2002

Land capability assessment for farm forestry in the Illawarra and Shoalhaven regions

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Land Capability Assessment for Farm Forestry in the Illawarra and Shoalhaven Regions.

By

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A research report submitted in partial fulfilment of the requirements for the award of the degree

HONOURS MASTER OF ENVIRONMENTAL SCIENCE

ENVIRONMENTAL SCIENCE PROGRAM
FACULTY OF SCIENCE
THE UNIVERSITY OF WOLLONGONG

February 2002

Acknowledgement

First and foremost, I would like to express my sincere thanks to my supervisor, Rob Whelan, who gave me a wealth of valuable advice and direction, without which this thesis would have remained incomplete. I would also like to thank the head of the Wollongong University Environmental Science Department, John Morrison, for his invaluable contributions to this work. I wish to express gratitude to Sharyn Langford, a helpful and courteous member of Kiama Council, who was of great assistance to this study. Also deserving of my gratitude is Richard Scarborough, whose instruction and guidance in fieldwork, is highly appreciated. For his helpful and instructive guidance regarding the use of GIS, I wish to express my earnest appreciation for the assistance of John Marthick. I would also like to extend thanks to Kiama Council, Australian Water Technologies, the Bureau of Meteorology, Richard Miller, David Farrier, Sandra, Elisabeth, my loving and supportive Family, and also, Don.

Abstract

Currently, farmers have environmental and economic problems because of their non-environmentally sustainable businesses. Farm forestry is one of the potential alternatives that can improve both the environment and economy. In spite of these benefits, farm forestry has not been adopted in the Illawarra and Shoalhaven regions. One of the reasons for this is because of a lack of knowledge and research on farm forestry. This study aimed to assess the potential for commercial tree plantation in farmland in the Illawarra and Shoalhaven regions with local native species to these regions. This was evaluated by (1) the area of land available and its capability for plantations; (2) potential local native species for commercial plantations; and (3) matching of the available lands, the plantation species and site characteristics (including climate, geology and topography). As for the matching, a case study was conducted in Kiama LGA.

There are a significant number of lands that are available for farm forestry. Most of these lands have mild climate and productive soils, which would support optimal tree plantations. Some areas in the regions that have high rainfalls and volcanic soils have a high potential for rainforest plantations as well.

It is concluded that *Eucalyptus* species would be the most suitable local native species for commercial plantations because of their relatively fast growth rates and wide range of timber uses, from posts and poles from thinning, to furniture and cabinet timber from mature trees. Currently, the market for local native rainforest timber is small due to the limited supply of timber and small consumer demand. However, the fact that some furniture and cabinet workers look for rainforest timber from other regions shows that there is a potential to create a bigger market by increasing the supply of rainforest timbers through expanding the plantations.

Matching of available lands, land capability and potentially commercial local native species was conducted with GIS, as a case study, for Kiama LGA. There are significant areas of potential sites for local native eucalypts and rainforest plantations on cleared, private land in the LGA. The GIS study still needs to be developed to obtain more reliable and accurate results of the study.

It is concluded that there is a high potential for the establishment of farm forestry, using local native species in the Illawarra and Shoalhaven. In order for farm forestry to grow in the regions, the support of local and state governments is vital.

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1.1 Background

Land clearing has been taking place all over the world. It is occurring at high rates in tropical climate regions, such as Africa, Latin America and the Asia-Pacific region. The main reason for the land clearing is the establishment of agricultural land (World Resources Institute, 1994). FAO (Grainger, 1996) reported that the land clearing rate of the world's tropical forests between 1980 and 1990 was 15.4 million ha per annum. The countries of highest clearing rates over that time were Brazil (3.7 million ha), Indonesia (1.2 million ha) and Zaire (0.7 million ha). Clearing rates of Asia-Pacific countries are 515,000 ha in Thailand, 401,000 ha in Myanmar and 396,000 ha in Malaysia (World Resources Institute, 1994). The rates of land clearing in Australia are, surprisingly, equivalent to those in the tropical countries. Over the decade 1983-93, annual rates of land clearing for agriculture in Australia, estimated by National Greenhouse Gas Inventory (1996), were around 518,000 ha.

In Australia, since the time of European settlement, almost half of the forested land (92.5 million ha) has been cleared (Barson et al., 2000). In the 1960s and 1970s, large areas of vegetation were cleared for agricultural purposes (Glanznig, 1995). The land clearing for agriculture has been extensive in New South Wales (NSW). Total area of land clearing for agriculture in NSW between 1991 and 1995 was 51,860 ha while those of harvesting of forest and land clearings for development were 16,130 ha and 8,070 ha respectively. At the same time, vegetation cover was increasing on some of the farmlands, which was mainly due to regrowth of vegetation. The total area of vegetation increase on farms was only 1,140 ha, (Barson et al., 2000). The rates are much smaller, compared to those of vegetation decrease. These data show that a significant percentage of forested areas in NSW turns into agricultural lands each year.

Most Australian agriculture consists of cropping or pasture-based grazing on cleared land. This dramatic change of the environment from forested to agricultural lands, has brought various environmental problems. The clearance of vegetation and the monocultural systems of agriculture have brought habitat loss and fragmentation of native animals, as well as a decline in biodiversity (Glanznig, 1995). Intensive agriculture and irrigated agriculture have been proven to cause soil erosion and degradation, dryland salinity and rising groundwater (NSW Environmental Protection Authority (EPA), 1995). Livestock manure and excessive or inappropriate use of fertilisers and pesticides pollute ground water and water catchments (Walker, 1986; Watson, 1992). These effects are not only the cause of environmental degradation, but also actively decline agricultural production. In addition, these effects have a detrimental impact on the economy as the costs of environmental degradation are incurred. The NSW Landcare Working Group (1992 in NSW EPA, 1995) reported that the degradation of agriculture resources cost $700 million per year in NSW in lost production, and the cost of the improvement was estimated at $800 million. Furthermore, Barson et al. (2000) reported that the 77 % of the land clearing for agriculture contributes to greenhouse gas emissions. After all, agriculture is one of the most important rural industries in Australia. According to NSW Agriculture (1994 in NSW EPA, 1995), "agriculture contributes over $6 billion a year and uses 75 % of land and water resources in NSW". NSW EPA (1995) concluded that the current agricultural activities are not environmentally sustainable. More environmentally sustainable methods of agriculture are required if the industry and its effects on the environment are to be improved.

Australian forestry has historically depended on harvesting native forests (NSW EPA, 1995). After the introduction of Regional Forest Agreements, the industry had to reduce itself in size because of its non-environmentally sustainable management when the demand for forest products is increasing (Basin 1998, NSW EPA, 1995). Losses due to the harvesting of native forests can be partly complemented by increasing area of tree plantations. The area of established tree plantations has been rapidly increasing in the last decade in response to Plantations for Australia: The Vision 2020, which was launched in 1997 by Commonwealth, States and Territory as well as industry. The main plantation in NSW is softwood such as exotic pine (246,934 ha), followed by hardwoods such as eucalypts (44,451 ha) (Australia's National Association of Forest Industry (NAFI), 2001?). The area of total softwood plantations in NSW consists of 22% of that in Australia while hardwood plantations in NSW is 11% of that in Australia. Industry significantly depends on plantation resources (63.9% of total forest resources), currently, in NSW, although most of the plantation resources are softwood (NSW State Forests, 2000?). As for hardwood, industry still largely depends on native forest hardwood, which makes up for approximately 90% of total hardwood resources (NSW State Forests, 2000?). The reason is that the quantity and variety from hardwood timbers produced in plantations has not reached those of natural forests due to the limited range of species planted and relatively small areas of established plantations (NSW EPA, 1995). Further development of tree plantations, especially hardwood plantations, is necessary to complement the loss of natural forests. In the forestry economy, Australia imports approximately three times as much forest products as it exports, which resulted in a trade deficit of $2.02 billion in 2000-2001 (NAFI, 2001?). Reduction of this deficit and the growth of the industry can not occur without the increase in the supply of domestic forest production. Furthermore, considering the potential for sustainable development of the industry, there is no doubt that plantation forestry could play an important role in Australian forestry in the future. Expansion of plantation forestry and targeted research for its further development of plantation forestry would encourage the growth of Australian forestry.

Farm forestry is recognised as one of the options that meet the requirements of environmental sustainable development on farmland. Growth of tree plantations has the potential to improve the negative environmental effects that agriculture has had on its surrounding area. The reason for this is that farm forestry can provide several benefits. The benefits are not only an alternative income source through the marketing of the forest product, but also ecological (the conservation of biodiversity and the improvement of land and water quality), social (the promotion of amenity) and economic (the development of forestry industry, resulting in the increase of employment) (Greening Australia, 1996; Abel et al., 1997) as well as sinks for carbon dioxide, which may reduce net greenhouse gas emissions (AFFA, 2001a). Furthermore, it is expected to increase agricultural production due to the improvement of the surrounding environment and provide shelter for stock and crops (Abel et al., 1997). Because of these benefits, Agriculture, Fisheries and Forestry – Australia (AFFA) (Commonwealth government) has set out several programmes to encourage farm forestry, and the Natural Heritage Trust and the Wood and Paper Industry Strategy have supported farm forestry programmes through funding. Furthermore, there are currently many organizations that support farm forestry projects, such as Regional Plantation Committees, Australian Master Tree Growers, Greening Australia and so on. Farm forestry is relatively popular and widespread in Tasmania, Victoria and Western Australia. However, farm forestry has not yet been widely adopted in NSW, especially in the Illawarra and Shoalhaven regions, which are located on the south coast of NSW.

Agriculture is still a major rural industry in the Illawarra and Shoalhaven regions while urban development is extending to some of the agricultural lands. A common characteristic of the farmers in these regions is that they have relatively small properties (Dayal, 1980?). Currently, there are some economic and environmental problems that the farmers have to face if they wish to continue agricultural production. Traditionally, the majority of farms in the regions have focussed on dairy cattle (Fuller, 1980; Dayal, 1980?). However, the dairy market in Australia is presently stagnant and the industry is being consolidated (Australian Dairy Industry, 2000). In addition, recent deregulation of the dairy market makes it difficult for small dairies to survive (Davidson, 2000). The critical situations of the dairy industry have caused some farmers to seek alternative income sources. Another drawback is that there is an evidence of environmental problems occurring associated with agricultural activities in these regions (Kiama, Shellharbour, Shoalhaven and Wollongong SoEs, 1999/2000). Agriculture in the Illawarra and Shoalhaven regions needs to move towards implementing Environmental Sustainable Development.

To improve the situations described above, farm forestry is one of the alternatives in the Illawarra and Shoalhaven regions. A study of an impact assessment of alternatives to dairy farming in the regions (Dostal, 2001) evaluated that only farm forestry would benefit the environment. In addition, the climate and geology in the Illawarra and Shoalhaven regions are generally ideal for tree plantation. These regions have relatively mild climates, high rainfalls and rich soils, which provide a suitable environment for the establishment of rainforests as well as wet and dry sclerophyll forests (Fuller, 1980). The farm forestry strategy for the Illawarra and Shoalhaven Regions (Turner & Lambert, 1999) also recognised great potential for plantation forestry in the Illawarra and Shoalhaven regions because of the land capabilities as well as their proximity to markets in Wollongong and Sydney.

In spite of the potential, some intrinsic problems have hindered the spread of farm forestry in these regions. Firstly, the long-term nature of the industry makes it a complicated task to predict the future income of such a venture. Secondly, growth rates and the performance of planted trees vary greatly within regions and between tree species. Therefore, it is difficult to apply data from other regions to the Illawarra and Shoalhaven regions. Furthermore, the few farm forestry studies in these regions are insufficient to provide reliable information about farm forestry to local farmers. Thirdly, there are currently few forest industries in these regions, which means that the forestry markets and timber processing facilities in the regions are limited. Fourthly, it is difficult to find investors for farm forestry because of the small size of planted areas. Moreover, it has been suggested that the main reason for the limited development of farm forestry is due to the lack of knowledge and of demonstration sites in these regions (Greening Australia, 1996). It is obvious that investigation of these problems and circulation of the information to farmers will greatly help them in decision-making related to farm forestry, and also contribute to the growth of the industry in the Illawarra and Shoalhaven regions.

1.2 Farm forestry

Farm forestry is the integration of agricultural activities and tree plantations, which is defined as "the incorporation of commercial tree growing into farming systems under a range of activities that are generally smaller in size and variable in configuration, species and purpose" (Andrew and Race, 2000). Farm forestry varies greatly according to the objectives of landowners (Figure 1.1). These can be aimed to improve agricultural production by providing shelter for stock and crops, and also to improve the surrounding environment such as salinity control and protection of biodiversity as well as commercial plantations.

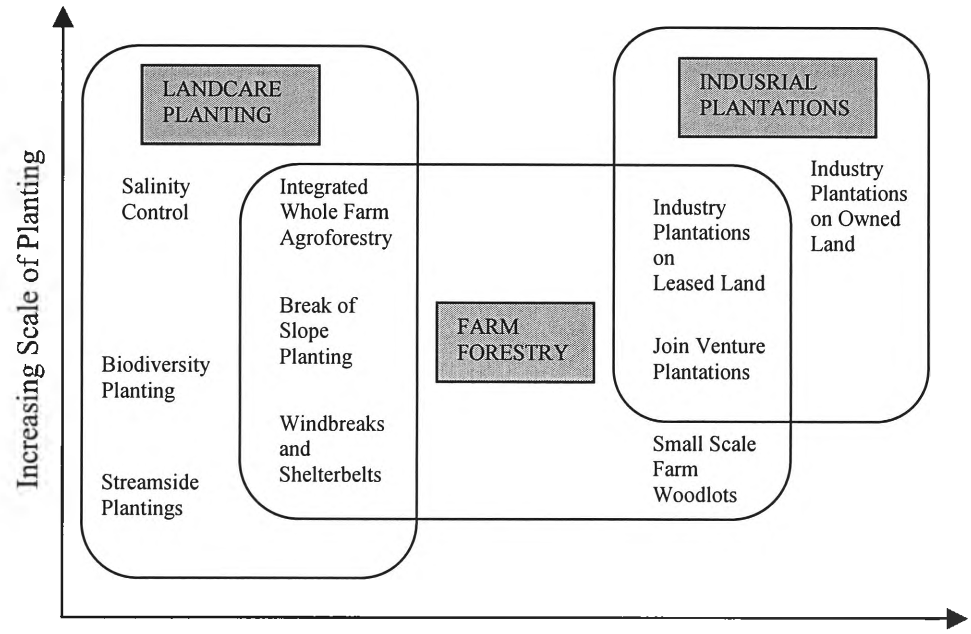

Figure 1.1 Outcomes of farm forestry according to objectives of landowners

(Source: AFFA, 2001b)

Selection of species is one of the important factors to be considered to design tree plantations in farms. Understanding characteristics of each species is important to determine suitable species for environmental plantings and/or commercial plantations. Agricultural production improvement considering can be achieved by effective design of planting positions in farmlands rather than characteristics of tree species. Figure 1.2 shows the relationship between selection of tree species and the potentials of their outcomes. Selection of exotic species or non-local native species would result in high returns from sale of the timber while the contribution to the environmental improvement would be lower than that of local native species. On the other hand, selection of local native species for environmental objectives may have fewer opportunities for markets than that of exotic or non-local native species, however, it will maximise the chances that meets the needs of local fauna and flora as well as scenic improvement in farmlands through the existence of the plantation. As a result of planting commercial local native species, one would expect both environmental and economic outcomes. Monoculture plantations of commercial local native species would have greater economic outcomes and have less environmental benefits than multi species plantations.

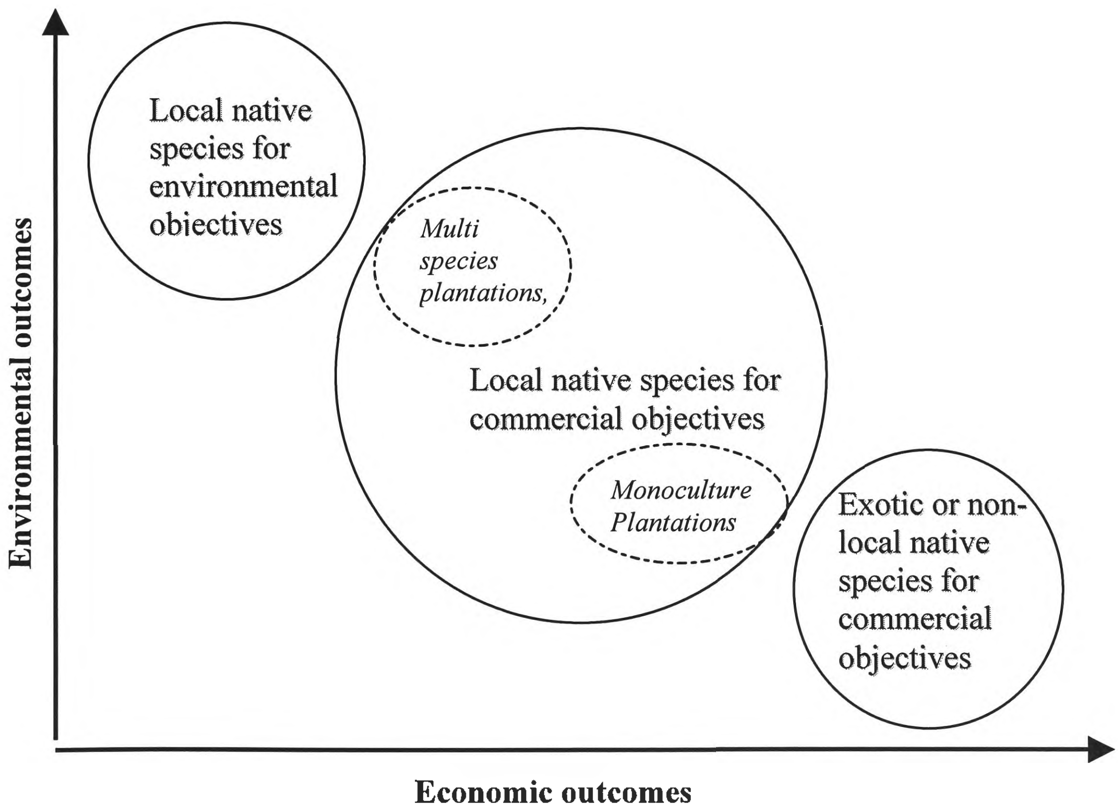

Figure 1.2 Relationship between selection of tree species and their environmental and economical outcomes.

Currently, the following main species are used for plantations in Australia: Radiata Pine (*Pinus radiata*); Tasmanian blue gum (Eucalyptus globulus); Shining gum (*E. nitens*); Mountain ash (*E. regnans*); Flooded gum (*E.grandis*); Blackbutt (*E. pilularis*); and Karri (*E. diversicolor*) (NAFI, 2001). It may be mentioned that these species are not native in the Illawarra and Shoalhaven except for Blackbutt.

Significant area of native vegetation has been lost by land clearing over the past years. Environmental and scenic degradation as well as decrease of agricultural production due to the loss is not negligible. If there is a potential for commercial plantations with local native species, benefits of farm forestry will be maximised. However, there is little research on the potential of the local native species for commercial plantations. One of the aims of the farm forestry program by AFFA (2001b) is to develop new tree crop products and industries with an emphasis on native species. It is necessary to examine the potential for commercial plantations with local native species at regional level.

1.3 Aims of study

As discussed above, farm forestry with local native species would have a potential for both environmental and economic benefits. This study aims to assess the potential for commercial tree plantations on farmland with local native species in the Illawarra and Shoalhaven regions. In order to maximise forestry potential, it is important to identify (1) the area of land available and its capability for plantations, (2) potential local native tree species for commercial plantations, (3) matching the available lands, the plantation species and site characteristics (soils, rainfalls, altitudes and topography).

1.4 Outlines of the thesis

Availability and capability of the land for farm forestry in the Illawarra and Shoalhaven regions is studied in Chapter 2. Potentially local native species for commercial plantations in the regions are investigated in Chapter 3. A case study of matching the potential lands for farm forestry and their suitable species in Kiama LGA is conducted with Geographic Information Systems (GIS) in Chapter 4. Discussions and Conclusions of the study are described in Chapter 5. Chapter 6 is reference for this study, and Chapter 7 is the appendix.

Chapter 2 Background

2.1 The study regions

This study was conducted in the Illawarra and Shoalhaven regions, which cover Wollongong, Shellharbour, Kiama and Shoalhaven Local Government Areas (LGAs). There are some issues to be considered for the development of farm forestry at the regional level. The issues are: the sizes of available lands; legislative restrictions; distance from markets; climatic, geological and topographical limitations; and existing demand for forestry production at or around the region. As for the distance from markets, the Illawarra / Shoalhaven Regional Forest Strategy (Turner and Lambert, 1999) recognised that transportation in the regions is very suitable to the marketing of products, and there are close markets in Sydney, Wollongong, Port Kembla and Canberra. Although further study is necessary in this area to discover how much the distance affects the industry, this will not be discussed in this study.

The aims of this chapter are (1) to investigate availability of lands for farm forestry in the regions in terms of land use and legislative restrictions, and (2) to study land capability for farm forestry in the regions by reviewing past studies of climate, topography and geology in the regions. Land availability and capability for farm forestry will provide the basic information for estimating forest productivity on farms in the regions. This information will give some ideas to potential farm foresters. As for the demand for forestry production within and around the Illawarra and Shoalhaven regions, one is investigated in Chapter 3.

2.2 History and characteristics of these regions

All the four LGAs are located on the South Coast of New South Wales (Fig, 2.1). The total area of land is 577,140 ha, most of which (466,025 ha) is in the Shoalhaven LGA (Table 2.1). Each LGA has similar characteristics in land uses. Urban areas are mainly concentrated on the coast and coastal plain; rural areas are located on the coastal plain and lower escarpment; and most of the area on the plateau and mountains belongs to National Parks and State Forests. Although the gross area of Shoalhaven LGA is much larger than that of any other LGA (Table 2.1), over half of Shoalhaven LGA (68%) is in public ownership, such as Crown Land, State Forest and National Park. The private land component is approximately 149,000 ha. This is still a large proportion of the total land area within the four LGAs.

Table 2.1 Gross area (ha) of each LGA in study areas

Shire	Gross area (ha)
Kiama	25,600
Shellharbour	14,115
Shoalhaven	466,025
Wollongong	71,400
Total	577,140

(Source: Kiama, Shellharbour, Shoalhaven & Wollongong SoEs, 1999/2000)

Histories of the Illawarra and Shoalhaven regions tell of the large area that used to be covered by forests. In the early 1800s, large amounts of Red Cedar (*Toona ciliata*), which was recognised as high value timber, were removed from the Illawarra and Shoalhaven regions. At the same time as cedar getting, European settlement started. First, vegetation on flat and fertile lands such as rainforest was cleared for agricultural purposes, then the eucalypt forests were cleared (Fuller, 1980; Mills & Jakeman, 1995). Mills (1995) estimated that approximately 75% of the rainforest has

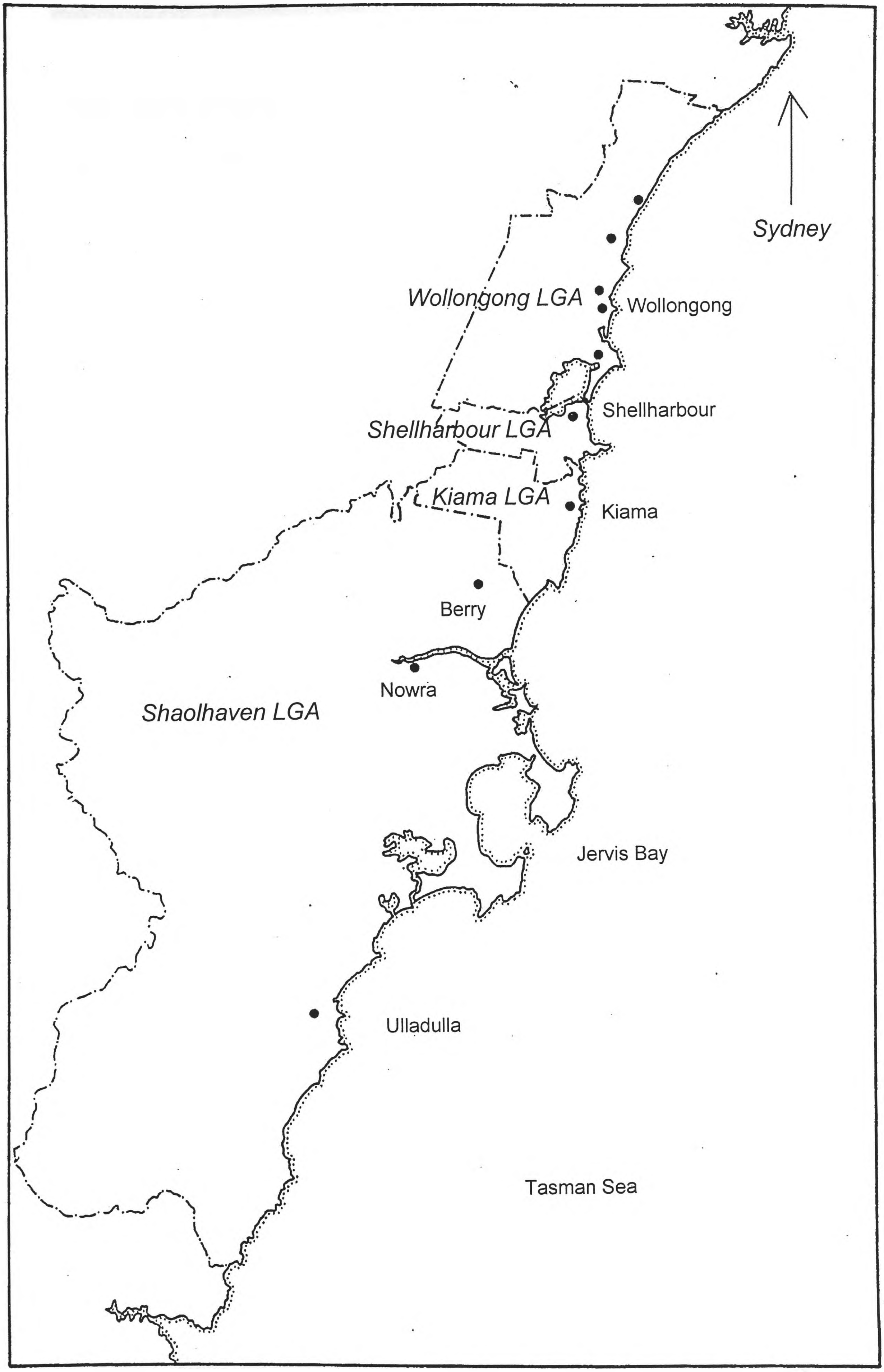

Figure 2.1 Location of studied four LGAs

been cleared in these regions since European settlement. After clearing, these regions became the centre of dairy farming in the Illawarra and Shoalhaven area (Fuller, 1980).

This history shows that there is a high potential for tree plantations of valuable rainforest species such as Red Cedar in these regions. However, the intensive clearing of rainforests that has occurred hinders information gathering on the precise distribution and site preference of the rainforest species. Currently, while agriculture in the study area has been decreasing with the growth of urbanisation and other industries, agriculture is still one of the major industries in rural areas of the regions. It should be noted that the major agricultural practices in the study area consist of dairy farming and beef farming.

2.3 Agricultural and Cleared lands

Table 2.2 lists the cleared area and agricultural area within each LGA. The total area of agricultural lands is highest in Shoalhaven, followed by Kiama. Data for Wollongong LGA could not be obtained for this study, however, the main agricultural area within the LGA is concentrated on the southwest of the LGA. Data on "cleared area" in Table 2.2 typically include the cleared agricultural lands as well as urban and other rural lands. It is interesting to note that the total agricultural areas in Kiama and Shoalhaven are larger than the total cleared areas. This indicates that some agricultural landholders have remnant or planted vegetation on their properties. The target areas for farm forestry establishment are cleared agricultural lands. Cleared agricultural area in Kiama LGA has been determined with GIS (see Chapter 5). The area is 10,223 ha, which consists of 68% of the total agricultural area in the study region. Mills (Shellharbour SoE, 1999/2000) reported that the proportion of total cleared area on "rural area" (8,754 ha) in Shellharbour is 63%. It is important to investigate "the cleared agricultural area" in order to estimate land availability for farm forestry.

Generally, the cleared lands within the Illawarra and Shoalhaven are concentrated on coastal plains and escarpments. Coastal plains having good soils, and being on flat sites close to rivers and streams, have been intensively cleared. There are some remnant forests remaining in the escarpment and adjacent to rivers and streams. In Shoalhaven, which makes up a large percentage of the area in the four LGAs, cleared lands are concentrated in the north of Shoalhaven LGA including Kangaroo Valley; in and around Milton and Ulladulla; and Sassafras (Figure 2.2).

Table 2.2 Agricultural areas and Cleared areas in each LGA

Shire	Cleared area (ha)	Agricultural area (ha)
Kiama	13,118	15,139
Shellharbour	—	4,415
Shoalhaven	52,519	52,594
Wollongong	—	—

(Source: Kiama, Shellharbour & Shoalhaven SoEs, 1999/2000)

2.4 Legislation

2.4.1 Plantations and Reafforestation Act

Plantations and Reafforestation (Code) Regulation 2000 was set out in pursuance of section 70 of the Plantations and Reafforestation Act 1999 (NSW Department of Land & Water Conservation (DLWC), 2000).

