CHAPTER 2

STUDY SITE LOCATION, DESCRIPTION AND EXPERIMENTAL DESIGN

This chapter serves to provide a broad overview of the study. A more comprehensive and specific materials and methods will be provided for each chapter.

2.1 Geographical location of study area and plots

Field sampling took place in Mpumalanga Province, Republic of South Africa (Figure 2.1.). Study areas were located on the eastern Drakensburg escarpment, in the Sabie River catchment located near the towns of Sabie (25° 06' S and 30° 47' E) and Graskop (24° 56' S and 30° 51' E) (Figure 2.2.). Study plot co-ordinates, altitudes and finer scale location schematics can be seen in Appendix 2.

2.2 Climate

Climate data were available for the towns of Sabie and Graskop, near the study areas. Temperatures range from an absolute maximum of 39 °C in October, to an absolute minimum of -1 °C in June. Average daily temperatures (1959 to 1989) were ±20.9 °C maximum and ±10.3 °C minimum. From the Sabie Forest Research Centre (FRC), mean maximum and minimum temperatures were also available on a monthly basis showing the hottest month to be January and the coldest month July (Figure 2.3).

Mean daily sunshine was highest in the winter months, from April to September, due to less cloud cover. Monthly rainfall was highest during January, with a mean of 229 mm (1959 to 1989). The mean rainfall from Sabie FRC shows that precipitation follows a strongly summer rainfall pattern (Figure 2.3). Mean total precipitation per annum was ±1480 mm in Graskop and ±1105.6 mm in Sabie (South African Weather Bureau 1997).

2.3 Geology

Soils in the area are complex and are derived from the Transvaal Super-group, consisting of the black reef series, dolomite series, and the Archaean basement complex. Archaean granite, gneiss and rocks of the Barberton sequence underlie the Archaean basement complex (Visser 1989). The lithology of each study area is somewhat variable (Figure 2.4.).

High altitude study areas, both on the Sabie and the Waterhoutboom Rivers (Graskop), have lithology comprised of potassic granite and granodiorite of dolomitic origin. The high altitude Sabie River study area also has dolomitic origins, whereas the Waterhoutboom study areas have shale, quartzite, conglomerate and basaltic rocks. The dolomite series lies above the black reef series and comprises magnesium limestone rather than dolomite. Intercalated in the dolomite are frequent beds of chert (Schwarz 1925).

