1 INTRODUCTION

1.1 Background

1.1.1 Origins of the study

This dissertation is the culmination of a study of the transitional, or boundary, vegetation that separates the tall wet sclerophyll forest (WSF) and the warm temperate rainforest (WTRF) occurring in the southern compartments of Nullum State Forest in the far north east of New South Wales (Fig. 1.1). This location was attractive for ecological study because it represented the last relatively undisturbed co-occurrence of these forest types in the region. Consequently, the transition, or boundary, zone between the two forest types was considered "natural". That is, the processes which led to their location, their form and their floristics were believed to have not been directly influenced by the activities of European settlers. European settlement has, however, had an unknowable, indirect effect on the forests of the study area because of the cessation of the deliberate cyclical burning practices of aborigines. Such practices are assumed as no information which specifically confirmed them for the study area was available from the current local aboriginal spokespeople. Field inspections prior to this study suggested a period in the order of 100 years since the last fire and 250-300 years since the last major fire. Those periods predate European selection[1] of the, then, subtropical rainforest which occupied the creek flats and footslopes below the study area. This fire history context is important because fire has been regarded as having an integral role in the characteristics and location of forest boundaries. It is a subject which will be returned to in much of the discussion throughout this thesis.

The WSF comprises many species throughout the range of the formation, which extends from southern Queensland to Tasmania. In the region of this study, WSF occupying the acidic soils at higher altitude is dominated by *Eucalyptus pilularis* (Blackbutt), a member of the subgenus *Monocalyptus*, while on other substrates and at different