The objects of the Act are:

- to facilitate the reafforestation of land, as well as

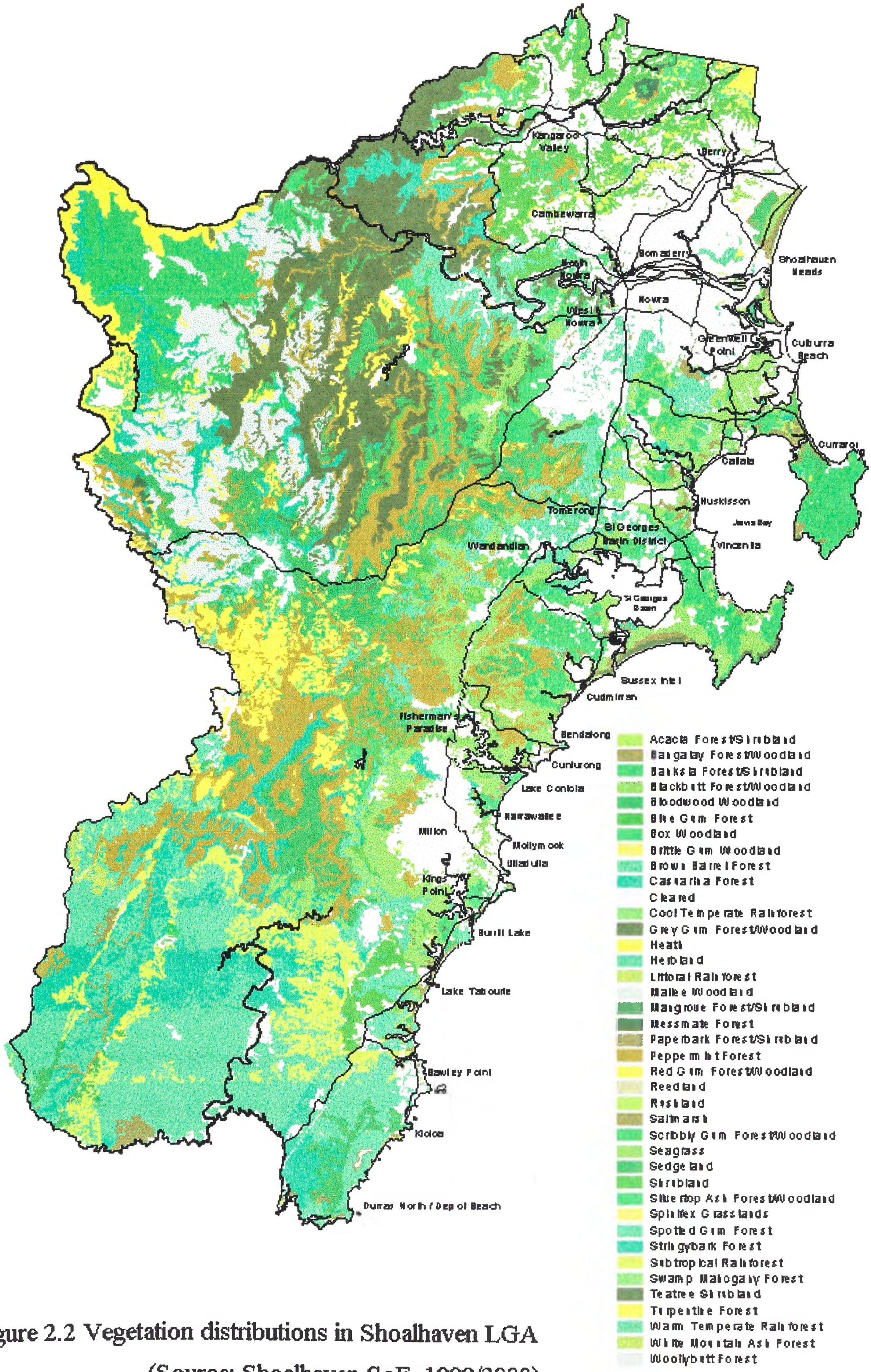

Figure 2.2 Vegetation distributions in Shoalhaven LGA

(Source: Shoalhaven SoE, 1999/2000)

- to promote and facilitate development for timber plantations on essentially cleared land, and
- to codify environmental standards and provide a streamlined and integrated scheme for the establishment, management, and harvesting of timber and other forest plantations, and
- to make provision relating to regional transport infrastructure expenditure in connection with timber plantations, and
- to be consistent with the principles of ecologically sustainable development."

The Plantation and Reafforestation Act (PR Act) provides for three levels of plantation operations, which are:(1) Exempt farm forestry (EFF), (2) Complying plantation and (3) Non-complying plantations.

Farm forestry that does not exceed 30 ha on the one property is in EFF category, and does not require authorisation. It is exempt from a harvesting limit under the PR Act, and development consent under the Native Vegetation Conservation Act 1997. In other words, farm forestry that exceeds 30 ha on a property needs authorisation, which requires compliance with all the standards determined in the PR Act. Many of the potential farm forestry sites in the Illawarra and Shoalhaven regions would be categorised as EFF because of the relatively small sizes of farms in these regions.

EFF has many advantages in establishing plantations due to the exemptions, but there is still a need to comply with other legislation such as the State Threatened Species Conservation Act 1995 (TSC Act) and the Federal Environmental Protection and Biodiversity Conservation Act (EPBC Act). These Acts examine whether plantation management activities are likely to have a significant impact on threatened species and on matters of national environmental significance. If there is a possibility for environmental impact as a result of the plantation management activities, a license must be obtained from the National Parks and Wildlife Service (under the TSC Act) or the Commonwealth (under the EPBC Act). Under the EFF provisions, the applicants can choose to seek authorisation under the PR Act to receive a harvest guarantee. In section 37, the PR Act defines that plantation growers can claim compensation if "harvesting operations are delayed, restricted or precluded in order to protect unique and special wildlife values" (NSW DLWC, 2000).

As for the relationship between the PR Act and the Environmental Planning and Assessment Act 1979 (EPA Act), in section 7 and 47 of the PR Act, plantation operations on an authorised plantation and EFF are not subject to the EPA Act. However, the PR Act does not apply to land that is within Wollongong LGA; and land that is within a zone designated "residential" (but not "rural-residential"), "village", "township", "industrial" or "business" under the EPA Act. The PR Act also does not apply to land that is dedicated or reserved under the Forest Act 1976; National Parks and Wildlife Act 1974, Fisheries Management Act 1994; or Heritage Act 1977. The authorisation under the PR Act considers these Acts.

In the Code of Practice that forms parts of the PR Act, there are detailed regulations for plantation sites, defining environmental standards for the establishment, management and harvesting of plantations. EFF sites, which many farm forestry sites in the Illawarra and Shoalhaven regions would be categorised as, are not required to meet the standards. However, there would be many environmental benefits of requiring EFF sites to meet these standards too. For example, the Code of Practice defines buffer zones for drainage features such as wetlands, rivers and other drainage lines. These zones must be at least 20 metres wide in wetlands and rivers, and at least 10 metres in drainage lines. The code of practice determines slope limits for plantation activities, depending on annual average rainfall and soil types. In annual average rainfall from 0-3999mm, to which the Illawarra and Shoalhaven regions belong, the code of practice prohibits slopes over 25 degrees on any soil types because the potential for environmental degradation through soil erosion, sedimentation and water pollution from plantation activities (Table 2.3).

Table 2.3 Slope limits for plantation activities in annual average rainfall from 0-3999mm under the code of practice

	Soil class			
Plantation activities	R1	R2	R3	R4
Mounding	25°	15°	20°	5°
Line ripping & ploughing	25°	20°	25°	5°

R1: high coherence soils with low potential to deliver sediment
R2: low coherence soils (when wet) with low potential to deliver sediment
R3: high coherent soils with high potential to deliver sediment
R4: low coherence soils (when wet) with very high potential to deliver fine sediment

(Source: NSW DLWC, 2000)

In addition, the code of practice gives standards of management, which include road building, fire protection and control of pests, weeds and diseases.

2.4.2 Local Environmental Plans

After introduction of the PR Act 1999, authorised plantations and EFF do not need to comply with the EPA Act. However, the PR Act does not apply to the land that is within Wollongong LGA and some zones defined by the Local Environmental Plan (LEP) under the EPA Act (see section 2.4.1).

The EPA Act (1979) requires each Council to make a Local Environmental Plan (LEP), which is "the principal legal document for controlling development at the council level" (Urban Affairs & Planning, 2001). The LEP establishes permissibility of uses and regulates the extent of development by zoning. It classifies any proposed development into "without development consent", "only with development consent" or "prohibited". An applicant who intends to carry out the development that is classified "only with development" needs to obtain consent from a Council. The application for consent would include proposal details, a management plan and a statement of environmental effects of the development. The zones to which the PR Act does not apply are "residential" (but not "rural-residential"), "village", "township", "industrial" or "business" (see section 2.4.1). However, most agricultural lands would be covered by Rural Zones (or Non-Urban Zone) or Environmental Protection Zones. Therefore, it is suggested that the PR Act applies to most agricultural lands within Kiama, Shellharbour and Shoalhaven LGAs.

The main legislation that would potentially regulate farm forestry within Wollongong LGA is LEP. In the Wollongong LEP (1990), farm forestry would be defined as forestry. The potential zones for forestry are "Non-Urban Zone", "Public Recreation Zone", "Special Environmental Protection Zone" and "Environmental Protection Residential Zone". All of the zones need development consent from the council although it might not be difficult to obtain development consent.

2.5 The surrounding environment

One of the critical considerations for tree plantation development is land capability. Higher quality sites should result in higher forestry production. Understanding of the environment in the study areas is vital in order to estimate the land capability. At a species level, growth and performance vary significantly according to the environment. If species are grown in their preferable environment, better growth and performance can be expected. In this section, the capability of the environment in the study areas for farm forestry is discussed.

Fuller (1980) defined the fundamental factors influencing the vegetation are:

- Latitude and altitude
- Climate
- Geology and soils
- Proximity to the sea
- Historical influences (European)
- Introduced weeds
- Present man-induced influences such as pollution, disturbance etc.
- Bushfires

Fuller (1980) suggested that these factors influence patterns of natural vegetation distribution. Many of these could also be applied to tree plantations. Modified factors for tree plantations in tree growths and their performance are as follows:

- Latitude and altitude
- Climate
- Geology and soils
- Proximity to the sea
- Land use influences
- Preparation of soils (fertiliser, ripping and mounding, mulching and weed control, which can remedy for the tree's favourable conditions)

There is no significant difference in the latitude, which influences climates within the study areas. However, some species have distribution limits in the study areas, which are discussed in Chapter 3.

Fuller (1980) found that regrowth vegetation is not the same as the vegetation used to be because of altered environment. Land used for farm forestry is already cleared, and has been used for agricultural activities. This will have altered the properties and nutrients of soils significantly. The extent of the alteration would be different for each of the various agricultural activities and the location of the sites. In some places where environmental degradation is severe, the alteration would be critical.

Altered lands may be possible to remedy by application of fertilisers and ground operations such as ripping and mounding. The management of tree plantations is sometimes more important than the other factors (see section 3.4.1).

Proximity to the sea affects tree growths and limits the number of species that can grow. Generally, the closer to the sea, the stronger are the effects of sea winds and salt spray from the sea. The effect would depend on the environment and how much of the vegetation between the sea and plantations sites is cleared. In the remnant forest close to the sea, there are particular species that are only seen in that area, such as Bangalay (*Eucalyptus botryoides*), Coast Banksia (*Banksia integriforia*) and littoral rainforest species (Fuller, 1980; Fuller & Mills, 1985). These species show better performance in these areas than any other species. However, it is unknown exactly how much their proximity to the sea would affect the tree growths and performances.

Altitude, climate and geology vary greatly within the study areas. These factors limit the number of tree species and influence the tree growth and performance significantly. The study of these factors will be the basic information used to evaluate the land capability for tree plantations.

2.5.1 Altitude

All the study areas, Wollongong, Shellharbour, Kiama and Shoalhaven LGAs, are located near the coast. Altitudes in the study areas range from a few metres above sea level to about one thousand metres. Figure 2.3 shows altitude zones in the Illawarra region, which cover Wollongong, Shellharbour and Kiama LGAs. Altitudes of a part of Shoalhaven LGA are described in Figure 2.4. The figure does not cover the whole area of the LGA. However, it gives enough information to explore the potential area for farm forestry because most of the west part of the LGA is National Park and State Forests (Fig. 2.2).

The differences in altitudes relate to several landforms. These are the coastal plain, the escarpment and its foothills, and the plateau in the study areas (Fig. 2.5). Just as soils and climates vary greatly with the landforms, the distribution of vegetation is significantly influenced by the landforms. On the plateau in the Illawarra region, dry sclerophyll eucalypt forest is common except for wet sclerophyll forest and rainforest in valleys and river gorges (Fuller, 1980). Tall wet sclerophyll forests and rainforest are seen on escarpment benches while dry sclerophyll forests dominate on steep slopes and escarpment foothills. On the coastal plain ,however, eucalypt forests are common sheltered areas and gullies between foothill spurs support rainforests. Mills & Jakeman (1995) define the coastal area below an arbitrary altitude of 100 metres as coastal plain. The coastal plains along the coast stretch along the area adjacent to Lake Illawarra and the eastern half of Shoalhaven LGA (Fig. 2.3 & Fig. 2.4). The plain in Kangaroo Valley is called inland plain. In the study areas, most of the areas used as agricultural land are located on the coastal and inland plains, and the smallest areas of these are placed in lower escarpments in the Illawarra regions and Kangaroo Valley.

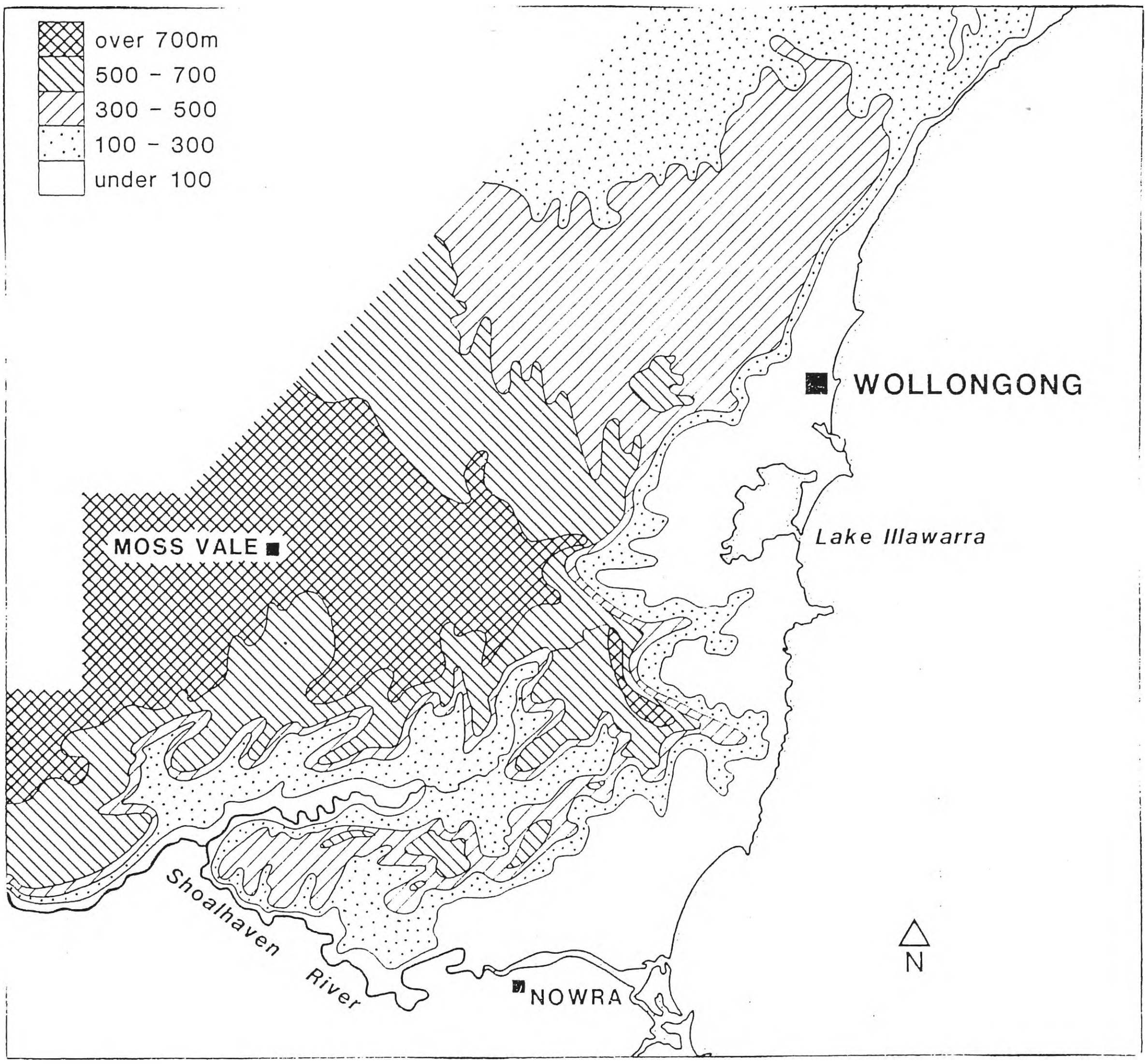

Figure 2.3 Altitude zones in the Illawarra district

(Source: Mills & Jakeman, 1995)

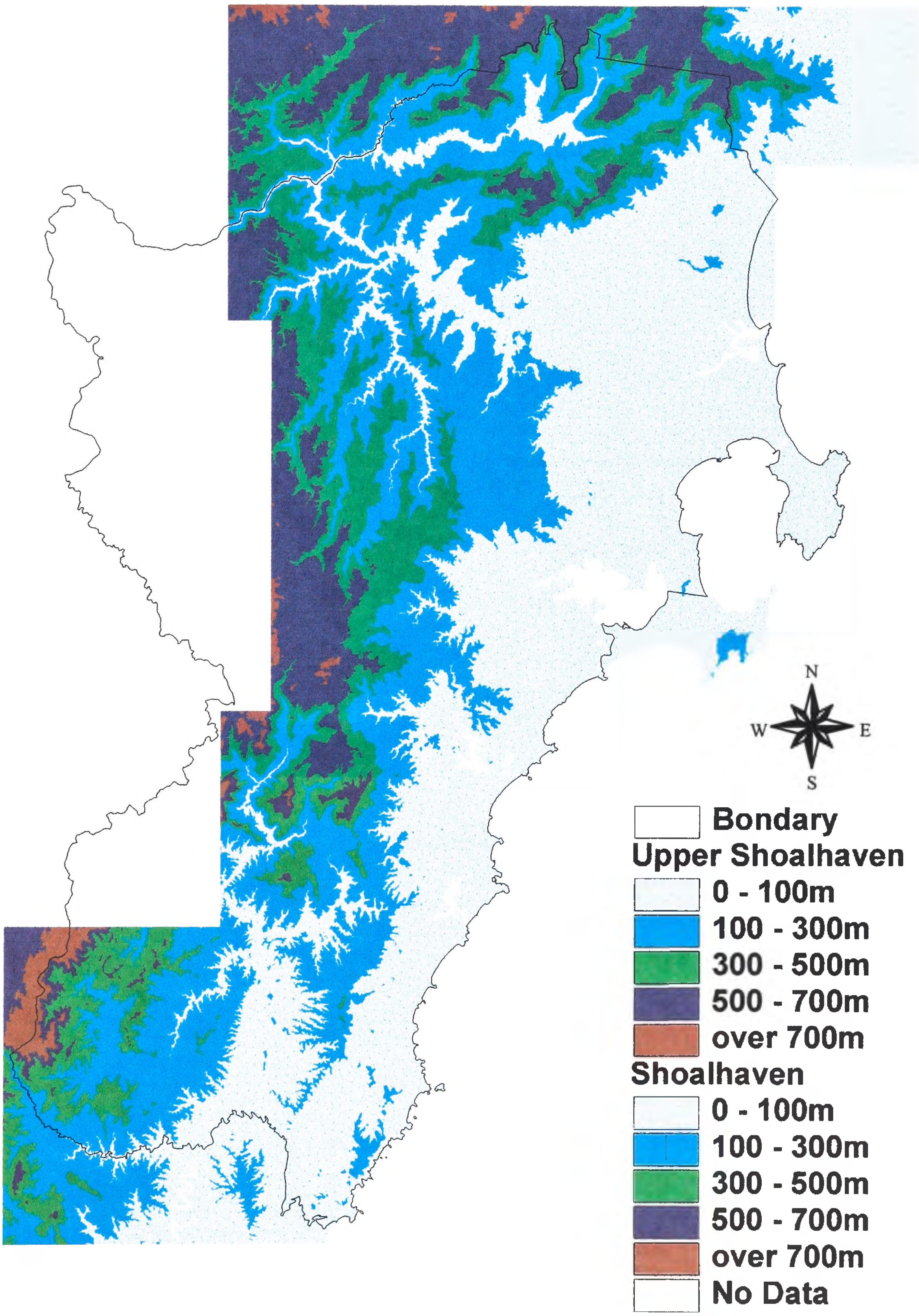

Figure 2.4 Altitude zones in Shoalhaven LGA

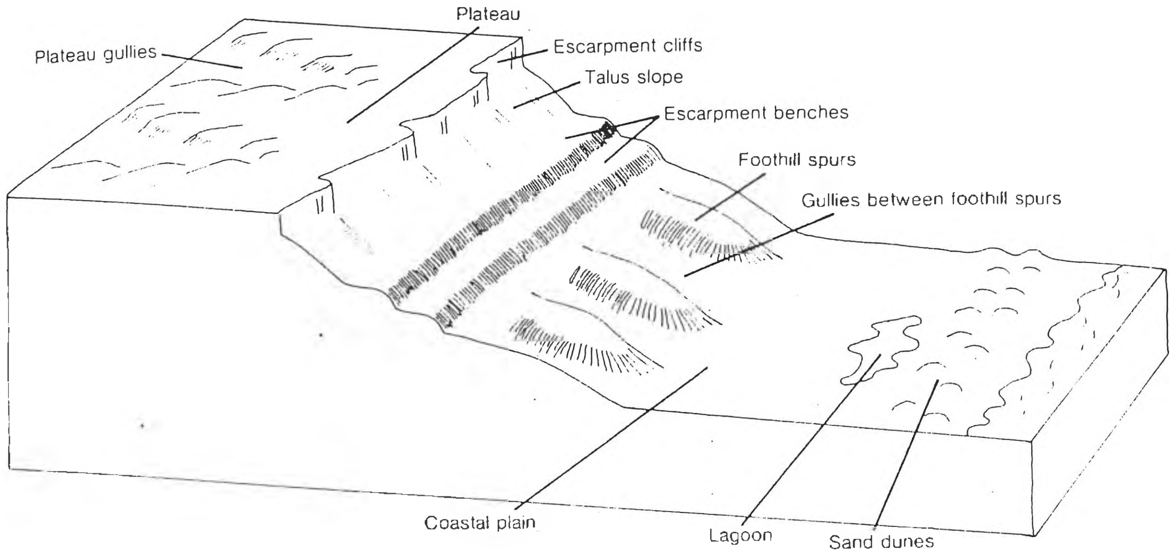

Figure 2.5 Relief drawing of main physical features of the Illawarra region

(Source: Fuller, 1980)

The landforms have significant relationships with climate, geology and vegetation. These have been interacting with each other and creating the landforms. Inversely, the landforms also influence these factors. This results in the difference of climate, geology and vegetation in relation to the landforms. Fuller (1980) and Fuller & Mills (1985) claimed that the landform is one of the most important factors to determine the distribution of native trees in the Illawarra region.

2.5.2 Climate

Edwards (1979) gave explanations of climates in NSW by classifying them into several zones. Much of the agricultural lands within the study areas would belong to Zone 9, which covers the whole area of the Illawarra region, upper Shoalhaven and coastal strip, including Kangaroo Valley, Berry, north of Nowra, Milton and Ulladulla. The zone has warm summers and mild winters, and the rainfall can be expected to be between 900 mm and 1400 mm per annum. The rainfall is generally higher in the warm season. The soil moisture in the zone is relatively high throughout the year (at least 80%), which is adequate for plant growth. Low temperatures in winter and lack of soil moisture in spring-summer will limit plant growth, but only to a minor extent. The western area of Shoalhaven LGA is included in Zone 4B. Most of the cleared lands in the zone are only in areas located south of Nowra and Sassafras. The climate in the zone has mild to cold winters and mild summers. The rainfall, which is higher in summer, ranges from 820 to 980 mm per annum. The rainfall is lower than that in Zone 9 but soil moisture is adequate for tree growth due to relatively low evaporation rates. The higher elevated areas experience very cold winters while the others have mild winters. Low temperatures in winter will greatly affect tree growth by slowing it down and limiting the varieties of species that that particular environment can support.

There is little detailed data on temperatures and precipitations in the study area, especially Shoalhaven LGA, because of few existing stations. However, there are a variety of different climate ranges within the areas. Temperatures are influenced by altitude and proximity to the coast (Mills & Jakeman, 1995), and precipitation is largely affected by the topography of the region and the prevailing mass movement of air (Edwards, 1979; Cox, 1983). As for the temperatures, lower altitudes, where most agricultural lands are located, would have adequate temperatures for tree growth throughout the year.

Frost is also an important factor that may limit the distribution of vegetation. Although frost is very common in inland areas and at higher altitude, it is rare in lower altitudes such as coastal plains (Mills & Jakeman, 1995).

There are some studies on precipitation over the Illawarra and upper Shoalhaven regions. The rainfall in these regions is relatively high compared with much of the area of New South Wales. Although the rainfall tends to be higher in autumn and lower in winter and spring, it is evenly distributed throughout the year (Cox, 1983; Mills & Jakeman, 1995). The availability of moisture in the air is determined by atmospheric conditions, and the distribution of precipitations is controlled by site and topography (Cox, 1983). In these regions, the escarpment plays an important role in the rainfall distribution. Warm, moist air from the sea is forced to rise at the escarpment and cooling with increasing altitude, it causes condensation and, subsequently, rain. In addition, proximity to the escarpment and the alignment of the escarpment vary the distribution of rainfall (Cox, 1983; Mills & Jakeman, 1995). The effects of the escarpment on weather patterns decrease with increasing distance from the coast (Mills & Jakeman, 1995). These effects can be seen in Figure 2.6. There is a high range of average annual rainfall within the regions, from just under 1000 mm per annum, in and around Lake Illawarra, Shoalhaven River and lower Kangaroo Valley, to over 1800 mm per annum at Barren Grounds (Fig, 2.6).

The distribution of some tree species is largely affected by this rainfall. Rainforest species are especially known to prefer higher rainfall. Mills & Jakeman (1995) defined the minimum average annual rainfall required by rainforest species as 1200 mm per annum.

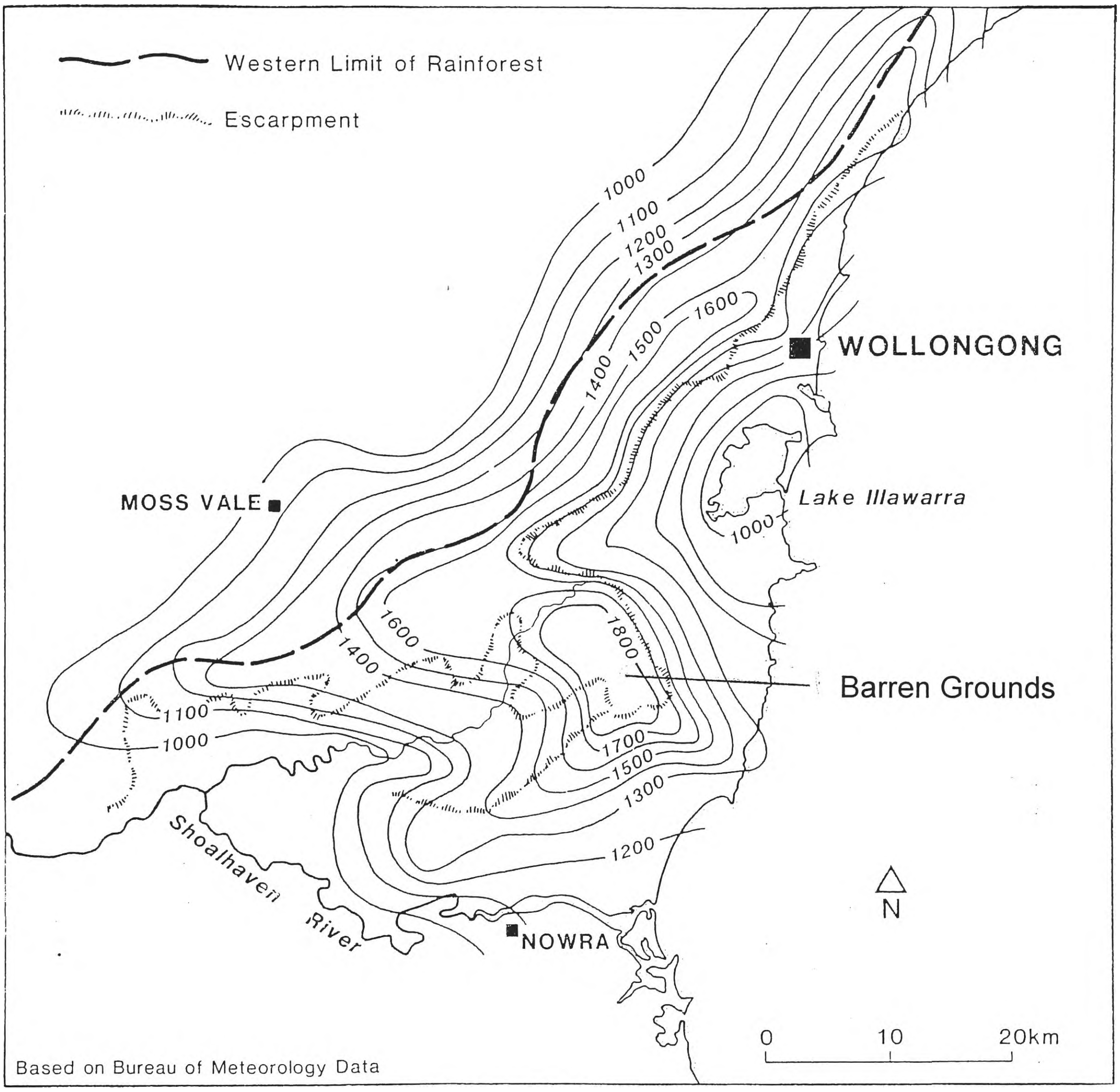

Figure 2.6 Average annual rainfall over the Illawarra distict

(Source: Mills & Jakeman, 1995)

Wind is another factor to contribute to the climate and suitability of conditions for forestry. Southerly and easterly winds bring moist airs, which maintain atmospheric humidity while westerly winds are relatively dry. The exposure to the westerly winds limits the growth of the moisture plant community and sometimes causes bushfires (Fuller, 1980; Fuller & Mills, 1985). The distribution of rainforest communities is restricted in gullies and sheltered areas such as between foothills, which are protected from the dry westerly winds (Fuller, 1980).