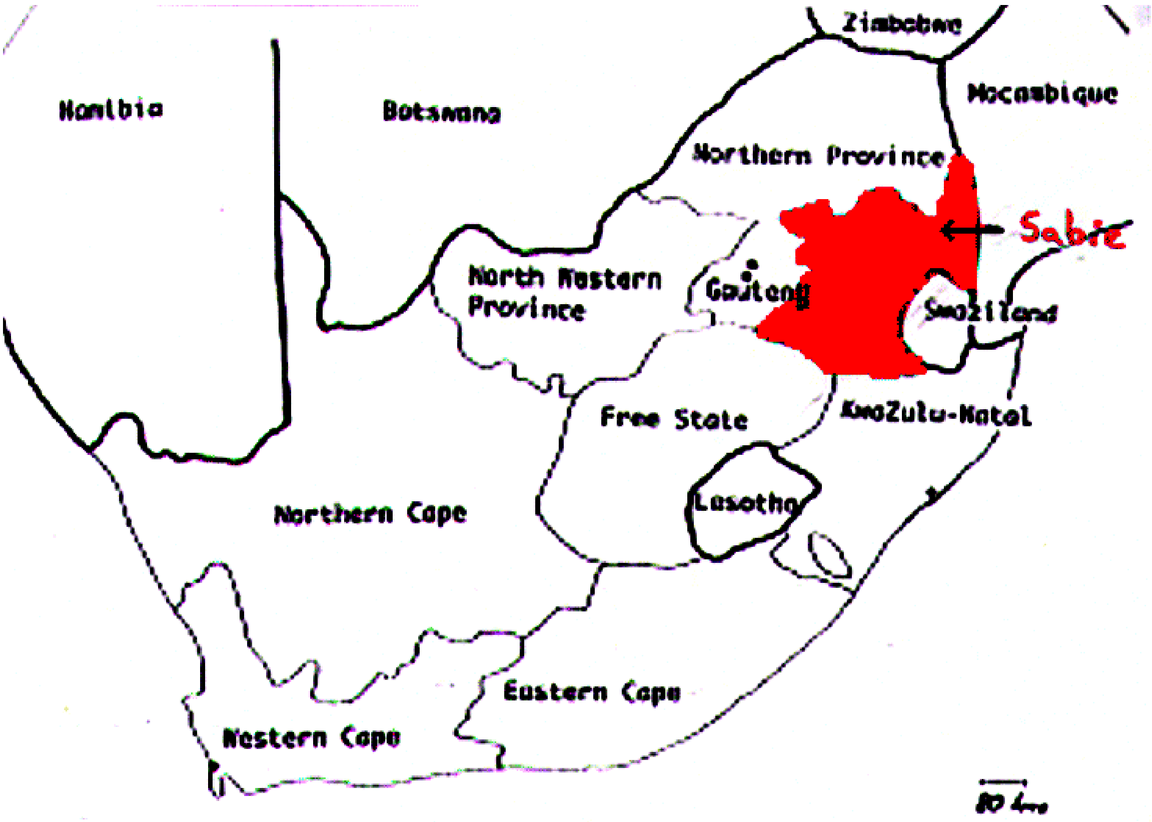

Figure 2.1 Map of South Africa, highlighting the Mpumalanga Province (in red). Sabie Town has been marked in for reference in locating the study areas (Figure 2.2)

2.4 Vegetation of the eastern escarpment silvicultural zone

Broad vegetation types were distinguished with difficulty, as both the savanna and grassland biomes meet in the vicinity of the study sites (Rutherford & Westfall 1994). This inability to distinguish between biomes was further compounded because riverine bush traverses through both the savanna and grassland biomes. Topographically, grasslands are found on flat to rolling coastal plateaus but also occur in mountainous areas and typically range in altitude from 300 m to 2850 m above mean sea level. Savanna's however, extend between altitudes of 2000 m down to a few hundred metres above sea level (Rutherford & Westfall 1994). Rainfall requirements for both biomes do not differ greatly although frost frequency does (Rutherford & Westfall 1994). Acocks (1988) Veld Types of Southern Africa gives a summary of vegetation found in these biomes within the study area.

