PART I

BACKGROUND



Tree decline on the Northern Tablelands of N.S.W.

Chapter 1

Introduction and General Description of the Northern Tablelands

The first recorded episode of eucalypt dieback on the Northern Tablelands of N.S.W. (Fig 1.1) was in the 1850s (Norton, 1886) and the most recent and most severe from 1971 to 1980. An important effect of this most recent episode has been to severely reduce the abundance of shade and shelter trees on grazing land and there is wide concern about how these lost trees can be replaced. The overall aim of this thesis is to obtain a better understanding of the mechanisms of natural regeneration of the species of eucalypt which have been severely affected so that effective re-establishment strategies can be designed for areas affected by tree decline.

The Northern Tablelands[1] is part of the mountain chain which runs the length of N.S.W. and ranges in altitude from 800 to over 1,500 metres (Swan, 1977; Walker, 1977). The broad centre of the tablelands is undulating country with gentle slopes of 3-5°. There are occasional flatter areas and steeper hills and gorges. Its favourable topography, climate and soils have led to extensive use for grazing and agriculture, with broadscale clearing. Because this zone is the most intensively used and the one where the worst tree decline and dieback have occured, it is the area on which this thesis concentrates.

This broad central area is flanked on either side by steeper areas, precipitous in the east, and hilly in the west (Fig 1.1). The eastern area has a high rainfall (1,000- 1,500 mm per annum) and primarily red podzolic and skeletal soils derived from Palaeozoic sedimentary rocks and granites. In a few places there are chocolate and black soils derived from small outcrops of basalt. Because of its rough inaccessible nature much of the eastern area is still forested, its main vegetation types being rainforest, and wet and dry sclerophyll forest, with small patches of heath, fen and scrub[2] (Williams, 1963; Lea *et al.*, 1977). The rough hilly country to the west of the region has a lower rainfall (500-750 mm per annum); its soils are derived mainly from granite and porphyry and are consequently sandy and skeletal and relatively infertile. The western area supports dry sclerophyll forest and scrubland plant communities, which remain largely uncleared because of their relatively low agricultural value (Williams, 1963; Lea *et al.*, 1977).

[1] For convenience the Northern Tablelands Statistical Subdivision will be used to define the region throughout this thesis.

[2] Vegetation descriptions throughout this thesis will be based on Beadle and Costin (1952) as modified by Williams (ca 1987), with some modifications from Specht (1970) and Walker and Hopkins (1984), see Table 5.1.

GEOLOGY

The geology of the broad centre of the Tablelands is dominated by Palaeozoic metamorphic sediments. These are the oldest rocks of the region and include greywackes, cherts, and metamorphosed volcanics and sandstones which are locally known as "trap". Intruded into the sediments are granites of varying types. Overlying both of these in places are the remnants of the basalt flows which erupted over the surface 10 - 65 million years ago in the Tertiary period (Premier's Dept., 1951; Harrington 1977).

SOILS

The wide variety of rock types, topography and climate of the Tablelands is reflected in the diversity of soil types (Premier's Dept., 1951; Jessup, 1965; McGarity, 1977). The effects of topography on soils derived from the different parent materials are summarized in Table 1.1. Red podzolics dominate the eastern and southern sections of the Tablelands. Yellow solodics, yellow and gley podzolics dominate much of the central plateau areas, but black earths, euchrozems and chocolate-prairie soils predominate in those parts of the central section that still carry remnants of the tertiary basalts. The northern and western parts are dominated by yellow solodics and yellow podzolics (Lodge *et al.*, 1984).

Table 1.1: Main Soil Groups of the Northern Tablelands Modified from Hubble and Isbell (1983)

Parent Material	Typical Toposequence Upper slope*——————lower slope
Basalt	chocolate —— prairie —— euchrozem —— black earth
Basalt (moister areas)	kraznozem —— chocolate —— prairie —— black earth
Granites	siliceous sands — yellow podzolics — gleyed podzolics or solodics (with rock outcrops)
Metasediments	red podzolics — yellow podzolics — greybrown podzolics — gley or lateritic podzolics

*Lithosols occur on the upper slopes of all rocks types.

CLIMATE

The climate of the Tablelands is cool to mild temperate and varies with topography, relief, distance from the coast, and latitude. In winter the weather is mainly influenced by the predominantly westerly and south-westerly air streams from the interior of the continent or the ocean to the south which usually bring drier and more stable conditions. In the summer an easterly air stream commonly dominates the weather, bringing moister air, unstable conditions and numerous thunderstorms (Hobbs and Jackson, 1977).

The median yearly rainfall is approximately 750 mm at Armidale, increasing towards the eastern escarpment to 1200 mm p.a. (Hartridge, 1979). About 60% of the rain falls from the beginning of October until the end of March (Table 1.2), with a slight secondary peak in the winter (June). In spite of the summer predominance of rainfall, the summer and autumn are often the period of greatest moisture stress (Beggs, 1959).

Table 1.2: Median Monthly Rainfall for Armidale (mm)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
90	69	54	42	32	53	44	44	52	61	74	71

Source: N.S.W. Water Conservation and Irrigation Commission, River Basin Reports in Hobbs and Jackson (1977), rounded to nearest mm.

There is great rainfall variability between years and this is supplemented by variablity within years and by local spatial variablity. The rainfall in any particular season may be above or below average so that wet or dry seasons may occur in any sequence. The local spatial variablity results from variations in relief, local temperature and wind patterns and because, in many years, a high proportion of the rain occurs in localized storms. Although the median rainfall for a station gives some idea of the rainfall pattern for a region, it is only part of a much more complicated picture (Hobbs and Jackson, 1977).

Plant growth is commonly limited by low soil water in summer and by low temperatures in winter. The mean daily maximum temperature in January at Armidale is 27°C, and the mean daily minimum for June, July and August is of the order of 1°C with temperatures as low as -12°C having been recorded (George *et al.*, 1977). Frosts usually occur from April to the end of October and average about 50 per year – June to August being the coldest period (Hartridge, 1979). Snow falls 1 to 3 times per year, but it rarely lasts for more than a few days.

Temperature and temperature ranges are affected by season, sunshine hours, cloud cover, wind speed and direction and local relief. In the western parts of the tablelands summer temperatures are higher, winter temperatures are lower, frosts are less severe and temperature ranges are greater than nearer the coast. Temperatures decrease with altitude, with the lowest temperatures occurring around Armidale to Guyra.

VEGETATION

The vegetation of the main Tablelands area has been much modified and now consists mostly of open pasture with scattered trees and remnants of grassy forest and woodland. Some dry sclerophyll forest and scrub can also be found along the rockier ridges, gorges and some creek areas which have poorer soils. (Williams, 1963; Jones, 1977; Smith and Turvey, 1977; Williams, 1985). In many places these different community types merge together and the same floristic associations may exhibit different structures in different places.

The number of tree species growing in this area is relatively small - the dominants being *Eucalyptus blakelyi*,[3]. *E. bridgesiana* ssp *bridgesiana, E. caliginosa, E. dalrympleana, E. laevopinea, E. melliodora, E. nova-anglica, E. pauciflora, E. radiata, E. stellulata, E. viminalis* and *Angophora floribunda*, with some associated eucalypt, *Acacia* and *Casuarina* species. Of the 56 eucalypt species which occur in the New England region (Williams 1985), only 12 are

[3]Throughout this thesis plant nomenclature follows that of Jacobs and Pickard (1981)

common in the main Tablelands area. Much of this area and most of its dominant eucalypt species have been affected by dieback (Chapter 3; Table 1.3).

LANDUSE

Over 75% of the whole Northern Tablelands region is used for agriculture, predominantly for grazing sheep and cattle (Dulley, 1980). Non agricultural land, such as state forests, national parks and vacant crown land, occurs chiefly in the eastern edges of the Tablelands; only a little occurs in the main Tablelands area. Areas least developed for agriculture or grazing generally have poor soils or a rugged terrain. Such areas include: the dry sclerophyll forests on the granites; the steep country of the gorges, and the rugged granite and porphyry hills in the west (Nadolny, 1984).

PASTURES

Natural pastures constitute a major part of the Tablelands (1.82 million hectares), while completely native pastures, consisting only of native grasses and forbs, comprise a minor component (Lodge *et al.*, 1984; Whalley *et al.*, 1978). Much of the pasture areas has been improved using aerially applied superphosphate and white clover. In addition approximately 23% of the area of rural holdings on the Tablelands has been sown down with exotic pasture species, such as *Phalaris tuberosa* and *Festuca arundinacea* (Lodge *et al.*, 1984).

Table 1.3: The main vegetation types and eucalypt species on the Northern Tablelands and how they were affected by dieback

VEGETATION TYPE*	LOCATION	SOILS/GEOLOGY	MAIN TREE SPECIES AND DIEBACK EFFECTS §	DIEBACK AND TREE DECLINE
Wet Sclerophyll Forest (= tall open forest)	Extreme east of Tablelands and into escarpment. Often sheltered position. Steeper slopes.	Medium - high fertility soils. Usually basalt derived rocks. Sometimes granite or metasediments.	o *E. fastigata* ⊕ *E. viminalis* o *E. obliqua* ⊕ *E. laevopinea* o *E. andrewsii* o *E. cameronii* o *E. nitens* o *E. saligna* *E. andrewsii* ssp. *campanulata*	Mostly uncleared No dieback.
Dry Sclerophyll Forest (= shrubby open forest)	a) Eastern and south-eastern parts of Tablelands, extending into parts of central area. Often rugged and hilly.	Low - medium fertility soils. Coarse granites eg. leuco adamellite	o *E. cameronii* ⊕ *E. caliginosa* o *E. ligustrina* ⊕ *E. acaciiformis* o *E. deanii* ⊕ *E. stellulata* o *E. quadrangulata* ⊕ *E. youmanii* o *E. dives* o *E. oreades* o *E planchoniana* o *E. approximans* o *E camphora* † *E. nova-anglica* ⊕ *E. dalrympleana* ssp *heptantha* o *E. andrewsii* spp *andrewsii* • *E. radiata* spp. *radiata* • *E. pauciflora* ssp. *pauciflora*	Mostly uncleared. Mostly no dieback except in localized instances.
	b) Central parts (south of Deepwater)		⊕ *E. dalrympleana* ssp. *heptantha* ⊕ *E. bridgesiana* ssp *bridgesiana* Ecotonal: • *E. blakelyi* • *E. melliodora*	Mostly uncleared. No dieback except a little caused by drought.
	c) Western parts of Tablelands. Rugged and hilly.	Low - medium fertility soils. Coarse granites.	o *E. mckieana* o *E. bancroftii* o *E. macrorhyncha* o *Callitrus enlicheri* o *E. caleyi* ⊕ *E. caliginosa* o *E. crebra* ⊕ *E. laevopinea* o *E. melanophloia* ⊕ *E. albens* o *E. sideroxylon* • *E. youmanii* o *E. dealbata* o *E. banksii* o *E. andrewsii* spp *andrewsii*	Mostly uncleared. No dieback except some caused by drought.
Grassy Sclerophyll Forest (= grassy open forest).	a) Macleay Gorges	Range of soils. Metasediments, granites.	o *E. punctata* ⊕ *E. viminalis* o *E. cameronii* • *E. caliginosa* o *E. saligna* • *E. melliodora* o *E. michaeliana* • *E. bauerana* o *E. aff. cypellocarpa* o *E. andrewsii* ssp *campanulata*	Mostly uncleared. Minimal dieback.
	b) Central parts of Tablelands. Usually on ridge tops	Medium - high fertility soils Metasediments, granites.	† *E. caliginosa* † *E. melliodora* plus other species found in woodlands	Most have been partly cleared. Bad dieback in smaller woodlots where clearing was more complete Little dieback in larger tracts of forests.
Woodlands (sometimes intergrade into grassy sclerophyll forest) Central parts of Tablelands	a) Higher altitidues (above 1100m) or colder sites on lower altitudes (= subalpine woodlands)	Usually basalt	Hills: † *E. pauciflora* † *E. viminalis* Lower slopes: † *E. stellulata* Valley floors: ‡ *E. nova-anglica* Localized: • *E. acaciiformis* • *E. dalrympleana* ssp *heptantha*	Much clearing for grazing Extensive dieback in some places (particularly open flat valleys). Many places quite healthy.
	b) Independant of altitude. Hilltops or other well-drained situations. (often intergrade into grassy forest).	Medium fertility soils such as podzolics. Richer soils	† *E. caliginosa* • *E. dalrympleana* ssp *heptantha* • *E. laevopinea*	Mostly still forested. Little dieback
	c) Usually below 1100m, slopes Slopes in wetter areas, towards east. Lower slopes, towards east. Dominant in limited areas.	Medium fertility soils. Metasediments, sometimes basalt.	‡ *E. melliodora* ‡ *E. blakelyi* ‡ *E. bridgesiana* † *Ang. floribunda* † *E. viminalis* (on better soils) ‡ *E. melliodora* † *E. caliginosa* ‡ *E. conica* • *E. amplifolia* • *E. nichollii* o *E. moluccana* o *E. banksii* † *Ang. floribunda* • *E. radiata* • *Ang. subvelutina*	Dominates much of country between Walcha & Guyra plateau. Much cleared. Severe dieback over much of area. Often very bad dieback where partially cleared. Mostly uncleared. Little dieback.
	d) On broad plains and valley bottoms. Above 900m altitude	Medium - high fertility. Basalt and alluvial	† *E. viminalis* ‡ *E. nova-anglica* (extends to areas with impeded drainage).	Mostly cleared. Extensive dieback.
Woodlands Western parts of Tablelands	Mid-lower slopes Riverbanks Bendemeer locality Mid-lower slopes	Euchrozems to soils derived from coarse granites Alluvial	• *E. melliodora* • *E. blakelyi* • *E. albens* • *E. bridgesiana* • *Ang. floribunda* o *E. camaldulensis* • *E. mannifera* spp *elliptica* • *E. bridgesiana* ssp *malacoxylon*	Mostly out of dieback area. Localized occurences of dieback only.

*See Table 5.1 for definitions.

§Dieback effects: ‡Severe dieback over much of the species geographical range within the Tablelands
†Dieback over extensive areas •Localized dieback
oLittle or no dieback ⊕Little or no dieback in the particular area mentioned but dieback elsewhere

Adapted from Nadolny (1984); Williams and Nadolny (1981).