2.5.3 Geology & Soils

Because soils directly affect tree growth, the depth, texture and fertility of soils are important factors to predict the productivity of tree plantations. Private Forest Tasmania (2001) suggested that the minimum soil depth for commercial tree plantations is 65 centimetres, otherwise the depth restricts the root capability and water-holding capacity of the soil. Stony or sandy soils will also limit plant growth due to their poor water retention (Murphy et al., 2000). In low fertility soils, fertiliser will be necessary. Soil is generated through parent rock weathering, which means that geology influences the total amounts of clay, quartz and minerals in soils (Turner & Lambert, 1999). In addition, steepness of slope and freedom of drainage give a complexity to the soil in the form of variations in fertility, soil depth and texture (Mills & Jakeman, 1995). There are normally a number of soil types derived from any one geological unit. Table 2.4 shows the main soil types in the Illawarra and upper Shoalhaven regions. While only a few studies of soils have been done in the study areas, geological maps have been developed for the areas because of the interest in land resources such as mining.

Table 2.4 The main soil types in the Illawarra and Shoalhaven regions

Geology	Soil types	Dustribution	Prominent vegetation
Quaternary Sediments (Qa)	Red podzolics and red earths Siliceous sands and podzols Alluvium soils	Talus slopes Coastal dunes Major streams	Tall eucalupt forest, rainforest Closed scrub, woodland Forest, rainforest
Teriary Basalt (Tv)	Kraznozems		Rainforest, tall eucalypt forest
Hawkesbury Sandstone (Rh)	Lithosols (skeletal soils) Lateristic soils (serricrete) Yellow earths Acid peats (organic soils)		Heathland, woodland Heathland, woodland Open forest, woodland Closed sedgelands
Narrabeen Group (Rn)	Podzolics, brown earths, chernozems	Plateau gullies, upper escarpment	Rainfores, rall eucalypt forest
Illawarra Coal Measures (Pi)	Podzolics, brown earths	Escarpment slopes	Tall eucalupt forest, rainforest
Shoalhaven Group Volcanics (Psb)	Kraznozems	Coastal plain and foothills	Rainforest, tall eucalypt forest woodland
Shoalhaven Group Sediments (Psb, Psn)	Grey Podzolics, and soils similar to Rh above	Southern Illawarra, Kangaroo Valley	Forest, woodland, heathland

(Source: Mills & Jakeman, 1995)

In geological terms, the Illawarra and Shoalhaven regions are located in the southern half of the Sydney Basin. Triassic and Permian sedimentary outcrops dominate most of the regions. However, the geology of the study area varies greatly with sites (Fig. 2.7 & Table 2.5). As mentioned in section 2.3, cleared lands in the study areas are restricted to the Illawarra and upper Shoalhaven regions, and in and around Milton, Ulladulla and Sassafras. Therefore, only major geology and soil types of the cleared areas are discussed in the following section. However, it is necessary to have more detailed analysis on soils and geology in relation to individual sites.

- Volcanic (Tv, Mv, Psb and Duv on Figure 2.7)

  Large areas of volcanics called the Gerringong Volcanics are seen north of Lake Illawarra, and from south of Lake Illawarra to the north of Berry. There are also volcanics in and around Milton (Mezoic), and in the south west of Shoalhaven (Devonian volcanics), and scattered small areas of Tertiary Volcanic. Kraznozems, which are soils derived from volcanic rocks (Table 2.1), have high fertility and well-structured deep red loams or light clays, which provide for excellent tree growth and which are capable of supporting rainforests (Stace et al, 1968; Mills & Jakeman, 1995; Turner & Lambert, 1999).

- Alluvium (Qa on Figure 2.7)

  Quaternary alluvium is located on the coast and near rivers, which were built up from deposits of material in the wash from this higher ground. The alluvium occurs in the north of Wollongong, Jervis Bay, Ulladulla, around Lake Illawarra and Minnamurra River, and large areas in the Nowra region. This geology produces red podzolics and red earths, siliceous sands and podzols, as well as

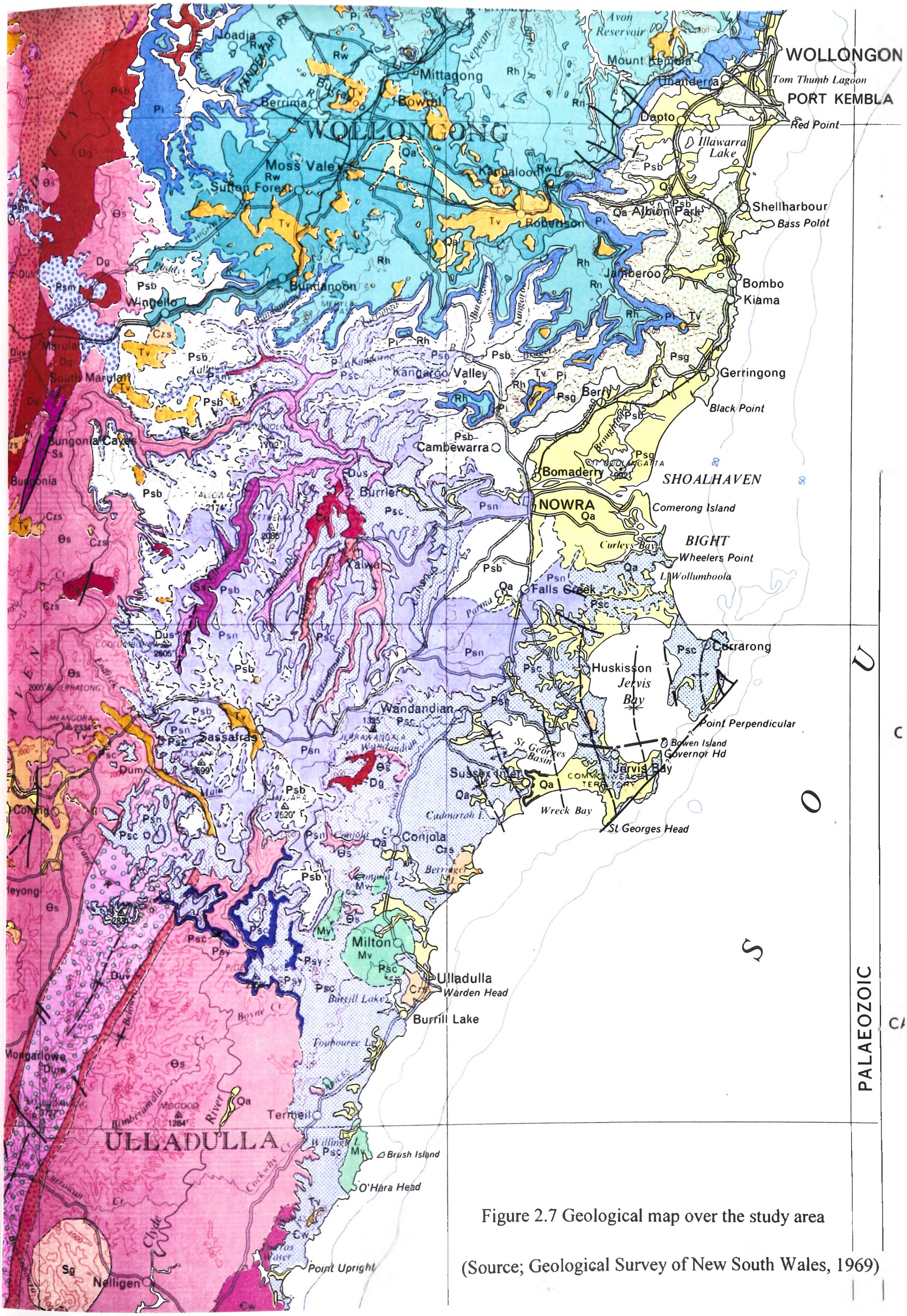

Figure 2.7 Geological map over the study area

(Source; Geological Survey of New South Wales, 1969)

Table 2.5 Codes for geological faromations in Figure 2.7

Code	Period	name	Contents
Qa (yellow)	Quaternary		Gravel, sand, silt and clay
Czs (blown)	(CAINOZOIC)		Poorly consolidated sandstone, conglomerate siltstone and "perched" alluvium
Tv (orange)	Tertiary		Basalt, dolerite, microsyenite, trachyte and tinguaite
Mv (green)	(MESOZOIC)		Microsyenite, teschenite, trachyte, phonolite, monzonite and essexite
Rw (green)	Triassic	Wianamatta Group	Sandstone and shale
Rh (green)	Triassic	Hawkesbury Sandstone	Quartz sandstone with some shale
Rn (light green)	Triassic	Narrabeen Group	Multi-coloured chert sandstone, quartzone sandstone, shale and claystone
Pi (blue)	Permian	Illawarra Coal Measures	Shale, sandstone, conglomerate, tuff, chert, coal and torbanite seams
Psg (light blue)	Permian	Gerrigong Volvanics	Latite, tuff, tuffaceous sandstone and sandstone
Psb (light blue)	Permian	Berry Formation	Siltstone, shale and sandstone
Psn (light blue)	Permian	Nowra Sandstone	Quartz sandstone
Psc (light blue)	Permian	Wandrawandian Siltstone	Siltstone, silty sandstone, sandstone and conglomerate
Psy (blue)	Permian	Pigeon House Ck. Siltsone and Clyde C.M.	Conglomerate, sandstone, shale and coal
Cg (red)	(CARBONIFEROUS)		Granite and granodiorite
Duv (light red)	Devonian	Bindock Porphyry and Comerong Volcanics	Porphyry, dacite, tuff, basalt and siltstone
Dum (light purple)	Devonian	Merrimbula Fm.	Sandstone, quartzite, conglomerate, siltstone and claystone
Dus (light purple)	Devonian	Undifferentiated	Sandstone, conglomerate, siltstone and claystone
Dg (red)	Devonian		Granite, tonalite and granodiorite
Ss (purple)	Silrian	Undifferentiated	Sediments, volcanics and limestone
Qs (pink)	Ordovician	Undifferentiated	Grey slate, quartz rich and feldspathic greywacke and andesite

(Source: Geological Survey of NSW, 1967) alluvial soils (Table 2.4). However, soils on the cleared lands would be siliceous, podzols or alluvial soils. The siliceous sands occur on the coast, which will not support tree plantations because of the poor water-holding capacity and effects from the ocean. The podzols are formed on coastal dunes, which are acidic sandy soils with differentiated profiles. The fertility of the soils is relatively poor, and some nutrients are deficient. However, the soil would support sclerophyll woodland to forests (Stace et al., 1968). The alluvium soils are quite variable in fertility, depth and texture of the soil, depending on the sites. However, the alluvium soils are fertile in the Illawarra region because of the deposits of the volcanic material (Gerringong Volcanics) (Fuller & Mills, 1985). Acid sulphate soils, especially near the mouth of Shoalhaven River could not support tree growth due to the strong acidity (Young, 1982; Shoalhaven SoE, 1999/2000).

- Sediments
  - Hawkesbury Sandstone (Rh on Figure 2.7)

The Hawkesbury Sandstone covers much of the plateau and cliff lines in the Illawarra and Kangaroo Valley. This is quartzose sandstone with interbeds of laminite, siltstone and claystone (Moffitt, 2000). Soils derived from the sandstone are lithosols, lateritic soils, yellow earths and acid peats (Table 2.4). These soils are usually shallow, acidic and sandy, and tend to be infertile (Stace et al., 1986; Fuller, 1980; Young, 1982; Turner & Lambert, 1999). However, only yellow earths, which have high sandy clay loam to sandy loam, and are of considerable depths, would support tree plantations with some soil operations, such as fertilisation (Stace et al., 1986).

- Narrabeen Group & Illawarra Coal Measures (Pi on Figure 2.7)

The Narrabeen Group and Illawarra Coal Measures dominate much of the escarpment in the Illawarra region and upper Shoalhaven. These are the terrestrial sedimentary rocks and overly marine Shoalhaven Group. The Illawarra Coal Measures in the Illawarra region sometimes consist of volcanic sandstone and claystone derived from Gerringong Volcanics (Moffitt, 2000). This type of geological formation produces podzolics, brown earths and chernozems (Table 2.4). Benches on the escarpment are formed in the geology due to differences in erosion resistance of rock strata (Fuller & Mills, 1985). The benches have moist and quite deep clayey soils as well as sheltered conditions, which support the development of rainforest and wet tall sclerophyll forest (Fuller, 1980; Fuller & Mills, 1985).

- Shoalhaven Group Sediments (Psb, Psn and Psc on Figure 2.7)

Shoalhaven Group Sediments are seen west of Lake Illawarra and north to southeast of Shoalhaven Shire in large areas. The sediments in the Group were deposited in a marine environment, and contain a wide variety of shallow marine and shore-line sedimentary rocks (Snedden, 1982; Turner & Lambert, 1999). The sediments produce low to moderate fertile soils, which are often sandy loams overlying brown pedal clay subsoils (Turner and Lambert, 1999). Berry Formation produces red, yellow and grey podzolic soils (Young, 1982). Tree plantations in these soils are possible, however, fertilisers would be necessary in areas where the soils are infertile. The soils derived from Nowra Sandstone are similar to those from the Hawkesbury Sandstone (Young, 1982; Mills & Jakeman, 1995).

There are some species that prefer specific types of soils. For example, Forest red gum (*Eucalyptus tereticornis*) is known to prefer poor drainage alluvium soils (Boland et al, 1984). Natural rainforest species occur on soils originated from volcanic rocks (Fuller, 1980; Fuller & Mills, 1984). However, in general, most soils will support tree plantations, but matching of species and additional soil preparation such as fertiliser and mounding would be necessary in some places for tree plantations to be effectively established.

2.6 Conclusions

Agriculture is the main rural industry in the Illawarra and Shoalhaven regions. Cleared area and agricultural area are not consistent because forests of significant area still remain on the agricultural lands. When it comes to estimating potential area for farm forestry, it is important to investigate the extent of the area of cleared agricultural lands.

The agricultural lands in the Illawarra and Shoalhaven regions have adequate climates and geology to support tree growth. It is suggested that many agricultural lands are suitable for tree plantations. In actual fact, agricultural lands are established on good agriculturally productive sties. On the other hand, the climates, geology and topography vary the land capability within the lands greatly. This means that potential tree species for the plantations differ in relation to the land capability. Plantation sites for rainforest species especially, would be greatly limited.

There is much legislation in place at this time, which could effectively regulate farm forestry. The main legislation within Kiama, Shellharbour and Shoalhaven LGAs is the PR Act while that within Wollongong LGA is the LEP (the

EPA Act). These affect farm forestry differently with the location and size of the plantation to be established. Many potential sites for farm forestry within Kiama, Shellharbour and Shoalhaven LGAs would be exempt from regulations under the PR Act due to the relatively small size of their properties. Farm forestry within Wollongong LGA would be allowed in many agricultural lands with development consent from the Council. Obtaining development consent for farm forestry in these areas should not be exceedingly difficult. It has been suggested that the PR Act would give advantages to farm forestry in the study areas, and Wollongong LEP would work farm forestry in a way that is both economically and environmentally positive.

There are some problems associated with the legislation. There are many other pieces of legislation that relates to farm forestry besides the PR Act and the LEPs. One of the problems is the complexity of the relationship between each piece of legislation. An applicant categorised as EFF has many exemptions from regulations under the PR Act, however, they would need to understand these relationships, otherwise, they may be required to meet the regulations under the PR Act. Another problem is lack of knowledge about the legislation at the local government level. LEPs zone lands are dedicated or reserved under some of the pieces of legislation. However, none of the councils in the area of this study have considered farm forestry in their LEPs. This might explain why farm forestry has not yet been widely adopted in the Illawarra and Shoalhaven regions, and not even been seriously considered by the farmers and Councils of the areas that this study is concerned with.

Criteria for evaluating potential sites for farm forestry include :(1) sites which have already been cleared; (2) sites that belong to private landholders; (3) sites which are in areas where tree plantation is allowed by legislation; and (4) sites that are suitable for tree plantations according to environmental factors, such as climate, soil and geology, and topography. The environmental factors also need to be considered when choosing suitable species for the site because they provide a variation in the land capability for the tree plantations.

Chapter 3 Choosing Trees

3.1 Introduction

As discussed in Chapter 1, selection of the species is one of the critical issues to design tree plantations in a farm. Environmental outcomes, such as control of salinity and increase in biodiversity, would be varied greatly by selection of species. Moreover, selection of species influences economic outcomes according to growth rate and performance of the species, value of the timber product and the end use of the timber product. It is important to consider land capability as well as selection of species because environmental outcomes and growth rate and performance of the species would vary between regions. Considerations of suitable species for plantations at local level are essential. Therefore, in designing a farm forestry, it is necessary to understand the characteristics of species, and discuss the matching of species and objectives of landowners, considering the land capability.

In this study, local native species in the Illawarra and Shoalhaven regions are considered. Selection of commercially local native species results in significant environmental benefits as well as economic outcomes. In addition, there is a high potential in local native species for demonstrating good growth and performance in the region because of their natural habitats in the region. This chapter is aimed to examine the potential of local native species in the Illawarra and Shoalhaven regions for commercial plantations.

The criteria for species selection are as follows:

- Local Native Trees

In the study area, there exists a wide range of local native species just as there is a wide range of variations in the environment. There is no study on the local native species that have a potential for commercial tree plantations.

- Value

  Value of timber differs significantly with the tree species and the end use of the timber products. Investigation of the strength, durability and appearance of each species is important because the end use of the timber products is determined by these factors (AFFA, 1999). The highest valued timber for special furniture and cabinet wood could be sold in small volume. On the other hand, low valued timber for firewood and pulp could be difficult to sell in small volumes.

- Fast-growing and good performance trees

  Fast-growing trees may generate a quick return if the suitable species is selected. Trees with vertically straight performance would produce a suitable shape for timber.

- High quality and recovery of timber

  Warped shapes and cracks in the timber would reduce its value and limit its uses. Tolerance of a particular species to disease needs to be considered because disease could reduce the value of timber by changing its colour or holing the timber. Some tree species have a relatively high tolerance to disease. Although some defects are prized and add value to the sawn product, normally, defects of the timber are removed. The defects would differ between species and their size. Species of higher recovery (which means the timber of that species has fewer defects) would be more productive.

- Secondary Products

Secondary products are produced before and at the final stage of harvesting from thinning operations. They can generate some additional income for the plantation owner. Secondary products can include posts and poles, firewood and seeds.

It is important to examine the potential aspects of commercial local native species in terms of all these criteria. However, information about many of these criteria is seriously limited. This study investigates the potential of all local native species existing in the Illawarra and Shoalhaven regions in timber production as well as the potential of end uses of their timber products. Also, available market prices and research on growth rate and performance of some local native species are discussed.

3.2 Local native trees

Lists of local native species including non-rainforest and rainforest species in the Illawarra region were compiled from "Wollongong's Native Trees" (Fuller, 1980) and "Native Trees of Central Illawarra" (Fuller and Mills, 1985). As for the Shoalhaven region, the species were identified by asking Dr. Kevin Mills, who has been working in the region. Timber uses and the characteristics of the species were investigated, based on several books. The texts consulted for the purpose of this study were, "The Tree of New South Wales (4th Ed.)" (Anderson, 1967); "The Hardwoods of Australia and Their Economics" (Baker, 1983); "Wood in Australia" (Bootle, 1983); "Forest Trees of Australia (4th Ed.)" (Boland et al., 1984); and "Rainforest Trees of Mainland South-Eastern Australia" (Floyd, 1989).

Table 3.1 shows the local native species and their timber uses as well as characteristics of the timber. The timber uses were categorised under "construction

Explanation of categories in Table 3.1

Durable class
1- Very Durable – pole untreated 25-50 years in ground, >50 in outdoor above ground
2- Durable – pole untreated 15-25 years in ground
3- Moderately Durable – pole untreated 8-15 years in ground
4- Non Durable – pole untreated 1-8years in ground, 1-8 untreated outdoor

Strength & Stress (12%moisture)
SD1 High – SD8 Low (seasoned timber)

Strength & Stress (Green)
S1 High – S8 Low (seasoned timber)

Construction Uses
B=building frame timber, Br=bridge, C=cladding, Ca=crossarms, D=exterior decking, E=structural engineering, F=internal flooring, G=general building, Gr=Girders/beams, H=heavy construction, J=jetty piles/marine construction, L=light construction, M=mine timber, P=fencing/posts/poles, Pv=paving, S=sleepers, Sr=slabs/boards, W=weather boards

Other Uses
A=aircraft, Al=artificial limbs, B=bench tops, Be=bearings, Bl=wood blocks, Bs=brush stocks, Bw=bent work, C=craftwood/turnery, Ca=cases, Cb=coach/railway building, Cg,=carriage/waggon, Co=wooden cogs, Cr=carving/engraving, Cs=corestocks, Cw=cabinet work, F=furniture, Fr=fishing rods, Ft=fittings, G=golf/crequet heads/mallets, H=tool handles, Hb=hardboard, I=inlays/marquetry, It=interior/decoration trims, J=intorior joinery, Ku=kitchen utensils, L=lining, La=lattice, M=mouldings, Md=models, Mu=musical instruments, O=racing oars, P=panelling, Pl=plywood, R=roof shingles, Rc=rulers, S=boat building, Sc=wooden screws, Sp=spokes, St=staves, T=tanning bark, Te=template, Tr=tennis racquets, Ts=T-squares, Ty=toys, V=veneers, Va=vats, Vi=Violin backs, W=window frames, Wc=wine casks, Wr=wheel,shipwrights, Ww=woodwear, Y=yokes, Z=stair treads

Firewood / Pulp
F=firewood, P=pulp for paper making

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Mills, K. species lists in Shoalhaven

Table 3.1 Timber uses and timber characteristics of local native species in the study area

	species	subname	forest type	colour (heartwood)	Durable	Strength	Strength	Density	construction uses	Other uses	Fire/pulp	comments
S	*Abrophyllum ornans*	Native hydrangea		pale brown						C		
C	*Acacia binervata*	Two-veined hickory		dark brown						Cb,Cg,H		
S	*Acacia binervia*	Coast myall		dirty pink								seldom used, knotty
S	*Acacia elata*	Cedar wattle		pale						Ca		one of the most ornamental of the wattles
S	*Acacia falciformis*	Hickory wattle										minor use
I,S	*Acacia implexa*	Hickory		dark brown	2	SD5	S4	800		Be,Bl,C,Cb,Cg,Cw,F,H		good resistance to shock
S	*Acacia irrorata*	Green wattle				SD3	S3	800				
I,S	*Acacia maidenii*	Maidens wattle		pale						Cg,Cw,F,W		
S	*Acacia mearnsii*	Black wattle		pale to light brown		SD4	S4	800				inferior timber, valuable tanning barks
C	*Acacia melanoxylon*	Blackwood		brown	3			640	F	Bw,C,Cb,Cr,Cw,F,Ft,I,J,P,S,St,V,Vi		one of the mose decorative timbers, fast growing?
I,S	*Acmena smithii*	Lilly pilly	R	brown orgreyish brown	3	SD6	S5	700	F,G	J,W		borers
C	*Acronychia oblongiforia*	Common acronychia	eR	creamy white						C,Cv,H		
S	*Actephila lindleyi*	Actephila	R	yellowish brown						C		
S	*Alectryon subcinereus*	Native quince	R	pale brown						C,H		
C	*Alphitonia excelsa*	Red ash	R	bright orange or red	3	SD3	S3	740	G,F	C,Ca,Cb,Cg,Cw,F,H,J,L,P,V		
S	*Angophora bakeri*	Narrow-leaved apple		pale					G	Cw		
W	*Angophora costata*	Smooth-barked apple		light pinkish brown	3	SD3	S3	800	B,F,P			borers
I,S	*Angophora floribunda*	Rough barked apple		light brown	3	SD5	S4	800	C,F,P	P,Sp		borers
C	*Backhousia myrtigoria*	Ironwood	eR	pinkish grey		SD2	S1	1020	Gr	C,Cg,Fr,G,H,Sc		
C	*Baloghia lucida / inophyila*	Brush bloodwood	R	brown				650-850	F,G	C,Cb,Cg,Wr		
C	*Banksia integrifolia*	Coast banksia		pinkish to red		SD7	S7	530		C,Cw,P,S,V		
C	*Banksia serrata*	Old man Banksia		red		SD7	S7	720		S,Ww		borers
C	*Brachychiton acerifolius*	Flame tree	R	white	4	SD8	S7	400		Bl,Ca,Cs,Md,Pl,Ty		borers
C	*Brachychiton populneus*	Kurrajong	R	creamy				450		F,La		too valuable, useless
C	*Callicoma serratifolia*	Callicoma		pinkish brown		SD6	S6	560		C		borers
C	*Callistemon salignus*	Pink tips		reddish					P			
I	*Callitris muelleri*	Native cypress										no particular use
S	*Callitris rhomboidea*	Native Cypress		brown				680	B,F,P	P		
I,S	*Canthium coprosmoides*	Coast canthium	R	pale yellow						C,Cg,Cw,P		too small
I,S	*Cassine Australis*	Bed-fruited olive-plum	R	pinkish						H		
C	*Casuarina cunninghamiana*	River oak		darkreddish or purplish brown	2	SD4	S3	900	P	C,Cr,F,H,R,Y,Ww		
I,S	*Casuarina glauca*	Swamp oak		brownish				980	F,J,P	C,Cg,Cw,H,R,Y		
C	*Casuarina littoralis*	Black she-oak		reddish						R		
C	*Casuarina torulosa*	Forest oak		dark	2	SD2	S2	960	F	C,Cg,Cw,P,R,Ru,V,Ww,Y		
I	*Celtis paniculata*		R	white						Ca		
C	*Ceratopetalum apetalum*	Coachwood	R	pinkish brown to light brown	not external	SD4	S5	630-690	F	C,Ca,Cb,Cr,Cw,F,H,J,Pl,L,Tr,V		
S	*Ceratopetalum gummiferam*	NSW Christmas bush										
I,S	*Cinnamomum oliveri*	Oliver's sassafras	R	greyinsh yellow or pale brown	not external	SD5	S5	560-660		Cw,J,L,Pl		fragrant
C	*Citronella moorei*	Churnwood	R	pale grey	not external	SD4	S4	650-800		C,F,H,M,V		Scarce, irregular shape
S	*Claoxylon australe*	Brittlewood	R	yellow						Cw		no particular use
S	*Clerodendrum tomentosum*	Hairy clorodendrum	R	yellow								no particular use, too small
S	*Commersonia fraseri*	Brush Kurrajong	R	white								no particular use, too small
C	*Croton verreauxii*	Native cascarilla	R	yellowish brown						F		too small
C	*Cryptocarya glaucescens*	Native laurel	R	pale brown	not external	SD4	S5	630	F	C,Ca,Cg,Cr,Cw,F,J,P,Pl		Scarce
C	*Cryptocarya microneura*	Murrogun	R	pale								too small
I	*Daphnandra micrantha*	Socketwood	R	yellow grey ot brown	not external	SD5	S5	700		C,Ca,Cw,H,J,Pl,V		Rare
C	*Dendrocnide excelsa*	Giant stringing tree	R	brown								no particular use
C	*Diospyros australis*	Black plum	R	grey				700	F	C,Ca,G,I		
C	*Diospyros pentamera*	Myrtle ebony	R	grey				700	F	C,Ca,Cg,F,G,I		
C	*Diploglottis australis*	Native tamarind	R	pale				900	F	Ca		fruit-jam-making,borers
C	*Doryphora sassafras*	Sassafras	R	yellow	not external	SD5	S5	550-600	F	C,Cw,H,J,L,M,Pl,V		resistant to termite attack
C	*Duboisia myoporoides*	Corkwood	R	pale yellow or white		SD8	S7	450		Cr,Cw		too small
C	*Ehretia acuminata*	Koda	R	light brown						Cw,F,L		
C	*Elaeocarpus kirtonii*	Pigeonberry ash	R	Pale brown				400-550	F	A,F,It,L,O		1st-class bending timber
I,S	*Elaeocarpus reticulatus*	Blueberry ash	R	creamy white						C,I		borers
C	*Emmenosperma alphitonioides*	Bonewood	R	pale yellow to golden brown	3	SD3	S3	850-900	F,G	C,H,J,P,S		G-bending seldom milled
C	*Endiandra sieberi*	Corkwood	R	light				750-800	F	Cw,H,L		
C	*Eucalyprus amplifolia*	Cabbage gum		red					P			inferior
S	*Eucalyptus agglomerata*	Blue-leaved stringybark		light brown	2	SD3	S2	930	B,F,G,P			
I,W	*Eucalyptus bosistoana*	Coast grey box		light brown	1	SD1	S1	1100	Br,Ca,Gr,H,P,S	Cg		borers
C	*Eucalyptus botryoides*	Bangalay		deep pink to red	2 to 3	SD3	S2	930	B,F,G,H,S			
S	*Eucalyptus capitellata*	Brown stringybark		pale brown	3	SD3	S3	800-950	B,G,P,S	Cg,Cw		
S	*Eucalyptus consideniana*	Yertchunk		light brown	3	SD3	S3	935	B,D,F,G,P,S	Cb,Cg,S,Wc,Wr	F	borers
I,S	*Eucalyptus cypellocarpa*	Mountain grey gum	TOF	pale brown	3	SD2	S3	960	Br,E,F,G,J,P	F,J,P,V	F	attractive appearance
C	*Eucalyptus elata*	River peppermint		pale brown	3	SD4	S4		B,L	J		
C	*Eucalyptus eugenioides*	Thin leaved stringybark		light brown	2 to 3	SD3	S3	900	B,E,G,P,S	Cr,s		
I,S	*Eucalyptus fastigata*	Brown barrel		light brown	not external	SD4	S4	800	E,F,G,J,W	Ca,Cb,F,Pl		common timber
C	*Eucalyptus globoidea*	White stringybark		light brown	2 to 3	SD3	S3	900	B,G,P,Pv,S			
C	*Eucalyptus gummifera*	Red bloodwood	DSF	pink to deep red	1	SD3	S3	865	M,P,S	P,Hb		
C	*Eucalyptus longifolia*	Woollybutt		red	2	SD3	S2	1060	B,G,P,S	Cg,Cw		common timber
C	*Corymbia maculata*	Spotted gum		dark brown	2 to 3	SD2	S2	970	F,G,H,M,P	Bw,F,H,O,Pl,S,Sp,Wr		most suitable for tool handles and poles
S	*Eucalyptus moluccana*	Grey box		light brown	1	SD2	S2	1100	Br,Ca,H,J,P,Pv,S	Bl,Co,S,Sc		resistant to temite, borers
C	*Eucalyptus muelleriana*	Yellow stringybark	TWSF	yellow brown	2	SD3	S3	860	B,Br,Ca,F,G,J,P,S	Bl,Cg,S		common timber
I	*Eucalyptus obliqua*	Messmate stringybark		pale brown	3	SD3	S3	830	G,F,S	Cw,F,Ft,J,P		

