complete inventory of the collection (McBride and Nowak, 1989; Smiley and Baker, 1988) which was in keeping with the needs of an arboretum or plant collection (Cross, 1990; Cullen et al., 1985; Sales, 1990; Stungo, 1982). This included a catalogue of the current collection, maps of the current collection at 1:200, a catalogue of the previous collection, development of various archives, and creation of some herbarium and photographic records. A comprehensive inventory is essential for an arboretum (Ashton, 1989; Heywood, 1989a; Walter, 1989) and distinguishes an arboretum from a park (Heywood, 1987). These data provide an essential basis for various planning and management purposes including collection management policies (Heywood, 1987) and development of a scientifically ordered collection (Heywood, 1987; WWF and IUCN, 1989).

There were only two issues relating to the inventory at Eastwoodhill. The data should be kept current, raising a resource allocation issue which is associated with the general issue of resources (section 7.3.3.6). A suitable plant record format should be selected, preferably a botanic garden style record such as the ITF (IUCN, 1987a). The final selection will be related to the choice of mission and the implications thereof (section 7.3.3.3).

Table 7.1 Summary of outcomes

ISSUES FOR EASTWOODHILL	OUTCOMES AT EASTWOODHILL	STEP	NEW METHODS AND CONCEPTS
• The purpose and goals of landscape management. • The use of systematic management. • Allocation of scarce resources to systematic management.	• A management framework for the collection. • Three workshop reports	**Overall process**	Landscape management model for a plant collection.
• To be an arboretum or park? • Purpose underpinned by biological values.		**Purpose**	
• Keeping the inventory current. • Selecting the record type.	• Maps, catalogues, archival documents.	**Inventory**	
• The collection is highly significant but some condition indicators are not ideal. • Eastwoodhill is a category two landscape when it should be category one. • The biological management paradigm applies.	• The evaluation result. • New data for use in management. • Proposed goals and priorities.	**Evaluation**	• Evaluation process. • Landscape category. • Landscape management paradigms.
• The need to resolve the issue of mission and strategic position.	• A taxonomic collection based upon key genera is most likely.	**Mission and strategic position**	• Consideration of strategic issues in relation to an arboretum.
• Goals and priorities need to be considered in light of the strategic position when one is developed.	• Key genera, future key genera, roles of the Arboretum, future direction.	**Goals and priorities**	
• Comprehensive plans are needed for the whole collection. • Plans for composition, condition, appearance and layout are needed. • Layout planning should be initiated.	• A method for developing park and genus plans. • Genus and park plans.	**Strategies**	• Vegetation management framework. • Physical recycling method. • Design process.
• Resources for implementation of the plans.		**Daily operations**	
• Planning outcomes should be monitored. • Conflict of interest for the curator.		**Monitoring and control**	

An evaluation of the collection was also completed. This had four main outcomes. Significance and condition of the collection were established, which showed that the Arboretum contains the most significant collection of its type in New Zealand. Examination of condition showed that condition needs to be carefully managed otherwise significance may be reduced, i.e. the Arboretum was a category two landscape when it should have been in category one. The processing stage of the evaluation showed that the collection had suitable features to achieve most of the existing goals. The landscape management paradigms indicated a hierarchy for management of the collection, placing biological values ahead of visual values. Finally, the evaluation generated another set of data, e.g. knowledge of plant material in other collections, which could be used in planning and management.

The evaluation showed that the most logical collection development was a taxonomic collection based upon the most significant genera. A series of priorities were proposed. Significant genera should be considered first, with plans developed for each significant genus, including renewal or improvement of condition where necessary. Within the group of significant genera, the shorter lived groups or those in poorest condition should be examined first. Management of parks should focus first on the most significant areas in poorest condition. Parks with high visitor exposure should have a higher priority than parks without such exposure. (Details are given in Chapters 3 and 5.)