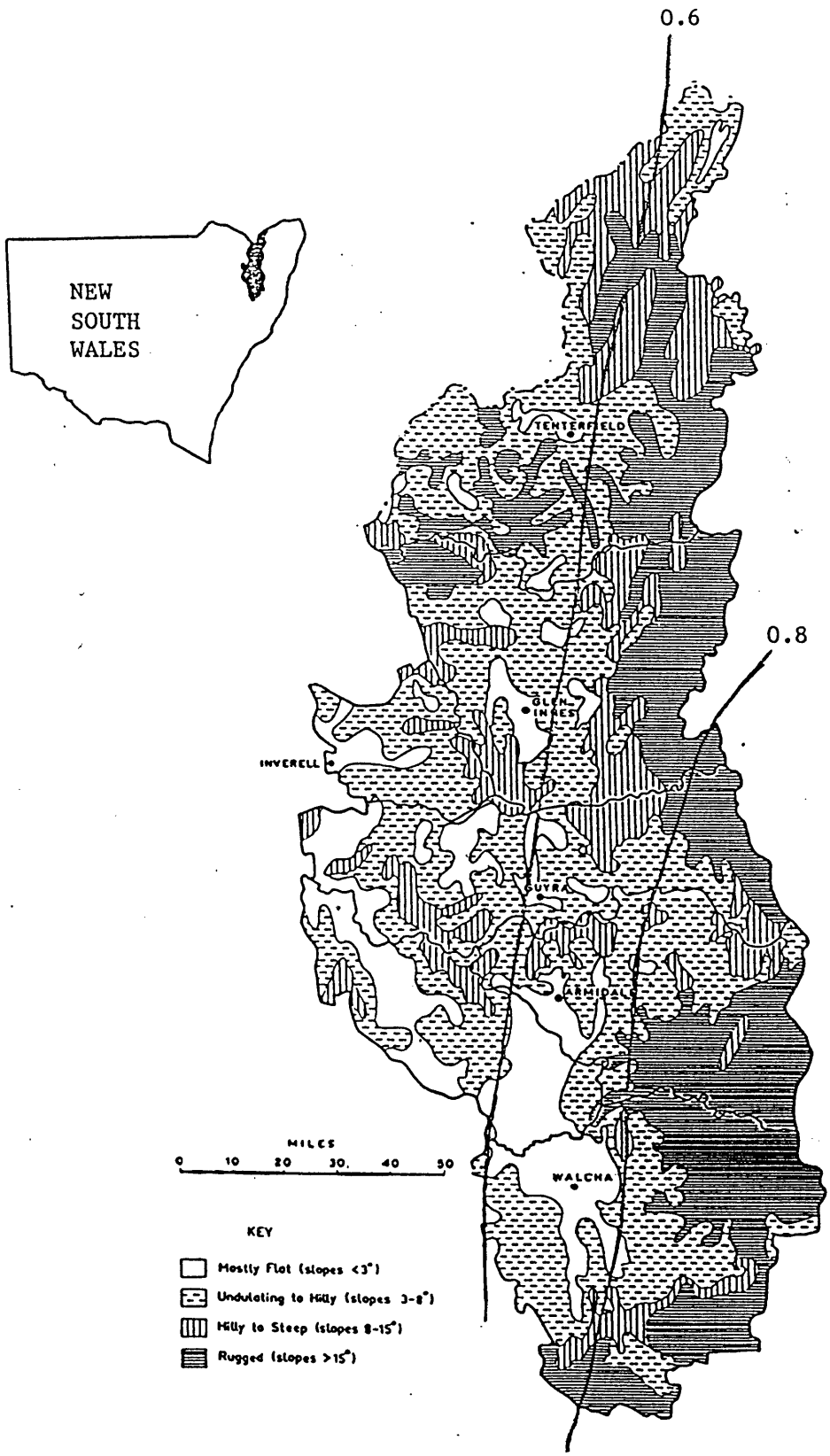


Figure 1.1: A Generalized topographic map of the Northern Tablelands region (from McDonald, 1968, adapted by Robinson, 1988), its location within N.S.W., and the average summer moisture index (Hobbs and Jackson, 1977). The area of concern in this thesis approximates to the areas with slopes less than 8°.

Chapter 2

Vegetation Changes on the Northern Tablelands Since White Settlement

The invasion of European culture to the Northern Tablelands brought a great many changes in landuse. Through the clearing of the tree cover and the building of roads, railways and towns, through the disruption of aboriginal life, through mining and forestry operations, and most of all through the establishment of the agricultural, pastoral and horticultural industries, great changes have occurred in the landscape and its vegetation. To properly evaluate these effects it is first important to determine what the vegetation was like at the time of the European invasion. There are two main ways to do this. One method is to use the descriptions of the flora and vegetation by early explorers, settlers, botanists, surveyors, and descendants of the original inhabitants, but these descriptions are extremely scanty. The other method involves inference from the present day flora and vegetation, which is difficult because of the great changes that have occurred. The two methods can be combined to build up a picture of the original vegetation. We can then analyse the changes which have occured, and see how they relate to the present dieback syndrome (see chapter 3).

2.1 The Vegetation before European Settlement

The opening of the Tablelands by Europeans was relatively late compared with areas closer to Sydney. It followed exploration by Oxley in 1818, Cunningham in 1827, Mitchell (south of Tamworth) in 1831 and Cory (Tamworth to Uralla) in 1833 (Atchison, 1977). The botanist explorer Allan Cunningham passed to the west of the Tablelands in his expedition of 1827 from the Liverpool Plains to the Darling Downs in Queensland. He described the west of the Tablelands as lightly timbered and occasionally very open with patches of plain (Dalton, 1959; Norton, 1972).

OXLEY AND MAIDEN

Surveyor General John Oxley and his party were the first Europeans to set foot on the Tablelands. Coming from the west, they passed over the Moonbi Range and crossed the southern part of the Tablelands on their way to the coast in September 1818 (Cambell, 1922). Figure 2.1 shows their route as they passed near present day Walcha, Apsley Gorge, Yarrowitch and thence to Port Macquarie. Oxley made frequent mention of the forests and woodlands they passed

through with descriptions of 'noble forests', 'stately stringybark trees', 'fine open country' and so on. Most of his comments on the vegetation are indicated on Table 2.1, as are observations made by the botanist J.H. Maiden when he travelled through the area in 1898 plus observations I made in 1983.

The impression gained from reading Oxley's account is that most of the area was timbered, with open, perhaps grassy forest being common on the hills and tall or grassy woodland in the valleys. He made frequent mention of the trees (mainly stringybarks and *E. viminalis*), which were frequently large and probably quite old. Oxley did not mention a well defined shrub layer in the forests until he moved into the gorge and escarpment country, nor did he mention the grasses much. We are left to assume that the grasses were numerous while the shrubs were only scattered - presumably if he had had trouble struggling through 'scrub' he would have mentioned it. He made mention of grassy treeless areas on river flats beside the Sydney River (now the MacDonald) and the Apsley River east of Walcha. These were amongst the first places settled by squatters on the Northern Tablelands.

Oxley's most often quoted description is "...proceeded for 9 miles through the finest open country or rather park imaginable...", referring to the area around Walcha. This parklike description of the lower slopes and valleys of the Tablelands has also been used by others (see Everett - next section) and deserves special comment for it is open to some interpretation. These Englishmen would have been used to English parks where the trees would have been quite big with large rounded crowns and spaced $\frac{1}{2}$ - $1\frac{1}{2}$ times the crown width apart. This accords to the description of tall woodland or grasssy woodland (Table 5.1) which by definition has tall to medium sized trees, rounded crowns and a well developed grass layer. It is important to keep this 'parklike' description in context for, as Table 2.1 shows, Oxley also passed through much forested country in the Walcha area.

Nowadays most of the country of the Walcha area is almost completely cleared of forests and in many areas only a few scattered trees remain (Table 2.1). Where Oxley wrote of noble forests of stringybark there are now open pastures with scattered trees or clumps of trees. Occasionally small remnant areas of grassy forest occur, usually on ridge or hill tops. The species present are still those that Oxley saw - that is stringybark and *E. viminalis*. Eucalypt dieback is now very common as is the introduced Hawthorn. Maiden (1898) mentioned many shrubs, especially *Acacia* spp, when he travelled through the area. Except near rivers and along some roadsides there are relatively few shrubs in the area now. Also many of the existing trees are rather stunted possibly because they are regrowth after clearing.

EARLY SETTLERS AND TRAVELLERS

The first stock came up from the Hunter Valley in 1832 to Walcha (Gardner, 1854). The squatters came from the southern Tablelands, the slopes and plains and the Hunter Valley, each lot pushing further north. Many of them were connected with big pastoral and grazing concerns of the Hunter Valley and also overseas funded pastoral companies such as the Australian Agricultural Company (Atchison, 1977). Henry Dangar squatted near Gostwyck in 1835, Henry Dumaresq established Saumarez in 1834. By 1838 Europeans had moved as far

Table 2.1: Descriptions of the vegetation in the Walcha area by Oxley in 1818 (reported in Campbell, 1922), Maiden (1898), and myself in 1983. Numbers refer to location on the map (Figure 2.1).

Oxley's Description (1818)	Maiden's Description (1893)	Present Day
1.§ Slate country 'Bastard box' (*E. hemiphloia* [1])		
2. "Open forest land...blue gum...in great luxurience... great quantities of stringybark...well covered with grass"		
3. Country "perfectly open...much fallen timber. Banks of river ...clear of timber...great numbers of fallen trees..."		
4. Country either side of river open forest country.	23. All this country ring barked, much swainsona. Undulating grassland with a little timber (ring barked). Wooded hills *E. viminalis*, peppermint, *E. coriacea*, *E. stuartina*, *E. stellulata*.	7. Open paddocks, scattered trees, occasional clumps but mainly stumps. Trees mainly small *E. bridgesiana*, *E. viminalis*, *E. blakelyi* and stringybark.
5. "...noble forest of stringybark generally on sides and ridges of stoney barren hills" (*E. eugenoides* [2], *E. capitellata*, *E. macrorhyncha*).	24. Tia-Walcha Various eucalypts (*E. pauciflora*, *E. eugenioides*, *E. stellulata*, *E. radiata*, *E. viminalis*, *E. melliodora*, *E. tereticornis*)[3] Many grasses (*Poa*, *Andropogon*, *Danthonia*, *Sorghum*, *Anthistinia*, *Aristida*, *Stipa*). Some shrubs (*Acacia*, *Daviesia*, *Swainsona*). Stunted timber.	8. Hills sloping to river. Very cleared. Scattered *E. viminalis*, *E. blakelyi*, willows, elms.
6. "...finest stringybark ever saw...also the other timber chiefly Blue gum (*E. viminalis*) for better and larger than usually seen in forest lands...Casuarina also seen for the first time."		9. Hilly, heavily cleared, scattered trees.
15. "...spacious valley...much wildlife".	26b Tia Largely cleared for pasture and mining. Shrubs - *Grevillea*, *Colletia*, *Lomatia*, *Polygala*, *Acacia dealbata*. Herbs - *Helichysum*, *Swainsona*, *Pimelea*. Grasses - *Poa*, *Chloris*, *Dichelachne*. Introduced weed - *Eryngium expansum*.	10. Stringybark forest on hill tops. Treeless paddocks on lower slopes. Scattered stunted trees.
16. "...proceeded for nine miles through the finest open country or rather park, imaginable..."		11. Walcha Road to Walcha - open paddocks, scattered trees, stunted stringybark, *E. nova-anglica*. Dieback evident.
17. "stream, its bank quite clear of timber...fine open country."	29. Open forest of eucalypts (*E. tereticornis*, *E. coriacea*, *E. stellulata*, *E. engenoides*, *E. viminalis*, *E. amygdalina*) with *Exocarpus*, *A. melanoxylon*, *Casuarina suberosa*,[4] *A. decurrens*, + roadside shrubs and herbs *Oxylobium*, *Olearia*, *Helipterum*, *Cassinia*, *Ammobium*, *Leptospermum*, *Alternanthera*, *Velleia*, *Lissanthe*, *Melichrus*, *Pimelea*, *Cyperus*, *Billardiera*, *Stylidium*, *Stackhousia*, *Scleranthus*, *Deyeuxia*, *Dichelachne*, *Danthonia*.	12. Grassy forest - *E. radiata*. Some tall *E. viminalis* and stringybarks. Open paddocks nearby.
18. "...still open...".		13. Paddocks - scattered trees - *E. viminalis*, *E. nova-anglica*, *A. filicifolia*, Hawthorn. Small trees. Small dieback. Clumps of trees on hill tops.
19. "...thickly timbered with stringybark and gums".		14. Hill top - grassy forest. *E. viminalis*, stringybark. Lower slopes - open paddock, scattered trees, *E. nova-anglica*, *E. viminalis*.
20. "...thick stringybark forest...fine open forest ended abruptly on the precipes".		
21. "impassable glens...climbing plants abounding with new and beautiful plants...stateliest stringybark we ever beheld...timber unusually good".	30. Shrubs - *A. melanoxylon*, *A. decurrens*, *Banksia integrifolin*, *Bursaria spinosa* all common. *Callistemon salignus*, *Leptospermum flavescens*, *Prostanthera lasiantha*, *Zieria smithii*, *Aristotelia australasica*, *Olearia*, *Daviesia*, *Dillwynia*, *Pultenaea*, *Dianella*, *Goodenia*, *Pimelea*. Herbs - *Polygonum*, *Scleranthus*. Fern - *Aspidium*. Native grasses - *Themeda*, *Dichelachne*, *Echinopogon*, *Sorghum*, *Agropyron*, *Ehrharta*, *Poa*, *Pennistum*, *Deyeuxia*, *Cynodon*. Introduced herbs - thistles, wireweed, *Epilobium*, *Solanum*, *Poa* spp, *Holcus*, *Bromus*, *Dactylis*, *Lolium*.	16. Around Walcha - treeless valley floor, scattered trees to semi-woodland on hill tops around the town. Urban area many exotic ornamentals planted.
22. "open forest...thickly timbered large stringybark, casuarines, stoney".		24. Very open pasture; a few clumps of eucalypts on upper slopes. Basalt. Much hawthorn and dieback. Trees only scattered - mostly *E. viminalis*, some *Angophora floribunda*.
25. partly heavily timbered above falls - "clear and open".		26a Tia-stoney creek Undulating treeless pasture on lower slopes and flats. Scattered trees. Hill tops - grassy forest in places (Stringybark and *E. viminalis*). Forest along gorge. Occasional scattered clumps of trees in open pasture. Dieback evident.
29. "poor, badly timbered...stoney hills".		
30. "thickly clothed with timber blue gum and stringybark".		27. Tia falls Grassy forest - stringybark. Grasses - *Themeda*, *Cymbopogon*, *Sorghum*. Shrubs by creek - *Acacia* spp., *Callistemon*, *Leptospermum*.
32. dense brush		28. Scattered trees and occasional clumps in pasture. Stringybark, *E. radiata*. Very open.

§ Numbers refer to locations on map - see Figure 2.1.

Notes on species

1. Campbell's *E. hemiphloia*, which Oxley called Bastard Box, is now called Grey Box - *E. moluccana*.

2. Campbell refers to *E. eugenoides* being one of the stringybarks Oxley would have seen. This was possibly *E. caliginosa* or *E. laevopinea*.

3. *E. tereticornis* is rare on the tablelands so the trees so named were probably *E. blakelyi*.

   Other eucalypts which Maiden mentions have also had name changes.
   E. coriacea = *E. pauciflora*.
   E. amygdalina = *E. radiata*
   E. stuartina = *E. bridgesiana*
   Narrow leaved peppermint = *E. nicholii*

4. *Casuarina suberosa* = *C. littoralis*.