C	*Eucalyptus paniculata*	Grey ironbark		dark brown	1	SD1	S1	1120	Ca,D,F,G,H,P,S	Cg,S,Sp		
C	*Eucalyptus pilularis*	Blackbutt		light brown or yellowish brown	2	SD2	S2	900	B,F,G,P,S	Cg,S,Wr	F	borers, major timber for building and structure
W,I	*Eucalyptus piperita*	Sydney peppermint		pale					D,G	Cg,Cw,F		poor quality, essential oil
S	*Eucalyptus punctata*	Grey gum		pale red to red	1	SD2	S1	1070	G,H,P,S			quality is similar to ironbark
C	*Eucalyptus quadrangulata*	White topped box		pale yellow	1 to 2	SD2	S2	1020	C,F,H,P,S			common timber
W,I	*Eucalyptus racemosa/haemastoma*	Scribbly gum/Snappy gum		pale pinkish brown	3	SD5	S4	930				high shrinkage
I	*Eucalyptus radiata*	Narrow leaved peppermint		light brown	3	SD4	S4	720	G			
S	*Eucalyptus resinifera*	Red mahogany		dark red	2	SD3	S2	950	C,F,G,P,S	Cw,F,P		borers
C	*Eucalyptus robusta*	Swamp mahogany		red	2	SD4	S3	800	Br,Cw,G,J,P	Bl,Cg,S		
W,I	*Eucalyptus saligna*	Sydney blue gum		dark pink or red brown	3	SD3	S3	900	C,F,G,S	Cb,Cg,Cw,F,,S,P,Pl,Wr		common timber
C	*Eucalyptus saligna/botryoides*											
C	*Eucalyptus sieberi*	Silvertop ash		light brown	3	SD3	S3	830	B,Br,E,F,G,J,P,S	Ca,Cb,Cg,H,Pl	P	woodchip, borers
C	*Eucalyptus smithii*	Gully gum		pale					Br,G	Cb,Cg		borers
C	*Eucalyptus tereticornis*	Forest red gum		red	2	SD3	S3	1100	Br,H,J,P,S	Be,Bl,Cg,F,S		borers
C	*Eucryphia moorei*	Plumwood	R	pinkish brown		SD8	S7	750-800		C,Cw,H		most favoured for brake blocks on waggons
C	*Eupomatia laurina*	Bolwarra	R	yellow								too small
C	*Euroschinus falcata*	Ribbonwood	R	pinkish grey	not external	SD7	S7	450		Cs,F,J,Pl		Rare
C	*Exocarpos cupressiformis*	Native cherry		reddish brown						C,Cr,Cw,G,I,J		
C	*Ficus coronata*	Sandpaper fig	R	yellow								
C	*Ficus macrophylla*	Moreton Bay fig	R	pale brown						Ca		
C	*Ficus obliqua*	Small-leaved fig	R	light						Ca		
C	*Ficus rubiginosa*	Port Jackson fig	R	pale				580		Ca,Ty		borers
C	*Ficus superba*	Deciduous fig	R	pale				580		Ca,Ty		borers
I,W	*Geijera salicifolia*	Brush wilga	R	light brown	2	SD3	S2	1000	Br,H,J	Bl,Cg,Cw,Fr,		borers
S	*Glochidion ferdinandi var. pubens*	Hairy cheesetree	R	grey				650-750		Ca		too small
C	*Glochidion ferdinandi var.ferdinandi*	Cheesetree	R	grey				650-750		Ca		too small
I,S	*Gmelina leichhardtii*	White beech	R	light grey		SD6	S6	550	F	C,R,Cr,Cw,F,J,S,Te		limited in this area, valuable all-round timber
C	*Guioa semiglauca*	Guioa	R	pinkish						H		too small
S	*Hakea eriantha*	Tree hakea	R	pale						H		
C	*Hedycarya angustifolia*	Native Mulberry	R	white						Ca		too small
W,I	*Hibiscus heterophyllus*	Native hibiscuss	R	white to pale yellow						Mu		
C	*Litsea reticulata*	Bolly gum	R	pale brown	3	SD7	S7	400-550		C,Ca,Cr,F,J,Pl,S		borers
C	*Melaleuca linariifolia*	Narrow-leaved paperbark		dark brown						Cw,V		
C	*Melaleuca styphelioides*	Prickly leaved paperbark		reddish brown					Br,G	Cb,Cg,Cw		very durable in water
C	*Melia azedarach*	White cedar	R	pale brown	not exyernal	SD8	S7	400-500		Cw,J,P,V		
C	*Myoporum acuminatum*	Boobialla	R	yellow								
W	*Neolitsea dealbata*		R	light brown								too small
C	*Notelaea longifolia*	Native olive	R	pale yellow						C,H		too small
C	*Notelaea venosa*	Native olive	R									too small
S	*Olearia argophylla*	Musk daisy-bush	R	pale yellow or light brown						Cw,V		too small
C	*Pararchidendron pruinosum* (*Abarema sap*	Snow wood	R	brown								
C	*Pennantia cunninghamii*	Brown beech	R							Cw,H		
C	*Pisonia umbellifera*	Birdlime tree	R	pale								no particular use
C	*Pittosporum undulatum*	Pittosporum	R	pale yellow		SD4	S4	850		Al,C,Cr,G,I,Ku,Sc		
C	*Planchonella australis*	Black apple	R	yellow		SD3	S3	1000		Al,Be,C,Cr,Fr,I,Ru,T,Ts		one of the best carving wood
C	*Podocarpus elatus*	Plum pine	R	pale brown or blown	2	SD7	S6	600	J	C,Cr,F,J,Ku,L,Mu,Pl,S		scarce, valuable softwood
C	*Polyosma cunninghamii*	Featherwood	R	pale								no particular use
C	*Polyscias elegans*	Celery wood	R	pale brown	not external	SD8	S7	480		Ca,I,J,Md,O,V,Vi		borers
C	*Polyscias murrayi*	Pencil cedar	R	pale	not external	SD8	S7	400		Ca,J,Md,V		borers
S	*Pomaderris aspera*	Rough hazel	R					740				too small
S	*Prostanthera lasianthos*	Mint bush	R									no particular use
C	*Quintinia sieberi*	Possumwood	R	pale brown or pink		SD6	S6	580		C,Cr		no particular use, borers, fungal attack
C	*Rapanea howittiana*	Brush muttonwood	R	creamy brown						Cw,F,H		
C	*Rapanea variabilis*	Mottonwood	R	pink						H		seldom milled
C	*Rhodaminia rubescens*	Scrub turpentine/ stringybark	R	yellowish brown						C,F		
C	*Sarcomelicope simplicifolia*	Yellow-wood	R	yellow						G,H		
C	*Schizomeria ovata*	Crab apple	R	light grey or brown	not external	SD5	S5	650		Bs,C,Ca,Cw,F,J,L,Pl,Va,Wc		borers
C	*Scolopia braunii*	Flintwood	R	pinkish						C,Cg,G,H		one of the best of the brush timber
C	*Sloanea australis*	Maiden's blush	R	rose or light brown	not external	SD6	S5	550-600		C,Ca,Cw,It,J,L,Pl		seldom available
C	*Stenocarpus salignus*	Scrub beefwood	R	dark red	not external	SD3	S3	850		F,It,J,P,Pl,Ww		
C	*Streblus brunonianus*	Whaledone tree	R	light brown						H,G		small size
C	*Symplocos thwaitesii*	Buff hazelwood	R	white or yellowish					F	C,Cr,Cw,F,J,L,P		
C	*Syncarpia glomulifera*	Turpentine		red to rish red brown	1	SD3	S3	900	B,Br,G,Gr,J,P,S	P,S		resistant to decay,termites,fire and marine organisms
C	*Synoum glandulosum*	Bastard rosewood/Scentless ros	R	reddish brown		SD6	S6	700	F	Bs,C,Ca,Cr,Cw,J		small size, borers
C	*Syzygium australe*	Brush cherry	R	greyish				730		H		small
W	*Syzygium oleosum*		R	greyish brown				850		Ca,H		too small
C	*Toona ciliata*	Red cedar	R	pink to rish red brown	2	SD8	S7	425-550		C,Cr,Cw,F,J,P,S,V		most-favoured, valued
C	*Tristania collina /Tristaniopsis*	Hill Kanuka	R,E	pinkish grey to red				900-960		Cw,G,H,S		
C	*Tristania laurina /Tristaniopsis*	Water gum	R	pinkish grey to red	3	SD3	S2		F	C,Cb,Cg,Cr,Cw,G,H,P,S,Sc,Sp		borers
W,I	*Trochocarpa laurina*	tree-heath	R	brown to pink						A,C,G,H		
C	*Wilkiea huegeliana*	Common wilkiea/Veiny wilkiea	R	brownish						C		

(W: species seen only in Wollongong area, I: species seen only in Shellharbour and Kiama areas, S: species seen only in Shoalhaven area, C: species seen over the study area)
(R: rainforest species)

uses" and "other uses", and the characteristics of the timber investigated in regard to the colour of heartwood, durability, strength, stress, and density. Some species have a distribution limit within the study areas. The distribution of species was described by each LGA in the study areas. Other specific information on species including resistance to borers and scarcity of the timber was also collected. The species that were not mentioned in the texts listed above were classified as having no timber uses, and these species were excluded from the lists.

A total 146 species of local native species have some information about their timber uses in these books. This shows that there is a wide variety of potential for local native tree species to be used for forest products in the study area. It is interesting to note that the timber uses of eucalypts are mainly for construction purposes while those of rainforest species are typically for non-construction use purposes such as furniture, cabinetwork and craft wood. This would be due to the timber characteristics of eucalypts, which have high density, strength and durability. However, many eucalypts could be used for other purposes as well. Appearance of timber, such as colour and its design is important in internal uses such as furniture, cabinetwork, craft wood and flooring. Spotted Gum (*Corymbia maculata*) and Blackbutt (*Eucalyptus pilularis*) are common furniture species (Timber Development Association, date unknown). Red colour timber is especially preferred for internal uses.

3.3 Valuable trees

The value of timber varies greatly with tree species, and is relative to the quality of the timber as well as the popularity and the availability of that species in the market. Market analysis on timber of local native species, especially eucalypts and rainforest species, was conducted via the Internet and by asking State Forests, as well as by surveying timber organizations and companies.

3.3.1 Eucalypts

Timber values of some kinds of eucalypts are available from Comprehensive Regional Assessments (CRAs) on forest wood resources in North East and Southern NSW (AFFA and BRS, 1999; BRS and State Forests of NSW, 1999). The CRAs were prepared for Regional Forest Agreements (RFAs) by the State and Commonwealth. CRAs on forest wood resources collated information on timber supply, forest harvesting, the hardwood resources, and their management. Some regions in this study, such as a part of Kiama LGA and the entire Shoalhaven LGA, were included in the analysis of the Southern CRA. In the CRAs, The Species Group and Market Value Potential are given to the timber of some tree species (mainly eucalypts, *Angophora* species and Turpentine (*Syncarpia glomulifera*)). The Species Group presents a relative value of individual species to the sawmill. Each species is categorised into 5 groups, which are "High Value"; "Medium to High Value"; "Medium Value"; "Low Value"; and "Coastal Redwood". The timber of "Coastal Redwood" species is identified as a suitable package for furniture. Market Value Potentials are derived from the Hardwood Log Value Pricing (LVP) system (refer the North East CRA). "The Market Value Potential is an estimation of the relative potential value of each species/size group. It is estimated by assessing the strength, durability and appearance qualities of the net wood component (i.e. free of estimated defect) for each species/size class" (AFFA and BRS, 1999). Many of the local native trees in the study areas are also common in other places that have a similar climate especially on the east coast of NSW. Actually, many of the valued species by the CRAs exist in the study areas.

Table 3.2 shows the local native species in the study areas that are valued in the CRAs. Market Value Potentials vary greatly between species and their sizes. In the Species Group, “High Values” are given to Grey Ironbark (*Eucalyptus paniculata*), Coastal Grey Box (*E. bosistoana*), Blackbutt (*E. pilularis*), Spotted Gum (*Corymbia maculata*), Blue Leaved Stringybark (*E. agglomerata*), White Stringybark (*E. globoidea*), Yellow Stringybark (*E. muelleriana*). and Turpentine. “Coastal Redwoods” are given to Bangalay (*E. botryoides*), Red Mahogany (*E. resinifera*), Sydney Blue Gum (*E. saligna*), Forest Red Gum (*E. tereticornis*) and Wollybutt (*E.longifolia*).

In the CRAs, Blackbutt, Spotted Gum, Sydney Blue gum, White Stringybark, Yellow Stringybark, Turpentine, Brown Barrel (*E. fastigata*), and Silvertop Ash (*E. seiberi*) are regarded as major timber species while other species are categorised as minor timber species. Major timber species have high strength and durability and are mainly utilised for high demand-structural and construction uses. Coastal redwood and other minor timber species have good appearance and are used for appearance grade uses such as furniture, flooring and panelling. In the CRA outcomes, there is no information on hybrid species, such as *Eucalyptus saligna/botryoides*, which is a very common species in the study area.

3.3.2 Rainforest species

Market prices of local native rainforest species were sought from State Forests NSW, the National Association of Forest Industries (NAFI), and the Forest Products Association and the Timber Development Association. However, State Forests NSW

Table 3.2 Relative values of local native species in NSW CRAs

Distribution	Common name	Scientific name	Species Group	Potential Market Value		
				40-49cm	50-69cm	70+cm
C	Grey Ironbark	*Eucalyptus paniculata*	High Value	$46.16	$54.77	$58.58
C	Coastal Grey Box	*Eucalyptus bosistoana*	High Value	$42.48	$50.87	$54.55
C	Blackbutt	*Eucalyptus pilularis*	High Value	$38.38	$47.24	$50.56
C	Spotted Gum	*Corymbia maculata*	High Value	$35.11	$45.23	$49.70
C	Bangalay	*Eucalyptus botryoides*	Coastal Redwood	$34.76	$36.93	$40.46
S	Red Mahogany	*Eucalyptus resinifera*	Coastal Redwood	$34.76	$36.93	$40.46
W,I	Sydney Blue Gum	*Eucalyptus saligna*	Coastal Redwood	$34.76	$36.93	$40.46
S	Blue Leaved Stringybark	*Eucalyptus agglomerata*	Medium to High Value	$34.59	$41.63	$45.33
C	Forest Red Gum	*Eucalyptus terticornis*	Coastal Redwood	$34.59	$41.63	$45.33
C	White Stringybark	*Eucalyptus globoidea*	Medium to High Value	$34.59	$41.63	$45.33
C	Yellow Stringybark	*Eucalyptus muelleriana*	High Value	$34.59	$41.63	$45.33
C	Turpentine	*Syncarpia glumulifera*	High Value	$32.76	$41.19	$43.87
I,S	Monkey Gum	*Eucalyptus cypellocarpa*	Medium Value	$32.91	$35.38	$38.92
S	Grey Gum	*Eucalyptus punctuata*	Medium to High Value	$31.27	$33.64	$37.11
C	Wollybutt	*Eucalyptus longifolia*	Coastal Redwood	$31.27	$33.64	$37.11
C	Brown Barrel	*Eucalyptus fastigata*	Medium Value	$31.27	$33.16	$36.89
I,S	Messmate	*Eucalyptus obliqua*	Medium Value	$30.70	$33.15	$36.61
C	Apple Angophora spp	*Angophora* species	Low Value	$13.75	$17.99	$19.07
C	Gully Peppermint	*Eucalyptus smithii*	Medium Value	$13.75	$17.99	$19.07
I,S	Narrow-leaved Peppermint	*Eucalyptus radiata*	Medium Value	$13.75	$17.99	$19.07
C	River Peppermint	*Eucalyptus elata*	Low Value	$13.75	$17.99	$19.07
W,I	Sydney Peppermint	*Eucalyptus piperita*	Medium Value	$13.75	$17.99	$19.07

(W: species seen only in Wollongong area, I: species seen only in Shellharbour and Kiama area.
S: species seem only in Shoalhaven area, C: species seen over the study area)

(Source: AFFA and BRS, 1999)

has not sold rainforest timber since 1982 (NSW SoE, 1995), and the other organizations do not trade in the local native rainforest timber. This would be due to the scarcity of rainforests and the movement into rainforest protection.

Market prices were also requested from local sawmills and timber trading companies. The research was conducted by posting questionnaires (Appendix 3.1) to 21 companies. Eight out of the 21 companies (38.1%) replied the questionnaires. However, none of the responses included answers to the questions about rainforest timber. The reason for this is that the companies look after only eucalypts and specific species which are from other States or overseas. Therefore, they have no idea about the pricing of local native rainforest timber.

Generally, rainforest species have less durability and strength, and lower density than any eucalyptus species. These features limit the uses of rainforest species to internal uses. Some rainforest species have attractive features in the appearance and properties of the timber, however, these species are rarely available in the market because of their scarcity. The specific features and the scarcity of rainforest timber make their value higher. It is well known that Red Cedar is one of the most valuable local native rainforest timbers. These valuable local native rainforest timbers are sometimes seen used as furniture, cabinetwork and craft wood at markets. The species that were observed by the author at markets were Red Cedar (*Toona ciliata*), Coachwood (*Ceratopetalum apetalum*), Red Ash (*Alphitonia excelsa*), White Cedar (*Melia azedarach*), and Sassafras (*Doryphora sassfras*). Craft workers obtain small amounts of the timbers from local private properties or State Forests NSW as salvage timber from destruction of forests by natural disaster such as storms. It is suggested that the marketing of local native rainforest timber takes place on the individual level rather than at an industry level. Furniture, cabinet and craft wood are highly valued uses of timber compared to construction uses such as poles and posts, but the demand volume of the timber for furniture, cabinet and craft wood is lower than the demand volume for its construction uses. It is difficult to estimate the values of rainforest timber because values would be greatly affected by variation in the supply and demand for the timber.

Some furniture companies look for rainforest timbers that are mostly from overseas. The examples of rainforest species from overseas are Kauri (*Agathis dammara*) and Kwila (*Intsia bijuga*) from Papua New Guinea and Malaysia, Western Red Cedar (*Thuja plicata*) from North America and Canada, and New Zealand White Pine (*Podocarpus dacrydioides*) from New Zealand (Timber Development Association b, date unknown). New Zealand White Pine has the same genus as Plum Pine and timber of Western Red Cedar has similar characteristics to Red Cedar. This shows that there is a potential to create a bigger demand for local native rainforest timber in Australia.

3.3.3 Other local native species

There are many other local native species that have the potential to be valuable timbers. Acacias are fast growing (sometimes faster than eucalypts), and some timbers of Acacias have an attractive appearance. Timber of Blackwood (*Acacia melanoxylon*) has a variety of colours ranging from light golden-brown to deep brown. This attractive appearance and high quality of the timber make it possible to use the timber as veneer, cabinet and craft wood (Tasmania Timber Promotion Board, 2000).

There are potentially valuable species that are adapted to special environments such as swampy places and places with shallow soils. Swamp Oak (*Casuarina* *glauca*) can grow well on swampy ground. Brown Barrel (*Eucalyprus fastigata*) and Gully Gum (*E. smithii*) are seen as tall trees in upper part of the escarpment that have relatively shallow soils.

3.4 Growth rates of trees

3.4.1 Studies on growth rates

Higher income is expected by choosing the species that show fast growing and good performance as well as quality of the timber. It is well-known that *Eucalyptus* species are relatively fast-growing, compared to most rainforest species. It is assumed that growth rates significantly differ with the species themselves. Fletcher (1999) studied growth rates of eight eucalyptus species in Bega, which is further south on the coast of NSW. The study includes some species that are local native ones in the Illawarra and Shoalhaven. According to the study, Bangalay (*E. botryoides*) and Sydney Blue Gum (*E. saligna*) showed better growth rates than any other studied species in all sites while Forest Red Gum (*E. tereticornis*) showed poor growth rates in the sites. However, Fletcher (1999) concluded that site quality such as the degree of shelter is more influential in growth rate than the nature of the species itself. She also found that growth rates on S, SE, E and NE aspects are greater than that on other aspects. She measured the degree of shelter with surrounding hills and vegetation, and suggested that protection from winds blowing from N, NW, W, and SW directions is significant.

The University of Wollongong has 7 experimental plots for farm forestry study in the Illawarra region and north of Shoalhaven LGA, which are Mt. Keira, Stockyard Mountain, Kiama, Jamberoo Pass, Toolijooa, Kangaroo Valley and Jerrara Dam. These plots were established between 1996 and 1998, and a range of local native species was planted on each plot. Some studies in the plots have been done on growth rates, performance and tolerance to herbivory and disease. Keyzer (2000) and Rogers (2000) found significantly different growth rates in species. Acacias have the fastest growth rates in the plots, followed by eucalyptus species, and rainforest species have the slowest growth rates. However, these authors also suggested that site quality is the most important factor to influence growth rates. Maintenance of the sites was considered to be even more critical than the degree of shelter and aspects (Keyzer, 2000; Rogers, 2000).

There is a problem with incorporating the studies by Fletcher (1999), Keyzer (2000) and Rogers (2000). The reason is that those plots were established only a few years ago. The measured trees are immature, as they were only about 5 years in age. CSIRO Forestry and Forest Products (date unknown) reported that growth rates differ for different age groups. Trees that display large growth rates in early stages of development do not always show consistently high growth rates in their mature stage. Therefore, it is not possible to use those data in the early stage as the overall growth rates of the species. It is necessary to monitor the studies of Fletcher, Keyzer and Rogers, which will help to establish more complete figures for the growth rate of each species in future.

3.4.2 The distribution of species

Observation of the natural distribution of local native species is another way to predict growth rates of species. Generally, tree species have their preferable environment, depending on environmental factors, such as climate, topography, geology and soil types. In the natural distribution, species should show great growth rate and performance. Therefore, the consideration of natural distribution of species would be of great help to understand their environmental requirements. Unfortunately, the studies of Fletcher, Keyzer and Rogers did not consider the environmental requirements of species against the growth rates. Nevertheless, Fletcher (1999) studied growth rates of *E. botryoides, E.nitens and E. viminalis* on the three different rock types, basalt, granite and shale. The result shows the greater growth rate of *E.nitens* on shale and that of *E. viminales* on basalt. Shale tends to produce more infertile soils compared to basalt (2.6.3). This proves that fertile soils do not always support better growth rates of any species. In other words, each species has different environmental requirements and shows greater growth in their favourable environment rather than better land capability.

However, the distribution of species in the field (natural niche) is usually more constrained than its biological potential (physical niche). The natural distribution of species is controlled by pressures, such as competition for light, water and nutrients, as well as suitable situations such as climate, soils and topography (Figure 3.1).

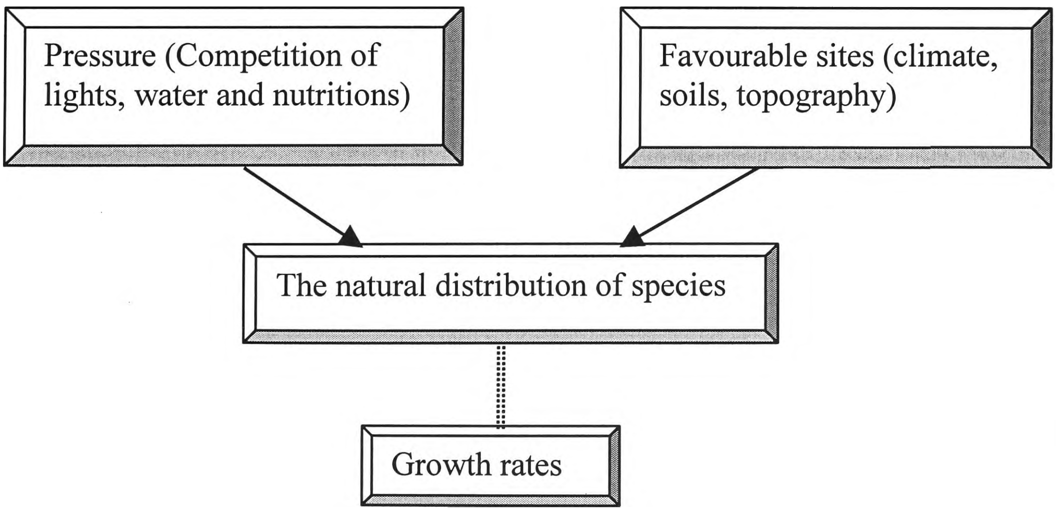

Figure 3.1 Factors controlling the natural distribution of species

Without these pressures, the distribution of species would be more expansive or the location would be different. It is unknown how much the distribution of species could be interpolated as the species requirements. The degree of the interpolation would also differ in species. It is necessary to compare the study of the species requirements by the natural distribution to the studies of growth rates in further studies.

There are some examples of available information on the distribution of the local native species in the Illawarra and Shoalhaven regions. "Forest Trees of Australia" (Boland et al., 1984) describes most of the local native species in the regions, and provides values of the species requirements, such as levels of rainfall, elevation, soil types and topography. Because the information is too wide for the regions, some of the values would not be applicable to the regions. "Wollongong's Native Trees" (Fuller, 1980) and "Native Trees of Central Illawarra" (Fuller & Mills, 1985) show general distribution of the local native species in the Illawarra region as maps. These books in some cases describe sites where larger specimens of species are found, which could be interpolated to the sites where better growth is expected. In addition, "Illawarra Remnant Bushland Database", a website composed by the Nature Conservation Council of NSW (2000) shows information on species compositions of remnant forests over the Illawarra region.

3.5 Conclusions

There is a variety of local native species potential for commercial plantations. The local native species include eucalypts, acacias, casuarinas and rainforest species. Timber from eucalypts is more likely to be used for structural and construction purposes, while other species are mostly used for internal structure or other purposes such as furniture, cabinetwork and craft woods.

It is suggested that eucalypts would be the most important local native species for farm forestry in the study area. One of the reasons is that eucalypts are fast-growing and tend to show good performance, compared to other species. Another reason is that there is a variety of timber uses that Eucalypts can provide. Eucalypts are common timber species for structural and construction purposes. However, some eucalypts can be used for higher valued uses, such as furniture and cabinets. Moreover, timber harvested during a thinning operation can be sold as poles and posts, which would provide additional income to the farmers.

As for the selection of the eucalypts, relative values provided by the CRAs would be the most useful indicator of timber value. "High Value" and "Coastal Redwood" species in the CRAs, which are Grey Ironbark, Coastal Grey Box, Blackbutt, Spotted Gum, Blue leaved Stringybark, White Stringybark, Yellow Stringybark, Turpentine, Bangalay, Red Mahogany, Sydney Red Gum, Forest Red Gum and Wollybutt, are recommended for commercial plantations. However, there are no studies on growth rate and performance of these species in the study area. It is necessary to investigate these valuable species in the experimental sites in the Illawarra and Shoalhaven regions with precedence over other less important species.

Timber value of local native rainforest species could not be estimated in this study. The reason for this is that there is limited trading of the rainforest timber, which means little supply and demand of the timber. The rainforest species are known to have a significantly slow growth rate. These facts seem to illustrate the considerable difficulty of a potential of local native rainforest for commercial plantations. However, furniture and craft companies look for rainforest timber from other regions and overseas. It is suggested that the reason of small market for rainforest species is due to the limited supply of the timber. There is a high potential of creating a bigger market for local native rainforest timber if the supply of timbers is increased through expansion of rainforest plantations.

There are many other valuable local native species such as acacias and casuarinas and species that grow in a special environment such as swampy grounds and shallow soils. These species need to be investigated in a further study. There are other factors influencing the value of timber that are not considered in this study. These are growth performance of species, quality of timber produced, tolerance to disease as well as the distance of the source from markets for the timber. These aspects should be researched in further studies. Targeted study about markets for the end use of timber of important species is also necessary because timber prices would be different depending on their end use.

Chapter 4 Suitable Sites in Kiama LGA

4.1 Introduction

After evaluation of land capability and selection of suitable species for farm forestry, the next step needs to match potential plantation sites with their suitable species. The land capability would be determined by the availability of lands and environmental factors such as climate, topography and soils. The selection of species should be decided by the objections of landowners with considerations of species characteristics. The suitability of potential sites and species would be examined according to the matching of the potential plantation sites and environmental requirements of species.

Geographic Information Systems (GIS) is currently widely used in decision-making and problem solving in many fields of study because of the high ability of spatial analysis and high quality of mapping output. In the case of tree plantations, the suitability of sites can be analysed by integrating information about climate, geology, topography factors, distance from markets and sawmills, and plantation controls (AFFA, 2000).