1. Government Titles Office records indicate the lowlands were surveyed for release as leasehold properties in 1901.

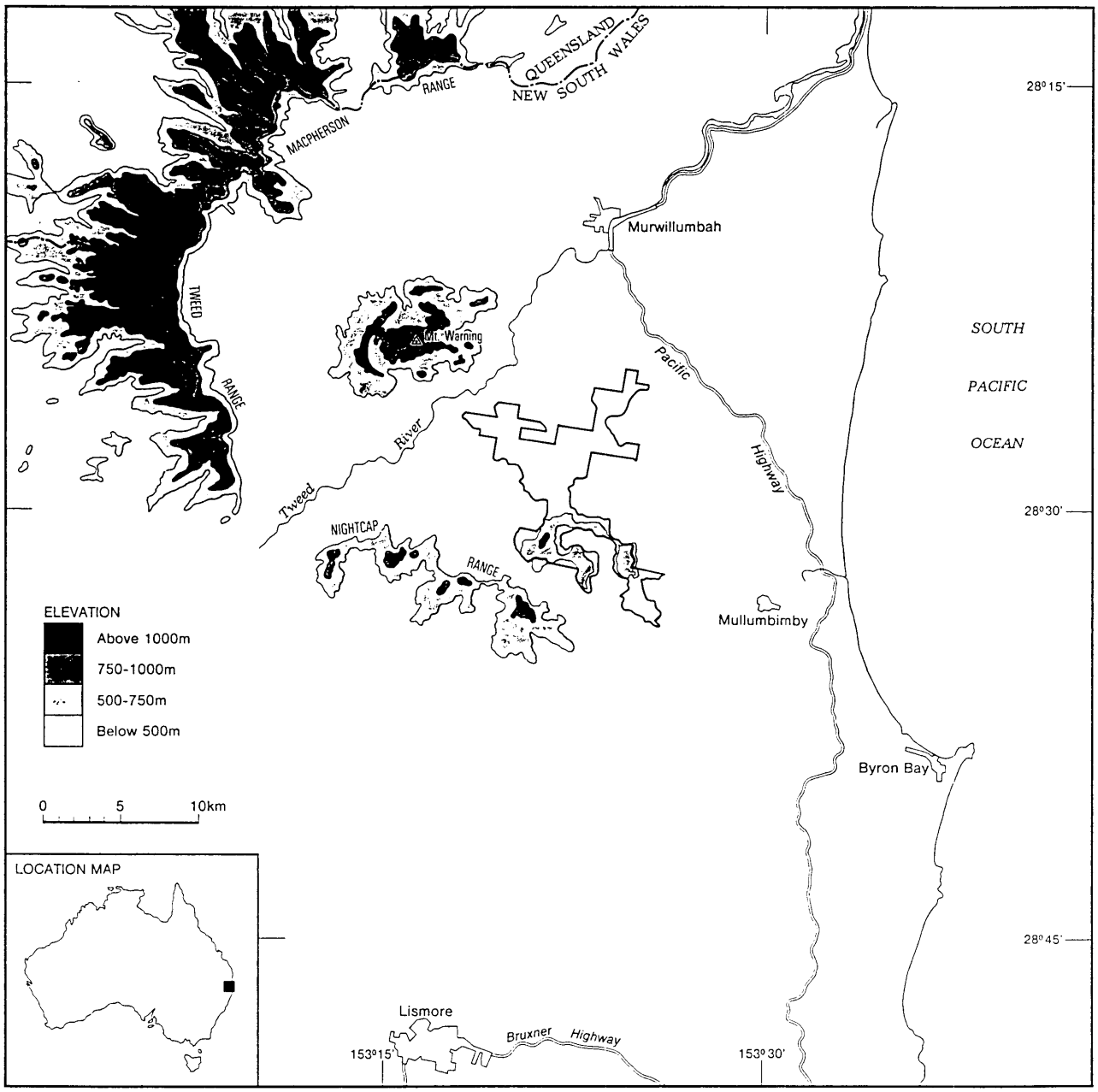


Figure 1.1 The regional geographic context of the study area. The outline at the centre of the map is of Nullum State Forest showing its location on the southeast rim of the Mt Warning caldera.

altitudes in the region other species of *Eucalyptus* may attain local canopy dominance. WTRF in the region is identified by its structure and, usually, the presence of two main canopy species, *Ceratopetalum apetalum* (Coachwood) and *Schizomeria ovata* (Crabapple).

Over 30 years ago Florence (1963) wrote that Blackbutt forests are not contiguous with rainforest (without an associated distinct environmental change) and yet Baur's (1957) data showed that, in terms of the range of his measured soil nutrients, there was a significant overlap between the soils of the *Ceratopetalum-Schizomeria* forests and the wet sclerophyll forests.

There has not been any work which has either explained or even examined Florence's findings. Knowing that in the far northeast of New South Wales these two forest types were at least sometimes contiguous, it was my intention to examine the nature of their co-occurrence by conducting a major study of the transition zone between them. I deliberately sought a location where the forest types and their common boundaries occurred in an undisturbed condition and one of the best examples was the unlogged southwestern section of Nullum State Forest.

1.1.2 Objectives of the study

The primary focus of the project was to study the boundary zones occurring between the old-growth eucalypt forest and the warm temperate rainforest. The study specifically addressed the variation in the vegetation and some of the processes taking place along transects through the boundary, or transition, zones. Statistical modelling and novel extensions of existing numerical analysis techniques were then applied to analyse those processes. A number of aspects were given consideration. These aspects could be placed into two main groups. The first was the composition of the vegetation which included the floristics and the forest structure. The second includes the site characteristics such as disturbance history and topographical aspects as well as the processes microclimate and litterfall. The proposed study of these aspects led to the formulation of the following specific objectives.

(i) Identify differences in terms of floristics, vegetation structure, litterfall, microclimate and disturbance between the boundary zone and the adjacent old-growth eucalypt forest and warm temperate rainforest.
Hence determine whether there exists a distinct forest boundary community.

(ii) Investigate the extent of variation in the boundary zones themselves. Evaluate any differences in terms of floristics, vegetation structure, diffuseness and disturbance. Relate these differences to the characteristics of the specific adjacent forest communities.

(iii) Analyse vegetation floristics and structural characteristics to determine whether succession is proceeding within the boundary zones.
Hence, evaluate the relative instability of the boundary zones.

There were four further methodological objectives in which novel approaches were to be applied.

(iv) In the light of the evaluation of succession, use perturbation modelling techniques to predict the effect of the continued absence of fire on the future importance of the key species as indicator species.

(v) Use numerical analysis techniques to identify diagnostic species of both the eucalypt and rainforest communities and investigate the possibility of alternative species being diagnostic of the transition zone.

(vi) Use statistical modelling to identify environmental factors to which the diagnostic species show sensitivity.

(vii) Use statistical modelling to identify historical and site factors which influence boundary zone variability.

1.2 Description of the study area

1.2.1 Location

The study area constitutes the northern section of the Koonyum Range and an elevated southwestern spur of that range with an altitude varying between 500 m and 700 m asl. It comprises approximately 500 ha of the southern section (Compartments 52, 53, 57 and 58) of Nullum State Forest in the (now) State Forests of N.S.W. District of Casino. The location is 12 km west of the township of Mullumbimby and 32 km northeast of Lismore. Latitude is 28°17' S and Longitude is 153°23' E (Fig. 1.1).
Extensive logging has taken place in the vicinity of Mt Jerusalem, north of the study area, such that the structure of the surrounding forests is markedly different to the study area in terms of stand heights and density of the subcanopy tree layer. The study area is accessible only on foot and involves a very steep climb of about 250 m such that it has largely escaped human disturbance. Efforts by local residents to establish that the plateau was significant to, or even used by Aborigines have proved fruitless. The existence of sites of aboriginal activity in the adjacent Nightcap Range (S. Dunn, NPWS, pers. comm.), see Figure 1.1, however, suggests that the whole forest area would have been utilised. The isolation and prominence of the study area suggests that major fire (i.e. a fire which kills the canopy trees) ignition history is probably related to lightning events.