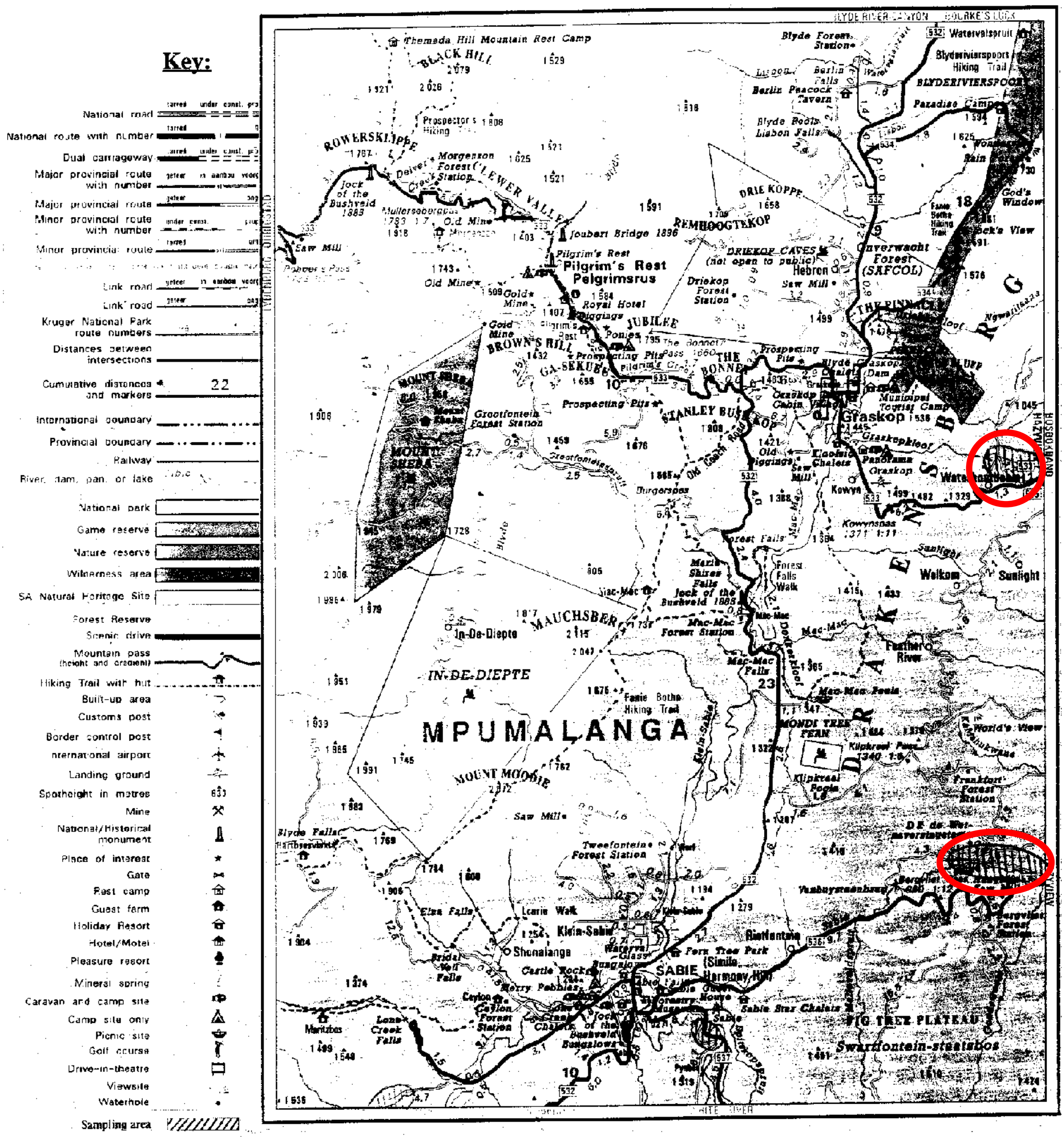

Figure 2.2 Map of Sabie/Graskop, Mpumalanga, showing the location of study areas (in red) used for sampling in this study (Map courtesy of AA Motoring South Africa, 1997).