The third major outcome was the three workshop reports. A number of strategic issues were considered in the workshops, resulting in proposals on the role of the Arboretum, its future direction, the main collection theme and key genera and future key genera. Some broad collection management goals were also determined along with principles for development of the remaining land. Subsequent examination of the workshop outcomes showed that most of the goals proposed at the workshops were feasible, although some need another planning cycle. The results were important components of a strategic position, but a full strategic position was not completed and some components of this stage remain to be developed. The workshops also resulted in a variety of operational plans for the collection, particularly park and genus plans which could be implemented immediately at daily operations level. The plans contained sufficient detail to relate to daily operations level.

Some components of a vegetation management strategy were developed. The basis for a composition plan was made by identifying key genera and potential future key genera. The process of developing a plan for each key genus was started with the genus plans developed in this programme. The park plans were the basis for developing a plan for each area, although the time frame should be longer and the physical issues must be addressed. Plans for appearance and layout were not considered in this programme, but their role has been recognised. A method for merging visual layout with biological layout was proposed, although it was not used in this workshop series.

These collection management outcomes were developed using the workshop method, which was a useful contribution to management of the Arboretum because it provided management inputs (data, expertise) and processes (planning, decision making) that were not previously available. The workshop method generated outputs at a strategic level as well as at daily operations level. Plans developed were based upon sound planning approaches and rigorous decision making methods. Rating scales were used to quantify plant attributes and agreed trigger points for action were used to decide actions and priorities. Suitable expertise was used to make collection management decisions.

The final result of this research was the proposal for a potential collection management framework, which could be used to manage the collection at Eastwoodhill. This was a key result for a collection in a human-made landscape that changes over time, and faces increasing competition from other plant collections and recreational sites. Such a management framework could be used to develop long term plans and ensure that:

- significant aspects of the collection are not lost or unrecognised.
- the Arboretum maintains its place as the leading collection of its type in New Zealand.
- the desired utility functions of the Arboretum can be achieved.
- the Arboretum is as well placed as possible to achieve its potential.

Many of the overall conclusions and the proposal for a collection management model, however, were derived after reflection upon the workshop series after it was completed. Critique of methods used at the time showed that, if one was faced with the same scenario again, different approaches might be used at some stages. Thus, the model is the result of the wisdom gained having done the inventory, evaluation and workshop series. It describes how collection management should be approached, which is not necessarily the same as how it was approached at the time. This cyclical development is a natural feature of research, but in terms of the practicalities of collection management it raises the issue of how the final conclusions of this work might best be applied to the Arboretum in the future.

7.3.3 Future approaches: utilising this research for collection management

The overall results of this research must be placed into the context of the future of the Arboretum. What opportunities and challenges do these results provide for the Trust Board in terms of future management approaches? How can the results be used to generate effective collection management outcomes in the future?

7.3.3.1 Opportunity: reviewing the purpose, mission and goals of landscape management

In considering the application of this research to Eastwoodhill, it is useful to begin by taking an overview of landscape management. The broad purpose is to manage the landscape to achieve optimum value, whatever those values might be on a particular site. The management task, therefore, is to ensure that the landscape continues to exist in an acceptable form, and then manage it for the selected human uses. This is usually done by pursuing some form of the broad goals of preservation, protection, improvement, development of sustainable landscapes, and provision for human use.

Each of these general notions applies to Eastwoodhill, and the Trust Board can use the discussions in this thesis (particularly Chapter 1) to review these topics. Such a review may prove a useful basis for discussion on the application of such ideas to Eastwoodhill, and clarify ideas on management of the Arboretum. This would be a useful component of a workshop on strategic planning.

7.3.3.2 Opportunity: reviewing systematic management approaches

Long term management of human-made landscapes requires systematic approaches, but motivation to use such methods requires a belief that they are either necessary or useful, and an appreciation of the potential benefits. Therefore, the use of systematic approaches would be another useful starting point for the Trust Board's discussions of future collection management, and could also be an early topic at a strategic planning workshop. This should involve discussion of the purposes of management in relation to a human-made landscape, which support the need for systematic approaches. Those purposes of management are: managing change, meeting objectives, using resources, and resolving problems (Bromley, 1990).