1.2.2 Physiography

1.2.2.1 Geology and geomorphology

The Koonyum range forms part of the rim of the erosion caldera of the Mt Warning shield volcano (Figs. 1.1, 1.2). The range was built up by successive lava flows from the volcano during the Miocene epoch. There were three main periods of flow. The first flow is named Lismore Basalt which, together with the Kyogle Basalt which it overlaid, was over 500 m thick (Duggan and Mason 1978) and which has now been exposed by erosion in the valleys surrounding the study area. This is the source of the krasnozem soils which, prior to settlement by

Europeans, supported large tracts of rainforest east and north of Lismore. The second flow consisted of acid volcanics, called Nimbin Rhyolite. It was also about 500 m thick and included rhyolites, porphrytic pitchstones, obsidian, tuff and agglomerates. The details of the composition of the rhyolite have been presented by Crook and McGarity (1956). The last flow from Mt Warning reverted to a basic rock named Blue Knob Basalt. The study area was formerly overlain by a layer of Blue Knob Basalt but this has since been eroded although it is possible that a few very small traces of the basaltic layer occur. The remaining more erosion resistant rhyolite now exists as a block fringed by cliffs, the result of rock shear caused by undercutting of softer rock by the erosion gullies of the surrounding Commissioners, Doon Doon and Coopers Creeks and the Wilson and Brunswick Rivers (Fig. 1.2). The exposed rhyolite massifs of these ranges (Figs. 1.1, 1.2) represent the most outstanding regional examples of the type. Rhyolite is a commonly occurring igneous rock and, from my examinations of geological maps for the mountainous regions of eastern New South Wales, has been found at almost all locations where volcanic activity has occurred.

1.2.2.2 Landform

Lying at the southern end of the spur, the southern part of the study area has a central ridge running virtually north-south. Below the ridge the landform is a plateau which subsequently falls away to sheer cliffs which almost encircle the spur. It is connected to the neighbouring Mt Jerusalem by a narrow ridge. The northern part of the study area is similar except, being narrower, it cannot be considered a plateau. The Koonyum Range, together with the Nightcap Range to which it is tenuously linked at the Doon Doon Saddle (a low grassy ridge occurring at the point where Nullum State Forest and the Nightcap Range are nearest, see Fig. 1.1), forms an island of high altitude forested country isolated from the remainder of the Mt Warning caldera rim by low lying valleys and flats now cleared for agriculture.

1.2.2.3 Soil types

The soils of the area are all derived from the acidic Tertiary rhyolite flows of the Miocene epoch. As a result of the erosion of the