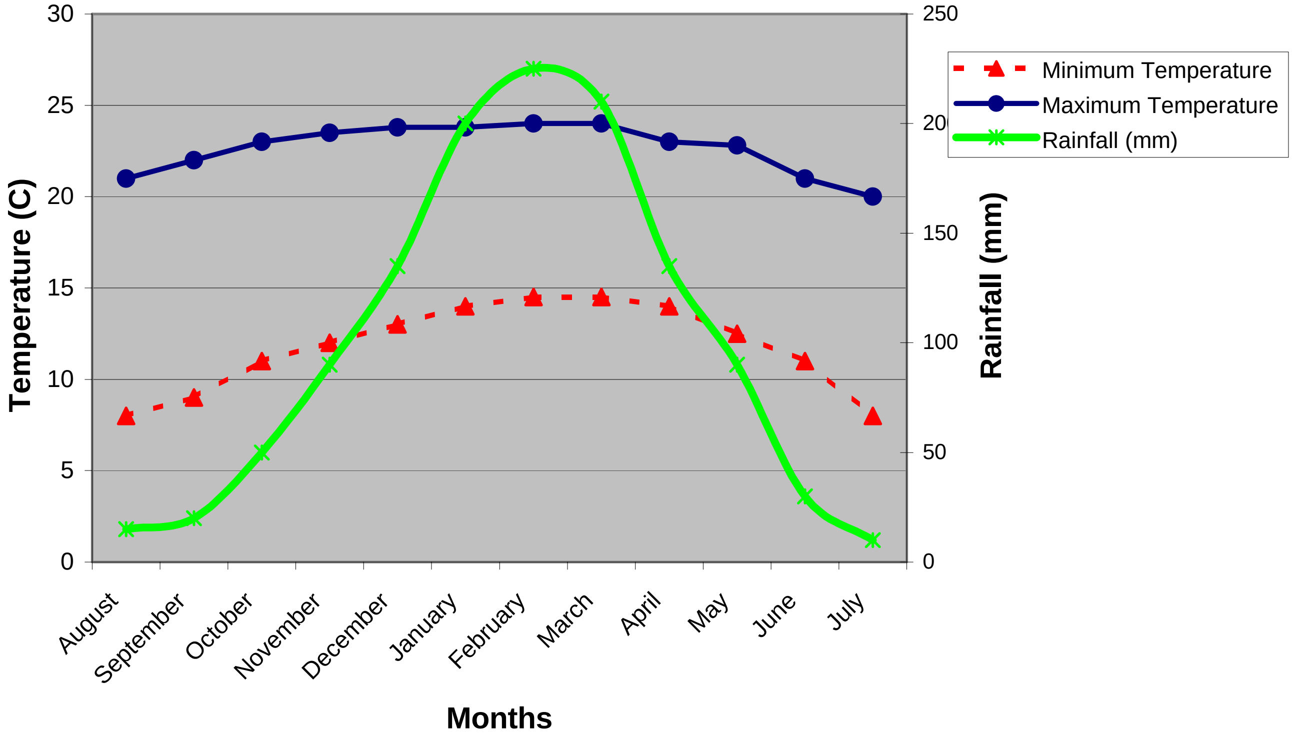

Figure 2.3 Minimum and maximum average months temperatures with mean rainfall for the Sabie Region. Temperature and rainfall associations illustrate a summer rainfall pattern.

2.5 Invasion on the Eastern Escarpment

In both grassland and savanna biomes woody plant invaders are mainly wattles (*Acacia* spp.), and some commercially utilized species such as *Eucalyptus* spp. and *Pinus* spp.(Rutherford & Westfall 1994). Other introduced species are also present, such as *Solanum mauritianum* Scop. and *Sesbania* spp. In the Sabie area, invasion is primarily due to the large disturbance caused by the timber industry and the introduction of the above mentioned exotic commercial species.

A climatically marginal variation of the grassland biome is found on the eastern escarpment and is maintained by fire and persistent wood removal (Henderson & Wells 1986). It is in these habitats that periodic disturbance occurs with sufficient frequency to facilitate establishment of new individuals (Henderson & Wells 1986). Riverine thicket/bush is an ideal environment for the introduction of exotic species and due to its location next to plantation workings, it is subject to an even greater risk of invasion.

The most recent and closely related study to the present situation seen in Mpumalanga Province was conducted in KwaZulu-Natal Province, South Africa, by MacDonald & Jarman (1985). This study illustrates the problem species found in most land uses, and silvicultural zones in particular. Species that are of importance to the Mpumalanga timber belt fall within the same environmental range (Figure 2.5). Table 2.1 shows the species that are the principal problem exotics of the Zululand state forests. These include acacia species, eucalyptus, pine and *S. mauritianum.* All four were rated as important exotic invader species for forests, stream banks, state and private forests and grasslands, along with invasive species such as *Lantana camara* and *Chromolaena odorata* (MacDonald & Jarman 1985).

2.6 Important fauna present along the Sabie River

A number of seed dispersal vectors exist within the riverine thicket and adjacent plantations.
Fruit eating bird species exist in abundance within this region. Species such as pigeons (*Columbidae* spp.), Barbetts (*Pogoniulus* spp.), common Bulbul (*Pycnonotus barbatus*) and Francolin spp. (*Francolinus* spp.) are all fruit and seed eaters and are directly involved in the distribution of propagules. There are also a number of indigenous herbivores that exist in the Sabie region. These also contribute to the dispersal of seed, although to a lesser degree relative to birds. Species present in the study area are: red duiker (*Cephalophus natalensis*), common duiker (*Sylvicapra grimmia*), bush buck (*Tragelaphus scriptus*), hippopotamus (*Hippopotamus amphibius*) (lower altitude areas only), vervet monkey (*Cercopithecus aethiops*) and baboon (*Papio ursinus*).

2.7 Silviculture in the study area

The study area has been highly utilised by the silviculture industry for many years. The Sabie and Graskop areas have been the "flagship" for the South African timber industry for pulp and soft woods, and are only surpassed by the northern Natal silvicultural zone. Sappi, Mondi and Safcol are the three main timber companies involved in the timber industry in the study region. The predominant silvicultural crops planted by these companies are *Eucalyptus grandis* W. Hill ex Maiden (bluegum) and *Pinus patula* Schlechtd. & Cham. (pine). Other silvicultural crops do exist however, but these occur on a small scale and distribution compared to the above mentioned species. The less common silvicultural crops that were encountered in the study region are *Acacia mearnsii* De Wild. (black wattle) and experimental stands of *Quercus* spp.