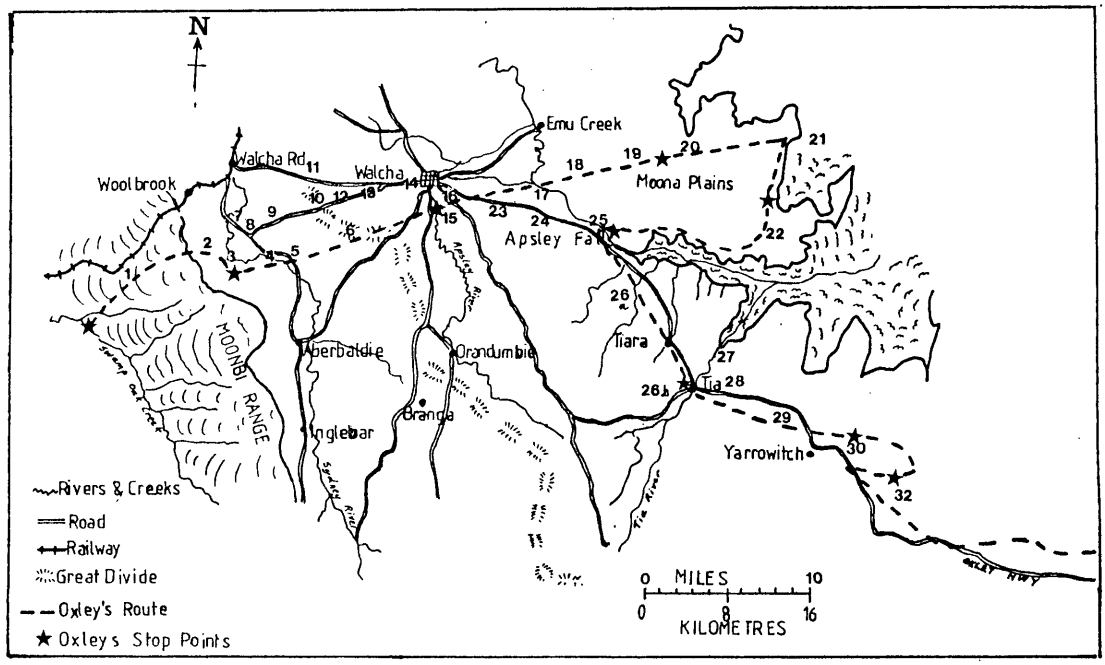


Figure 2.1: Map showing Oxley's journey through the southern portion of the Northern Tablelands in 1818. Numbers on the map refer to where he commented on the vegetation, plus the comments of Maiden who travelled over much of the route in 1898 and myself who travelled a similar route in 1983 (see Table 2.1.) Adapted from Campbell (1922).

north as Guyra/Inverell/Moree while the north eastern pocket remained the domain of the aboriginal people. By 1840 most of this area too had been settled and squatting runs dotted the landscape from the Liverpool Plains to the Darling Downs (Campbell, 1922).

> "When the pioneer pastoralists of New England reached the tableland they found an extensive tract of well watered woodland country, interspersed with numerous lightly timbered patches of grassland, but the coarse and sour nature of much of the pasturage, together with the inclement winters, and the difficulty of access to the tablelands from the east, south and south-west, militated somewhat against permanent or at least perennial occupancy in the early stages." (Campbell, 1922).

Development followed the stock routes and head stations of pastoral enterprises (Oppenheimer, 1977). Later roads, railways and postal routes followed the early stock routes, which usually took ways that had plenty of available water and which two wheeled drays could negotiate.

The settlers brought with them from England, an image they considered ideal and this influenced their attitude toward the Australian native vegetation:

> "Nurtured by despondency and homesickness, the idea of the 'interminable forest' and the yearning for 'clear acres', persisted for the remainder of the eighteenth century and for most of the nineteenth, thereby ensuring that the contempt for trees, especially 'gum trees', would long remain a character of Australian settlers" (Gilbert, 1971).

Much of N.S.W. was covered with forest, often seen as monotonous to those early English eyes:

> "...westward stretch of one continued wood...Australia is an immense wood..." (Gilbert, 1971 p148)

and to most settlers the trees were simply a nuisance, to be cleared to make room for building or farming (Bolton, 1981).

Existing references to the vegetation on the Tablelands by early settlers are extremely scanty – the main references in their writings being about clearing the trees or ringbarking. For example the Saumarez Station diaries of F.J. White 1883-1924 make frequent mention of ringbarking, clearing trees, felling trees for firewood, and pulling trees. In fact they had teams of workers on such jobs for weeks on end over this period. There is no other description of the timber otherwise. The same was true for the Deepwater Station diaries from 1845-1885. [1]

The settler descriptions suggest that much of the Tablelands was timbered, with open plains being present in some locations. Occasional mention was made of scrub and also the pasture which seemed to be dominated by tussocky grasses. For example an early squatter described droving sheep in 1847 north of the Gwydir River: "...there are scrubs of all kinds to drive through - sometimes to cut through – sometimes for miles"[2]. Another squatter, Frederick Lamotte, who settled on the Severn River just north of Glenn Innes wrote in 1840:

> "Our run is a good one, capable of supporting more sheep than we shall ever have. We have fine open country, with small plains and beautiful ridges with abundance of water...Since we have been on the ground we have cleared 12 acres and begun ploughing."[3]

John Everett, writing in 1838 described the New England district, on a trip he made to Ollera:

> "...the peppermint tree grows abundantly ... There is plenty of grass in all directions and plenty of water. It is too open for cattle...Plenty of kangaroo and turkey, or bustard – quail, snipe, and ducks. No ironbark but plenty of stringybark. Large flats with water running through them, open downlike plains, one part is called Salisbury Plains ...it is not densely wooded but more like open park scenery...the soil of some of the flats very good, no necessity for clearing."[4]

Some letters by Leonard and Edward Irby in the early 1840s make occasional mention of the vegetation. In 1842 Edward wrote wistfully:

> "How I long for once more setting eyes upon something like English foliage and verdure! There certainly is a great deal to be said about the beauty of this climate in England, and certainly it is true that the sun is almost perpetually shining, and consequently the atmosphere is fine and dry...As for the trees, they are really nothing more nor less than caricatures, excepting in the rough country. There they certainly grow finer, and you may also see the wildflowers; but then again you seldom go into the rough country unless it is some unpleasant expedition after lost sheep, and at that time you think very little of wildflowers and scenery...The grass grows very differently here to what it does in England. At a distance it appears as though the ground were well covered with it, but when you are walking you will perceive that half the surface is bare."[5]

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[1] See U.N.E. archives.

[2] Allan MacPherson, Mount Abundance: or the experiences of a Pioneer Squatter in Australia Thirty Years Ago, London ca. 1870. Quoted in Oppenheimer (1977).

[3] In Dawson (1929).

[4] J. Everett diary 1838. U.N.E. archives. John Everett and his brother George took up Ollera.

[5] Memoirs of Edward and Leonard Irby 1841-45, typescript of book published by William Brooks, Sydney, 1908, passim. pp28-31, 38, 41. Most of the letters and diaries are concerned with the battles with sheep farming and aborigines.

Another squatter of the New England wrote: "The country generally is very open forest and plains here and there, (but) on some of the ridges the trees are much thicker."[6]

In 1860 Andrew Murray set off droving cattle from Uralla to Mackay (a two year journey) and made frequent mention in his diary of the bush he passed through:

> January 17 1860 "...passed Tilbusta (sic) about four miles and camped on creek, night cold. Timber box and Stringybark...
>
> January 18 ...crossed over the pinch and had dinner on a small plain near Guyra ...country thickly grassed; prevailing rock Basalt...went on and camped at Baggot's Lagoon near Ben Lomond head station. densely grassed country, much shotey Ironstone pebbles. Timber peppermint. patch of red soil...
>
> January 20 ...Travelling along the Tenterfield road [from Glen Innes] to Off's Creek ... country poor of granitic formation. Much stringybark and blackbutt. Little grass to be seen, and of poor quality...
>
> January 21 ...passed Dundee thence over a somewhat better class of country timber peppermint after a few miles the country much improved and the timber changed to Yellow Jackey and two white box trees; crossed Deepwater on the edge of the plain ..." (Murray, 1860).

Aberbaldie, near Walcha, was described in about 1845-60 by Frederick Milford:

> "Numerous gum trees, and apple trees so called grew all round the station and gave it a parklike view resembling some of those which I saw in England...the soil was rich, quartz and basalt and flint abounded while ironbark, cherry trees and ferns with abundance of grass were the principle products of the soil...kangaroos were abundant ...and on three occasions saw emus on the run." (Milford, ca. 1845)

A. Norton made extensive descriptions of sections of New England when he passed through in the 1850s:

> "Beside Nowendoc's boggy creek was a narrow flat, while ...[nearby was] the range covered with immense stringybarks, and ... hundreds of well-grown tree ferns...the trees on the stringybark ranges...many were over 20 inches in breadth...
>
> Soon after we passed Inglebar, [heading toward Hanging Rock] the road, such as it was, led us into dense stringybark forest. I had never seen such a quantity of magnificent timber trees ... Between the butts...there was a a tangled mass of undergrowth...
>
> ...Big trees and monster granite rocks are abundant all over the Moonby...
>
> [Near Armidale] ...I wandered about after the fashion of boys amongst the magpies and gillbirds, rosella and lory parrots, poked up ringtail possums in their snug bark nests, and kangaroo rats in their warm grass-made snuggeries...
>
> [Tenterfield to Bolivia]...the Mole River...[or] Bluff River; the large holes in it are said to give shelter to fine Murray River codfish. I never saw any there, but like other New England streams it is the resort of the duck billed platypus...
>
> [Glen Innes]...no ringbarked country, but white-stemmed gumtrees, rough barked Bastard box, and silver leaved peppermints with an occasional intervening patch of green wattle..." (Norton, 1903).

Weeta Wright reminisced on Wongwibinda at the time the Wright family acquired it in 1885:

> "...[it] was almost in its wild natural state ... there were streams with rocks and waterfalls, and the primaeval forest...there was little grass for cattle owing to the number of trees ...and the dampness was not good for sheep; they used to get foot-rot, as well as other diseases... Albert

[6] H.M. Marsh. Overland from Southampton to Australia, London, 1867, p55. Quoted by Walker (1963).

> Wright...immediately set to work to get it drained, and some of it cleared, and fenced ... The children were full of delight ... and explored the beautiful wild creeks and gullies, discovering ... all kind of flowers and ferns."(Wright, 1927).

Owen Wright, writing recently on the history of the Wright family at Wongwibinda, described the original vegetation of the area thus:

> "Most of the country was covered with trees, predominantly stringybarks and gums of various kinds on the trap rock ridges, with New England peppermint, black sallee and snow gum ... on the softer soils. In the heavy timber on the ridges there was a scattering of she-oaks and native shrubs, such as blackthorn and tea-tree species. Patches of black wattle grew around the edges of the heavy timber, but generally there was not much undergrowth and the really thick stands, mainly of stringybark, came later from regrowth after initial ringbarking of the older trees. The more open country would have been comparatively well grassed, without the dense canopy of the big trees to exclude the sun and so make the feed underneath them sparse and sour and less palatable to stock. Treeless areas were confined to 'flats' along the creeks and gullies and to some grassy hollows, which ran back between the timbered ridges and provided the chief grazing grounds for both stock and kangaroos." (Wright, 1985 p15)

Anne Harris has written of the Abington area:

> "When John Cameron ... took up his run in 1836 it was open forest country, timbered with redgums and silver gum, with ironbark, native apple and yellow and white box, with some kurrajong in the hills and river oaks along the creeks, and river. The country was covered with wire grass ... After the country was ringbarked [in the 1890s] the red-grass came in and scrub began to grow up quickly unless the clearing was maintained; there was apparently no growth of scrub on this country until clearing began." (Harris, 1982).

There are occasional references to some of the natural plains in the area, which were among the first places to be settled. In 1847 Godfrey Mundy wrote of the Salisbury Plains area:

> "The country we passed through latterly did not give us a very favourable idea of the soil of New England, its vegetation or its scenery. The timber is poor in size and tiresome of aspect. Being lightly wooded, it is however well calculated for stock farming[7] ...Salisbury Plains is an undulating tract clear of trees and scrub, and clothed with good grass. Both Pasturage and climate are admirably adapted to sheep farming."[8]

He also noted that: ..."the bare patch of Salisbury Plains, extensive though they be, [are] almost lost in the vast expanse of bush."[9]

Natural plains are also reported to have occurred at Kelly's Plains and at Armidale. Commissioner McDonald wrote in 1839, when he first arrived at the site of Armidale:

> "...I have fixed my Head Station on an extensive open plain, well watered and sheltered, centrically situated, and contiguous to the establishment of Messrs. McKenzie,Dangar, and Dumaresq..."[10]

A few decades later, in 1866, Armidale was described as: "surrounded by country elevated and mountainous, the country being rugged and well grassed and timbered", the neighbouring

[7] G.C. Mundy (1852) p33. Quoted in Norton (1972).
[8] G.C. Mundy (1952) p36. Quoted in Norton (1972).
[9] G.C. Mundy (1852) p226. Quoted in Smailes and Molyneux (1965).
[10] Report of Commissioner of Crown Lands, New England Squatting District 30 Sept 1839. Quoted in Scholes (1920) and Smailes and Molyneux (1965).

country being "well wooded with stringybark"[11]. The setting for the town was described as a "large piece of naturally clear land, looking precisely like an English race course framed in gum trees"[12]. Photographs of Armidale taken in the 1860s and '70s[13] show a small township on an open plain beside Dumaresq Creek with all the hills around covered with forest or woodland. Some of these photographs show profuse regeneration of *E. viminalis* following clearing. Similar photos of Uralla and Tamworth show a similar pattern of small villages ringed with forest or woodland (Plate 2.1).

GARDNER

One of the earliest detailed works on the New England was that by Gardner (1854- 55). In 6 volumes of beautiful copperplate writing he described various districts of N.S.W. and Victoria, the history of settlement, goldmining, agricultural pursuits with some mention of the native flora (Gilbert, 1974):

> "-Bush Flowers of New England. During December and January the bush flowers display all their beauty in New England; of these there is an innumerable variety of every colour, tint and shade, many of these are remarkably beautiful and the uncommon appearance they have, unlike the flowers to be seen in Europe or America attracts the attention of every beholder, these in the poetical language of Scripture cause 'the wilderness and the solitary place to be glad and the desert to rejoice and blossom as the rose'. During the months of January and February the seeds of the bush flowers are easily procured..."(Gardner 1854, Vol II).

Gardner's writings indicate that flowering shrubs and herbs were fairly widespread on the Tablelands but the imprecision of their actual situation allows us to deduce little else. He mentioned some edible plants such as the native raspberry "...everywhere found in the bush" and also Native Cherry (*Exocarpos*), *Banksia* species, *Hardenbergia*, dogwood (*Jacksonia*), and *Indigofera* (Plates 2.2 – 2.4). All of these are still widespread, but possibly not as common.