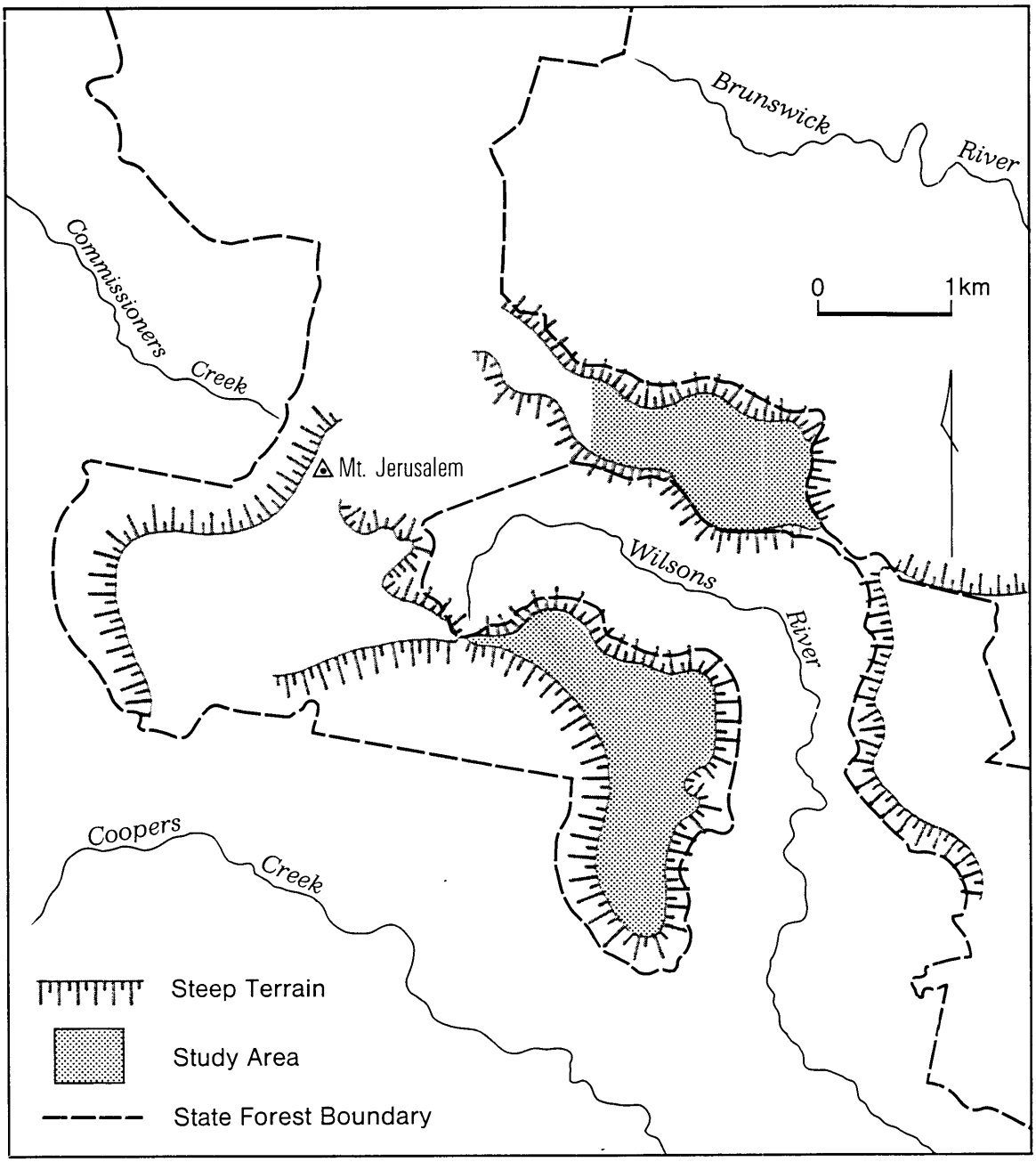


Figure 1.2 Southern section of Nullum State Forest showing the location of the study area and the pattern of drainage.

subsequent covering layer of basalt and the resultant landform, the soil along the exposed ridgetops above 600 m is a weathered and shallow yellow podzol with large areas of exposed rock. Because of the similar elevation (500 m to 600 m) of the rest of the study area below the ridgetops, there has been an aggregation of material such that the soils are deeper. There is the possibility (Chapter 4) that at least one location retains some of the basaltic colluvium giving rise to the more fertile brown forest earths which could explain the increased vegetation biomass at that location. Turner (1984) portrayed similar soils at the nearby Terania Creek basin but the difference in landform in that catchment has resulted in the yellow podzolic soils extending to a lower altitude and a larger basaltic component in the brown forest soils.

1.2.3 Climate

The climate is subtropical (Baur 1962) with a strongly predominant summer rainfall and prevailing southeast maritime airflow. The nearest meteorological station is Byron Bay which is about 20 km southeast of the study area, almost 600 m closer to sea level and situated right on the coast. The data from that station are useful only as a guide to the climate in the study area. Annual average rainfall for the study area is uncertain although 14 years of observations in the valley below the study area average 2525 mm (Watson 1978-1991 unpub. data) and as precipitation generally increases with elevation (Phillips *et al.* 1992), it is reasonable to estimate the annual rainfall to be well in excess of 2500 mm.

The temperature varies from a summer maximum (average maximum temperature in the warmest month) of approximately 37°C to a winter minimum (average minimum temperature in the coolest month) of 5°C with an average daily range of about 12°C. Frosting presumably does occur but it has not been recorded and from personal observations can be regarded as an unusual event. Nunez and Bowman (1986) have noted that unlogged forest actually discourages frost. They found that the dense forest minimises air turbulence thereby maintaining ground level temperature inversions which result in the coldest air being a few centimetres above the ground. Their finding was based on the

assumption that the forest is not a sink for cold air drainage, an assumption which applies to the study area.

The study area is frequently shrouded in low cloud and evening mists and is of sufficient relief that it will intercept prevailing winds from all directions. Wind and cloud data were not recorded during this project but as those data provide a useful background to both microclimatic and litterfall data, a summary of wind and cloud records from the Byron Bay meteorological station is tabled and discussed in Chapter 4. Data on forest microclimates for the district were not available hence one of the objectives of this study was to measure microclimatic data along the vegetational gradient.