This Chapter aims to examine the suitability of potential plantation sites and commercial local native species in the Illawarra and Shoalhaven regions. Similar research has been done for the area as part of the Southern New South Wales Comprehensive Regional Assessment (CRA) by the Bureau of Rural Science (BRS) (2000). The study has examined two popular plantation species, *Pinus radiata* (Radiata Pine) and *Eucalyptus nitens*. However, these species are not native to the Illawarra and Shoalhaven regions, and the study found unsuitability of Radiata Pine plantations in most parts of the Illawarra and Shoalhaven regions (BRS, 2000).

Therefore, It is necessary to investigate other potential commercial species suitable in the regions. Moreover, detailed research in the regions would be more useful to the landowners in decision-making about farm forestry.

A case study was conducted in Kiama LGA with the information provided by ArcView, one of the GIS programs. The reason why this area was chosen is due to the cooperation of Kiama council with the project, and the availability of digital data for GIS. The other reason is that cleared agricultural lands covering about 68% of total agricultural area within Kiama LGA. As well as this, the environmental conditions in this area are eminently suitable for the introduction of farm forestry, as Kiama LGA enjoys the advantages of good soil quality and high levels of rainfall, due to its proximity to the coast.

4.2 Land availability

There are some limitations to evaluating potential sites for farm forestry, which are (1) sites that are previously cleared; (2) sites that belong to private landholders; (3) sites which are in areas where farm forestry are allowed by legislation; and (4) sites that are suitable for tree plantations according to environmental factors, such as climate, soils and geology, and topographical factors. The environmental limitations are discussed in next section (4.3) with environmental variations,

4.2.1 Cleared lands

Cleared areas in Kiama LGA were estimated by identifying forested areas and categorising the remaining areas as cleared lands. The forested areas were digitised from the aerial photo of Kiama LGA (Fig 4.1). The digital aerial photo obtained from

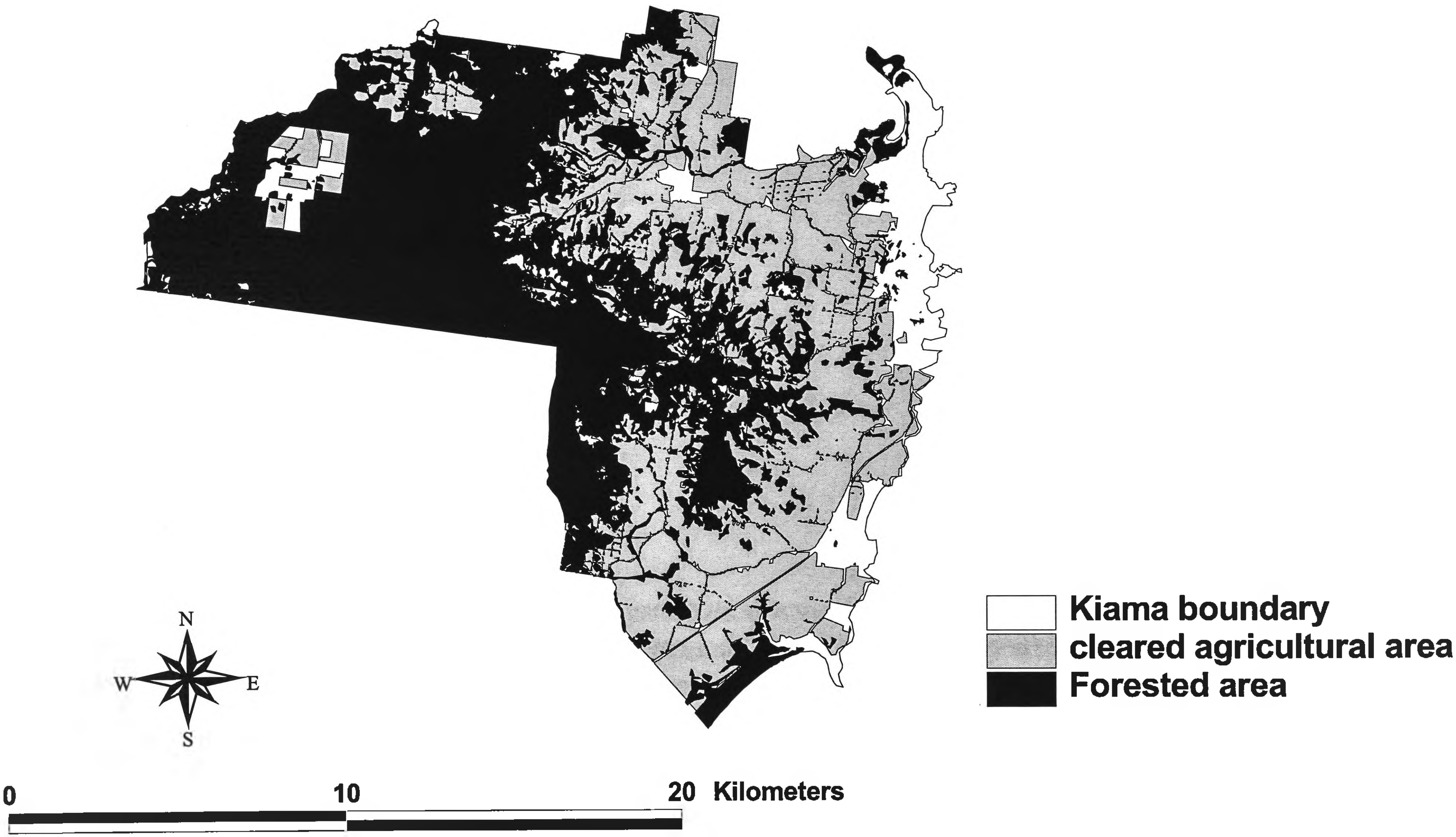

Figure 4.1 Forested and cleared agricultural areas in Kiama LGA

Kiama Council was taken in 1999. Patches of dark green in the photo were recognised as forested areas. The forested areas are concentrated on National Parks and Nature Reserve. Large areas of plateau and escarpments, which have poor soils or steep slopes, are also forested. On the other hand, vegetation on plateau and escarpment benches that have fertile soils have been intensively cleared. As for coastal plains, most of these areas are cleared. The size of the cleared lands was calculated by subtraction from the forested area. The total size of the cleared lands is 13,118 ha and consists of more than half of the LGA (51%). After subtracting the cleared lands from the forested areas, we have an estimate of the total area potentially available for farm forestry. However, not all of this is agricultural land, but also includes residential and industrial lands.

4.2.2 Agricultural lands

The digitised map of rural land use obtained from Kiama Council is shown in Fig. 4.2. The total agricultural area is 19,031 ha, which comprises 74% of the LGA. Main rural land uses are dairy farming (4,490 ha) and cattle grazing (8,540 ha), both of which constitute 68% of the total agricultural area. "Other animal based activities" includes horse agistment and stud, poultry, deer farming, bee keeping, goats and animal husbandry as well as worm farming, the total area of which is 881 ha. The total agricultural area is larger than the total cleared area. This means that some agricultural lands have forests on their properties. The cleared area on agricultural lands is 10,223 ha, a percentage of which is 68% of total agricultural land in Kiama LGA (Fig. 4.1). These areas can be considered as potential areas for the establishment of tree plantations.

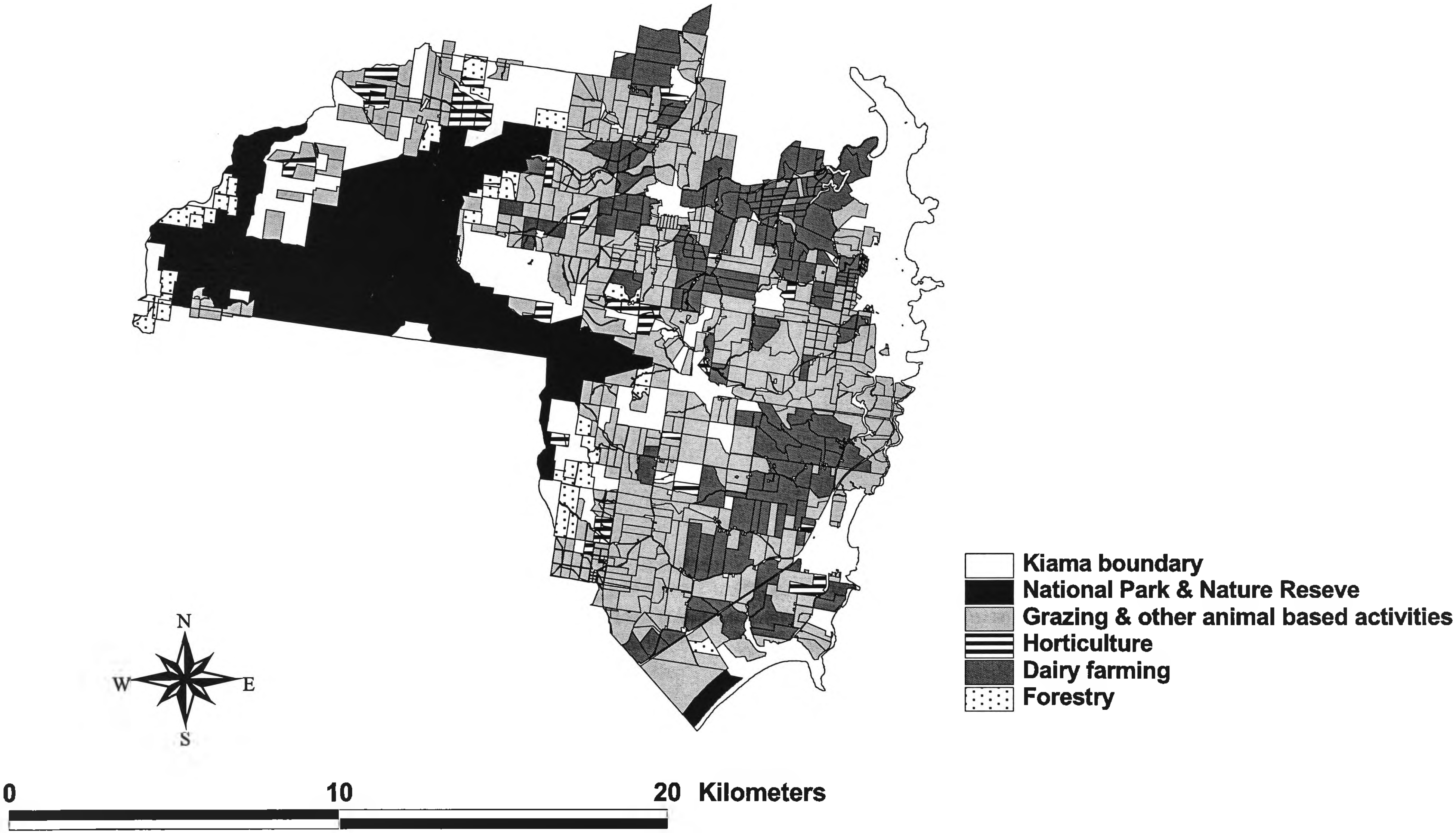

Figure 4.2 Rural landuse and National parks and Nature reserve in Kiama LGA

4.2.3 Plantations and Reafforestation Act (PR Act)

Within Kiama LGA, the main legislation that applies to farm forestry activities is the PR Act (see section 2.4.1). Farm forestry that does not exceed 30 ha on the one property (EFF) is exempt from regulations under the PR Act. On the other hand, farm forestry that exceeds 30 ha on the one property must adhere to the regulations of the PR Act. The regulations define buffer zones from water drainage, and slope limits depending on the soil drainage. However, in Kiama LGA, many future farm forestry sites are expected to be EFF due to the relatively small size of the farms. In addition, digital data on the water and soil drainage were not available for the study. Therefore, these regulations of the Code of Practice are not considered as a limitation to the land capability although it is possible to include the buffers and slopes in the ArcView.

4.3 Environmental variations

Climate, soil and geology, as well as topography are factors that influence the land capability of areas in Kiama LGA. Some of the factors may classify the lands as non-suitable sites for tree plantations.

4.3.1 Climate

There is insufficient information on temperatures in the study area because of the few stations regularly recording temperatures over the area. However, it is known that temperatures reduce with increasing altitudes. This would indicate different temperatures around landforms, such as coastal plains, the escarpment and the plateau. The temperatures on coastal plain are relatively cool in summer and mild in winter. On the other hand, the temperatures on the plateau are cool in summer and severe cold in winter (see section 2.6.2). Figure 4.3 shows mean daily maximum temperatures and mean daily minimum temperatures of each month throughout the year in Kiama, which is located on coastal plain, and Figure 4.4 shows those in Moss Vale, which is situated on a plateau. The elevations of the stations are 10 m in Kiama, and 675 m in Moss Vale. Moss Vale is not located in Kiama LGA, however, the data could possibly be similar to that recorded on plateau areas in Kiama LGA. The Kiama station records that the temperatures have never dropped below 2 degrees since the weather station was built. It is suggested that temperatures on coastal plains would not be a factor that limits tree growths. On the other hand, the Moss Vale station reports that temperatures have sometimes dropped below zero from May to October. July is the month that has the greatest number of days in which the temperature falls below zero in Moss Vale (average 11 days). The data indicates the cool temperatures on the plateau, which are likely to affect tree growths and limit the quantity and varieties of tree species that can grow on the sites. In this study, the difference of temperature is considered as being caused by landforms, which include coastal plains, the escarpment and the plateau. The landforms are discussed in the section of "Topography" (4.3.3)

Rainfall over Kiama LGA varies greatly with the position and geography of the sites (see section 2.6.2). This variation needs to be considered because it could significantly affect growth rates of some species that are sensitive to the variation. Generally, rainforest species are known to require higher rainfall. Mills & Jakeman (1995) suggested that the areas which receive over 1200 mm of annual average rainfall are optimal for supporting rainforests. A digital average annual rainfall contour map over the area was generated from data recorded by 42 rain stations over

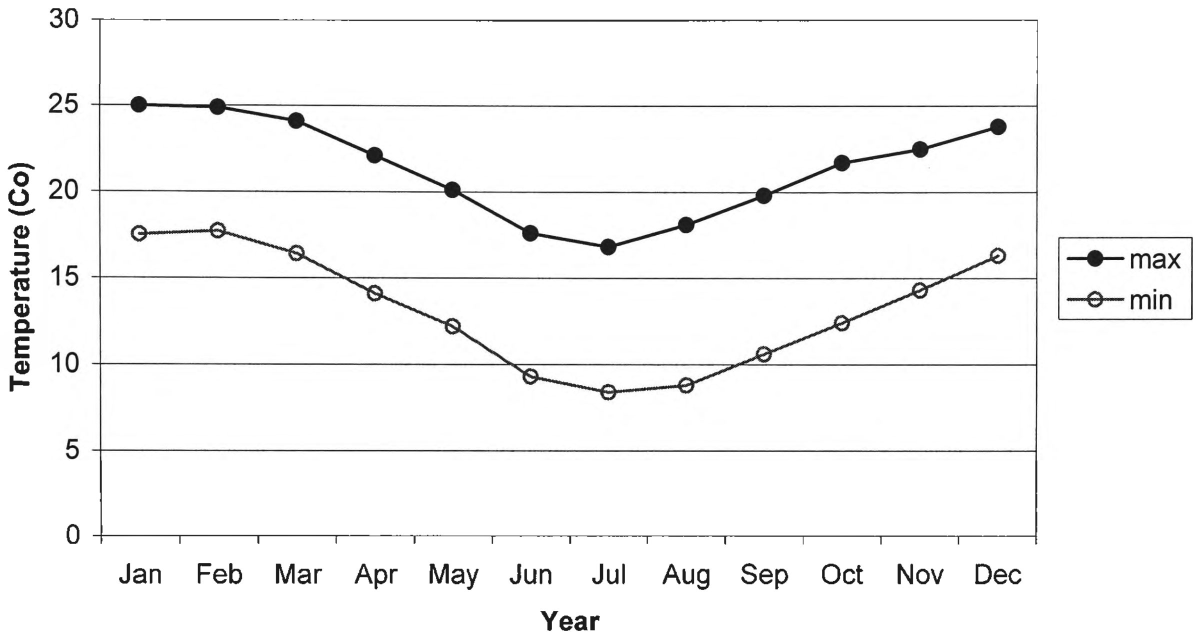

Figure 4.3 Mean daily maximum and minimum temperatures in Kiama

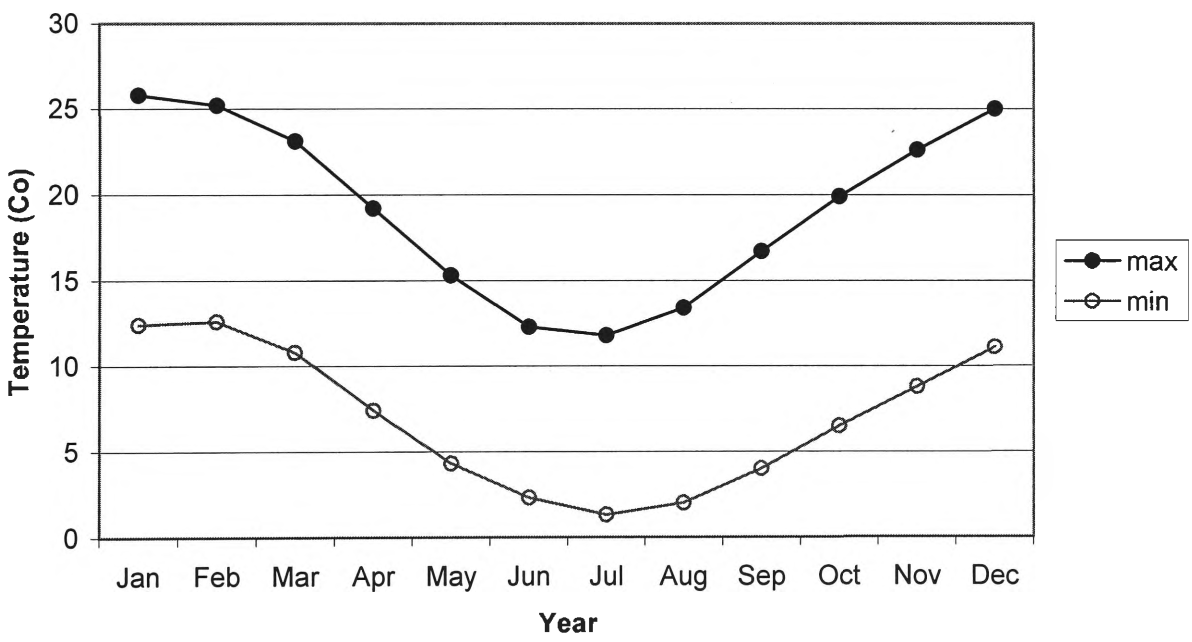

Figure 4.4 Mean daily maximum and minimum temperatures in Moss Vale

(Source: Bureau of Meteology, 2001)

the Illawarra region (Fig. 4.5). The rainfall data from the rain stations are shown in Appendix 4.1 and 4.2. The number of rainfall recording stations, especially in the escarpment, is insufficient to create precise rainfall contours around the escarpment. Maps interpolating the data with "tension" and "spline", which are functions in the ArcView, were compared, based on the location of the escarpment and the rainfall map created by Mills and Jakeman (see section 2.6.2). It was judged that the rainfall map with "tension" is reasonable for defining the critical value of the 1200 mm (Fig, 4.6). In this study, the areas that receive over 1200 mm are regarded as suitable sites for rainforest plantations while the areas that receive less than 1200 mm as non-suitable for rainforest plantations.

4.3.2 Soils

There are some studies of soils and geology that have been done in Kiama LGA. These are "Land Resources Survey of Kiama Municipality by Hird and Dolman (1983)" and "Soil Landscapes of the Kiama 1:100000 Sheet" (Hazelton, 1992)". The "Land Resources Survey" is based on geology and soils while the "Soil Landscapes" include soil layers and topographic factors that relate to soil generation as well as geology and soils. However, both of the maps of the surveys are quite similar in the soil classifications and their positions on the maps. In soil evaluation for tree plantations, soil depth, stoniness, soil texture, fertility, slope steepness and soil erodibility are important. The soil depth and stoniness are easier to interpret in "Land Resources Survey", and the survey also includes steep slopes into the soil classification. A digital soil map of Kiama LGA was obtained from the Department of Land and Water Conservation (DLWC). The explanatory notes of the digital soil map is not available from the DLWC, but the map is consistent with the

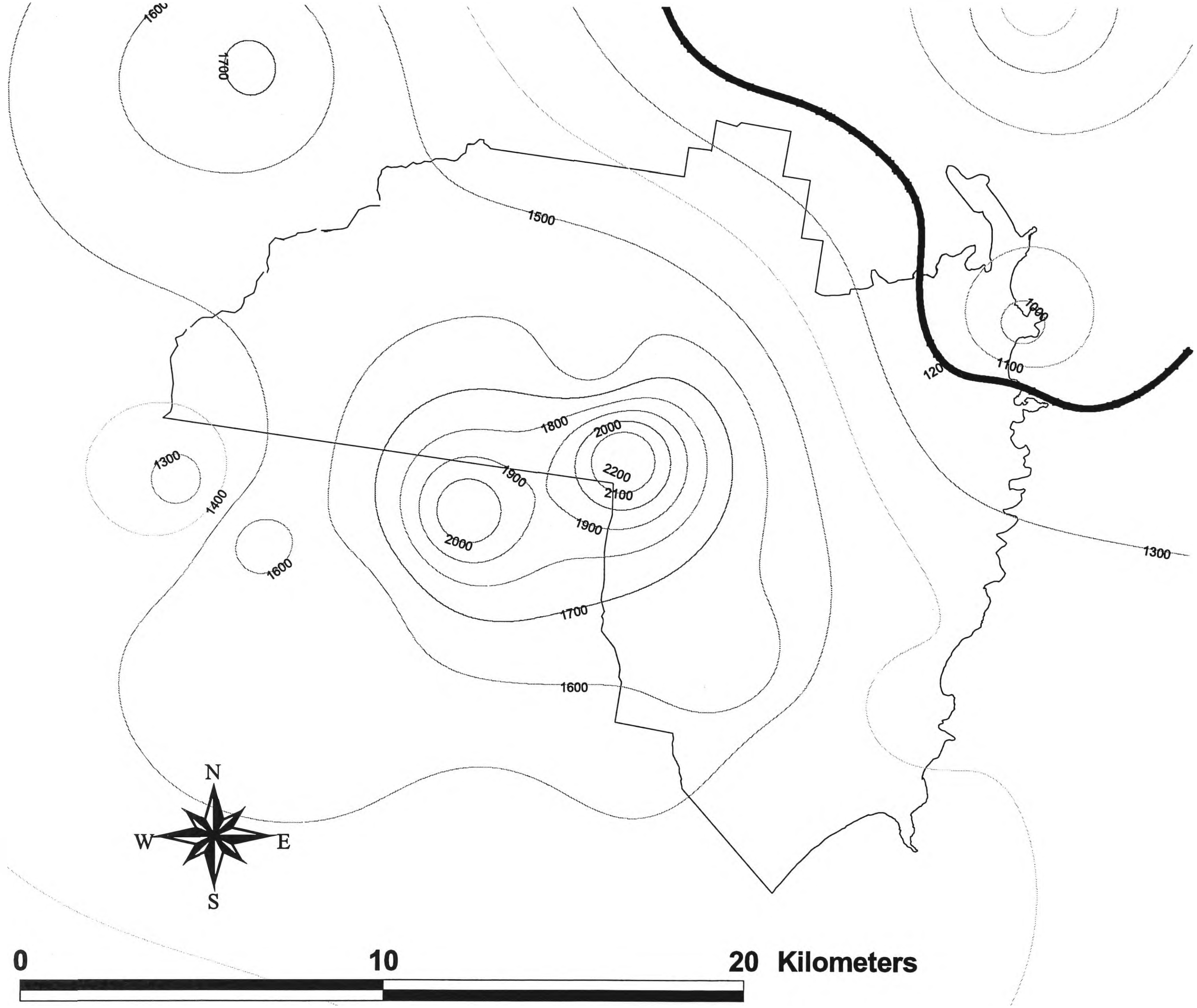

Figure 4.5 Average annual rainfall (mm) over Kiama LGA

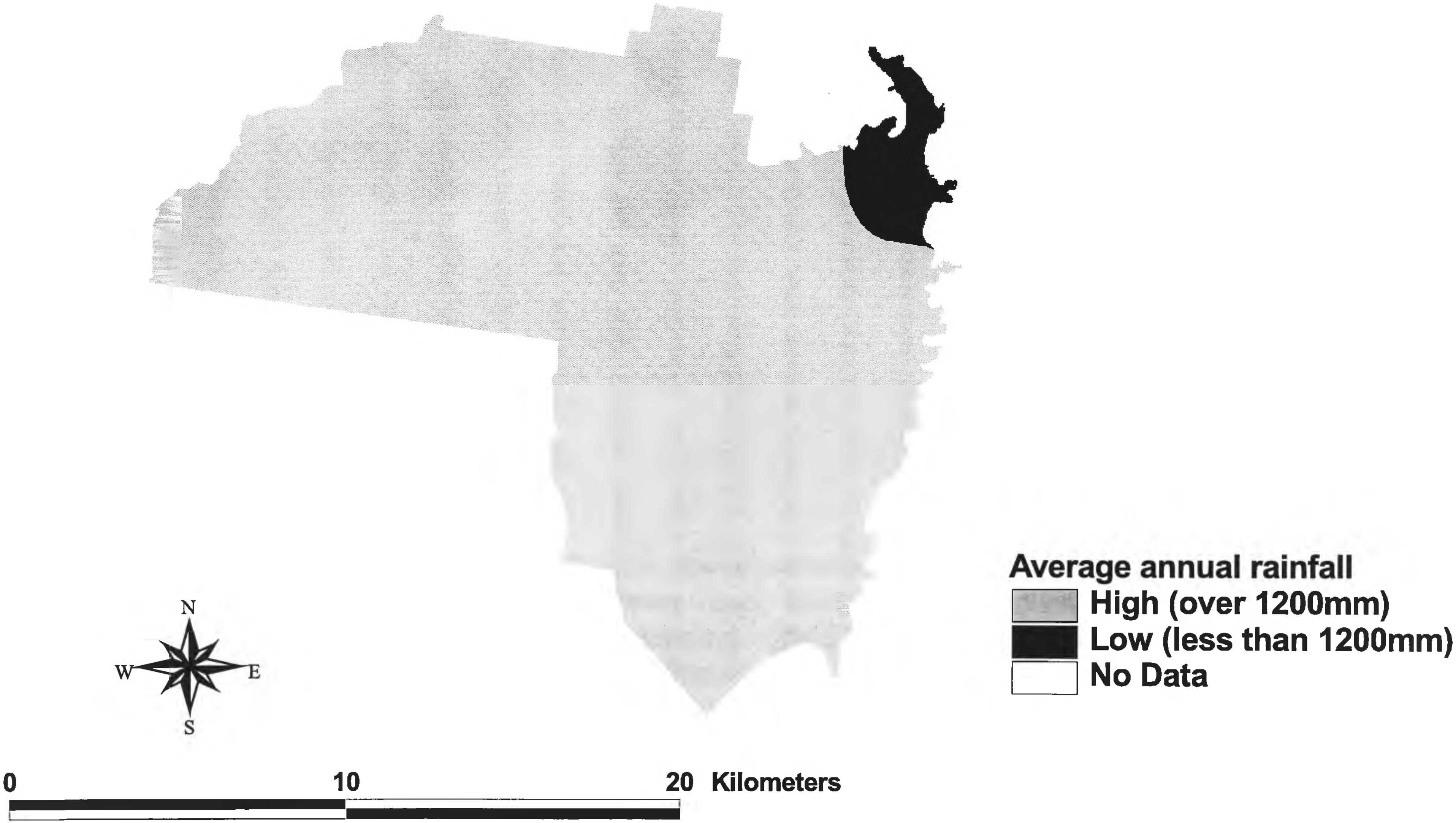

Figure 4.6 Rainfall classification in Kiama LGA

"Land Resources Survey". Because of these reasons, this study is based on the "Land Resources Survey", and the "Soil Landscapes" is referred to supplement the soil information of the "Land Resources Survey". General information about the soil types is also referred to "Great Soil Groups" (Stace, et al., 1968).

Hind and Dolman (1983) identified total 15 soil types and 3 non-soil types in the Kiama LGA. The soil types for tree plantations are classified from the 18 soil and non-soil types into 5 groups, depending on the fertility, texture and depth of the soils (Table 4.1 & Fig. 4.7). Soil depth and soil texture are the most critical soil properties for tree plantations because these physical properties affect root growth and nutrients and water-holding capacity (Hazelton, 1992; Murphy et al., 2000). These properties are difficult to modify while chemical factors such as soil acidity and nutritions can be easily improved by fertiliser application (BRS, 1998). Therefore, this study regards some of the soil physical properties as limitations to tree plantations.

Shallow and stony soils, lithosols, lithosols (steep) and colluvium lithosol complex are classified as "non-suitable" soils for tree plantations. The distribution of the "lithosols (steep)" covers places that have over approximately 25 slope degree. The relationship between slope degree and soil erodibility is significant. "Soil Landscape" study found that most of the soils in the LGA, especially topsoil, is erodible. Basin peats and ground water gleys, yellow earth and leached peaty sand are found on Hawkesbury Sandstone. These soils have sandy texture and relatively low fertility. In addition, these soils are strongly acid, which may require large quantities of lime and nitrogen as well as other nutrients for optimum plant growth (Hazelton, 1992). In this study, these soils are classified as "non-suitable". Swamp soils are deep, acidic and rich in organic matter, however, they have a high risk of flooding (Hird & Dolman, 1983). Sandy soils are known to have poor water-holding capacity.