The need to deliberately manage change in human-made landscapes (that are not self-perpetuating) has been stressed throughout this thesis. The influence of both internal and external change is evident at Eastwoodhill. Internal change was discussed in Chapter 3 where marked changes in collection composition were highlighted and potential future changes in both composition and condition identified. In managing change the distinction between appearance and condition is important; while the former has markedly improved at Eastwoodhill in recent years, the remaining population still has condition indicators that cause concern. Appreciating this distinction helps one avoid the 'daily maintenance = long term management' trap and helps recognition of the need to manage change in a long term frame. External change has also been discussed, particularly recent developments in other plant collections that will compete with Eastwoodhill. If Eastwoodhill is to remain a significant plant collection that can compete with other sites, then deliberate management of change in the collection (focusing on renewal) is essential.

The need to meet particular objectives is the second purpose of management. In general terms the broad purpose and goals of landscape management will apply to the Arboretum (preservation, protection, improvement and provision for human use) and it is the Trust Board's role to determine how these will relate to the Arboretum. In more specific terms the Trust Board has a statutory obligation to maintain Eastwoodhill as an arboretum. This focuses the purpose of the Trust Board in that they must develop and maintain significant living plant collections over the long term. If they are to achieve the accepted functions of an arboretum they would utilise that collection for science, education and recreation. Achieving both existence and utilisation goals of a plant collection requires focused management effort.

The third purpose of management is to use resources wisely, which is particularly important when resources are constrained. Limited funding constrains systematic management, but it does not prohibit it occurring, even if in a limited or targeted way. Resources have always been constrained at Eastwoodhill, reinforcing the usefulness of systematic management to target resource use at high priority activities, such as the perpetuation of the fabric of the collection. The fourth purpose of management is resolving problems and the analysis of Eastwoodhill in Chapter 3 showed that this purpose applies to the Arboretum, e.g. the transformation from a category two landscape to a category one landscape.

The four purposes of management apply to Eastwoodhill, supporting a systematic management approach, but the decision to take this approach rests with the Trust Board. If, following a discussion on systematic management, the Trust Board elected not to initiate some systematic approaches (at whatever level they can afford), then they would do so in the knowledge of the likely future outcomes for the collection.

7.3.3.3 Challenge: resolving issues relating to mission and strategic position

The mission and strategic position of an enterprise forms a crucial framework for management, and this highlights an unresolved issue for the Trust Board. While a key assumption underlying this work was that the statements in the Eastwoodhill Trust Act represented the mission of the enterprise, an examination of the Trust Board records suggested that the primary purpose was not resolved. This poses an important challenge for the Board, to address the issues relating to mission and strategic position and define the collection management framework.

The importance of the mission statement and strategic position has been discussed in section 7.2 and will not be repeated, except to stress the role in establishing an infrastructure for subsequent management steps. The Trust Board should appreciate those links and realise that selecting a mission has several important management implications.

In this regard, the Trust Board should consider the difference between a mission for an arboretum versus a park, as these are different and selection of a mission that emphasises one rather than the other has vast management implications. According to the Act (Eastwoodhill Trust Act, 1975), the responsibility of the Board is to develop an arboretum, i.e. a scientifically ordered collection of plants, documented and labelled (Heywood, 1987; WWF and IUCN, 1989). An 'arboretum' mission involves a series of complex planning exercises relating to development and long term management of a *significant* plant collection. The Eastwoodhill collection is highly significant but has some condition problems requiring a plan to restore the condition back to an acceptable level. Maintenance of good condition in the long term requires careful planning for long term renewal. These plans require a current inventory including a catalogue, herbarium, and maps. Plans are needed for biological layout, as although there are concentrations of genera in certain areas, there is no coherent biological layout. At some point the layout should be merged with landscape design, requiring a plan for that combination of factors. These factors establish management requirements that do not usually exist with public parks, and involve particular management approaches and allocations of resources.