1.3 Description of sites sampled

The study area contains 12 patches of WTRF. The five northern patches were even more difficult than the southern sites in terms of carrying in permanent site marking equipment so all the transects were set up in the southern section. Seven transects were placed from Blackbutt forest to all but the smallest rainforest patch. The transects were first positioned using aerial photographs such that they crossed from areas of apparently homogeneous WSF canopy to areas of apparently homogeneous WTRF canopy. The locations of the transects are shown on Fig. 1.3. The gross physiographic differences between the transects including the patch sizes of the community at each end of the transects are shown in Table 1.1. The position of the plots along the transects was determined on the basis of the API work. Aerial stereoscopic photograph pairs depicting the vegetative setting of each transect are shown in Plates 2-9.

1.4 Overview

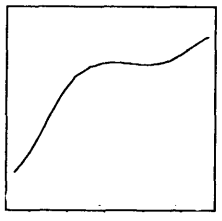
The overall procedure involved an initial identification and mapping of vegetation communities in the study area with the purpose of establishing the range of boundary types and their distribution. Using those data, transects stretching from the WSF to the WTRF were

Table 1.1 Gross differences between transects

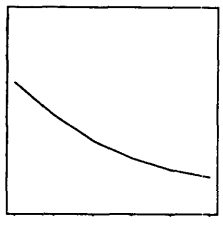
Transect	Bearing (a)	Length m	Slope %	Width of boundary m	Slope type (b)	WSF (ha) (c)	WTRF (ha) (c)
1	30	175	10	40	3	25	4
2	320	210	-14	60	4	25	6
3	230	160	- 6	30	1	30	10
4	335	160	7	30	1	15	2
5	185	110	3	45	4	12	2
6	340	225	12	70	3	15	10
7	160	170	24	60	3	18	10

(a) The bearing refers to the direction of the WTRF end of the transect from the WSF end.

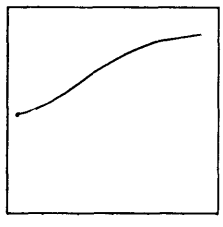
(b) By taking into account the slope trends above and below the start and finish of the transect, four possible slope profile types are illustrated below:



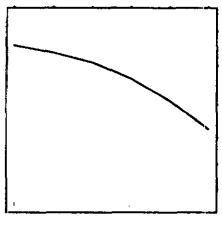
1 = concave-convex



2 = concave-concave



3 = convex-concave



4 = convex-convex.

(c) The size of the vegetation community that is "affiliated with" the transition zone is defined by the extent to which there is common membership of a drainage zone.

positioned such that they encompassed the range of boundary types between those forest types. The variation in the vegetation was sampled by study plots placed along the transects. Data were collected from these plots to interpret, using numerical analyses and statistical modelling, the impact of biotic and abiotic processes on the patterns, structure and dynamics of these two major plant associations in the study area and hence interpret the range of variability in their ecotones.

The contribution of a study such as this was foreseen by Florence (1969b, p. 84-5) when he wrote:

> "Statistical techniques .... could be used to advantage .... in elucidating the relationship between eucalypt sclerophyll and rainforest through studies on the ecotone between them."