Table 4.1 Soil classification for land capability study in Kiama LGA

Parent material	Soil type	Fertility	Soil texture	Depth	Classification
Beach sand	Siliceous sands	low	sand		non-suitable
Dune sand	Podzol	low	sandy loams	deep	Low fertile
Alluvium	Alluvial soils (medium)	medium	silty clay loams	deep	Alluvium
	Alluvial soils (coarse)	low	silty loams, gravels	deep	Low fertile
	Swamp soils		silty clay loam	deep	non-suitable
	Basin peats and goundwater gleys	low	sandy	deep	non-suitable
Volcanics	Brown podzolic		loams to clay	deep	Brown
	Lithosols		stony	shallow	non-suitable
	Lithosols (steep)		stony	shallow	non-suitable
	Basalt krasnozems	high	clay	deep	Fertile
	Latite krasnozems	high	clay	deep	Fertile
Colluvium	Colluvium	high		deep	Fertile
	Colluvium Lithosol complex	high	stony	shallow	non-suitable
Hawkesbury sandstone	Yellow earth	low	stony	shallow	non-suitable
	Leached peaty sand	low		shallow	non-suitable
	Rockshelf			none	non-suitable
	Quarry			none	non-suitable
	Waterbody				non-suitable

(Sorce: Stace et al, 1968; Hind and Dolman, 1983)

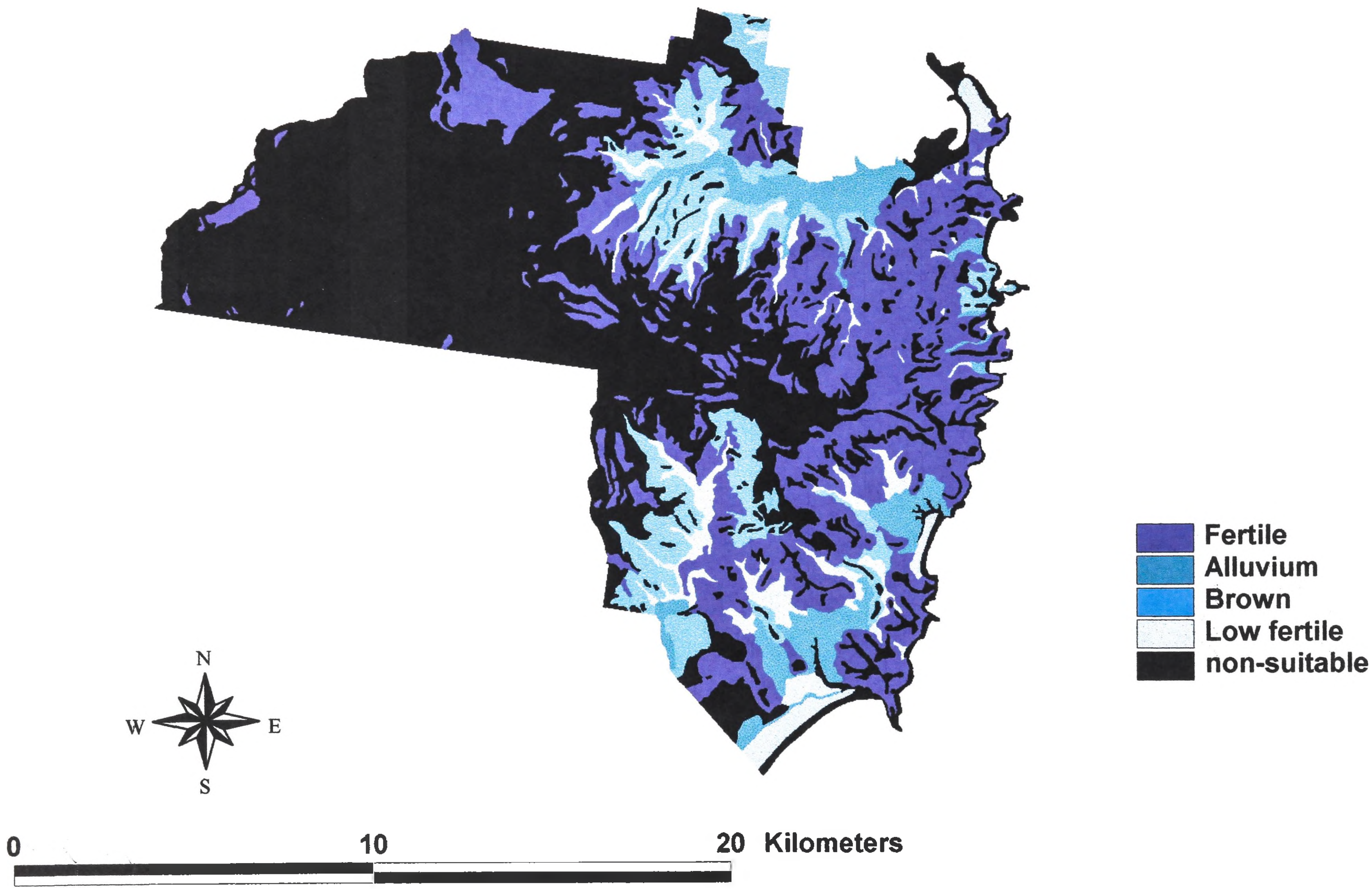

Figure 4.7 Soil classification for land capability study in Kiama LGA

The swamp soils and siliceous sands are categorised as "non-suitable". Non-soils types, rockshelf, waterbody and quarry are also "non-suitable".

Krasnozems, derived from volcanic rocks, have high fertility, clayey and deep soil. Colluvium occurs on the benches of escarpments, which also have high fertility, clayey and deep soil. These soils can support rainforests and tall sclerophyll forests (Fuller & Mills, 1985; Mills & Jakeman, 1995). Therefore, these soils are categorised as "Fertile". Alluvium soils generally have high variation of soil texture and fertility (Stace et al, 1968). However, alluvium soils (medium) in this region have moderate to high fertility because of the deposits from surrounding volcanic material (see section 2.6.3). The texture of the soils are silty loams and clay loam to light clay (Hird & Dolman, 1983). Alluvial soils, which could support tall sclerophyll forests, are grouped into the category "Alluvium". Brown podzolic soils are associated with krasnozems and yellow podzolics, which have moderately fertile soil and loams to clay soils. The soil is developed in relatively high rainfall and is known to have poor drainage (Stace et al., 1968; Hird & Dolman, 1983). Brown podzolics, which could support wet sclerophyll forests, are classified to "Brown". Podzols and Alluvial soils (coarse) are classified to "Low fertile", because they could have problems with their fertility.

4.3.3 Topography

The distribution of many species is largely affected by elevations (Fuller, 1980; Fuller & Mills, 1985). The reason for this would be due to the difference of climate with elevations (see 4.3.1). DEM (which is a data set representing the surface of the earth) of Kiama LGA was obtained from the Department of Geosciences at the University of Wollongong. The elevation was classified into four categories with the

DEM, based on studies by Fuller (1980), Fuller & Mills (1985), Mills & Jakeman (1995) (see 2.5.1). These are coastal plain (from 0 to 100 m above sea level), low escarpment (from 100 to 300 m), high escarpment (from 300 to 600 m) and plateau (over 600m) (Fig. 4.8).

Rainforest species prefer high moisture sites including sheltered sites and spurs between foothills. Rainforests do not occur in places exposed to dry westerly winds (Fuller, 1980; Fuller & Mills, 1985). Fuller (1985) suggested that NNE-SSW aspects are protected from the dry westerly winds and also catch the moist on-shore winds from the sea. Fletcher (1999) found that growth rates of eucalypt species are significantly higher in south and east aspects. Because of these reasons, aspect is regarded as one of the important factors that have to be considered in the land capability. The aspect of lands in Kiama LGA was also generated from the DEM with ArcView. The aspect is categorised as "SouthEast" aspects and "NorthEast" aspects (Fig. 4.9). "SouthEast" indicates flats and NNE-SSW aspects (from 22.5 to 202.5 degrees), and "NorthWest" means SSW-NNE aspects (from 0 to 22.5 degrees and from 202.5 to 360 degrees).

Because steep slope (appoximately over 25 degree) is already included in the soil survey by Hind and Dolman (1983) as lithosols (steep) as well as the fact that most of the steep areas are covered by forests, slopes that can be generated from DEM are not considered in this study. Private Forests Tasmania (Lyons, 1997) reported that labour costs are significantly different between flat/gentle pasture (0-17 degree slopes) and steep pasture (over 17 degree slopes). This information will be necessary to evaluate cash flow analysis of farm forestry in further studies. However, this study does not discuss economic suitability of farm forestry. Therefore, the slopes over 17 and 25 degrees are shown in Figure 4.10 as a reference.

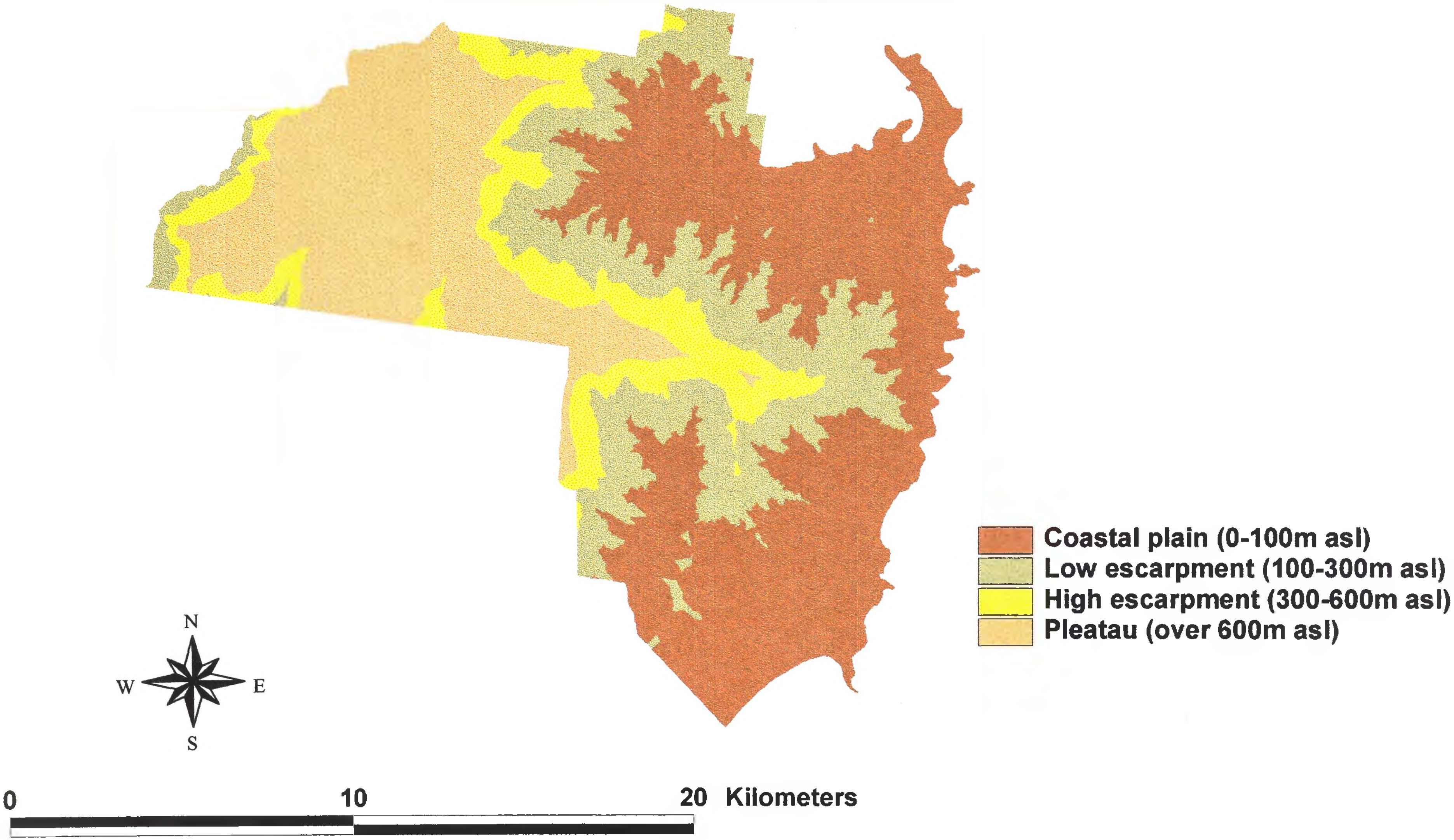

Figure 4.8 Elevation classification for land capability study in Kiama LGA

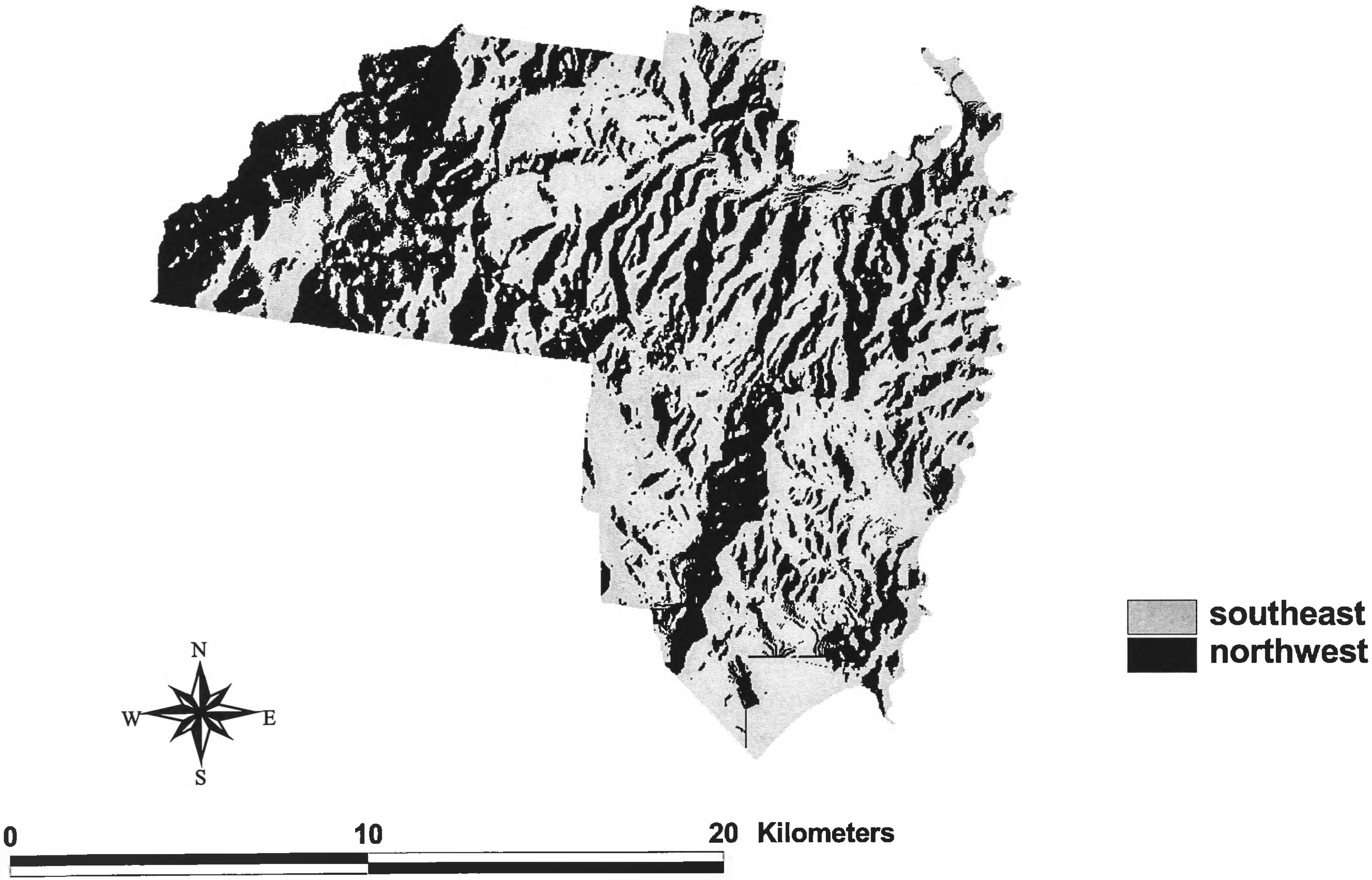

Figure 4.9 Aspect classification for land capability study in Kiama LGA

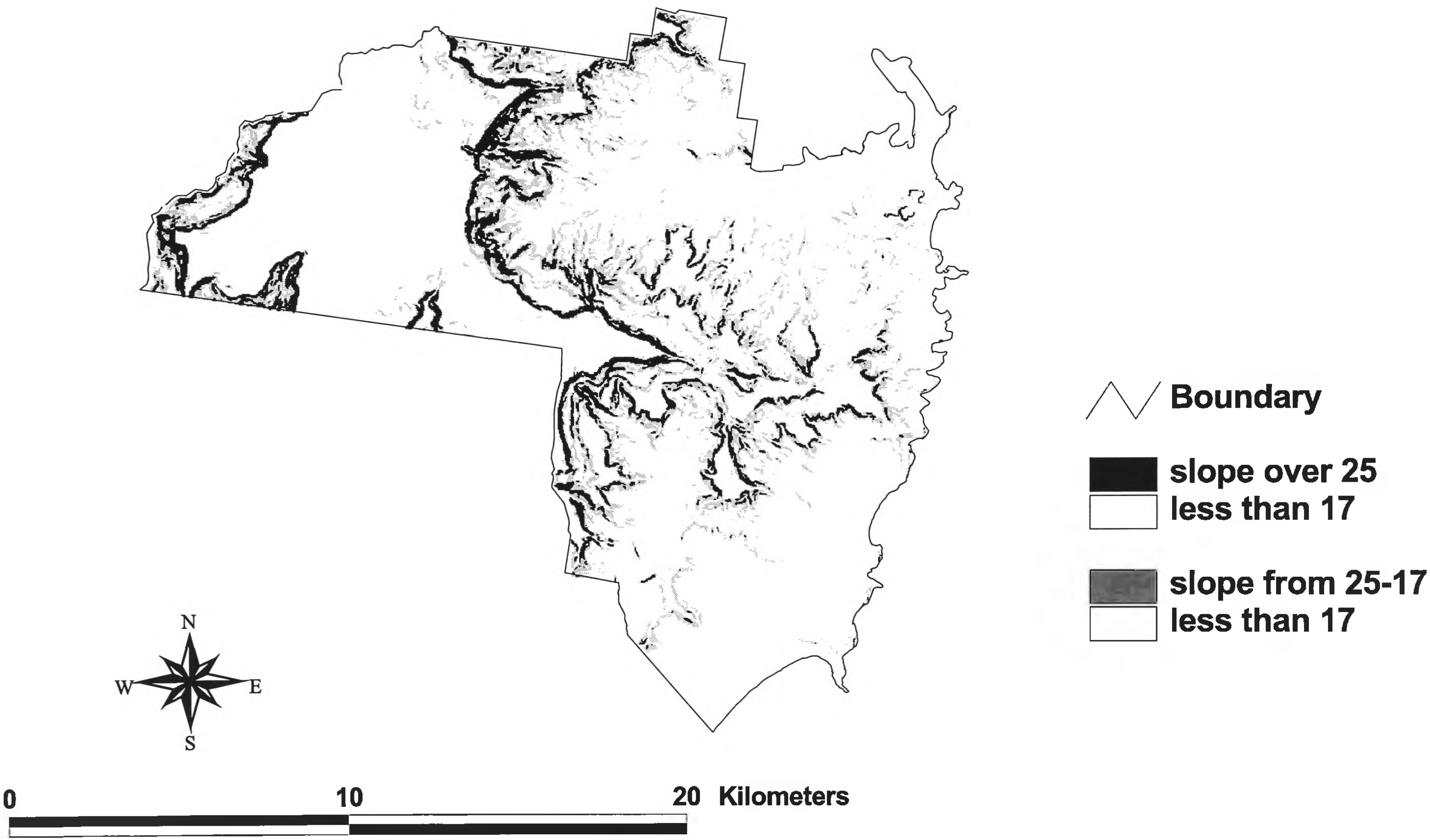

Figure 4.10 Slopes over 17 and 25 degree in Kiama LGA

Winds from the sea would also contribute to the limitation of tree growths, due to the salt spray and strength of the coastal winds. This should be necessary to be evaluated in especially Kiama LGA because many farms are located near the coast. However, the effects of see winds are not discussed in this study as there is not much information available about these.

4.4 Land capability

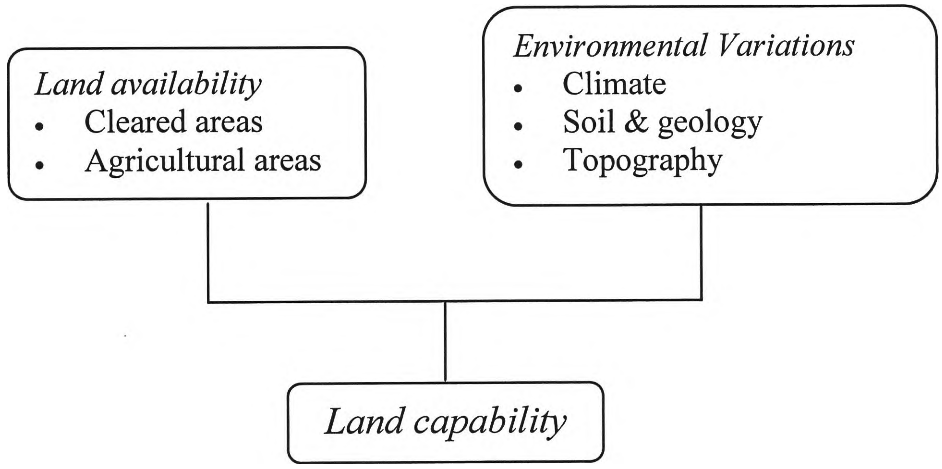

Figure 4.11 Factors considered in land capability for farm forestry in Kiama LGA

Land Capability was determined by integrating land availability and environmental variations (Fig. 4.11). Land availability observed through this study is (1) areas that are previously cleared; and (2) areas that belong to agricultural landholders. The environmental variations are (1) rainfall; (2) soil types (including steep slopes); (3) elevation and (4) aspects (including climate differences). In this study, the limitation from environmental variations to any kind of tree plantations is only soil unsuitability (see 4.3.2). Figure 4.12 shows the result of the land capability in Kiama LGA. The land is classified into 25 groups, explanations of which are listed in Table 4.2. The land classified as “Group 0” is regarded as un-suitable sites for any

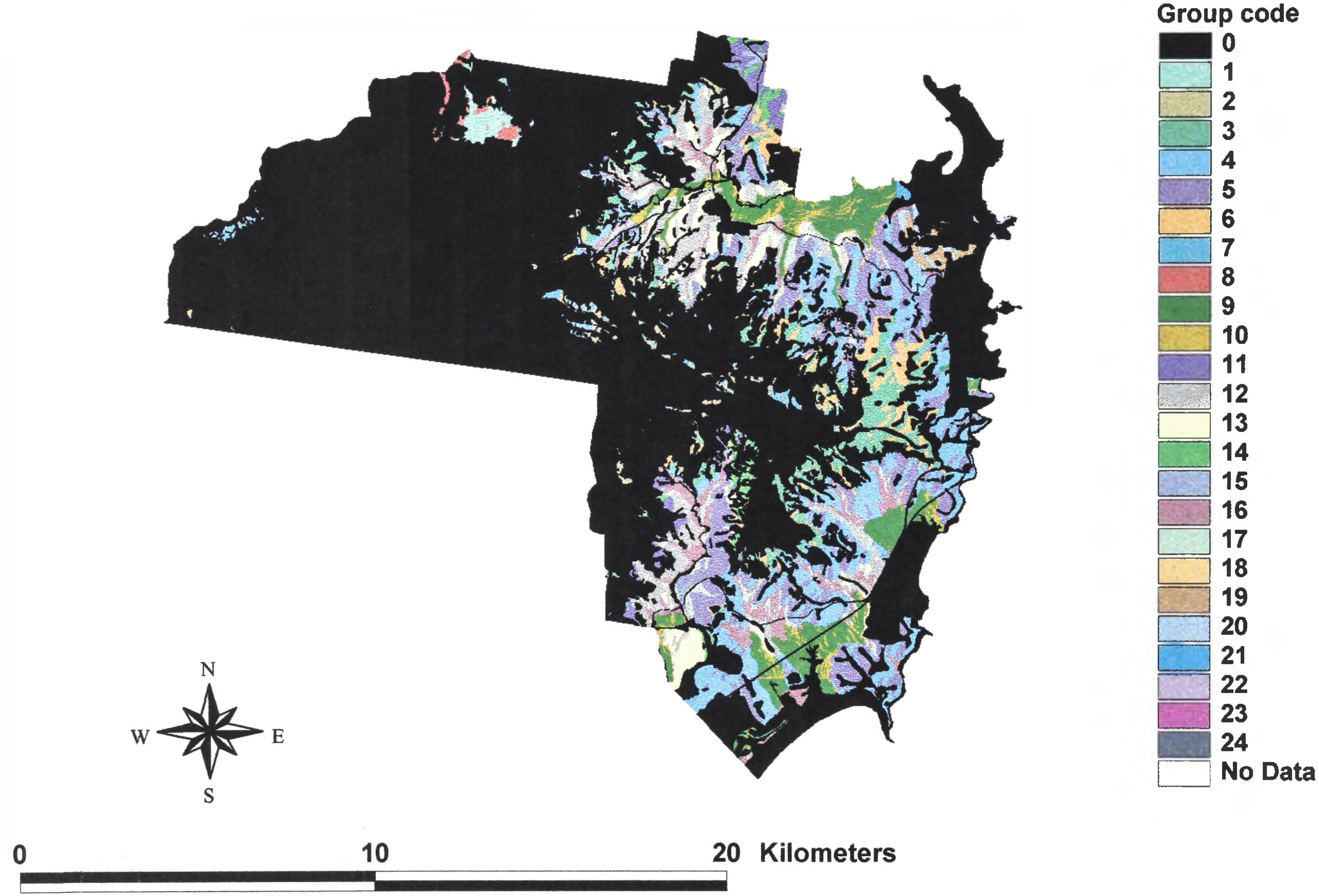

Figure 4.12 Land capability for farm forestry in Kiama LGA

Table 4.2 Explanation of land capability on Figure 4.12

Group	Rainfall	Soil types	Aspect	Elevation
0	non-suitable			
1	High	Fertile	SouthEast	P
2	High	Fertile	SouthEast	hE
3	High	Fertile	SouthEast	lE
4	High	Fertile	SouthEast	CP
5	High	Fertile	NorthWest	CP
6	High	Fertile	NorthWest	lE
7	High	Fertile	NorthWest	hE
8	High	Fertile	NorthWest	P
9	High	Alluvium	SouthEast	CP
10	High	Alluvium	NorthWest	CP
11	High	Brown	SouthEast	lE
12	High	Brown	SouthEast	CP
13	High	Brown	NorthWest	CP
14	High	Brown	NorthWest	lE
15	High	Low fertile	SouthEast	lE
16	High	Low fertile	SouthEast	CP
17	High	Low fertile	NorthWest	CP
18	High	Low fertile	NorthWest	lE
19	Low	Fertile	SouthEast	CP
20	Low	Fertile	NorthWest	CP
21	Low	Alluvium	SouthEast	CP
22	Low	Alluvium	NorthWest	CP
23	Low	Low fertile	SouthEast	CP
24	Low	Low fertile	NorthWest	CP

(P: plateau, hE: high escarpment, lE: low escarpment CP: coastal plains) kind of tree plantations. The reason is due to the land unavailability or/and limitations from environmental factors. The total area of "Group 0"in the whole Kiama LGA is approximately 17,121 ha. Conversely, the total remaining area of the LGA, approximately 8,479 ha (82.9 % of the total cleared agricultural area), has a potential for farm forestry. The potential suitable sites are shown in Figure 4.13, which are mapped on the aerial photo of Kiama LGA. As discussed in section 4.3, physical soil properties are difficult to modify while soil fertility may be improved by soil treatment such as fertiliser. Based on the soil fertility, the potential suitable sites were ranked as "potentially high productive" (sites that have moderate to high soil fertility) and "potentially low productive" (the sites that have low fertility) (Fig. 4.13).