Of the trees of New England he wrote:

> "...The timber on the main range of New England is inferior for firewood purposes, Peppermint, Gums and Iron bark being found on the range, and in Byron Plains and in the Bundarra country. Box tree is found on the ridges and the apple tree on the flats." (Gardner 1854, Vol I)

In another place he mentioned "tall pine trees" (*Casuarina cunninghamiana* or possibly *Callitrus* sp) along the banks of the Sovereign or Dumaresq River and other rivers "...fine straight trees without a branch for 50 or 60 feet" and used by the settlers for many purposes. He also mentioned a number of eucalypts of the more western areas ("White mahogony, Apple trees, Boxwood, Ironbark, Stringybark and Gum trees") which Gilbert and Elphick (1977) suggest were probably *E. albens, Angophora floribunda, E. melliodora, E. caleyi, E. caliginosa, E. laevopinea, E. macrorhyncha, E. viminalis* and *E. blakelyi.* Gardner noted that stringybarks were used by the settlers for barking huts etc. As well the ironbark, box and forest oak were much used. *E. nova-anglica* was recognized for its inferior burning and building qualities and the most valuable

[11] Quoted in Gilbert (1982), from the N.S.W. Gazetteer and Road Guide 1866

[12] Quoted in Gilbert (1982) from the Australian Encyclopoedia (1979)

[13] Available in the Armidale Historical Resources Centre, Armidale College of Advanced Education.

lands for grazing sheep were said to be "...the lands where the box tree is found on the ridges and the apple tree on the flat and plains".

Gardner's watercolour sketches of the stations of the district are possibly the earliest still is existence (Plates 2.5 – 2.8). They show that the squatters first settled near the rivers and streams. They began clearing the foot hills, lower slopes and flats, leaving the upper hillsides treed, many of these being cleared later. Around the houses were enclosures where they cultivated crops, fruit and vegetables. They also planted English trees like the oak and the elm (see also Connah, 1977 and Campbell, 1922).

J.F. Campbell was a gifted botanist, geologist, and historian, and was employed as a surveyor in the area from 1888 to 1903 and as chairman of the Armidale Forests Board in 1906-1907 (Atchison, 1980). In 1922 he attempted to summarize the pre-settlement vegetation of the Northern Tablelands. He suggested that the plateau was:

> "...an extensive tract of woodland country, timbered with some fifteen species of eucalyptus of tree dimensions....The slate ridges were usually monopolized by the 'stringybarks', especially the species botanically known as *E. eugenoides* and *E. capitellata*, both of which were largely used for the building of homesteads. Immediately off the ridges and along the shallow valleys the 'peppermints' (*E. Stuartina* and *E. amygdalina*) intermingled with the 'White and Red Gums' (*E. viminalis* and *E. Tereticornis*) and other species.
>
> The other formations, especially the basalt, were similarly wooded with certain species peculiar to each, but while the vegetation of the granite country was sparse and indifferent, that of the basalt, in many places, densely covered the ground.
>
> The pasture plants of the tableland consisted largely of true grasses ...[with a] carrying capacity of four acres to the sheep, as estimated by the pastoralists prior to the destruction of the timber.
>
> Of the many species of Australian grasses that carpeted our northern uplands in the early days, only the more abundant kinds, and those with conspicuous inflorescence seem to have been noticed and named by pastoralists, such as 'Kangaroo grass' (*Themeda*), 'Wild sorghum' (*Sorghum plumosum*), 'Wallaby Grass' (*Danthonia*), 'Blue Grass' (*Andropogon*), 'Tussock grass' (*Poa*), 'Star grass' (*Chloris*), and several others, but the majority of the indigenous grasses were, and still are, distinguished by their scientific names only."
>
> (See notes on Table 2.1 for present names of eucalypts mentioned by Campbell. *Sorghum plumosum* = *S. leiocladum*).

EARLY SURVEYS

Many of the early survey plans carry valuable information on the early vegetation. Galloway's maps of the 1840s have many useful descriptions [14]. For example in the Kentucky area Galloway mentions 'open peppermint forest' on granite, some stringybark and some 'scrubby' areas on sandy soils. 'Good open forest' was on all the hill country surrounding the Salisbury Plain. Such maps do not provide a systematic account of the vegetation in its natural state. The early portion plans often recorded information on the vegetation and are much more useful to acquire a detailed picture of the vegetation of an area (Jeans, 1978). Pre-1864 records were limited to marker trees, but after 1864 and the Robertson Land Acts, much more detailed records were

[14] A full set of Galloway's maps are available in the N.S.W. archives and copies of many of these are in the Armidale C.A.E. Historical Resources Centre.

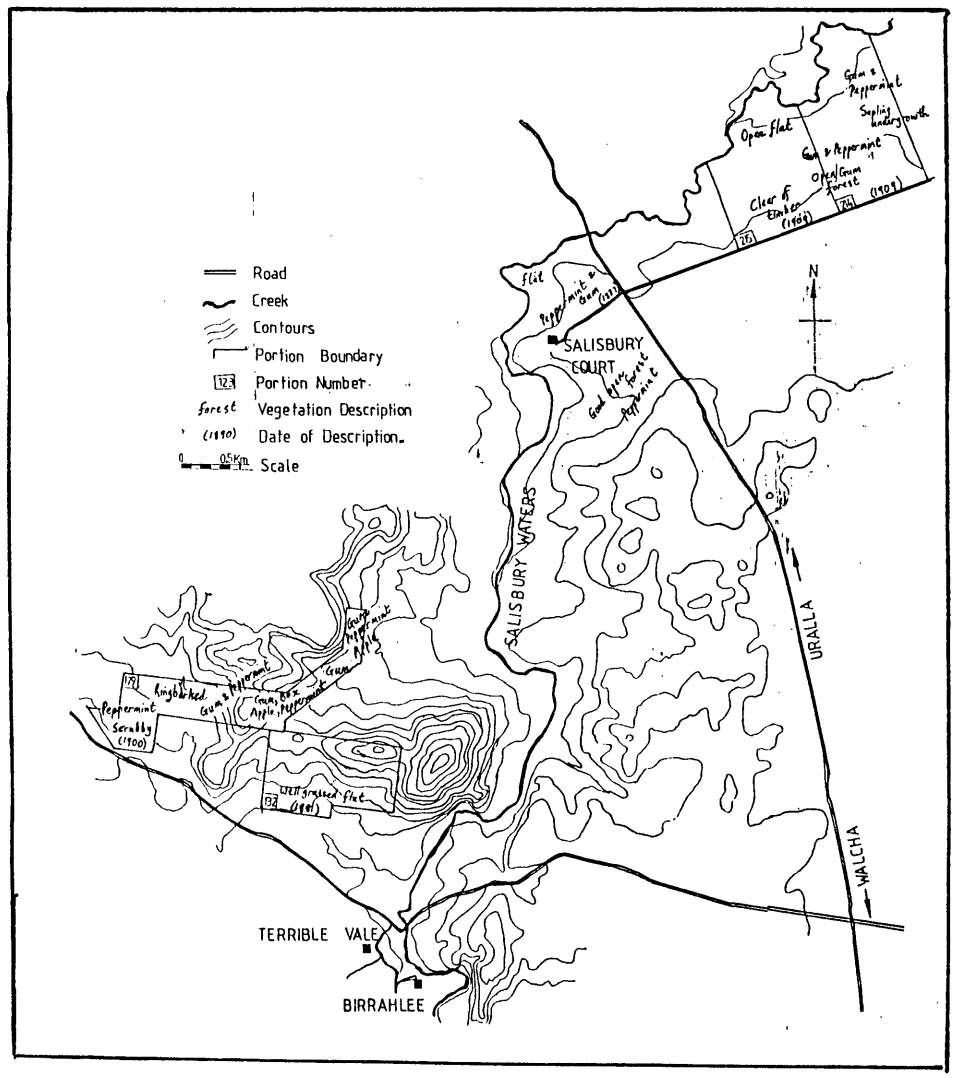


Figure 2.2: Vegetation of the Salisbury Plains area in the 1880s, taken from information from early portion plans, available from the Lands Dept. Office, Armidale

kept. The early portion plans indicate that timber came down right to the flat along Salisbury Waters and that Salisbury Plain, as described by Mundy (see above), was a relatively small plain surrounded by bush (Fig 2.2).

Carnahan (1976), in the Atlas of Australian Resources, attempted to piece together historic and other sources and arrive at a description of the Australian vegetation before European settlement. Because the Atlas covers the whole of Australia it is not detailed and only refers to the main vegetation types. It describes the Northern Tablelands as having been mostly covered with medium sized trees 10-30 m high with 10-30% foliage cover, or 10-70% foliage cover in some of the hilly areas, and dominated by eucalypts.

BOTANICAL INVESTIGATIONS

Botanical investigation of the region followed settlement by some decades and in the early period focussed on the flora and provided little information on plant communities and vegetation structure. One of the first botanical excursions was by Christie (1877) who described 21 eucalypt species and some herbs and shrubs growing in granite and basalt country of the Tablelands. Maiden listed the trees, herbs and shrubs he encountered on a trip to Walcha in 1898 (see Table 2.1). It was not until 1903 that the first detailed list was prepared by Turner. Cambage (1904, 1908) described the species of the granite country of Deepwater to Emmaville and the western slopes, and Campbell published surveys in 1907 (trees) and 1908 (grasses). More recently Roe (1947), Gray (1961), Norton (1971), Beadle (1971-87; 1981), Wheeler *et al.*

(1982), and Williams (1985) have described the species in detail while the structure and ecological relationships have been described by Premier's Dept.(1951), Williams (1963), Baur (1962), Williams and Nadolny (1981), Morgan (1981b) and Nadolny (1984).

Since all of these vegetation descriptions have been made long after settlement they describe an already changed vegetation. However, as Williams (1985) writes:

> "In spite of over a century of disturbance to the natural pattern of vegetation, large tracts of New England still carry continuous forest or semi- natural woodland mainly on the more infertile soils and rough hill country of the granite and porphyry areas. Even the extensively cleared parts of the tablelands on more fertile soils usually retain sufficient scattered trees to give a clear indication of the earlier plant cover."

VEGETATION BEFORE EUROPEAN SETTLEMENT - SYNTHESIS

Both the historical and the botanical evidence indicate that at the time of European settlement the Northern Tablelands were covered by grassy sclerophyll forests and tall woodlands on the hills and grassy woodland on the valley floors. The trees were probably much bigger and older than is common today and relatively well spaced (eg. the width of one tree apart). The rockier ridges, gorges and creek areas which have poorer, often rocky soils, probably carried dry sclerophyll forest or scrub. Forest, woodland, and scrub probably all intergraded. Small areas were probably covered in heath, scrub and swamp woodland. There is good evidence to suggest that there were some naturally grassy plains such as Salisbury Plains, Kelly's Plain, Guyra, and Armidale, although relative to the whole area these were probably quite small. In addition there were probably narrow belts of Casuarina woodland along some of the rivers and extensive swamp communities dominated by sedges.

Trees

Table 1.3 presents the main tree species and structures of the vegetation which exist now, and was constructed by examining remnant trees and timbered areas. Similar species, associations and subforms were probably present before 1830 although in places the species proportions are possibly altered due to selective clearing. The structure of the woodlands and forests has also been altered (see section 2.2).

Herbs - grasses

Other than trees, the chief element of the forests and woodlands was the well developed grass layer. There are some 140 species of native grasses on the Tablelands but according to Norton (1972) many of these are rare or uncommon and the main species that dominated the original woodlands and forests could be reduced to about 30. Norton (1972) and Whalley *et al.*, (1978) suggest that the grasses were dominated by tall, tussocky, warm season perennial grasses such as *Themeda australis* and the tall yearlong green perennial *Poa sieberana*, with most plants belonging to the tribe Andropogoneae (Table 2.2). The subdominants were frequently low growing, stoloniferous or decumbent perennial grasses. All of the dominants could appear as subdominants in places. There were few warm or cool season annuals. After the changes wrought by European settlement the original dominants decreased and often the subdominants

or minor species became dominant (Whalley, 1970 - see section. 2.2).

Table 2.2: Suggested graminaceous species composition of the original pastures on the Northern Tablelands of N.S.W. (From Whalley *et al.*, 1978)

	Dominants	Subsidary species
Higher elevations with basaltic, fine grained granitic or more fertile, traprock parent material.	*Poa sieberana* *Themeda australis*	*Danthonia* spp *Dichelachne micrantha* *Agropyron scabrum* *Sorghum leiocladum* *Dichanthium setosum* *Microlaena stipoides*
Lower elevations, podzolic and solodic soils derived from the Palaeozoic basement or relatively fine grained granites.	*Themeda australis* *Poa sieberana* *Sorghum leiocladum*	*Bothriochloa macra* *Sporobolus elongatus* *Dichelachne micrantha* *Danthonia* spp *Microlaena stipoides* *Eragrostis leptostachya* *Aristida ramosa*
Lower elevations, coarse textures soils derived from coarse grained granites, often on steep slopes.	*Themeda australis* *Aristida ramosa* *Cymbopogon refractus*	*Danthonia* spp *Sporobolus elongatus* *Bothriochloa macra* *Aristida vagans* *Dichelachne micrantha* *Poa labillardieri*

Other herbs

The herbaceous layer of the woodlands and forests of the Tablelands probably contained many herbs other than grasses, although there is relatively little information available. It seems likely that the common native herbs which can by found in native pasture or bushland today were common before European settlement. The following is a list of some of the common genera.

DICOTYLEDONS

ASTERACEAE	*Helichrysum* spp, *Ammobium, Vittadinia, Brachycome, Craspedia* etc
CAMPANULACEAE	*Wahlenbergia*
CARYOPHYLLACEAE	*Scleranthus*
CONVOLVULACEAE	*Dichondra*
EUPHORBIACEAE	*Phyllanthus*
FABACEAE	*Glycine* spp, *Desmodium* spp, *Hardenbergia, Swainsona, Zornia*
GERANIACEAE	*Geranium*
GOODENIACEAE	*Goodenia* spp
OXALIDACEAE	*Oxalis*
ROSACEAE	*Acaena*

MONOCOTYLEDONS

CYPERACEAE	Various genera
JUNCACEAE	" "
LILIACEAE	*Dianella, Tricoryne* etc
RESTIONACEAE	Various genera

Shrubs

Although shrubs may not have been a dominant feature of the grassy forests and woodlands of the main Tablelands area many were probably present, scattered throughout them. It is difficult

to discover how abundant shrubs may have been from the botanical and historical literature but it is clear that they were much more widespread than they are today. There is a long list of shrubs recorded from the region (Maiden, 1898; Turner, 1903; Gray, 1961; Beadle, 1971-1987; Society for Growing Australian Plants, 1982 p23-26). Most species occur naturally only in the western and eastern dry sclerophyll forests and scrublands with relatively few occurring in the grassy forests and woodlands. Table 2.3 includes the shrubs which are widespread and common today and which therefore probably occurred in the pre-settlement grassy woodlands and forests of the main Tablelands area. The list of 37 species is about a sixth of all the shrubs listed by Gray (1961) which occur in the whole Tablelands region. Interestingly many of these are more common on the rockier or sandier parts of the woodlands. The ones which probably grew amongst the grasses on the more fertile soils are marked with an *.