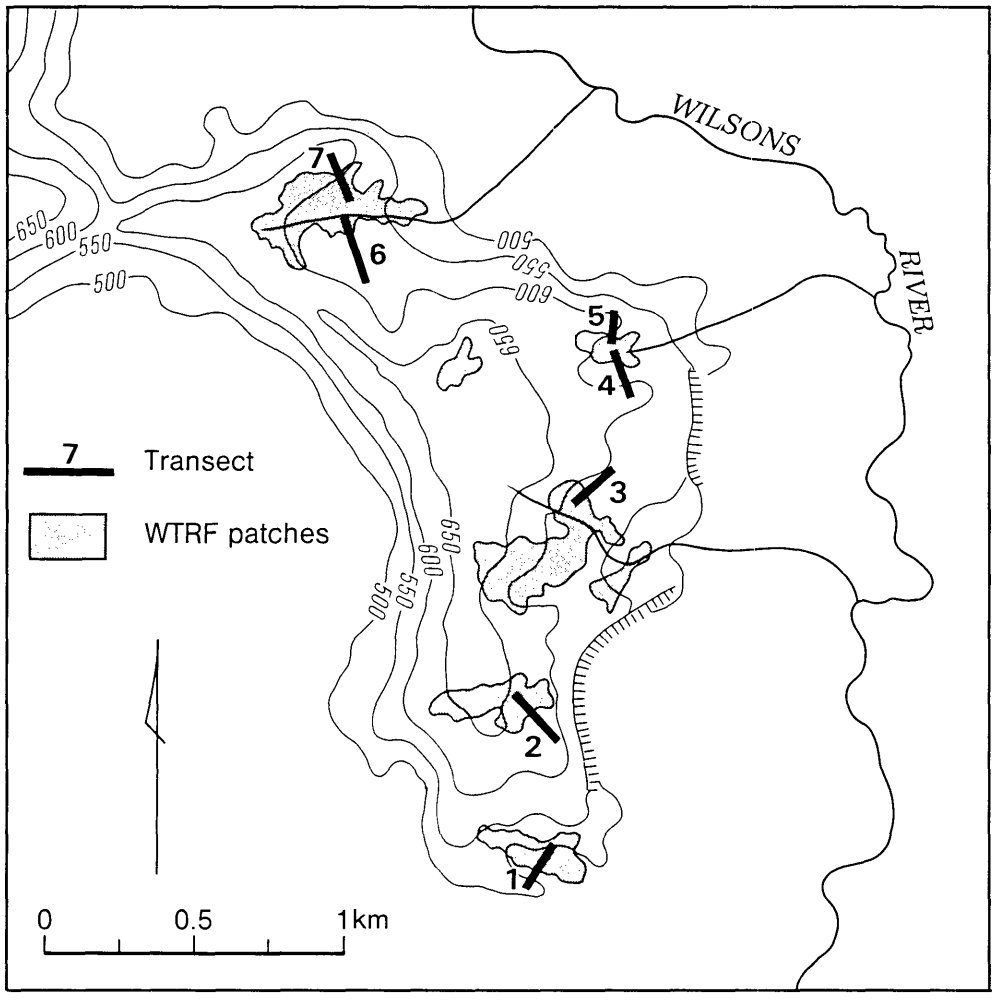
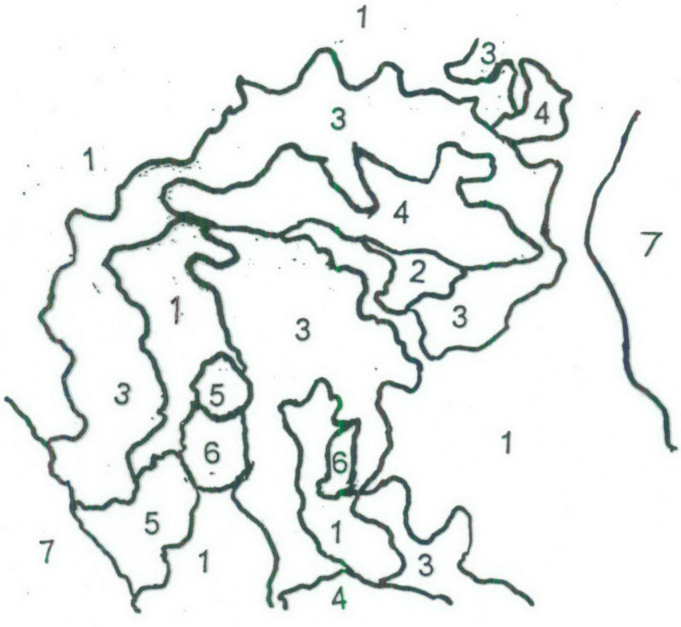
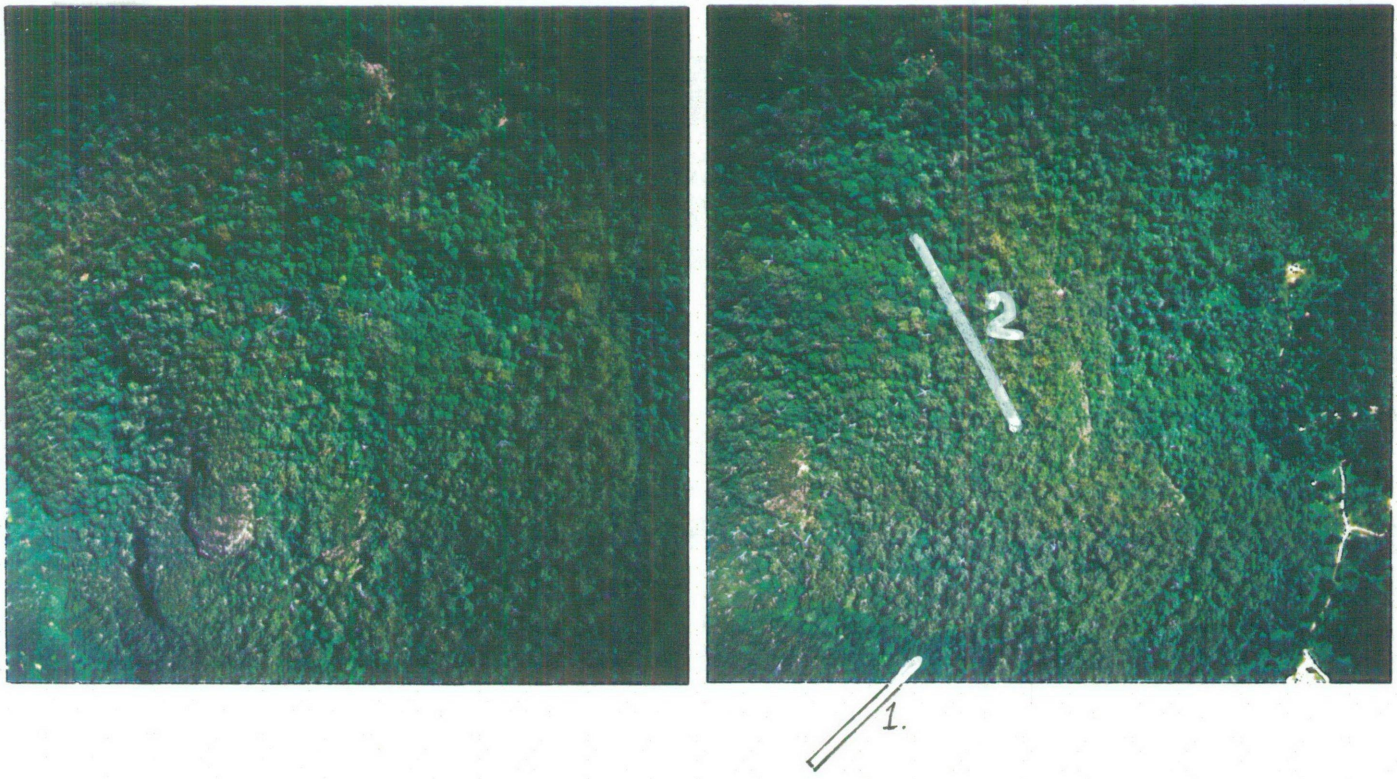