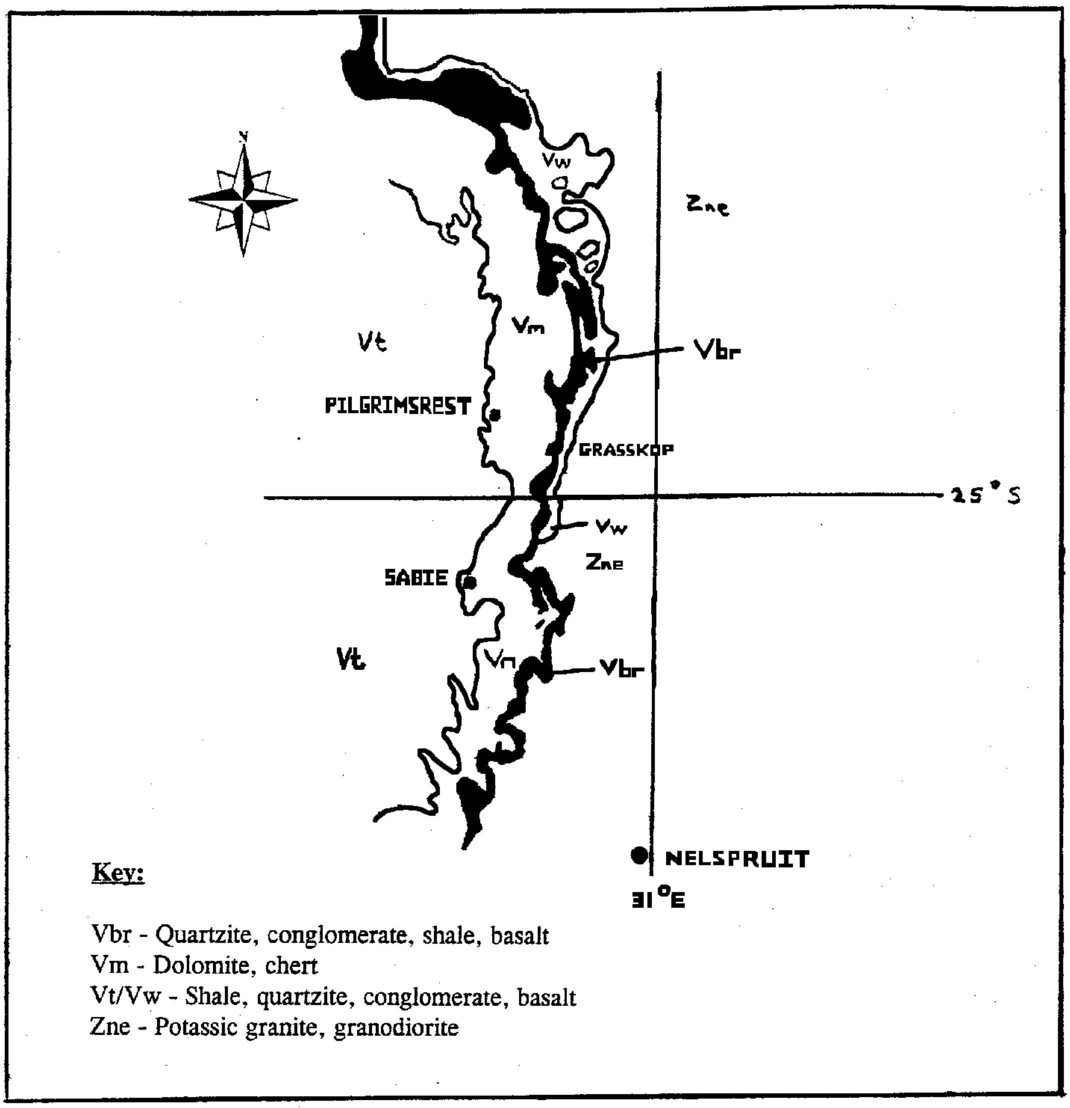

Figure 2.4 Geological map of the Sabie/Graskop area, illustrating the complex lithology of the region (produced from the 1:1 000 000 Geological map of southern Africa, fourth edition, 1984).