Although the Eastwoodhill Trust Act suggests that the mission for Eastwoodhill is centred on the 'arboretum' pathway, the management record suggests that the position was not resolved (Chapter 5). If Eastwoodhill is to develop and flourish as an arboretum in the future it is essential that the planning and management implications of an 'arboretum' mission are understood, including the implications of supporting (or not) a nationally significant arboretum. An informed development of a mission requires a rigorous debate on a range of issues including the role and management of arboreta, biological and human values of landscapes, the interplay between visitors and visual values, and the original concept for the landscape. Factors relating to the strategic position and mission, such as distinctive competence, scope, competitors, and collection type and themes may be included in the debate. It may be just as important to debate factors that would not be represented in the mission, partly as a focusing exercise, but also because financially constrained enterprises cannot be 'all things to all people'. The aforementioned debate would be a logical component of a planning cycle at the strategic level.

The ultimate selection of a mission statement and its associated framework is the responsibility of the Trust Board. If, however, the Trust Board selects the 'arboretum' pathway, they must also accept the management implications of that choice. Given the present significance and condition of the collection, the 'arboretum' pathway raises a series of management challenges for the Board. They need to initiate planning activities to develop the plans associated with arboretum management, even if this occurs only in a small way according to what they can afford. Even if limited planning action is possible in the short term, decisions on mission and strategic issues will strengthen the collection management framework and eliminate the need to make assumptions about strategic issues.

7.3.3.4 Opportunity: using a revised workshop method for collection management

If the need for systematic approaches is accepted, then the workshop approach (in a suitably revised form) could be used to develop collection management plans in keeping with the collection management model proposed in section 7.2.

Future use of the workshop provides a potential vehicle for the Trust Board to address the strategic issues that have been raised in this research. The purpose of such a workshop would be to develop a mission and strategic position. Topics might include the purpose and goals of landscape management, the use of systematic management, and the range of strategic issues already identified. The results of this research might also be reviewed, searching for any changes in approach that may be needed, e.g. key genera. Previous workshop results could be reviewed, with a view to identifying issues that should be addressed in the near future.

Subsequent workshops could address some of the operational issues that have been identified in this research. Management of the parks and development of layout planning are two obvious issues that should be addressed, and then synchronised with previous decisions.

Such use of the workshop would follow the general approach developed in this research but would be modified from the original series in several ways. First, the composition of the group should be reviewed, particularly addressing the need for arboricultural and design skills. Second, the use of the group versus individual consultants should be considered. The group confers a number of advantages, but some collection management functions may be best served by an individual, e.g. park inventory can be readily done by one person, whereas botanical ratings need the input of a group. The mix of group versus individual activities should be considered to achieve most effective use of resources. Third, the modifications to the method, as discussed in Chapters 4, 5 and 6 should be made. In particular the definition of the botanical rating scale should be improved, and more discussion time allowed, but otherwise the general approach is sound and the critiques in previous chapters will not be repeated here. Fourth, future workshops will need extra data, in particular, more comprehensive data on condition and on each park. At the same time the inventory should be kept current which will also require data gathering exercises.

The collection management approach developed in this programme could be used to develop various plans for the whole collection at Eastwoodhill. Plans are needed for each key genus and each park. In addition, an overview of the whole collection and Arboretum is needed. This would be part of comprehensive plans for each of composition, condition, appearance and layout. Interrelationships between each plan should also be addressed. For example visual and biological layout should be merged using the method in section 6.4.2.2. This project focused upon biological factors (composition and condition) and the development of a method, and has only resulted in a series of example plans. Details of the full set of plans needed for the Arboretum, including plans for appearance, visual layout and biological layout, should be the subject of other studies.

7.3.3.5 Challenge: making best use of the workshop and decision making methods

The workshops can be an effective management tool, provided they are operated appropriately, with suitable use of the workshop manager, chairperson and members, and correct use of the method. In particular, emphasis should be given to preparation and use of data, the decision making method, and positioning of the workshop so that it acts as a long term planning device and not a short term and crisis management device. Effective use of the workshops in future, raises two issues in anticipation of the Trust Board taking over that responsibility.