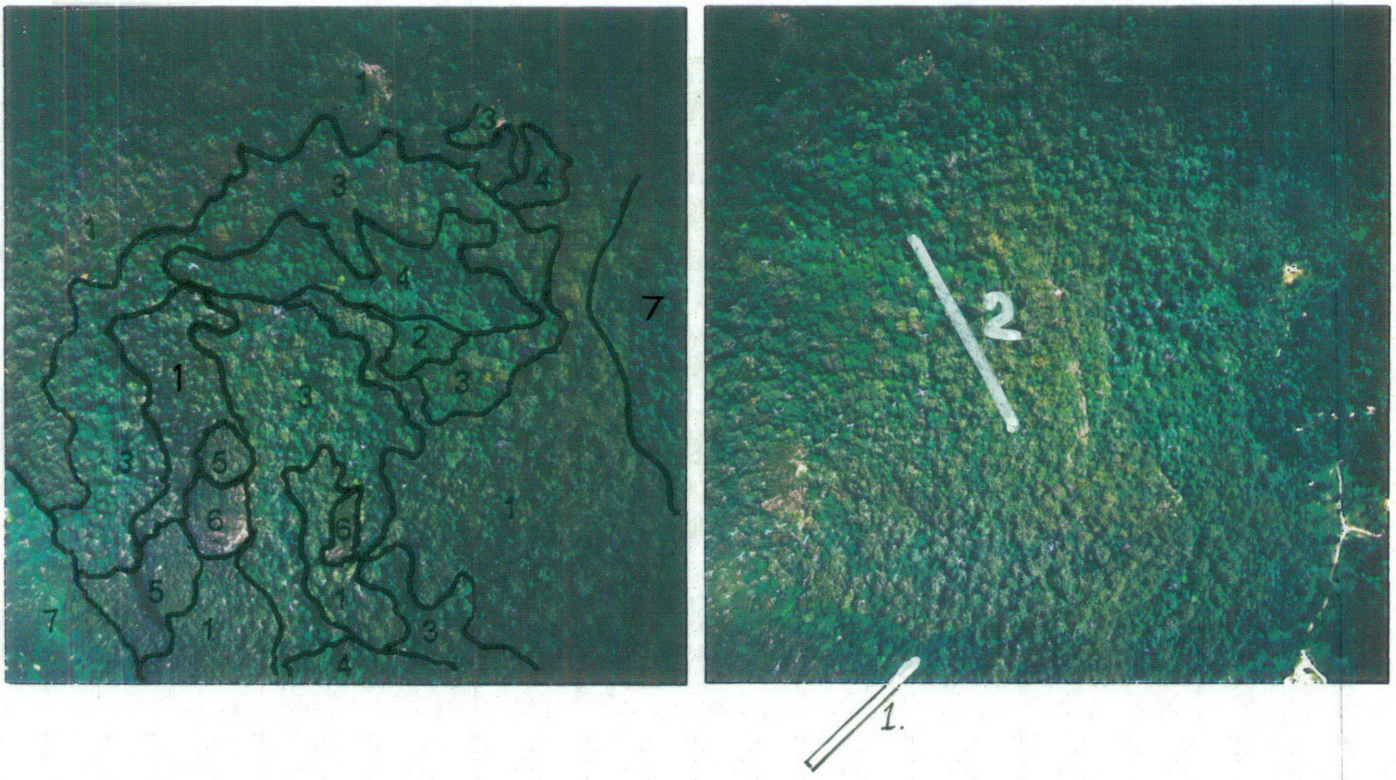
Figure 1.3 Location of transects and patches of warm temperate rainforest in the southern section of the study area. Contours are metres above sea level.