The different eucalypt alliances of the Tablelands vary in the dominance of shrubs. For example the *E. dalrympleana* ssp *heptantha* alliance described by Beadle (1981) has a dense understorey of shrubs, while the *E. blakelyi/E. melliodora* alliance has a less dominant shrub stratum, although many shrubs may be scattered through such woodlands.

The most common small trees are and probably were: *Exocarpos, Acacia filicifolia, A. dealbata*, and *A. implexa.* The most common tall to medium shrubs: *Bursaria, Jacksonia, Olearia, Daviesia,* and *Cassinia.* The most common small to low shrubs: *Pultenaea, Cryptandra, Pimelea* and some of the heaths such as *Lissanthe* and *Leucopogon.*

2.2 The Changes to the Tablelands Vegetation Since European Settlement

The changes to the Australian native vegetation caused by $1\frac{1}{2}$ centuries of European occupation have been vast and vary from place to place depending on soil type, the level of disturbance and the type of pre-existing vegetation. In fact it is virtually impossible to find an area on the main Tablelands where the vegetation has not been much modified. Figure 2.3 illustrates the changes.

CLEARING

In the 1840s development of the region was rather rudimentary with rough huts, boundaries marked with blazed trees, no fences, with sheep grazed on the uncleared land and tended by shepherds (Smailes and Molyneux, 1965). Except for flat cultivation areas, clearing was probably not extensive at first. However it was not long before clearing of trees and shrubs was widespread as squatters cleared the land for the ever increasing livestock, crops and to provide timber for fences, buildings, firewood and so on. Some areas were cleared for mining, particularly in the goldrushes of the 1850s (Walker, 1963).

Clearing throughout N.S.W. proceeded at such a rate that by the 1870s many people were writing with alarm at the arising shortage of wood, timber, shade and shelter for stock as well

Table 2.3: WIDESPREAD AND COMMON NATIVE SHRUBS, SMALL TREES, AND NON EUCALYPT TREES OF THE MAIN TABLELANDS AREA. (Compiled from Turner, 1903; Gray, 1961; Society for Growing Australian Plants, 1982; Beadle, 1971-87)

TREES	
Acacia melanoxylon (Blackwood)	- fairly common in forest of the eastern half
Casuarina cunninghamiana (River She Oak)	- common beside streams, eastern and western parts of the area but not higher parts
**C. littoralis* (Black She Oak)	- common in eastern parts
SMALL TREES	
**Acacia filicifolia* (Fern Leaf Wattle)	- woodlands and forests
**A. implexa* (Hickory)	- forests
**Banksia integrifolia* (Coast Banksia)	- common in east of area, mainly granite, but possibly more widespread in former times
**Exocarpos cupressiformis* (Native Cherry)	-common
Hakea eriantha	- forests and woodlands
**A. dealbata* (Silver Wattle)	- in forests
TALL SHRUBS	
**Bursaria spinosa* (Blackthorn)	- woodlands and forests
**Daviesia latifolia*	-sandy soils in forests
**Jacksonia scoparia* (Dogwood)	- woodlands and forests
**Leptospermum brevipes*	- rocky sites
**Olearia viscidula*	- woodlands and forests
MEDIUM SHRUBS	
**A. rubida* (Red Stemmed Wattle)	- common in hilly country
Callistemon paludosus (Bottlebrush)	- rocky creeks
Callistemon sieberi (Bottlebrush)	- usually beside watercourses, woodlands and forests
**Cassinia quinquefaria*	-common and widespread
**Dillwynia juniperina*	- widespread
Hakea dactyloides	
Leptospermum flavescens (Tea Tree)	- usually by watercourses, sandy soil in woodlands
Leucopogon lanceolatus	- common on hills
Olearia elliptica	
SMALL LOW GROWING SHRUBS	
**Brachyloma daphnoides* (Heath)	- usually sandy rocky situations
Correa reflexa	
**Cryptandra amara*	
**Hardenbergia violacea*	- widespread and common
**Hibbertia obtusifolia*	- sandy and gravelly soils
**Indigofera australis* (Native Indigo)	- woodlands and forests
**Leucopogon frazeri* (Heath)	- native pastures, among grasses in forests and woodlands
**Lissanthe strigosa*	- usually in rocky areas in woodlands
**Monotoca scoparia*	
**Melichrus urceolatus*	- sandy soils in woodlands and forests
**Pimelea linifolia* (Rice Flower)	
**Pomaderris eriocephala*	
**Pultenaea microphylla* (Eggs and Bacon)	

*Shrubs which may have occurred in grassy woodlands later cleared for grazing

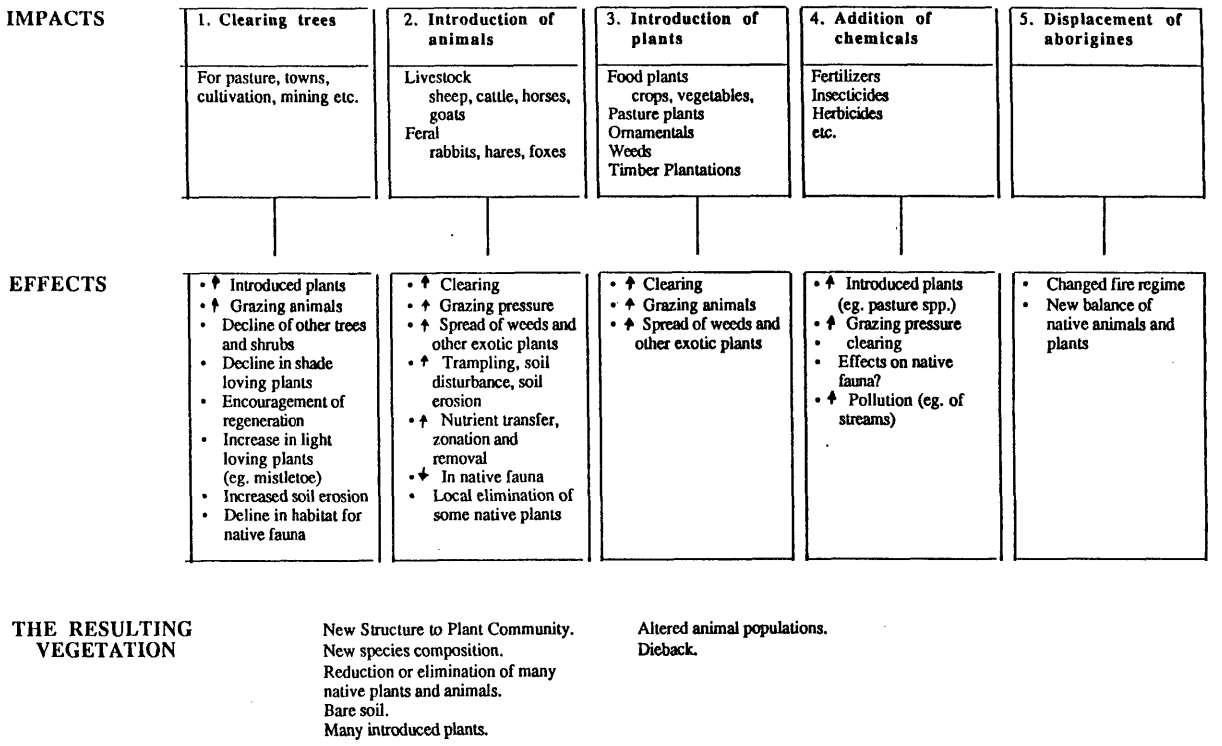


Figure 2.3: The impacts of European settlement and their effects on the vegetation of the Northern Tablelands of N.S.W.

as the worsening severity of frost and the effect of the landscape (Gilbert, 1971). For example Mrs. Louisa Meredith wrote at the time:

> "The system of 'clearing' here by the total destruction of every tree and shrub gives a most bare, raw and ugly appearance to a new place."(Gilbert, 1971)

In 1892 Rev Wools wrote on the possible consequences of overclearing:

> "No genus of plants in the colony of N.S.W. has suffered more extensively from the hand of man ... than that of Eucalypts ... it was necessary that many trees should perish, but, in the early days of the colony it seemed to be the policy of the settlers to clear off all of the trees irrespective of their industrial value or even their usefulness for fencing and firewood. Hence many of the so-called farms were completely denuded of timber. No trees were left to shelter the cattle from the summer sun, or to preserve wood for domestic purposes ... Opinions are somewhat divided on the subject of ringbarking, for whilst most people agree as to the policy of removing such as may be deemed cumberers of the ground, men of judgement lament the loss of useful species, or the contigency that a host of troublesome weeds may spring up where eucalypts once flourished ... rainfall is [also] affected ... by the increase or decrease of forest vegetation, and ... the shelter of trees is necessary for the preservation of the more delicate grasses ." [He is possibly referring to the good pasture species *Microlaena stipoides.*]

Another person who lamented the widespread destruction of trees on the tablelands was William Telfer who, while reminiscing of the 1840s to 1860s, wrote in 1903:

> "...when a run is overstocked they destroy the natural grasses there is nothing but rubbish to take its place ... they have to ringbark the timber to make the grass grow thicker ... thus destroying the green timber which is a shelter for stock in a cold winter such as we have had the last twenty years

> ... it is a foolish thing to destroy all the green timber as they are doing all over the state at the present time this wanton destruction of timber has been going on this thirty years .. destroy the vegetation and you have a country unfit for man and beast making the country very unhealthy ... also destroying the natural rainfall ...this timber would have kept the stock from starving outright ... there is nothing such as bushes and shrubs for them [stock] to eat those having been cut down or destroyed ..." (Telfer, ca 1900).

The idea that overgrazing lowered the quality of the native pastures was repeated by others (Bolton, 1981). It is interesting that many thought that the widespread use of ringbarking was responsible for drought conditions. Indeed controversy raged on this in the 1870s and 1880s (Blomfield, 1945; Gilbert, 1971; Bolton, 1981). Some Europeans also recognized the effect clearing was having on the food supplies of the Aborigines (Blomfield, 1986).

Nevertheless despite the concerns of some, tree clearing continued apace. Ringbarking was the chief method employed by the early settlers to kill trees (Mulligan, 1893[15]; Gilbert, 1971; Plate 2.9). Usually trees were ringbarked about 10 years before clearing. Once the trees were dead they were pulled down with bullock teams (Suttor, 1893), and burnt. Some ingenious contraptions such as the 'Australian Root Extracter' and the 'Forest Devil' were later invented for this purpose[16].

A.G. Hamilton estimated in 1892 that 9.5 million hectares of N.S.W. forests had been cleared or ringbarked - about $\frac{1}{4}$ of the area which was under forest one century earlier (Bolton, 1981). On the Northern Tablelands about 400,000 hectares had been ringbarked for pasture and 50,000 hectares cleared for cultivation by 1890 – about 10% of the total area of the four Tablelands electorates – (Walker, 1961). Ringbarking cost only about 1 shilling an acre while the cost of clearing for sown pasture or cultivation varied from 4 - 5 pounds an acre (Walker, 1961). Photographs of the 1890s reveal that by then much of the tablelands looked rather like it does today, with much of the original woodlands and forests cleared or semi-cleared. Fig 2.4 shows the tree density of the Northern Tablelands in 1968. The area that is most heavily cleared is that which carries the most stock (Thorpe and Holmes, 1963). The chief remaining treed areas are the eastern and western rougher country (ch. 1; Plate 2.10). Wells *et al.* (1984) estimated that of the 61.5 million hectares of N.S.W. which was wooded at the time of settlement 50% at a minimum has now been "severely modified", and that in many shires of the Tablelands the proportion is much higher.

Clearing on the Northern Tablelands occurred in bursts, rather than as a continuous process. In the late 1850s to 1860s much was cleared around gold mines (Plate 2.11). The Robertson Land Acts (in 1861) promoted closer settlement (one family per 1 square mile - 640 acres). This coincided with a supply of cheap labour after the end of the gold and a tremendous burst of ringbarking from the 1870s to 1890s (White, 1883-1924; Campbell, 1908; Harris, 1982 p68; Plate 2.9). Many of the trees cleared in the 1870s-1890s were possibly regrowth from the early

[15] Mulligan (1893). Diary written at Woodford mentions ringbarking areas, 28 Feb 1893.

[16] See photographs taken in 1906 of clearing at Goonoo Goonoo, at Armidale College of Advanced Education Historical Resources Centre

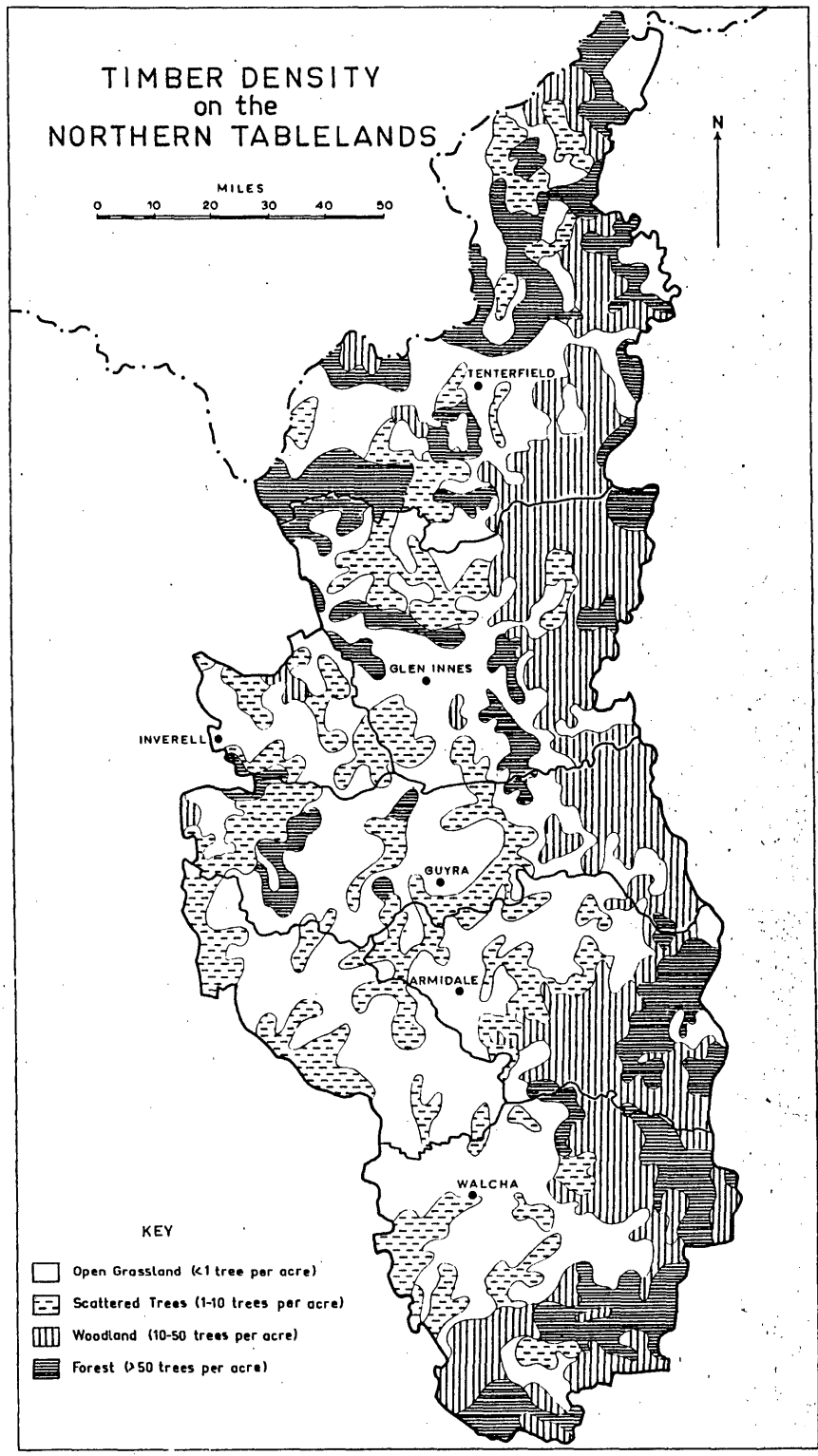


Figure 2.4: Timber Density of the Northern Tablelands about 1968. From McDonald (1968).

clearing. A further wave of clearing followed in the 1950s with the introduction of aerial pasture improvement (eg. Harris, 1982 p139).