The first issue is the split in the decision making process in which the workshop group were not involved in implementation and control. Those two steps included several opportunities for the decision making process to fail, particularly with respect to acceptance and motivation to implement. Management of the implementation and control stages could be solved by a Board member or the curator developing suitable expertise, or by adding another suitable person to the Board. Although the curator could logically take the monitoring role, there is a conflict of interest for the person in that position which would have to be addressed.

The second issue is the evolution of suitable landscape management expertise amongst the Trust Board and staff. Effective use of the workshop method requires that the workshop manager and chairperson have sufficient expertise to recognise different types of decisions and who should make them in relation to landscape management. Long range planning decisions at the strategic level should be made by executive managers, i.e. the Trust Board. Long range decision making requires the following inputs: a well considered, and agreed, mission; excellent data; a well honed future sense; and understanding of landscapes in general and the Arboretum in particular. Short range decisions are the primary responsibility of the front-line manager, i.e. the curator. This manager needs: the ability to derive daily operations from long term goals and ensure that daily operations contribute to long term goals; the ability to develop plans and strategies for the short term time frame; and technical expertise to conduct daily operations, e.g. grounds maintenance. Effective management of the workshops (and collection) requires that all these skills are available at the Arboretum. An examination of the skills currently available from the Board and associated people should be made, with a subsequent staff development programme if necessary.

7.3.3.6 Challenge: resources for collection management

Allocation of resources has a major influence on management outcomes. For example, there are resource commitments involved in keeping the inventory current, operating the workshop manager's role in the appropriate way, bringing the workshop group together, and implementing workshop recommendations. Systematic management requires resources, which in turn requires a commitment by the Trust Board. The Trust Board has limited resources and therefore such tasks must be paced and planned carefully, indeed some lower priority tasks may not be done. At the same time however, informal acceptance (Massie, 1979; Stoner et al., 1985) of the need for systematic management must occur before the Board will allocate resources to the workshop and associated activities.

It is an opportune time for the Trust Board to re-examine its resource allocation for collection management, in light of the completed clearing work, and the outcomes from the workshops and this research. The collection is the fabric of the Arboretum, and should be sustained in the long term. Therefore resource allocations should be balanced between long and short term outcomes. Unfortunately, when resources are constrained it is easy to bypass planning in favour of short term maintenance, but this trap should be avoided at Eastwoodhill if possible. The future needs of the collection should be adequately resourced through inventory and planning. Funds are limited but the natural decline of another series of collection elements is approaching and if the collection declines below a minimum significance, the capacity to 'be an arboretum' will be severely strained, perhaps lost. A changed balance of resource allocation may be needed.

Resource allocation patterns depend upon the priorities used by the Trust Board. These depend upon the management approach that they take, which in turn depends upon the attitudes and values they bring to the task. Management approaches have already been discussed in section 7.4.3.2. The influence of attitudes and values upon management is likely to be a powerful factor, but is beyond the scope of this thesis.

7.3.4 A possible plan of action for the Trust Board

The following is a possible plan of action that the Trust Board might use for utilising the results of this research and initiating the next cycle of collection management. The plan addresses the need to manage strategic and operational issues, data, and resources.

Strategic issues

- Initiate planning for a workshop to address strategic issues. Begin planning in 1997 for possible workshop in late 1997 or early 1998. Preparation for such a workshop should involve consideration of the workshop group and its possible modification, reflection upon previous workshops, and utilisation of this research, as well as the issues highlighted elsewhere in this chapter.

Data and data management

- Agree to student projects (if suitable students are available) to gather more comprehensive condition data on each park. Approximately one park per year could be done. Projects could start as soon as suitable students and finance were available, possibly 1998.
- Support a project to develop an ITF format for collection records. With suitable preparation this could be done by the curator, as long as the necessary time allocation was made. Collection data already held by the curator could form the basis of the files. This project could be started in 1997.
- Support, in principle, a project to computerise the inventory using techniques such as global positioning and GIS systems. Contribute by allowing the curator to contribute to mapping and plant identification, and providing his collection database to be incorporated into the data set. This is a major project that could not begin until suitable research funds were obtained.