A "patch work" of *E. grandis* and *P. patula* plantations exist, with both species being planted from the top of the Sabie river catchment to the bottom. There is however, a trend towards a greater abundance of *P. patula* on the upper (high altitude) reaches, as this species is more frost tolerant and has a higher turnover at these climes. *E. grandis* excels in a warmer, more humid habitat and is also frost sensitive. Government control of planting and distribution of exotic commercial species extends only to plantation location and permit control. Limitations on plantation placement is in the form of curbing the planting of timber closer than 30 m from a riverbank.

Table 2.1 Principal problem exotic plant species of the Zululand region state forests, KwaZulu-Natal Province. These species are also present in the Mpumalanga silvicultural zone as problem plants. (MacDonald & Jarman 1985)

Species	Effect on natural vegetation
Acacia species	XXX
Caesalpinia decapetala	XXX
Chromolaena odorata	XXX
Eucalyptus species	X
Melia azedarach	XX
Pinus species	XXX
Solanum mauritianum	XXX

Severity of problem: *X - Mild; XX - Moderate; XXX - Severe*

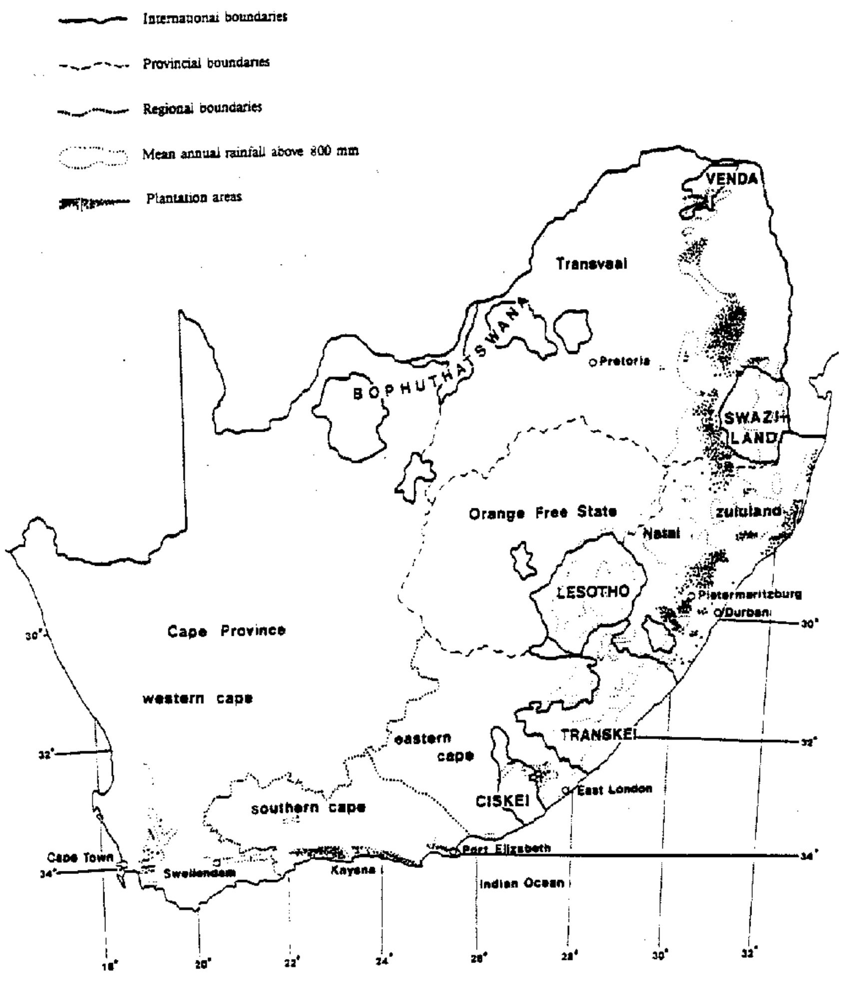

Figure 2.5 Forestry zones in South Africa in relation to annual rainfall >800 mm. Indigenous forests occur mostly in the areas within this rainfall zone (after Anonymous 1984).