The main effects of clearing on the native vegetation are:

- Removal of trees and shrubs resulting in a different plant structure (frequently open woodland or isolated trees in grassland - plates 2.12 and 2.13) and local extinction of many tree and shrub species;
- Decline in certain native herbs which prefer to grow under trees (eg. *Microlaena stipoides* and *Echinopogon* spp (Norton, 1971);
- Increase in herbs which are encouraged by the increased light availability;
- Increased grazing pressure (see next section);
- Encouragement of regrowth of suppressed seedlings which, if left to grow can result in an even aged stand of closely spaced young trees giving a more 'scrubby' appearance (Wright, 1964). Some shrubs such as *Acacia* spp and *Jacksonia* can also regenerate vigorously adding to the scrubbiness. This can often be seen along roadsides;
- Encouragement of mistletoe, the light loving eucalypt parasite (Anderson, 1941). Mulligan (1893) reported the spread of mistletoe in the New England area as early as the late nineteenth century;
- Increased soil erosion (Levy, 1985) which results in bare ground and/or a new regime of plants;
- Decline in habitat for native fauna.

PASTURE IMPROVEMENT

From the 1840s to early 1900s the main forms of pasture improvement were ringbarking the trees (which "precipitated a spectacular but short lived improvement in the grass quality") and burning the native tussock grasses to promote new growth (Wright, 1964). Many of the big shallow valleys had impeded drainage and swamps dominated by Restionaceae and Juncaceae were common (Whalley *et al.*, 1978). Most of these were drained giving rise to grassland (Gardner, 1854; Wright, 1964). The Australasian Pastoralist's Review (1896) reported on the 'Meredith's Draining Machine' which was apparently used extensively in this area to drain swamps. Ringbarking was said to reduce the tussocky *Poa sieberana* which was frequently found under the trees (Walker, 1961). This encouraged the invasion of other species such as *Trifolium, Lolium* sp., *Poa pratensis, Paspalum* and others. During this period small areas were sown with introduced fodder plants. About 3,700 ha were sown by 1900 (Table 2.4).

It was not until the 1920s that sowing of pasture really began in earnest when various individuals began introducing exotic grasses and legumes on a larger scale - including *Lolium perenne, Trifolium repens, Dactylis glomerata, Poterium sanguisorba, Poa pratensis*, and *Phalaris aquatica* (Wright, 1964). One of the earliest successes was Col. H.F. White at Bald Blair with *Phalaris, Trifolium repens* and later with *Lolium* spp and *Trifolium pratense.*

In the late 1920s fertilizers were seen as important in aiding the establishment of these exotic species. When aerial spreading of superphosphate began in the late 1940s a much more widespread sowing and fertilizing of introduced pasture plants was possible, and from that date the spread of improved pasture was rapid. For example in the 1963-64 season one distributor in Armidale alone handled 40,000 tons of super and sufficient seed to treat 52,600 ha (Wright, 1964).

Table 2.4: Amount of Land Sown to Pasture

1879	811 ha of sown pasture
1890	4,945 ha
1905	3,676 ha
1930	4,055 ha
1968	688,000 ha

From information in McDonald (1968) and Walker (1961)

Pasture improvement tends to be limited to the undulating hills or flatter areas where the slope is less than 8° (Thorpe, 1977; McDonald, 1968). Steep areas such as those to the east and west and densely treed areas are unsuitable. Over the whole Tablelands area nearly 40% (about 600,000 hectares) of the land suitable for pasture improvement had been sown by 1968 (McDonald, 1968). This varied from locality to locality with 70% of suitable land being sown in the Walcha district while 11% was sown in the Tenterfield area. Pasture improvement resulted in greatly increased stocknumbers (McDonald, 1968; Fig 2.5). Many pastures which are sown to improved pasture revert to native/naturalized grass-white clover pastures (ie. natural pastures). Consequently in recent times only about 31% of rural holdings is under sown pastures and clovers or is cropped, and the rest is natural pasture (Australian Bureau of Statistics, 1986).

Pasture improvement has affected the pre-existing native vegetation in the following ways:

- It has led to the spread over vast areas of a small number of exotic pasture species, including *Trifolium repens, T. pratense, T. subterranean, Medicago sativa, Lolium* spp, *Phalaris aquatica, Dactylis glomerata, Festuca* spp, *Poa pratensis.*
- It has hastened the spread of many other introduced plants particularly weedy herbs such as cool season annual grasses.
- More land has been cleared.
- It has caused a greatly increased grazing pressure with the consequent effects on the remaining native shrubs, trees and herbs (Fig 2.5).
- It has resulted in greatly changed plant communities, which frequently have less diversity in structure. For example a woodland containing trees, herbs and shrubs is typically replaced by pasture with a few scattered trees.

CULTIVATION

Historically the New England has not had a large proportion of its land devoted to cultivation of crops and orcharding. By 1973 only 2.5% of the whole region was under cultivation (or 80,000 ha) while 19% of the area was sown to improved pasture (about 600,000 ha) (Scott, 1979). Much of the cultivation that is carried out is in the central west and northwest portion of area. Crops include wheat, oats, maize, sorghum, lucerne, vegetables, orchard fruit, tobacco, soya beans, chick peas and sunflowers.

Cultivation was aways carried out on a small scale by the early settlers in the home paddocks for crops such as wheat (Norton, 1972). Edward Irby wrote in 1842:

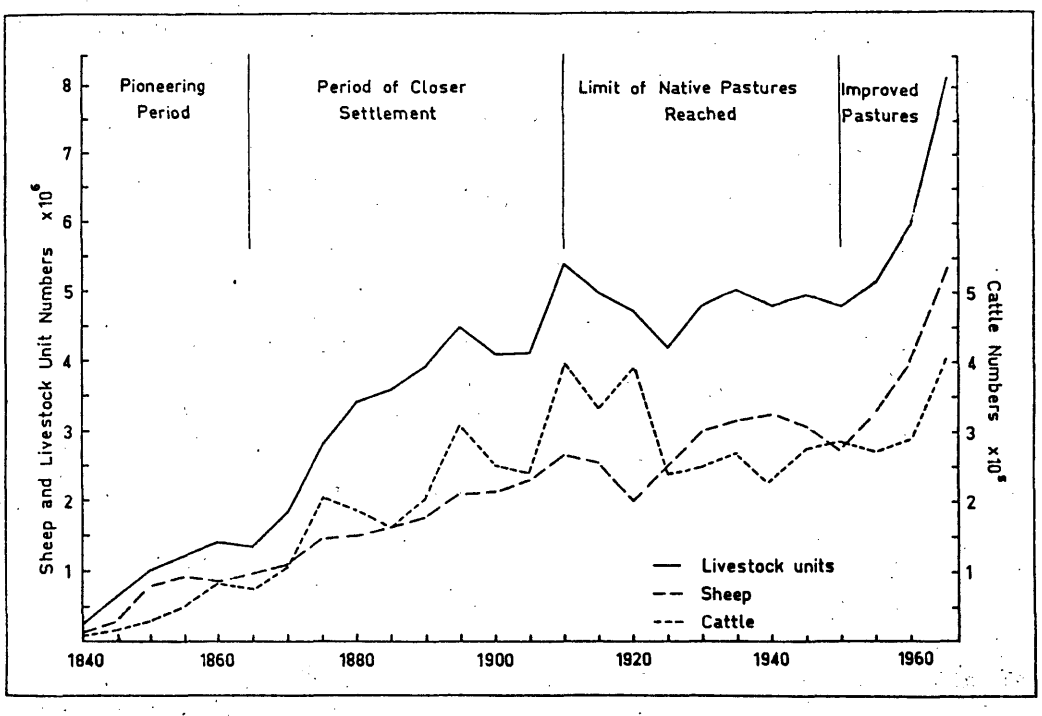


Figure 2.5: The trend in the numbers of sheep, cattle and sheep equivalents on the Northern Tablelands since 1832. (From McDonald, 1968)

> "When a man forms a station he must have a dray and 8 or 10 bullocks...he must also have for some weeks 2 splitters to build him huts and fence in 10 acres or so for wheat[17]".

In the 1860s and '70s cultivation of some crops flourished but due to economics and the climate many of these enterprizes did not last far into the 20th century (Walker, 1963). Also with settlement came the planting of exotic ornamental species such as elms, oaks, pines, hawthorn, willows and fruit trees which were planted around the houses of the early settlers, and in many places these trees are all that remain to point to the existence of these early dwellings (Connah, 1977).

The effects on the native flora of cultivation are, as with pasture improvement, the removal of native trees, shrubs and herbs, the intentional introduction of certain new plants species, and the unintentional encouragement of the spread of a large number of herbaceous weeds. In some places it has led to less diversity of species (eg. monocultures) and less diversity of structure (eg. trees, shrubs and herbs replaced with just herbs) although over the entire region it has meant an increase in the total number of species.

GRAZING BY DOMESTIC STOCK

The single most significant impact on the native flora of the Tablelands by Europeans has been the introduction of domestic livestock, ie.sheep and cattle and to a lesser extent horses, and goats. The amount of land taken up by pastoral interests make the land taken up by towns. roads, forestry operations and mining look minute by comparison (Lea *et al.*, 1977). The

[17] Irby, *op cit.* Letter by Edward Irby to his sister, 6 Aug 1842

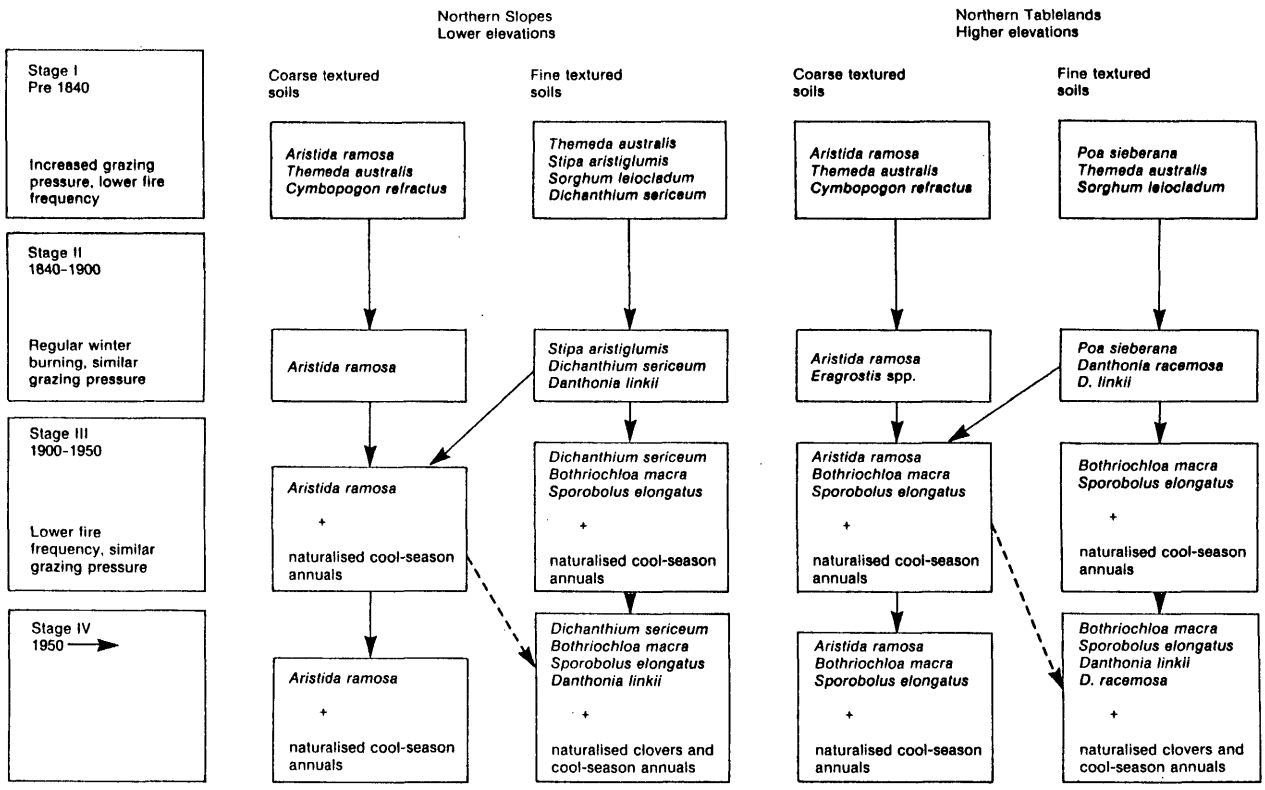


Figure 2.6: Postulated changes in the native and natural pasture dominants of the Northern Tablelands and Slopes of N.S.W. in response to changing land management practices. Changes resulting from superphosphate additions and heavy grazing are shown by dotted arrows. From Lodge and Whalley, 1989

introduction of domestic livestock has resulted in a huge increase in grazing pressure from the previous levels by native animals such as kangaroos. In 1978 there were about 5.7.million sheep and 1 million cattle on the Tablelands (Lodge *et al.*, 1984; Fig 2.5) and an increased grazing pressure from 0.62 sheep/ha in the early days (Campbell, 1922) to the equivalent of 7-8 sheep/ha now.

Effect of grazing on herbaceous plants

The main composition changes which occur in the native herb community with continuous grazing are summarized in Fig 2.6.