1. E. pilularis WSF
2. A. orites WSF
3. TZF
4. WTRF
5. Dry SF
6. Montane heath
7. Regrowth below study area



Plates 2 and 3. Transects 1 and 2 at the southern end of the study area. Scale is 1:7600

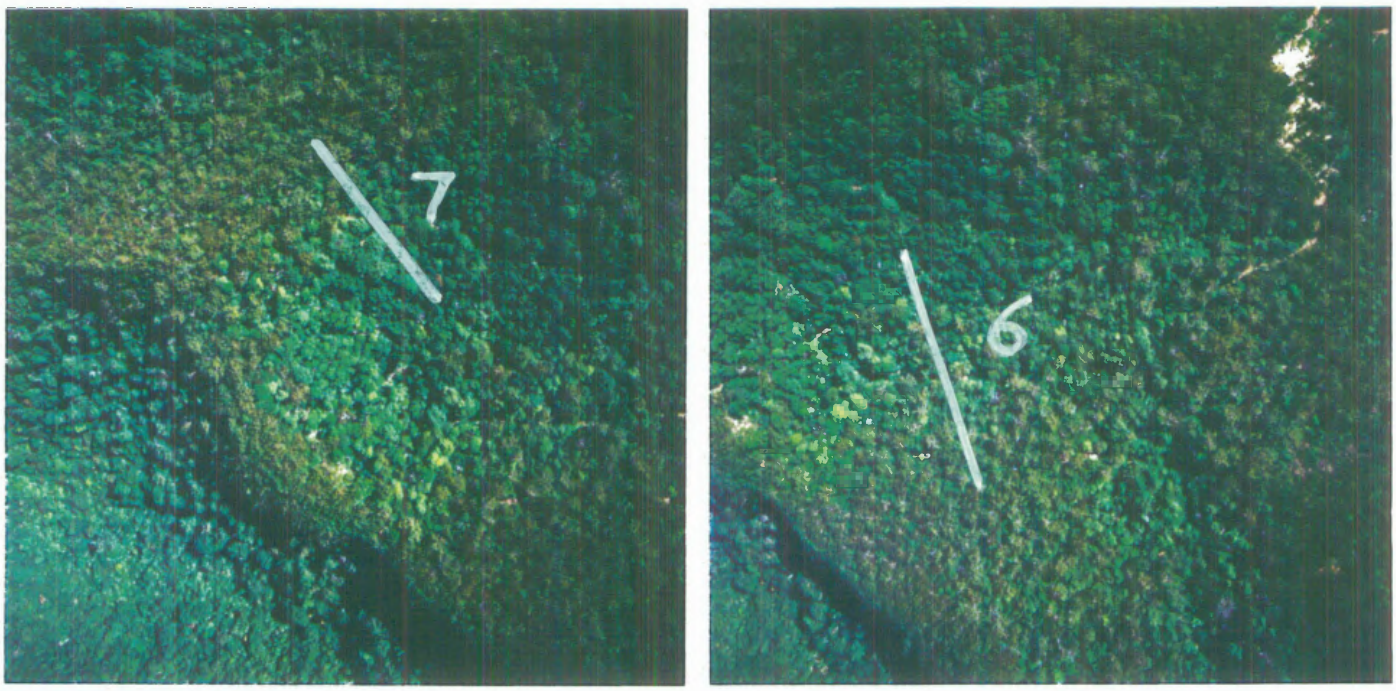


Plates 2 and 3. Transects 1 and 2 at the southern end of the study area. Scale is 1:7600

1. E. pilularis WSF
2. A. orites WSF
3. TZF
4. WTRF
5. Dry SF
6. Montane heath
7. Regrowth below study area

Plates 4 and 5. Transect 3 in the southeast of the study area. Scale is 1:7600

Plates 6 and 7. Transects 4 and 5 in the eastern part of the study area. Scale 1:7600.



Plates 8 and 9. Transects 6 and 7 in the north-western part of the study area. Scale is 1:7600.