2.8 Typical disturbance types for silvicultural riverine ecosystems

Silvicultural disturbance is immense, with constant vehicle movement along poorly surfaced roads and in adjacent "non-plantation" areas. A number of plantations border on the 30 m plantation exclusion zone defined by the government (Working for Water Programme). Plantation maintenance which involves the periodic (yearly to bi-yearly) clearing of below canopy vegetation and thinning of trees is a major disturbance, which is conducive to the invasion of exotic species which then spread to riverine areas. Plantation harvesting has large consequences for vegetation bordering plantations, as felled trees tend to roll down the steep hillsides and flatten indigenous vegetation in the 30 m exclusion zone (Figure 2.6).

Other disturbances originate from the river itself, as periodic flooding does occur and inundation of river banks (although rare in the higher altitude reaches) does happen in high rainfall seasons. Grazing of goats and cattle owned by local plantation workers are also a source of disturbance. The occasional prospecting for gold does occur, although infrequent. The collection of indigenous firewood is not a problem as there is an abundance of off-cut timber used for this purpose.

2.9 Positioning of plots along river corridors

Study plot positions were initially chosen using two observable invasion intensity categories: (a) a low to moderate invasion (0-50% of vegetation aerial cover), and (b) a high invasion (50-100% of vegetation aerial cover) category. Invasion intensity categories were sampled in areas (a) cleared more than 12 months preceding project initiation and (b) uncleared areas (Figure 2.7). For each management/treatment category, five modified-Whittaker nested plot replicates were established (Stohlgren *et al*. 1995). This sampling strategy was replicated in both the high (± 1100 m) and low altitude reaches (± 700 m) of the Sabie River (Figure 2.7).

Each modified-Whittaker nested plot was positioned centrally within the 30 m cleared riverine zone/corridor on each side of the river recognized by the Reconstruction and Development Programme: Water Conservation Programme (RDPWCP), and orientated with the long axis lying parallel to the river bank (Figure 2.8). Criteria for the placement of plots within the 30 m riverine corridor on each side of the river was that, (a) *Eucalyptus* species form the predominant woody exotic vegetation in and around all study plots, (b) that slopes of >20° were avoided for practical reasons, and (c) that plots were relatively uniform in terms of substrate (areas of > 35% exposed rock cover

(A)

(B)

Figure 2.6 Photographs of: (A) a typical area clear felled by the RDP Water Conservation programme illustrating the extent of environmental disturbance. (B) A typical uncleared invasion site of similar invasion intensity as that seen cleared in photograph (A). Both occurred on the banks of the Sabie river (1997).

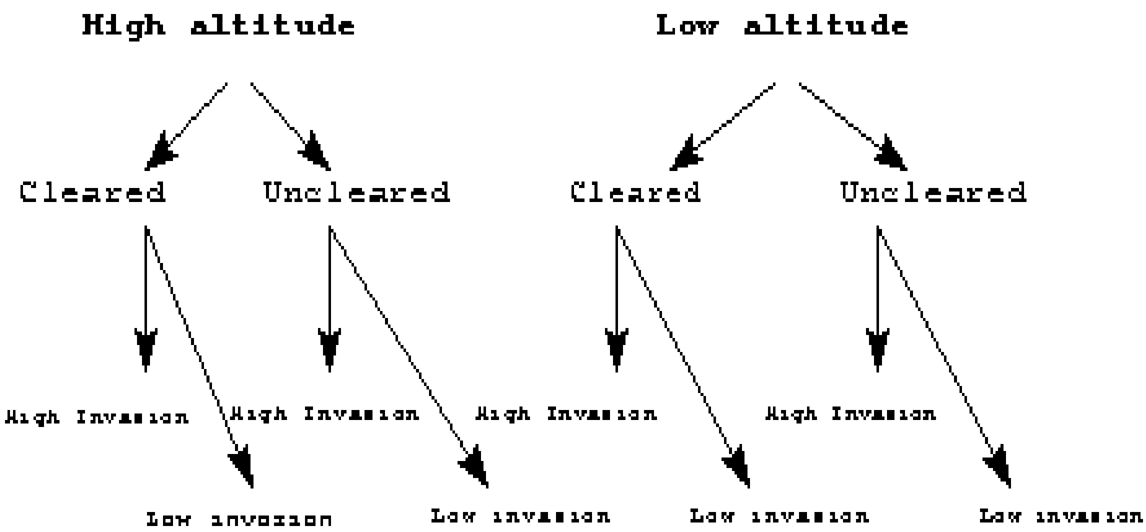

Figure 2.7 Flow diagram of the experimental layout of plots showing altitude divisions followed by clearing treatments and invasion categories.