The common plants of the herb layer before European settlement were probably the warm season perennial grasses *Themeda australis, Aristida ramosa, Cymbopogon refractus,* and *Sorghum leiocladum* and the yearlong green perennial grass *Poa sieberana.* These grasses are adapted to lower levels of grazing by native animals such as kangaroos, which merely prune the tufts leaving the lower parts untouched, compared with sheep and rabbits which graze more closely (Anderson, 1941). Thus they tended to be eliminated under grazing by sheep, giving way to short warm season native grasses (eg. *Bothriochloa macra, Sporobolus elongatus, Eragrostis* spp and *Chloris truncata*), yearlong green perennial grasses (eg. *Danthonia* spp, *Dichelachne* spp, and naturalized cool season annuals (*Vulpia* spp, *Aira cupaniana, Briza minor, Bromus* spp, and naturalized herbs such as *Hypochaeris radicata.* With pasture seeding, superphosphate and continued heavy grazing the prevalent plants become the introduced yearlong green perennials

(*Trifolium repens, Phalaris aquatica, Festuca arundinacea, Dactylis glomerata, Lolium perenne*) and cool season naturalized annuals (*Hordeum leporinum, Bromus brevis, Cirsium vulgare, Urtica urens*) (Whalley *et al.*, 1978; Lodge *et al.*, 1984).

Grazing animals affect the vegetation in other ways also. The action of hard footed animals leads to increased soil disturbance, compaction and erosion (Whalley, 1970). They aid the spread of many weeds whose seeds get carried in wool and fur such as *Aristida* spp, *Cenchrus* spp, *Rumex* spp etc. Their habits also lead to a nett nutrient transfer - from the paddock to where the animals congregate or out of the farm in the form of wool or meat. For example Hilder and Mottershead (1963) found up to 34% of sheep dung on 10% of the paddock (eg. in sheep camps or shearing sheds) and 22% over 3% of the paddock. This meant that nutrients were being concentrated in the sheep camps and depleted from the rest of the paddock. There was a corresponding change in the plants present. Plants favoured by high fertility (eg. clovers, *Phalaris, Lolium* and *Festuca*) and which had been sown throughout the paddock suffered because of less fertility while in the camp the plants had been destroyed by trampling and excess dung.

Taylor *et al.* (1984) examined sheep camps on natural pastures on the Northern Tablelands and found marked zonation around them, both in fertility (due to concentrations of dung and urine) and species composition. The higher fertility zones carried mostly exotic winter annuals (eg. *Hordeum leporinum*, and *Bromus brevis*) and many unpalatable weeds (eg. *Urtica* spp, *Cirsium vulgare, Marrubium vulgare* etc.).

Effect of grazing on native trees, shrubs and tree seedlings

The effect of grazing on native trees, shrubs and tree seedlings is discussed fully in chapter 8. The effects include:

- Reduction in size, density, and diversity of shrubs and seedling trees.
- Invasion of herbs (particularly vigorous exotic herbs).
- Reduction of the the flowering and fruiting of many shrubs, eg. *Indigofera australis* (Leigh and Holgate, 1979).

PLANT INTRODUCTIONS

An end result of many of the impacts of European settlement on the vegetation has been the invasion by hundreds of plant species, both intentional and unintentional. These include food and garden plants, pasture plants and weeds. Over the whole of Australia 10% of the flora is introduced while for the Sydney region this figure is 20% or 400 species (Adamson and Fox, 1982). For the north-eastern region of N.S.W. (which includes the Northern Tablelands , coast and western slopes. about 18% of the flowering plants, and 17% of the entire flora are exotic.[18] This is about 660 species. On the Northern Tablelands itself, 104 (or nearly one half) of the 256 grass species recorded are introduced (Norton, 1971).

The vast bulk of exotics are herbaceous (92%). Most of these are annuals or biennials (57% of all exotics) while the remainder are perennials (35%). There are very few naturalized

[18] The figures relating to plant introductions on the Northern Tablelands have been compiled from information presented in Beadle (1971-87)

trees or shrubs in the area (7% of the total) and of these most occur in the coastal area. The common naturalized shrubs and trees on the tablelands are *Rubus vulgaris, Rosa rubiginosa, Crataegus monogyna* and *Salix babylonica.* Most of the introductions come from Europe or North America. The more tropical introductions tend to grow in the coastal area. The bulk of the introductions (61%) are weed species which were probably introduced unintentionally and which spread easily in disturbed areas near habitation or in cleared country. The remainder of the introductions escaped from gardens or cultivated areas; The number of plant families which contain the introductions is surprisingly few. Most of the introductions come from four families - the Brassicaceae, Rosaceae, Asteraceae and Poaceae. The Solanaceae, Convolvulaceae, Scrophulariaceae, Verbenaceae, Lamiaceae and Iridaceae also contribute many. There are about 40 families which contain a large proportion of exotics compared with about 127 which contain virtually only native species.

Most of the exotic plants which have spread in Australia (and on the Tablelands) derive from the 'old centres of civilization', and were the pioneer and weedy species of those environments (Moore, 1966). Usually they were adapted to environments affected by people by having high seed production, efficient seed dispersal mechanisms, rapidity of establishment and persistence under defoliation and often originally developed in areas where the main grazing animals of today originated (Moore, 1966). They were therefore plants adapted to the kinds of disturbance the invading Europeans brought with them.

In Australia the native plants evolved under totally different conditions with a totally different grazing regime (Anderson, 1941), and many of the original dominants are not adapted to an environment which includes domestic herbivores (Whalley, 1970). In undisturbed forest native plants still predominate although a few aliens can penetrate such as *Rubus vulgaris* and *Hypochaeris radicata.* However in situations where disturbance is high or continuous such as cultivated areas and sheep camps, exotic plants tend to outcompete the natives (Moore, 1966; Amor and Stevens, 1976). Sometimes when the disturbance ceases (eg. stock removed from an area) native plants can re-establish to the exclusion of the exotics but where disturbance is ongoing (eg. heavy grazing, fertilizer application or soil disturbance) the alien plants tend still to dominate (Moore, 1966).

EFFECT OF DISPLACING ABORIGINES ON THE VEGETATION

The invasion of European culture had a tragic impact on the Aboriginal people as they were massacred and forced to move out of the area (Walker, 1966; Blomfield, 1986). How this in turn affected the flora seems to be related to the subsequent changes to the fire regime and native animal populations.

In Victoria Rev. Peter MacPherson wrote of extensive eucalypt dieback caused by a possum population explosion. Prior to European settlement the Aborigines had hunted the possums and kept their numbers in check. With the massacre of the local tribes by white settlers the possum population grew, causing widescale defoliation and death of eucalypts. "The tooth of the blackfellow operated on the opossum, and the tooth of the opossum operated on the leaves of

the eucalypt. The former of these two is now struck out of account and that leaves much larger scope for the operation of the second factor."(MacPherson, 1885). Mulligan (1893) reported a similar (although less severe) occurence on the Northern Tablelands until there was widescale shooting of possums for skins and because they ate maize crops. This virtually wiped them out.

Cane (1949) reported a buildup in kangaroo and possum populations after the blacks had been pushed out and there were massive slaughters of kangaroos and wallabies in the 1880s. Norton (1972) suggested that this buildup was less to do with Aboriginal hunting of the animals and more to do with more feed being available for kangaroos after clearing, and that "the large marsupials co-existed with the domestic livestock until real or imagined competion for pasture provoked the graziers to introduce control measures".

Changed Fire Regime

The changed frequency of fire on the Tablelands is still a matter of debate, the main problem being estimating how frequently fires occurred before European occupancy. Fires began by natural means, although their frequency is unknown. It is also apparent that Aborigines burnt vegetation for a variety of reasons including the encouragement of fresh young growth in the grasses to encourage kangaroos to graze so they were easier to hunt (Anderson, 1941; Norton, 1972). Early settlers made frequent mention of the fires lit by Aborigines although few of them seemed to perceive the rationale in the Aboriginal approach (Hodgkinson *et al.*, 1984). For example Edward Irby wrote in 1842:

> "The country round three sides of the station is now on fire...It is generally supposed that these large fires are caused by natives dropping their firesticks accidentally, and not from any design on their part of trying to burn the settlers out of their station. They sometimes burn the old grass off, in order that they may have a chance of killing kangaroos when they go to feed on the young grass that springs up, and also when they think they are likely to be pursued they fire it to prevent their tracks being seen.[19]"

An extract from Mundy reports similarly:

> "The great [summer] heat is sometimes increased by the burning grass, which is generally lighted by the aborigines carrying fire about with them; these fires, when there is a wind, will burn for days, but if there is no wind, there is almost always a dew at night, which often puts them out. The sight of fires is sometimes magnificent, as whole ranges of mountains are lighted up by them. They have a great effect on the character of the country, as they burn many of the young trees, and thus prevent the forest from being too thick. All the country, except when heavily stocked with sheep, is sure to be burnt at least every two or three years.[20]"

The effect of this burning was to limit the growth of shrubs and tree seedlings and probably contributed to the 'open' appearance of the woodlands referred to by the early settlers. In the large areas of hummock grassland in northern Australia the Aborigines burnt systematically, burning many small fires under cool conditions or in restricted patches of available fuel and several years apart. This "build up of a mosaic in space and time... established a patchwork of successional states; which both inhibited the spread of wildfires and provided a highly diverse

[19] Irby, *op cit.*. Letter by Edward to his father p41
[20] H.M. Marsh *op cit.* p413, quoted by Norton (1972)

and dynamic ecosystem" (Griffin, 1984). There is no direct evidence that they did the same thing on the Tablelands but it appears likely. Other circumstantial evidence that fire was common was the (apparent) widespread occurrence of *Themeda australis*, a perennial grass adapted to frequent fire and low levels grazing (Roe, 1947; Norton, 1972).

The early settlers probably increased the frequency of fires initially for it was common practice for them to burn off large areas of the accumulated dry grass at the end of each winter (Anderson, 1941; Norton, 1972). Although this gave a flush of green growth the continued act, year after year, had deleterious effects on the grasslands. Better native species such as native legumes gradually disappeared leaving only the harder tougher species with less nutritive value like *Bothriochloa* and *Stipa* (Wright, 1964). At the turn of the century overstocking combined with the regular firing and rabbits deteriorated an already fragile situation. Soil fertility and humus levels were drastically reduced in soils that had never been oversupplied (Wright, 1964). Fires were also used to clear the land for cultivation and were common near settled areas.

Many of the native plants have special methods of re-establishing after fire. Eucalypts sprout from epicormic shoots lying dormant under the bark of the stem.

Acacia seed, cracked by the action of heat, germinate readily after fire. Some species have wind borne seed to help them recolonize areas after fire (eg. *Cassinia* spp) while others have their seeds held in hard woody fruits which open after the action of heat (eg. *Callitris* spp and *Banksia*). Lignotubers in many species (notably eucalypts) which lie under ground level have the ability to sprout after fire has destroyed the above ground parts of the plant. Other plants have a deep underground rhizome for the same purpose (eg. *Imperata cylindrica*). However when fire is followed by grazing (as was probably the case on most farms of the area) extremely high mortality occurs in eucalypt or shrub regeneration unless the plants themselves are already quite large and well established. The end result of years of this type of regime would have been the gradual eradication of many native trees and shrubs.

Mistletoe is susceptible to fire and Anderson (1941) reported that while their host eucalypt may make good recovery the mistletoe plants may not survive fire. He also reported that in pastural areas firing results in the elimination of the leguminous *Medicago* sp. whose seed cannot survive the heat.

The time of year at which fire occurs can have a dramatic effect on the reactions of different species. For example the undesirable *Aristida ramosa* builds up following annual spring burning and heavy winter grazing. Conversely it can be reduced substantially from a natural pasture if it is heavily grazed and burnt in autumn. The same treatment will encourage the desirable grass *Danthonia linkii*, because of different growth and phenology of the two grasses (Lodge *et al.*, 1984). Information is scanty on when fires occurred prior to settlement, although Marsh (1867) (quoted above) mentions summer fire as being more common. How this affected pasture species is unknown, although it possibly favoured *Themeda* and supressed eucalypt and shrub regrowth, while the winter burns of the early settlers probably had the opposite effect.

Overall the changed regime of fire frequency would have led to a different plant community.

With the advent of pasture improvement - sowing pastures, aerial supering etc. fires have virtually been eliminated from the main Tablelands area in the last few decades. Possibly this has further helped the spread of many exotic pasture plants throughout the Tablelands. On the other hand many of the natives that are adapted to regenerate after fire (*Acacia* spp, *Jacksonia* etc.) may have been further reduced by this situation.

CHANGED WILDLIFE

Clearing, pasture improvement, the introduction of foxes and stock and mass hunting have had a dramatic effect on the native wildlife of the area. Some of the changes were documented by Phillip Wright (1889-1970) who spent much of his life in the Wongwibinda-Jeogla district. In his memoirs, first published in 1972, he noted how: "The bush had changed greatly since my youth, between the decline in native fauna and flora, and the introduction of new plants, animals and techniques." He mentions the great impact foxes had on animals such as kangaroos, bandicoots and wallabies, and ground-living birds such as curlews, plovers, cranes, scrub turkeys, wonga and pigeons. Rock wallabies, koalas, kangaroo rats, and native cats had all been drastically reduced by disease, shooting or foxes while kangaroos had become more numerous (Wright, 1982).

Other authors have also commented on the decline of wildlife due to European settlement (eg. Blomfield, 1945; Bolton, 1981). The main effect as far as the vegetation has been concerned has been the reduction of predators of many of the insect defoliators of trees.

In conclusion, the vegetation of the Northern Tablelands has been extremely modified in the last 150 years. From being largely covered in grassy (or sometimes shrubby) forests and woodlands, the area now mostly supports open pasture with scattered trees and isolated remnants of native vegetation. Accompanying the clearing has been a decline in native wildlife, increased grazing pressure, and a whole new regime of plants. How these changes are implicated in dieback is discussed in chapter 3.



Plate 2.1: Uralla 1866, showing the typical pattern of town development on the Northern Tablelands - the first settlement being along the creek, while the surrounding hills remain wooded. U.N.E. Archives A218; p. 687.