4.5 Suitable sites for commercial local native trees

In this section, suitable sites for potentially commercial local native species are discussed by integrating the land capacity and environmental requirements of the species. However, identifying the environmental requirements of local native species is critical. BRS (1998) studied suitable sites for *Pinus Radiata* and *Eucalyptus nitens* in the Eden region as part of the CRA. The study on *Pinus Radiata* regarded the species requirements as "site quality", determined by site index data (data from existing plantation sites). As for *E. nitens*, because of lack of its site index data, the study determined the "site quality" by pre-European vegetation types. It is ideal to identify species requirements from plantation sites of the species, however, plantations of native local species in the Illawarra and Shoalhaven regions were commenced only a few years ago, and the information from the plantations is insufficient to conclude the species requirements (see 3.4.1). The natural distribution of the species is another way to identify the species requirements because the natural

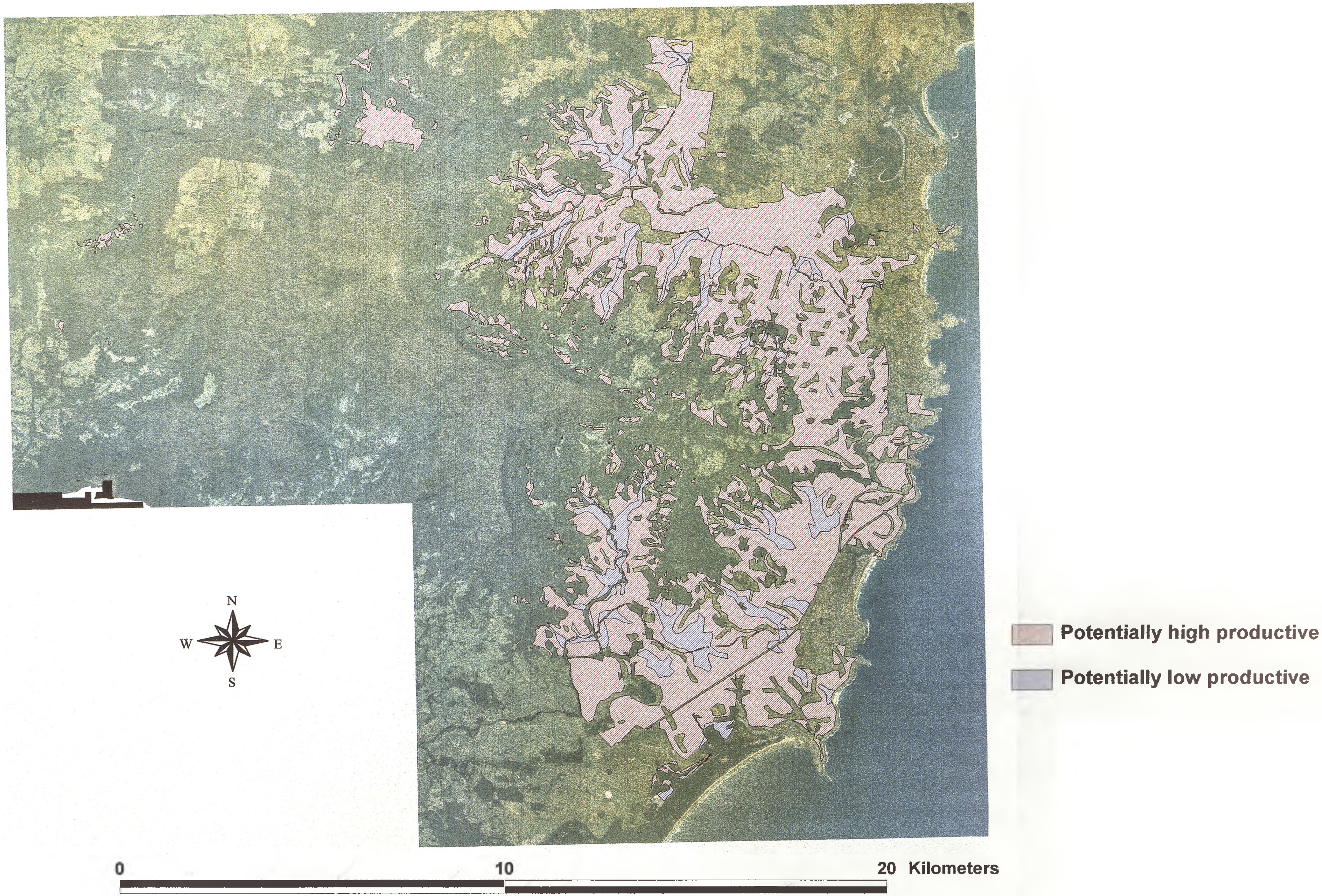

Figure 4.13 Potentially suitable sites for farm forestry in Kiama LGA

distribution would be interpreted as sites where species show good growth rates and performances (see 3.4.2). Therefore, in this study, species requirements are determined by the natural distribution of the species.

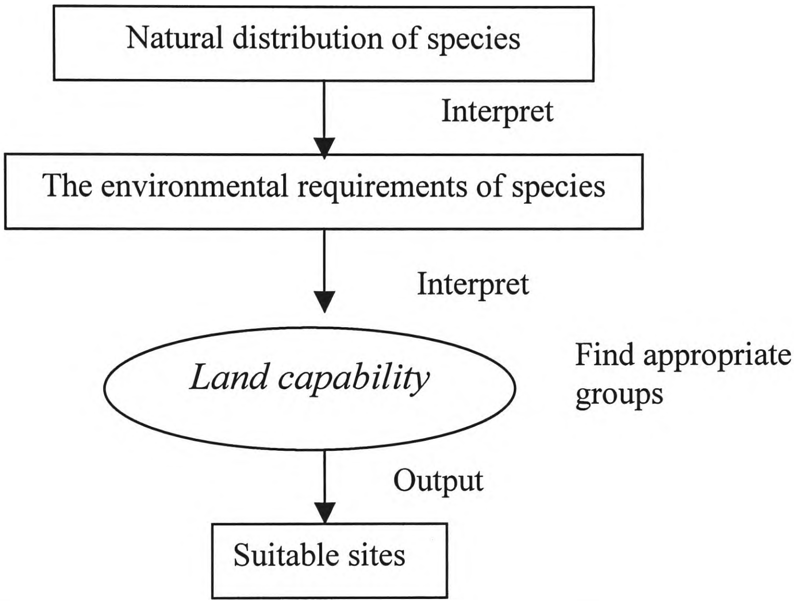

Figure 4.14 The method used to determine suitable sites for species with land capability

The natural distributions of potentially commercial local native species were investigated in "Forest Trees of Australia" (Boland et al, 1984) and "Native Trees of Central Illawarra" (Fuller & Mills, 1985) as well as "Illawarra Remnant Bushland Database" (Nature Conservation Council of NSW, 2000). The natural distribution of species was interpreted as the environmental requirements of the species according to climate, elevation, rainfall, soils and topography. Maps of the species' natural distribution in "Native Trees of Central Illawarra" and "Illawarra Remnant Bushland" were regarded as more reliable information than those from "Forest Trees of Australia" because of their more detailed studies in Kiama LGA. After the determination of the species requirements, they were interpreted into codes of groups in land capability (see Table 4.2). The suitable sites are determined by finding groups that are satisfied with the species requirements (Fig. 4.14).

Appendix 4.3 and 4.4 show the summaries of the environmental requirements of potentially commercial local native species, based on "Forest Trees of Australia" and "Native Trees of Central Illawarra" respectively. Table 4.3 shows the groups in land capability that satisfies the environmental requirements for each species. Moreover, the satisfied groups were ranked as "potentially high productive" or "potentially productive". Species usually have a favoured environment in which the species grow better than other places within their natural distribution. The groups that have this environment were ranked as "potentially high productive". On the other hand, the groups that have general occurrence of the species were ranked as "potentially productivity".

4.5.1 Non-rainforest species

The following non-rainforest native local species were defined as potentials for commercial plantations in Kiama LGA: Grey Ironbark (*Eucalyptus paniculata*); Blackbutt (*E. pilularis*); Spotted Gum (Corymbia *maculata*); Bangalay (*E. botrioides*); Sydney Blue Gum (*E. saligna*); Forest Red Gum (*E. tereticornis*); Yellow Stringybark (*E. muelleriana*); and Turpentine (*Syncarpia glomulifera*) (see Chapter 3). *E. saligna/botyoides*, which is a hybrid of two species, Bangalay and Sydney Blue Gum, occurs very commonly in Kiama LGA. The market value of this species is not available in this study, however, the species may have a potential for commercial uses because it is a hybrid of the two potentially commercial species. Therefore, the suitable sites for this species are also discussed.

Table 4.3 The environmental requirements of examined species and their satisfied groups in land capability

<table>
<tr><td>Species</td><td colspan="4">Species requirements</td><td>Potential outcomes</td><td>Values for land classification</td></tr>
<tr><td rowspan="2">Bangalay</td><td rowspan="2">Coastal plains within 2km from the sea</td><td colspan="3">Brown podzolics and alluvial soils</td><td>High Productive</td><td>(9,10,12,13) * the distance (2km)</td></tr>
<tr><td colspan="3">Other soils</td><td>Productive</td><td>(4,5,16,17,23,24)* the distance (2km)</td></tr>
<tr><td rowspan="2">Sydney blue gum</td><td rowspan="2">Low escarpment</td><td colspan="3">Brown podzolics</td><td>High productive</td><td>11,14</td></tr>
<tr><td colspan="3">Other soils</td><td>Productive</td><td>3,6,15,18</td></tr>
<tr><td rowspan="2">Forest red gum</td><td rowspan="2">Coastal plains</td><td colspan="3">Fertile soils, alluvial soils and Brown podzolics</td><td>High productive</td><td>4,5,9,10,12,13,19,20,21,22</td></tr>
<tr><td colspan="3">Low fertile soils</td><td>Productive</td><td>16,17,23,24</td></tr>
<tr><td rowspan="2">Yellow stringybark</td><td rowspan="2">Low escarpment</td><td colspan="2" rowspan="2">Fertile soils and Brown podzolics</td><td>South-East aspects</td><td>High productive</td><td>3,11</td></tr>
<tr><td>North-West aspects</td><td>Productive</td><td>6,14</td></tr>
<tr><td>Eucalyptus saligna/botyoides</td><td>Low escarpment
Coastal plains</td><td colspan="3"></td><td>Suitable</td><td>3,4,5,6,9,10-24</td></tr>
<tr><td>Rainforest species</td><td>Low and high escarpments
Coastal plains</td><td>South-East aspects</td><td>Fertile soils</td><td>High rainfall</td><td>Suitable</td><td>2,3,4</td></tr>
<tr><td>Red cedar</td><td>Low and high escarpments
Coastal plains</td><td>South-East aspects</td><td colspan="2">Fertile soils, alluvial soils and Brown podzolics</td><td>Suitable</td><td>2,3,4,9,11,12,19,21</td></tr>
</table>

The environmental requirements of Grey Ironbark and Spotted Gum are not clear due to their limited distribution in Kiama LGA (Fuller & Mills, 1985; Nature Conservation Council of NSW, 2000), therefore, the analysis of the suitable sites for these species was not conducted. Blackbutt commonly occurs in Shellharbour and Wollongong LGAs, however, it occurs only in Jamberoo Valley in Kiama LGA (Fuller, 1980; Fuller & Mills, 1985). The species requirements for Blackbutt were not clear from available information, therefore, the suitable sites were also not examined.

Bangalay occurs in coastal areas, and can grow on a wide range of soils. The best growth of this species is seen further inland and on moderately fertile loams of river valleys (Boland et al, 1984). The natural distribution of the species in Kiama LGA is arbitrary on coastal plains within 2 km from the sea, but does not extend to the escarpment (Fuller & Mills, 1985; Nature Conservation Council of NSW, 2000). As mentioned above, this study gives preference to information from species' natural distribution in Kiama LGA over those from "Forest Trees of Australia" by Boland et al (1984). Therefore, the examination of Bangalay was conducted only within 2km from the coast. The "potentially high productive" was ranked in sites on coastal plains within 2km from the sea; and on "Brown" and "Alluvial" soils, which contain high fertile loams. On the other hand, the "potentially productive" was ranked in sites on coastal plains within about 2km from the sea; and on the other soils. The groups that are satisfied with the "potentially high productive" in land capability are 9, 10, 12, 13; and those of the "potentially productive" are 4, 5, 16, 17, 23, 24 (Table 4.3). In addition, these groups were determined by adding the distance from the coastlines (2km), which was calculated by using buffer analysis in ArcView. The "potentially high productive" and "potentially productive" are shown on Figure 4.15.

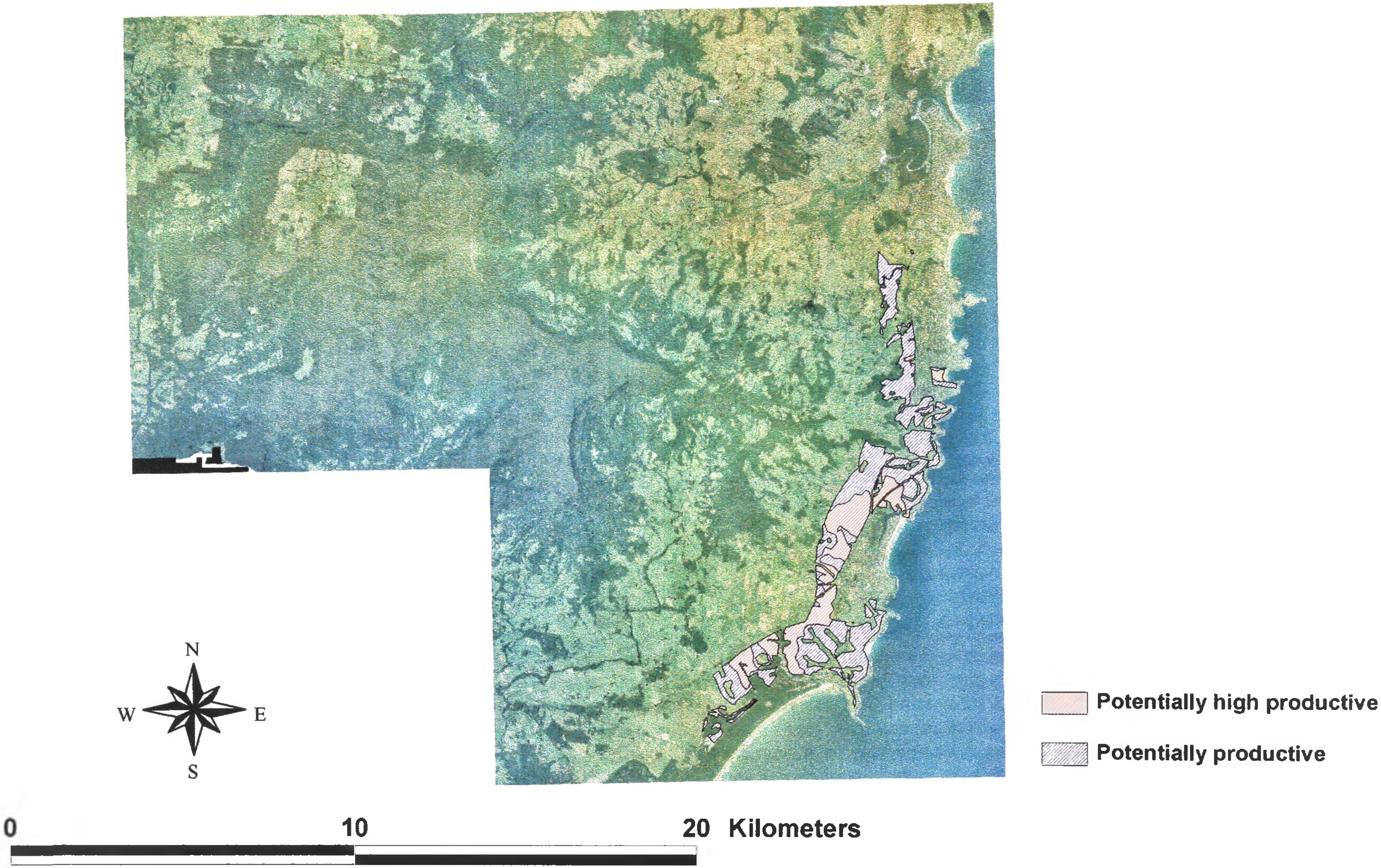

Figure 4.15 Potentially suitable sites for plantations of Bangalay in Kiama LGA

Sydney Blue Gum occurs in the lower half of the escarpment (Fuller & Mills, 1985). It occurs on a range of soils but displays its best growth on sandy loams (Boland et al, 1984). In addition, it prefers high moisture and fertile soils (Fuller & Mills, 1985). The "potentially high productive" sites were defined as being on lower escarpments and on "Brown", which have fertile loams (Group 11,14 in the land capability). On the other hand, the "potentially productive" sites were defined as being on lower escarpments and on the other soils (Group 3, 6, 15, 18) (Fig. 4.16).

Forest Red Gum is a common species on coastal plains in the Illawarra region (Fuller & Mills, 1985; Nature Conservation Council of NSW, 2000). It prefers fairly fertile alluvial soils including sandy to gravely loams, which are moist but not waterlogged (Boland et al, 1984). However, Fuller & Mills (1985) found that the species is most common on soil derived from latite (clayey krasnozems). The "potentially high productive" of this species was defined as being on coastal plains, on "Fertile" soils, "Alluvial" soils and "Brown" (Group 4, 5, 9, 10, 12, 13, 19, 20, 21, 22). The "potentially productive" was defined as being on coastal plains and on "Low Fertile" soils (Group 16, 17, 23, 24) (Fig. 4.17).

Yellow Stringybark is restricted in the lower half of the escarpment in Kiama LGA (Fuller & Mills, 1985). Boland et al (1984) defined the maximum preferred annual average rainfall of the species as 1200 mm, however, Yellow Stringybark is definitely found in the areas that have over 1200 mm average annual rainfall (Fuller & Mills, 1985; Nature Conservation Council of NSW, 2000). Therefore, the rainfall factor was not applied to this study. The species grows well on fertile clay loams but prefers moist valleys and sheltered places (Boland et al, 1984; Fuller & Mills, 1985). The "potentially high productive" site are on the lower escarpment, on "Fertile" soils and "Brown" as well as 'South-East" aspects, which tend to be moist, and are

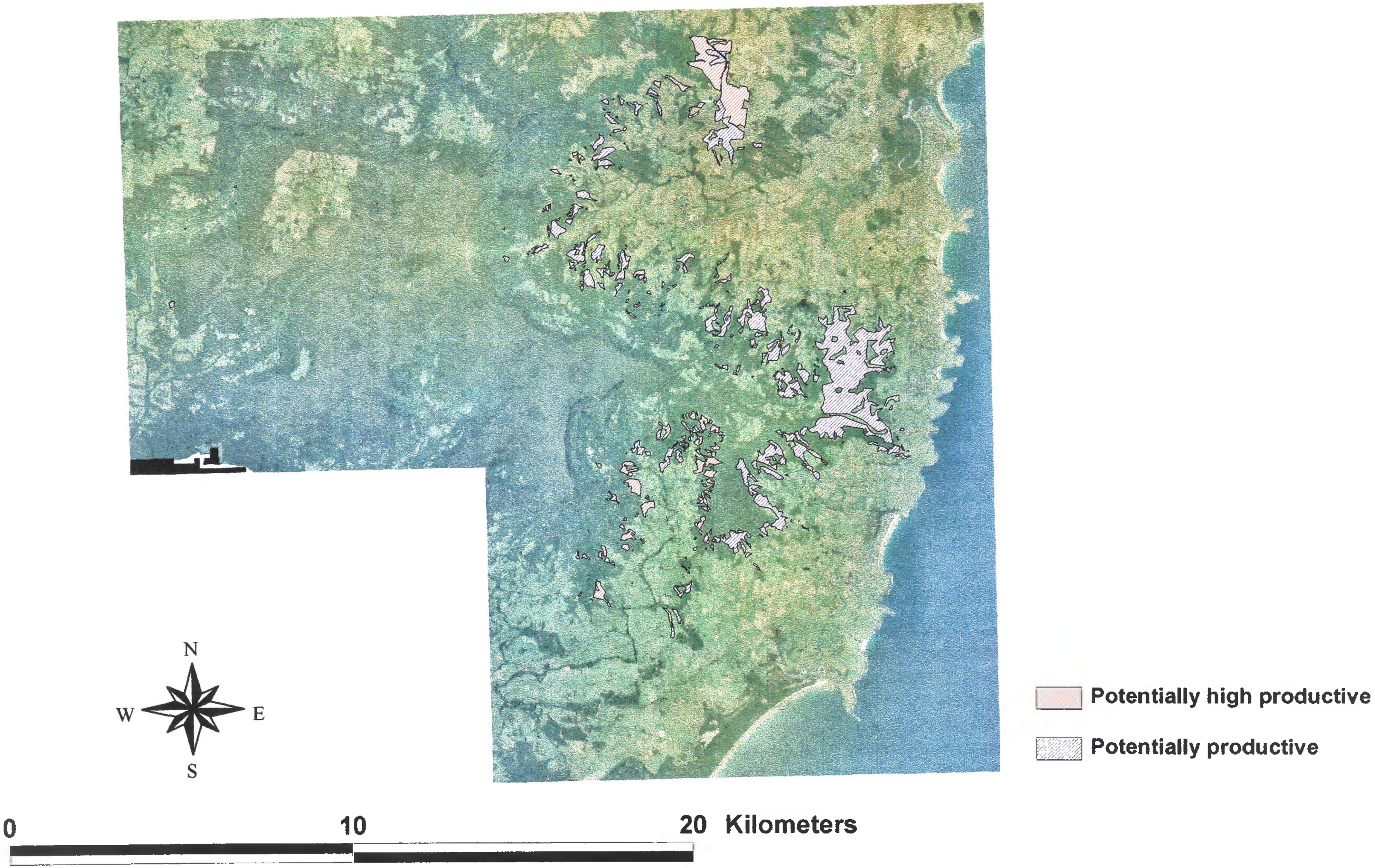

Figure 4.16 Potentially suitable sites for plantations of Sydney Blue Gum in Kiama LGA

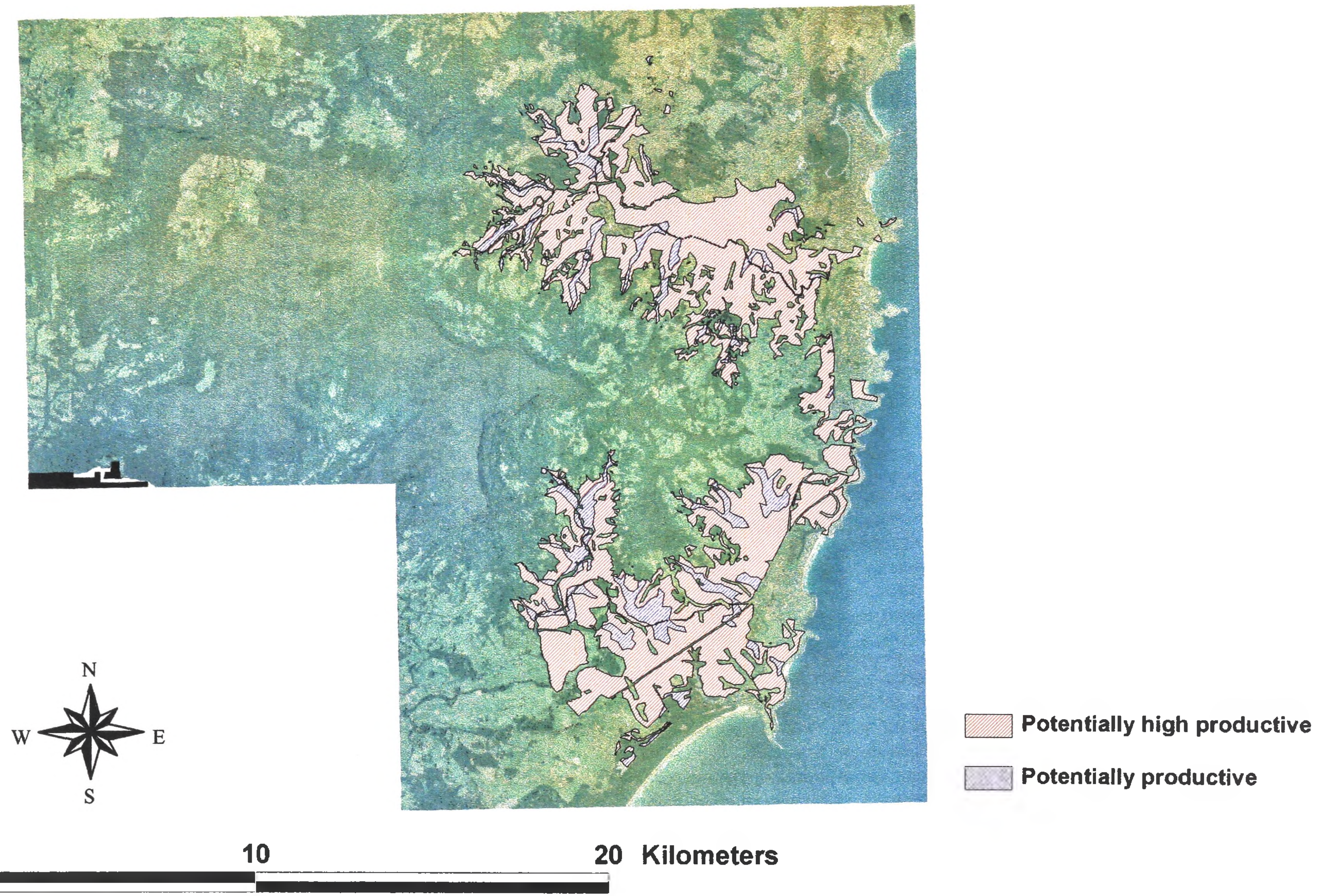

Figure 4.17 Potentially suitable sites for plantations of Forest Red Gum in Kiama LGA

protected from dry westerly winds (Group 3, 11). The "potentially productive" sites are on the lower escarpment; on "Fertile" soils and "Brown", with "North-East" aspects (Group 6, 14) (Fig, 18).

Turpentine occurs in the lower half of the escarpment, and also in the Jamberoo Valley, Kangaroo Valley, Budderoo Plateau and Seven Mile Beach on coastal plains (Fuller & Mills, 1985). However, the species are not found in the other valleys in Kiama LGA, although the environmental conditions are similar. The natural distributions on coastal plains in Kiama LGA were difficult to interpret into the group codes of land capability. Therefore, the suitable sites for Turpentine were not examined in this study. Fuller (1980) suggested that "Turpentine is most commonly found in association with Sydney Blue Gum". The suitable sites for Turpentine in the lower half of the escarpment would be similar to those for Sydney Blue Gum.

Eucalyptus saligna/botryoides commonly occurs on coastal plains and the lower half of the escarpment in Kiama LGA (Fuller & Mills, 1985; Nature Conservation Council of NSW, 2000). There is no information on this species in "Forest Trees of Australia" (Boland et al, 1984), Because of lack of information on the most preferred environment, only suitable sites for this species were examined. The suitable sites were defined as being on coastal plains and the lower escarpment (Group 3, 4, 5, 6, 9-24) (Fig, 4.19).

4.5.2 Rainforest Species

Discussed in chapter 3, information on timber value of rainforest species was not obtained. Therefore, the site suitability analysis identified general suitable sites for any of the rainforest species, as well as for Red Cedar (*Toona ciliata*), the timber

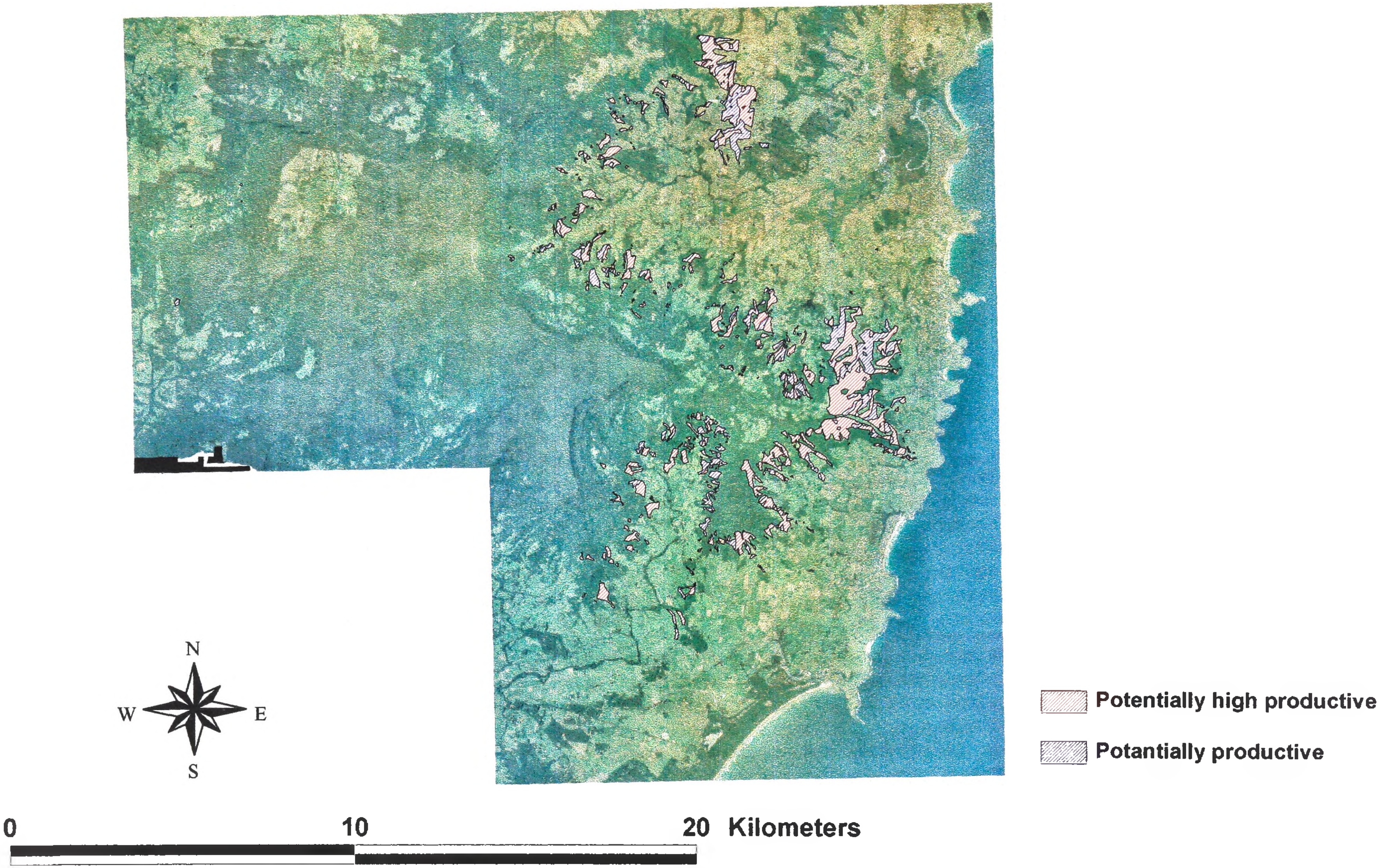

Figure 4.18 Potentially suitable sites for plantations of Yellow Stringybark in Kiama LGA

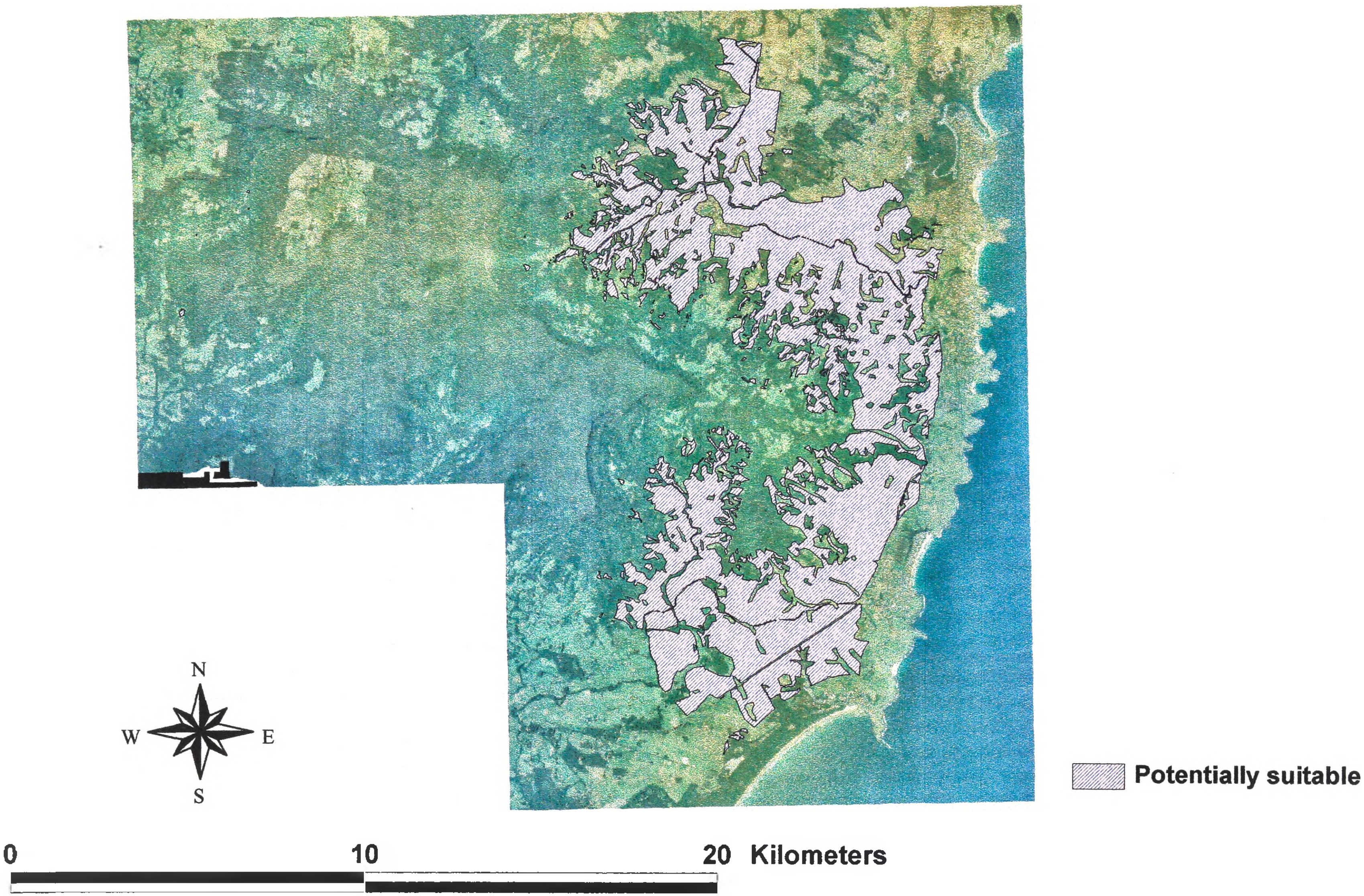

Figure 4.19 Potentially suitable sites for plantations of Eucalyptus saligna/botryoides in Kiama LGA

of which was in high demand and extremely valuable during the 19th century (see section 2.2 & 3.3.2).