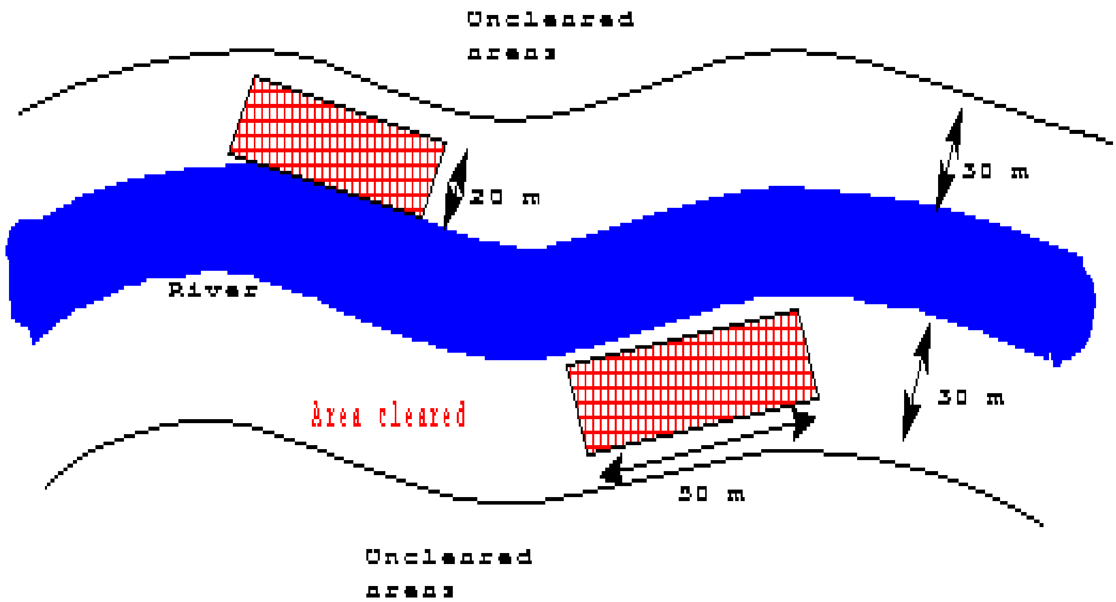

Figure 2.8 Placement of plots centrally within the 30 m cleared zone relative to the river.

were excluded from sampling).

Each 20 x 50 m plot was located using a Global Positioning System (GPS) (Garmin model No 12GX) and 1:50 000 orthophotos. Field work and data collection was initiated in August 1996, with the location and establishment of study plots. The collection of data took 5 months, starting in October 1996 and was completed by the end of February 1997. Laboratory analyses of field samples and specimens took five months in duration and was completed by July 1997.

2.10 Plot design (modified-Whittaker nested plots)

Within each 20 x 50 m modified-Whittaker nested plot, a 5 x 20 m, two 2 x 5 m quadrats and ten 0.5 x 2 m quadrats were positioned in fixed locations as described by Stohlgren *et al.* (1995). The 0.5 x 2 m (1 m^2) quadrats were marked out using a rigid steel quadrat and positioned using a tape measure. These were later removed from the plots once sampling was complete. The 2 x 5 m (10 m^2), 20 x 5 m (100 m^2) and 20 x 50 (1000 m^2) quadrats were marked out using a string boundary between fence droppers hammered into the ground as non-permanent markers. The four corners of the 20 x 50 m plot were marked permanently using 1.5 m fence droppers placed in a concrete core, 40 cm in depth and 15 cm in diameter. A strip of red barrier tape was attached to the top of the fence dropper for visibility. Details of the sampling will be covered under each chapter of the dissertation within the materials and methods section.