Operational planning

- Initiate layout planning, following the decisions at the strategic planning workshop. Preliminary discussion could be held at the strategic planning workshop.
- Plan for subsequent workshops to address park and genera plans, in tandem with planning for composition, condition, appearance and layout. Selected issues could be introduced to give variety in the strategic planning workshop (if time was available) and then developed in subsequent workshops.

Resources

- Consider the need for a staff development programme to develop new collection management skills amongst local participants. Consider sponsoring the assistant curator through an extramural Certificate in Horticulture, beginning in 1997, so that he may relieve the curator of some of his present duties. Consider sponsoring the curator through an extramural M.Appl.Sci, beginning in 1998, so that the resultant advanced collection management skills might be used to the benefit of the Arboretum. Consider seeking sponsorship for the new position of collection manager, either by seeking funding for another assistant and upgrading the curator's position, or by seeking funding directly for a collection manager.

- Examine resource allocation issues at the strategic planning workshop.

Using a plan of action such as this, or a similar alternative, the Trust Board could phase collection management activities according to the available resources.

7.4 CONCLUSION

Landscapes are formed by the combination of natural and human processes, and exist in a continuum from natural and undisturbed to the created landscapes of city centres. 'Landscape' can be interpreted in many ways, and landscapes have multiple values ranging from life support to social and cultural values. Managing those values is a key task of landscape management, with the overall mission of optimising values and ensuring the continued existence of the landscape. In turn this provides the opportunity for managed human use of the landscape. These tasks are achieved using a landscape management framework of 'understanding, management processes, and technical skills'.

An important result of this research was the adaption of basic management processes to suit landscape management, and the proposals for new concepts and processes where theoretical frameworks were lacking (Table 7.1). This was a useful contribution to landscape management, particularly the management of human-made landscapes where rigorous management practice is needed to sustain those landscapes and uphold their values.

Applying these management processes to the Eastwoodhill Arboretum revealed that it was a significant part of the 'natural capital' of New Zealand. This research has concentrated upon sustaining the underpinning biological value, which relates to the purpose of the Arboretum and which generates the various human values and uses. The result of this research was the creation of an holistic management system developed using a systematic approach. This system provided the necessary management inputs (data, expertise, processes) to complete stages in inventory, evaluation, development of long range goals, and specific plans for parks and genera. The latter two stages were completed using the workshop mechanism. The workshop approach was generally sound, although areas of improvement can be readily identified and debated. The key factor was the creation of the whole system, of which the workshop was a component. The workshops required a planned approach, which in turn required suitable inputs and resources. Moreover, resources would not be available unless a systematic approach was supported. Other connections also exist and some of these have been highlighted in the previous discussion in this chapter. These results were an important contribution to an enterprise that has been severely constrained by a lack of resources.

Overall synthesis of the results led to a proposal for a landscape management model for plant collections that included landscape management concepts. Such a model could be used to manage the plant collection at Eastwoodhill and sustain its values, thereby contributing to the overall purpose of landscape management on this site. The model and concepts could also be applied to other plant collections or other types of landscapes. The model illustrates the complexity of the whole landscape management system, including the role of each component and their interaction with other components. In this regard, this research illustrated an overview of landscape management and required understanding at an overview level.

Taking such an overview of Eastwoodhill, what of its future? It is a complex human-made landscape with multiple values, requiring systematic management to sustain those values. The Trust Board is dedicated to the task but has limited resources to deal with the biological change that threatens the plant collection. Douglas Cook succeeded in his "creation of a park in one lifetime", and now the Trust Board is charged with continuation of his work. The results of this research will assist the Trust Board in the long term management of the resource and sustaining an important part of the natural capital of New Zealand.

Eastwoodhill, October 1989.

Rock Point Pond, April 1993.

".... in my secret heart I hoped that some day all of that paddock would be a garden..." (Cook, 1948). Douglas Cook's dream lives on............

Chapter 8

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