Rainforests are found on the coastal plains and escarpment of Kiama LGA. They are not found on the plateau due to the dry climate and its infertile soils. Rainforests prefer volcanic soils, moist valleys and sheltered places (Fuller & Mills, 1985; Mills & Jakeman, 1995). Mills & Jakeman (1995) suggested that the minimum average annual rainfall for rainforests could be defined as 1200 mm per annum (see section 4.3.1). The potentially suitable sites of rainforest species are identified as being on coastal plains and the escarpment, "Fertile" soils, "South-East" aspects which could be described as moist and sheltered areas, and areas with high rainfall, at least over 1200 mm annum (Group 2, 3, 4) (Fig, 4.20).

The natural distribution of Red Cedar is more expansive than the areas that have less than 1200 mm of rainfall per annum (Fuller & Mills, 1985). Boland et al. (1984) explained that Red Cedar can grow in areas with lower rainfall where the soil's moisture is supplied from other sources. The species prefers fertile alluvial or volcanic soils; and moist gullies and sheltered areas (Fuller & Mills, 1985; Boland et al., 1984). The potentially suitable sites are defined as being on coastal plains and the escarpment; "South-East" aspects and "Brown", as well as on "Fertile: and "Alluvial" soils (Group 2, 3, 4, 9, 11, 12, 19, 21) (Fig. 4.21).

4.5.3 Suitable species for sites

In this section, potentially suitable species for sites are examined according to the environmental requirements of potentially commercial local native species and the land capability. Suitable species for each group in land capability were identified by Table 4.3. The species that have the groups ranked as "potentially high productive" in

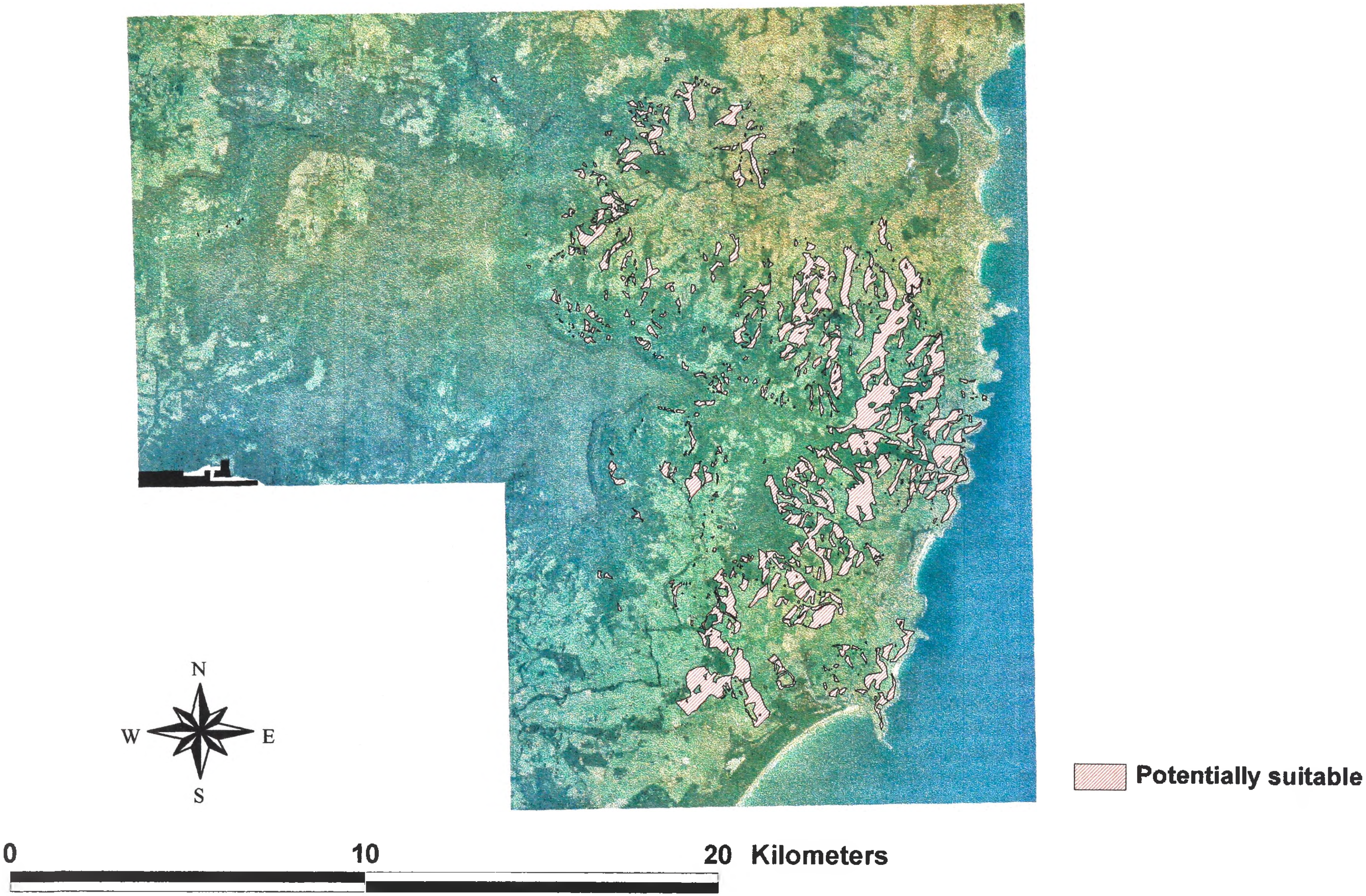

Figure 4.20 Potentially suitable sites for rainforest plantations in Kiama LGA

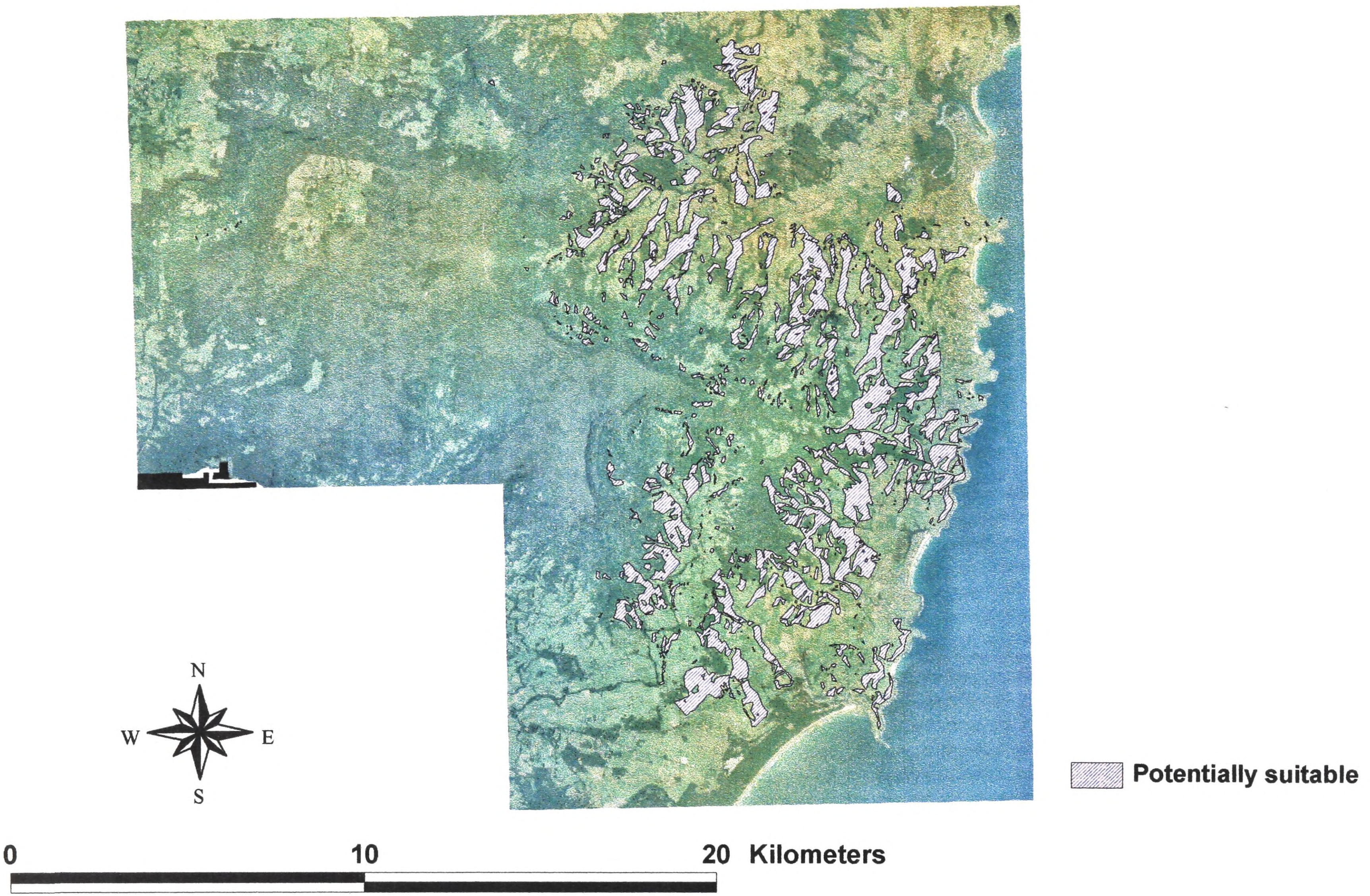

Figure 4.21 Potentially suitable sites for plantations of Red Cedar in Kiama LGA

Table 4.3, were identified as “potentially high productive species” in the groups in Table 4.4. Just like the “potentially high productive species”, “potentially productive species” for each group in land capability were identified. The species of which only potentially suitable sites were examined, were described as “potentially suitable species” for appropriate groups in Table 4.4. The results of Table 4.2 and 4.4 show that potentially suitable species for the plantation on coastal lands is Bangalay; those suitable for coastal plains are Forest Red Gum and *E. saligna/botryoides*; and those suitable to the lower escarpment are Sydney Blue Gum, Yellow Stringybark and *E. saligna/ botryoides*. There is also significant number of places suitable for rainforest plantations in Kiama LGA. The suitable species for the high escarpments and plateau could not be determined in this study.

4.6 Feed back

The University of Wollongong has established experimental tree plantation plots for the study of growth rate and performance of species (see section 3.4.1). The four sites are located in Kiama LGA, Kiama, Jamberoo Pass, Toolijooa and Jerrara Dam. Some studies have been done at the four sites, but the trees in the plantations are not yet mature enough to give reliable growth data. When data are available, they should be incorporated into the information on the environmental requirements of species. On the other hand, it is important to compare the land capability study to monitor growth rate and performance at the experimental plots. If there is any significant difference between the studies, the value that was used for the land capability study needs to be considered to rectify any possible problems in it.

Table 4.4 Potentially suitable species for plantation sites in each group of land capablity

Group	Bangalay	Sydney blue gum	Forest red gum	Yellow stringybark	*E.saligna/botryoides*	Rainforest species	Red cedar
0							
1							
2						S	S
3		P		H	S	S	S
4	P * the distance (2km)		H		S	S	S
5	P * the distance (2km)		H		S		
6		P		P	S		
7							
8							
9	H * the distance (2km)		H		S		S
10	H * the distance (2km)		H		S		
11		H		H	S		S
12	H * the distance (2km)		H		S		S
13	H * the distance (2km)		H		S		
14		H		P	S		
15		P			S		
16	P * the distance (2km)		P		S		
17	P * the distance (2km)		P		S		
18		P			S		
19			H		S		S
20			H		S		
21			H		S		S
22			H		S		
23	P * the distance (2km)		P		S		
24	P * the distance (2km)		P		S		

(H: Potentially high productive species, P: Potentially productive species, S: Potentially suitable species)

4.7 Discussions and Conclusions

Overall, it is suggested that there are significant areas of the Kiama LGA that are definitely suitable for farm forestry. The LGA has a mild climate and relatively high rainfall throughout the year. Moreover, most of the agricultural lands have fertile and productive soils. As for topography, the escarpment, which dominates the LGA, plays an important role in protecting the areas on escarpment and coastal plains from dry westerly winds. An environment with these characteristics could support a wide range of tree plantations including rainforest species. The area defined as potentially suitable for tree plantations, according to land availability and environmental factors, is approximately 8,500 ha, which makes up 83 % of the total cleared agricultural area.

There are some limitations of this study and needed to be considered in further studies. Firstly, this study is based only on the natural distribution of the species. This means that the environment in plantation sites, which provide less competition for species, is neglected (see 3.4.2). It is necessary to incorporate the data from plantation sites into the land capability/suitability when the data is available. Secondly, the effects of the escarpment on the surrounding environments were insufficient to describe in this land capability. Significant area of Kiama LGA is dominated by the escarpment, which influences rainfall and moistures, in places surrounding the escarpment, such as escarpment itself and valleys. It is important to include the effects of escarpment into the land capability in further studies. Thirdly, the effects of the sea winds are not included in this study. Because of the fact that there exists significant number of farmlands close to the sea, it is necessary to consider how much the effects of the sea winds affect growth rate and performance of trees. The other environmental and economic factors of farm forestry should also be considered in further studies, such as the alteration of the environment by human activities, slopes, accessibility of transportation, distance from markets, competing land uses and land values.

Land capability study with GIS (ArcView) is a useful tool to determine suitable sites and species for farm forestry. An evaluation of land capability and suitability for tree plantations could certainly be excellent material with which to relay useful information to the farmers who want to start farm forestry. In Figure 4.13 and 4.15-21, the layers of potentially suitable sites are put on the aerial photos of Kiama LGA. The layers are transparent in the computers, therefore, farmers can easily recognise the suitable sites on their properties by looking at their properties on the aerial photos through the layers. In addition, the maps can be enlarged and mistakes and changes which may occur over the years can be incorporated easily.

Land capability study is highly recommended to be conducted in other LGAs, Wollongong, Shellharbour and Shoalhaven. Some of the Councils already have gathered some digital data for GIS analysis, which could be directly used for the farm forestry analyses. The cooperation of the councils is required.

Chapter 5 Discussion

Land availability

Agriculture is one of the important rural industries in the Illawarra and Shoalhaven regions. Major agriculture in these regions consist mainly of pasture-based grazing. Land availability for potential farm forestry was examined according to cleared agricultural lands and legislation. The rate of cleared area on agricultural area is from 60 to 70 %. Limitation to land availability for farm forestry by legislation is negligible. It is concluded that there is a significant area of available lands for farm forestry in the Illawarra and Shoalhaven regions.

There are many pieces of legislation that relate to farm forestry. The Plantation and Reafforestation Act, which is applied to Kiama, Shellharbour and Shoalhaven, would give some advantages to many of the future farm foresters in the regions by exempting them from the regulations under the Act.

Land Evaluation

Significant area of the agricultural lands in the Illawarra and Shoalhaven regions has a high potential for tree plantations. Temperatures are mild and high rainfalls occur evenly throughout the year. Soils on most agricultural lands are productive. The natural environment on most agricultural lands in the region is very suitable for tree plantations. The environment in some parts of these regions could also support rainforest plantations.

Species Selection

There is a wide variety of the local native species that have potential for commercial plantations. However, many of the species are not currently being used for timber, which hinders assessment of the actual timber value of these species. Eucalypts would be the most important species for farm forestry in the Illawarra and Shoalhaven regions due to the fact that they are relatively fast-growing and their timber can be used in a wide variety of ways, from posts and poles to high-valued special uses, such as furniture, cabinet and craft wood. As for rainforest species, presently, the market of local native rainforest timber is small because of limited supply and small demand for the timber. However, some furniture and cabinet makers look for rainforest timber from other regions. This shows a high potential to create a bigger market for the local native rainforest timber by increasing supply from rainforest plantations. This plan also needs the cooperation of local furniture and cabinet workers. Other species such as acacias and casuarinas are needed to be considered in further studies.

Land Capability Study

A land capability study for farm forestry in Kiama LGA is useful to determine suitable sites for plantations of a range of local native species. This should also be conducted in other regions in the study areas. Many of the factors used for the land capability study would be applied to other regions due to the similarity of the environment of these regions to that of Kiama LGA. Other factors that were not considered in the study, such as effects of sea winds, water and soil drainage, distance from the market, need to be considered in further studies. A number of potentially commercial local native species should also be developed. Feed back of the land capability study to the study of monitoring growth rate and performance of trees in the regions is necessary to develop the land capability study.

Cooperation of Farmers and Governments

There is one main problem that has prevented the growth of farm forestry. The problem is that both farmers and the Councils in the Illawarra and Shoalhaven regions have so far failed to consider the option of farm forestry seriously. Farm forestry has many benefits, such as improvement of land production capability and the environment, and alternative potential income sources from agricultural activities. However, farm forestry also has many risks that relate to the nature of the industry, such as the long-term nature of the businesses' economic returns and difficulty of finding markets and investors due to the small amounts of forestry production and the small scales of plantations. It is suggested that farm forestry cannot grow without the active support of local and state governments. There are some reasons why the governments need to provide more adequate support for the establishment of farm forestry plantations. Firstly, the support of the governments is insufficient to help the growth of farm forestry specifically in the Illawarra and Shoalhaven regions. The state government has some programmes to encourage farm forestry activities, but they do not reach the Illawarra and Shoalhaven regions. Currently, local governments are required to lead environmentally sustainable development in their municipality (Kelly & Farrier, 1996). Farm forestry can be one of the important developments for the agricultural industry, which meet their goals of environmental sustainability. Secondly, in order to create a bigger market for timbers of local native species, cooperation of local farmers, local sawmill companies, and furniture and cabinet workers is essential. In addition, the growth of these markets would contribute to the local economy. Thirdly, farm forestry still needs more economic and scientific research, which means state or federal funding and University support are essential. It is suggested that only the governments can encourage the growth of farm forestry efficiently, and the benefits from the growth of farm forestry have a great potential to play an important role in agriculture, environment and economy at local and regional levels.

Chapter 6 References

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Chapter 7 Appendix

Appendix 3.1 Questionnare posted to sawmill companies

Species	*How much would you pay for logs of this rainforest species ($/m³)?*	*What is the minimum volume of this rainforest timber you would buy?*	*What products would you make from this species? (structural lumber, veneer, ???)*
Red cedar (Toona ciliota)			
Coachwood (Ceratopetalum apetalum)			
Lilly pilly (Acmena smithii)			
Red ash (Alphitonia excelsa)			
Plum pine (Podpcarpus elatus)			
Pencil cedar (Polycias murrayi)			
Pigeonberry ash (Elaeocarpus kirtonii)			
Black apple (Planchonella australis)			
Bolly gum (Litsea reticulata)			
Sassafras (Doryphora sassafras)			
Turpentine (Syncarpia glomulifera)			
Blackwood (Acacia melanoxylon)			
Other (please list)			

Please feel free to add any other comments you might have about the potential for rainforest timbers as part of a south coast forestry industry.

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APPENDIX 4.1 Average annual rainfall recorded in rainfall stations in the Illawarra and Shoalhaven

STATION NAME	LATITUDE	LONGITUDE	ELEVATION	RAINFALL	COMMENCE	CEASE	RECORDED YEARS
ALBION PARK POST OFFICE	-34.5697	150.779	8	1114.2	1/1/1892		30
BERRY MASONIC VILLAGE	-34.7811	150.692	10	1445	1/1/1886		27
DAPTO BOWLING CLUB	-34.5017	150.783	10	1166.7	1/1/1906		27
GERRINGONG	-34.7472	150.821	20	1372.8	1/1/1895		31
JERVIS BAY	-35.0936	150.8048	85	1244	1899		101.7
KIAMA BOWLING CLUB	-34.6758	150.851	10	1309.7	1/1/1897		31
MITTAGONG	-35.0936	150.8048	635	902	1886		100.8
MOSS VALE	-34.5444	150.3768	675	982	1870		130.2
PORT KEMBLA	-34.4772	150.6109	11	1277	1950		27.1
WOLLONGONG P.O.	-34.4333	150.8833	30	1136	1870		81.8
NOWRA RAN	-34.9449	150.6	109	1135	1942		43.4
NOWRA COUNCIL OFFICE	-34.8833	150.6	7.9	974	1884	1935	50.3
BARKELEY NORTHCLIFFE DRIVE	-34.4847	150.854	5	1165.4	1/1/1962		31
ROBERTSON	-34.59	150.608	760	1629	1/1/1962		31
WINDANG BOWLING CLUB	-34.5342	150.866	5	1154	1/2/1962		29
TOOLIJOOA	-34.7633	150.79	3	1404.1	1/3/1967		27
WOLLONGONG UNI.	-34.4033	150.8772	30	1374	5/23/1905		30.6
WATTANMOLLA	-34.7369	150.624	130	1571.2	1/1/1970		27
FOXGROUND ROAD	-34.735	150.767	50	1668.3	1/1/1972		28
OAK FLATS	-34.5575	150.815	4	1103.6	1/1/1974		13
JAMBEROO (DRUEWALLA)	-34.6575	150.728	115	1543.1	1/1/1963		24
WATTANMOLLA (GRIFFITHS)	-34.7225	150.648	140	1518.6	23/11/1982		7
ROBERTSON (THE PIE SHOP)	-34.5858	150.626	735	1728.2	1/1/1985		14
UPPER KANGAROO VALLEY	-34.6878	150.603	100	1264.7	1/12/1992		5
WINDANG KRUGER AVE	-34.525	150.871	5	963.4	1/7/1995		5

(Sorce: Bureau of Meteorology)

Appendix 4.2 Average annual rainfall recoreded in the Illawarra and Shoalhaven regions

STATION NAME	EASTING	NORTHING	ELEVATION	RAINFALL	COMMENCE	CEASE	RECORDED YEARS
UPPER CORDEAUX (No.2 DAM)	295779	6190162	330	1585.6	9/21/1973		16
UPPER AVON	291800	6184186	330	1477.3	1/30/1964		14
BROGERS No.2	288362	6158151	274	2089.8	9/25/1968		5
BUDDEROO	282630	6157186	640	1629.0	9/12/1973		11
TURPENTINE	268535	6121568	250	1079.2	5/23/1974		13
MOUNT KEIRA(KENTISH No.2)	299515	6194651	430	1381.7	2/5/1964		6
WOLLONGONG (SPS144)	307010	6188182	5	1152.3	9/11/1981	8/10/98	15
SHELLHARBOUR STP	304048	6172431	5	818.8	12/31/1974		6
BARREN GROUND	292658	6159575	615	2225.0	5/30/1968		10
KANGAROO VALLEY (BROOKES PluvioATEAU)	259682	6148629	313	1016.5	11/7/1977		15
NERRIGA (TALLOWAL CK)	240256	6134622	670	918.0	11/8/1977		15
NERRIGA (THE JUMPS)	238600	6119300	740	919.3	11/9/1977		14
YALWAL	261684	6131321	150	793.7	5/11/1982		12
CORRIMAL (COLLINS STREET)	307005	6194593	22	1213.5	10/13/1987		6
BOMBO STP	303680	6163361	22	972.5	10/2/1990		7
BERKELEY (BERKELEY SPORTS AND SOCIAL CLUB	303141	6182707	10	957.6	10/31/1990		8
DAPTO CITIZENS BOWLING CLUB	297878	6180590	10	870.4	9/21/1991		7

(Source: Australian Water Technologies)

Appendix 4.3 Summary of the distribution of potentially commercial species in Kiama LGA

Species	Climate	Elevation	Rainfall	Soil	Topography
Grey ironbark	Warm humid to subhumid H: 24-34C° C: 1-8C°	0-500m	1750-1700mm	Prefer good soil (fertile, sandy loams) Can grow moderately well on poor sandy ridges Occurs on relatively poorer & moderately drained sites	Valley bottoms to the slopes, tops of rides and hills
Blackbutt	Warm humid H: 24-32C° C: 5-10C°	0-300m	900-1750mm	Mainly occurs on sandy loams or loams Grow satisfactorily on clays and volcanic soils	Gentle slopes of hilly country
Spotted gum	Warm humid to warm sub-humid H: 25-30C° C: 1-8C°	0-950m	750-1750mm	Grows on a wide range of soils Best grow on slightly moist but well drained & of moderately heavy texture such as these derived from shales Occurs commonly on sandstone sites	Occurs on valley slopes or on ridges if the soil is not too dry
Bangalay	Warm humid H: 24-27C° C: 2-8C°	0-150m (300m)	750-1750mm	Grows on a wide range of soils Best grow and form occurs further inland & moderately fertile loams of river valleys	Coastal area
Sydney blue gum	Warm humid H: 24-33C° C: -2-8C°	0-1100m	900-1800mm	Best grow on good quality alluvial sand loams Other soils include podzols & volcanic loams	
Forest red gum	Warm to hot subhumid to humid & occasionally wet H: 24-28C° C: 1-19C°	0-1000m	650-3000mm	Generally occurs on alluvial flats Prefer fairly rich alluvial soils, sandy or gravely loams which are moist but not waterlogged	Lower slopes of hillsides & extends to mountain slopes & plateau
Yellow stringybark	Warm humid to sub-humid H: 24-28C° C: 1-6C°	0-450m (600m)	700-1200mm	Grow on wide range of soils but best grow on fairly deep clay loams	Prefer moist valleys and sheltered slops of undulating and hilly country

Species	Climate	Elevation	Rainfall	Soil	Topography
Turpentine	Warm humid to warm subhumid H: 26-30C° C: 5-10C°	0-300m	1000-2000mm	Prefer deep fertile soils Can grow on a wide range soils including poor soils derived from sandstone	Best grow in valleys on flats and in basins May also occur on ridges & other exposed situations
Red cedar	Warm humid to warm sub-humid H: 26-31C° C: 5-10C°	0-1100m	1200-3800mm Can grow in areas less than 1200mm where the soil moisture is supplied from other sources	Rrefer rich alluvial or volcanic soils	Best grow in moist gullies or along stream banks in wind-sheltered positions

(Source: Forest trees of Australia by Boland et al, 1984)

Appendix 4.4 Summary of the distribution of potentially commercial trees in Kiama LGA

Species	Elevation	Soil	Topography
Grey ironbark	Only occurs on a small hilly area about 2 km west of Bombo		
Blackbutt			Occurs on coastal plains & some parts of the lower escarpment Jamberoo valley
Spotted gum	Only occurs on a small hilly area about 2km west of Bombo		
Bangalay	0-300m		Coasts
Sydney blue gum		Prefer deep moist heavy and rich soils	Lower half of the escarpment
Forest red gum		Common in soil derived from latite	Wide spread in coastal plains
Yellow stringybark		Only occurs on the better soils	Lower half of the escarpment
Turpentine		Only occurs on the better soils	Lower half of the escarpment
Eucalyptus saligna/botryoides			Common in coastal plains to lower half of the escarpment, not in coasts
Red cedar			Grow in coastal plains to the escarpment Best grow in benches of the escarpment and gullies

(Source: Native trees of Central Illawarra by Fuller & Mills, 1985)