Plate 2.2: Gardner's sketch of *Indigofera australis*. He wrote that it was "... relished by cattle, when they are recently placed upon a run where it grows, they improve in condition...horses are remarkably fond of the leaves of young shoots" (Gardner, 1854, Vol.1)

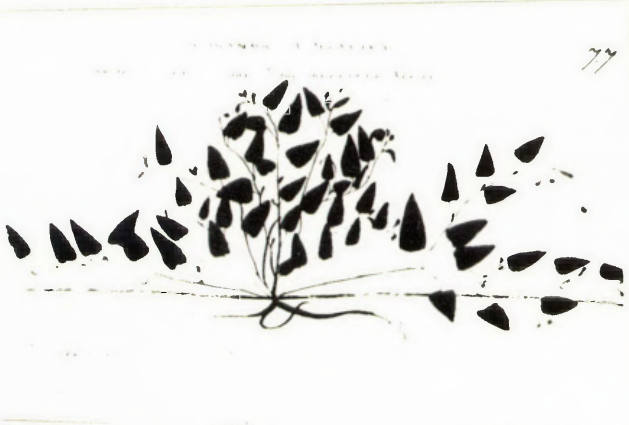


Plate 2.3: Gardner's sketch of *Hardenbergia violacea*. Of sarsparilla Gardner wrote that it "... Grows in every count y of N.S.W., it is everywhere found on the stringybark and Ironbark ranges; where it attains a foot and a half". The roots of this creeping plant he says can be used for beer and medicine and horses, cattle and sheep all graze the leaves. He also noted it grew to abundance among rocks. (Gardner, 1854, Vol.1)



Plate 2.4: Gardner's sketch of *Banksia integrifolia* which he mentioned occurred on the Northern Tablleands. (Gardner, 1854, Vol.1)



Plate 2.5: Aberfoyle, county of Sandon. Watercolour by Wm. Gardner ca. 1854, showing cultivation, paddocks and timbered hills. Trees in fore-ground are possibly scattered remaining eucalypts. (Gardner, 1854, Vol.1)



Plate 2.6: Lambing Down Station, Balaclava. Rockvale Run, county of Sandon. Watercolour by Gardner (1854), Vol.1.



Plate 2.7: Gualcanba on the Wolamubi River, County of Sandon. Watercolour by Gardner (1854), Vol.1.



Plate 2.8: Mill at Mount Mitch, County of Gresham. Watercolour by Gardner (1854), Vol.1, showing a diversity of animals present at the time.



Plate 2.9: Ringbarking on the Wellingrove Creek Estate, New England ca. 1900. (From Australasian Pastoralists' Review, January 15, 1900.)



Plate 2.10: Dangar Falls ca. 1914. Most of the steep gorge country was not cleared except near gold mines (eg. Hillgrove).



Plate 2.11: Rocky River Diggings. MacPherson sketches 1856-7. Much of the area near the diggings was apparently cleared except for some remaining trees.



Plate 2.12: Birrhalee, Salisbury Waters ca. 1890.



Plate 2.13: The same scene as plate 2.12 in 1986.

Chapter 3

Dieback and Rural Tree Decline

> "...deterioration and death of trees are far from new - trees have been dying since time immemorial, and new trees have been created 'for a little longer'. These events happened prior to settlement under circumstances that were disturbed largely only by natural events. Man has changed the tree environment in the areas he has developed for agriculture, and has introduced and induced a whole new range of additional elements that can hasten tree senescence and death, and impede or prevent regeneration." (Grose, 1980)

Dieback is a term describing abnormally extensive death and debilitation of trees. The term is also used to describe the progressive dying back from the tips of the twigs and branches of an individual tree. The first definition will be used in this thesis.

There are many forms of dieback worldwide. By no means exhaustive, the list includes: Dutch Elm Disease in the elms of Europe (Gibbs, 1978); Cinnamon Fungus -*Phythophthora cinnamomi* (Zentmyer, 1980); beech bark disease in North America (Houston, 1979); defoliation of birch forests in Lapland by caterpillars (Heatwole and Lowman, 1986); gypsy moth defoliation in oak forests in the United States (Campbell and Sloan, 1977) and the diebacks caused by photochemical pollution (Koslowski, 1979) and acid rain (Tifft *et al.*, 1985; Pearce, 1987; Hinrichsen, 1987).

In Australia, plant communities from dense forests to sparse trees in farming and grazing land are affected by dieback. Syndromes affecting Australian forests have been reviewed in Old *et al.* (1981) and by Nadolny (1984).They include diebacks caused by various insect outbreaks (such as phasmatids, leaf minors, and psillids), fungi (such as *Phytophthora cinnamomi* and *Armillaria* root rot) and climatic stress as in drought. In most cases human action has been implicated as responsible directly or indirectly.

In many rural areas across Australia dieback has also been severe, occurring on the central and southern Tablelands of N.S.W. as well as in Queensland, Victoria, South Australia and Western Australia (Neumann *et al.*, 1980; Kile *et al.*, 1981). Usually the causes involve a combination of many factors including 'natural' death of old trees, no replacement of trees by regeneration, insect defoliation, salinity, and tree stress, these factors varying in importance in different regions. Rural dieback has been reviewed by Kile *et al.* (1980) and in Old *et al.* (1981). Like forest diebacks, rural dieback is often the result of human actions, directly or indirectly through clearing etc. For this reason the term 'tree decline' is frequently used in reference to rural areas. This term encompasses trees lost due to dieback and also those killed directly by humans.

On the Northern Tablelands of N.S.W. dieback has been an ongoing but fluctuating phenomenon for over 100 years, with outbreaks getting worse and culminating in the extremely widespread death of trees in the 1970s. Norton (1886) recorded dieback in *E. nova-anglica* over thousands of hectares of the Walcha district in the 1850s and 60s, even in areas that were at that time uncleared. He deduced it to be caused by a combination of alternating drought and waterlogging, excessive cold, soil compaction by sheep, and insect defoliation. Some dieback associated with insect outbreaks were reported early this century (Boyd, 1965) and outbreaks of Christmas beetles and associated defoliation of eucalypts are part of the oral history of the area (eg. Ethel de Sylva, pers. comm.).

Increasing dieback of *E. nova-anglica* was observed in the Armidale district in the early 1960s (Williams and Nadolny, 1981; Morgan 1981a). In the 1964-65 drought there was widespread mortality of some of the more western Tableland species (Hoult, 1970). By 1970 there was severe dieback of *E. nova-anglica* and noticable dieback of some other eucalyts (Williams and Nadolny, 1981). However, the 1970s outbreak of dieback was by far the worst on record, affecting more species and a much larger area than previously and this has been referred to as New England Dieback (Ministerial Working Group, 1979a; Nadolny, 1984). In the years 1979-83 there was a general improvement in the vigour of trees. This recovery was not uniform and trees which had a low vigour (ie. less than 25% of foliage) continued to die (Nadolny, 1984). There were also some seasonal fluctuations within the general recovery.

This pattern has remained to the present, with many trees still (in 1989) in reasonable health while unhealthy trees continue to die (particularly exposed solitary trees). Seasonal fluctuations still occur, with widespread and severe defoliation of trees by scarab beetles and other insects in the summers and autumns of 1987/88 and 88/89. Indeed there are indications that a period of bad dieback may follow in the early 1990s.

A number of studies have been carried out on New England Dieback in recent years, many of which have been financed by The New England Eucalypt Dieback Research Fund, which was raised by the local community. Some of these studies are yet to be published. The most useful ones to date are those of Williams and Nadolny (1981), Nadolny (1984), Heatwole and Lowman (1986), Ford and Bell (1982), Ford (1985 a;b) and Ford *et al.* (1985).

GENERAL PATTERN OF RURAL DIEBACK ON THE NORTHERN TABLELANDS

The general pattern of Dieback on the Northern Tablelands can be summarized as follows:

- The main dieback area is the gentle sloping land (less than 8° slope) above 800m altitude, extending from Walcha to Tenterfield. Dieback was worst in grazing systems and on heavily cleared land, although there were local inconsistencies to this general pattern (Mackay, 1978; Mackay *et al.*, 1984; Duggin, 1983; Nadolny, 1984).
- The forests of the eastern gorge system and the western granite areas have generally been unaffected (Nadolny, 1984), although the trees in the latter areas had suffered extensive drought damage in

the mid 1960s (Hoult, 1970). Larger tracts of forest within cleared land have usually been relatively unaffected (eg. Eastwood State Forest, near Armidale).

- Dieback has affected relatively few of the 50 or so eucalypt species which grow on the Northern Tablelands. The main species affected are the 6 species which are common and widespread in the main dieback area: *Eucalyptus nova-anglica*, (the worst affected), *E. blakelyi, E. melliodora, E. bridgesiana* ssp *bridgesiana, E. viminalis*, and *E. conica.* To a lesser extent *E. pauciflora, E. stellulata, E. caliginosa* and *Angophora floribunda* have also been affected (Mackay *et al.*, 1984; Williams and Nadolny, 1981; Duggin, 1981; Nadolny, 1984). In the 40 or so other eucalypt species on the Tablelands dieback has only been sporadic or insignificant. Most of these species grow outside the main dieback area mentioned above (Table 1.3).
- No species has suffered dieback over its entire geographic range. Even the most severely affected species can be found without dieback - frequently where they are growing in unaffected areas (Table 1.3). However all species which commonly occur in dieback areas have been affected (Nadolny, 1984).
- Some differences in susceptibility between species have been apparent, eg. *E. nova-anglica*, *E. blakelyi*, and *E. melliodora* were severely affected while *E. pauciflora* seemed to show some resistance.

CAUSES OF DIEBACK ON THE NORTHERN TABLELANDS

Two chief factors are generally acknowledged to be responsible for dieback on the Northern Tablelands - a large buildup in insect numbers coupled with various stresses on the trees (see Fig 3.1).

Considerable circumstantial evidence has implicated insect damage, both above and below ground, as the main agent causing rural dieback on the Northern Tablelands and similar areas (eg. Ministerial Working Group, 1979a; Landsberg and Wylie, 1983; Mackay *et al.*, 1984; Nadolny, 1984; Lowman and Heatwole, 1987; Lowman *et al.*, 1987; Landsberg, 1988). Estimates of the degree of insect induced defoliation of trees were high in the 1970s when dieback was most active and low in the 1980s when trees were recovering (Nadolny, 1984). Crown damage directly associated with insect damage has been recorded (Nadolny, 1984), while insecticide injections and applications have offered some relief to trees with dieback (Nadolny, 1984; Mackay *et al.*, 1984; Taylor, 1985; Lowman and Heatwole, 1987).

The insects usually implicated are native to the area, indeed some defoliation is always present in a eucalypt community (Morrow, 1977; Fox and Morrow, 1983; Heatwole and Lowman, 1986). Although evidence is lacking, some defoliation may even be beneficial to a eucalypt community. For example leaf loss could slow tree growth and hence conserve water and nutrients (Florence, 1981) and make the wood more dense and resistent to decay (Jacobs, 1955). Insects may also hasten nutrient cycling through their frass (Florence, 1981) and certainly they provide an important food source for birds and other animals (Davidson, 1981a). Eucalypts are well adapted for recovery from damage to their crown with their production of dormant and epicormic buds (Chattaway, 1958a; Pryor, 1979). The question therefore is what conditions have arisen to allow insects to become such a problem for trees?

New England Dieback is a process, rather than a 'disease', the end result of a century of tree clearing and pasture improvement. All surveys confirm that it is largely confined to cleared grazing country. Less overall tree cover due to clearing has meant that the remaining trees are less able to 'soak up' insect populations than trees in forested areas. Lowman has collected evidence to confirm that trees in cleared areas suffer higher defoliation levels than trees in forested areas (Heatwole and Lowman, 1986; Lowman, unpub.).

Various cultural practices have encouraged a build up in defoliating insect populations. For example scarab beetles, whose larvae feed on pasture grass roots and whose adults feed on trees, are encouraged where tree densities are low (10-20%) and where pasture is dominant (Roberts *et al.*, 1982). Pasture improvement further improves the food supply for the insect larvae of these beetles.

As well, fewer predators are available in cleared areas to control the buildup of insects. In particular there are far fewer insectivorous birds in open paddocks than in healthy woodland, where they can exert a controlling influence on insect numbers (Ford and Bell, 1980; Ford, 1985b; Ford *et al.*, 1985). As woodlands contract in size and get more heavily grazed the habitat for birds becomes less, with consequent reductions in bird diversity and abundance (Loyn, 1984; 1987). A similar pattern probably exists for predators such as robber flies (Asilidae), assasin bugs (Reduviidae), lacewings (Chrysopidae), and spiders, and for parasites such as wasps (Scolioidea, Chalcidoidea, Ichneumonoidea) and flies (Tachinidae) (Davidson, 1980; 1982a). Fragmentation of habitat leading to decline of predators and a corresponding explosion in insect defoliation has also been shown in other ecosystems (Karieva, 1987; Lawton, 1987).

Clearing has meant also that any remaining trees, particularly those which are quite isolated, suffer more stress from hail, frost, wind, mistletoe, and direct damage from people and stock by soil compaction, stripping of bark, herbicide damage etc. (Nadolny, 1984). Coppice regrowth from previous clearing is also more susceptible to dieback (Mackay *et al.*, 1984).

Although it has been suggested that superphosphate damages eucalypts directly through acidification of the soil (eg. Mackay, 1978; Anon, 1979; Duggin, 1981), there is little direct evidence for this to date. However fertilizer has been shown to increase scarab beetle numbers through improving the food supply (grass roots) for the larvae (Nadolny, 1984).

Transfer of nutrients by sheep via their excreta to treed areas makes the foliage of the trees more nutritious and subject to much higher levels of insect defoliation than foliage of trees in ungrazed areas (Landsberg, pers. comm.). By increasing soil nutrition, fertilizer application could also be involved in this process.

Fungal root pathogens have not been found to be significant in causing New England Dieback, in contrast to some of the forest diebacks of Victoria, Tasmania, and Western Australia (Nadolny, 1984).

Isolated occurences of soil salinity have been noticed in the Armidale-Walcha area (Enders, pers. comm.; Barnet, pers. comm.). Whether this may be a cause of dieback in some waterlogged sites, an effect of tree decline, or unrelated to dieback in any way, remains unclear since soil

salinity has not been examined systematically in the region.

New England Dieback occurred when a sequence of moist summers in the early and mid 1970s triggered an explosion in insect populations, which, coupled with all the factors mentioned above, did tremendous damage to eucalypts. A whole suite of insects multiplied and caused damage to trees in the bad dieback years in addition to the oft cited Christmas beetles (Scarabaeidae) (Carne *et al.*, 1974; Roberts and Sawtell, 1981). These included leaf beetles (Chrysomelidae), caterpillars (Lepidoptra) and sawfly larvae (Pergidae), lerps (Psillidae), and scale insects (Coccidae) (Hadlington, 1972; Ford, 1985b; Heatwole and Lowman, 1986). In the drought years 1979-82 insect populations decreased dramatically and most trees correspondingly recovered (Nadolny, 1984).

The bad dieback years of the early 1960s, and 1860s also coincided with a series of moist summers. Whereas in forested areas, insect predators can reduce the severity of outbreaks arising from favourable weather, in the open areas there are no such balances and mass defoliation results. In the 1890s despite favourable weather conditions for insect outbreaks none were reported, possibly because the mass ringbarking at the time masked any insect induced damage.

The amount and duration of defoliation which is needed to kill a tree is difficult to determine and estimates vary. What does seem apparent is that defoliation must be sustained and continual. This gradually depletes the tree's carbohydrate reserves and over a period it dies (Bamber and Humphries, 1964; Mackay *et al.*, 1984).

Eucalypts suffering from dieback or other forms of stress tend to produce foliage which is higher in total nitrogen and other nutrients. Such foliage is more palatable to insects and further encourages insect attack (Landsberg and Wylie, 1983). As well, their flowering in disrupted and badly affected trees produce little or no seed, hence decreasing their capacity to regenerate (Landsberg, 1988). Regeneration is also inhibited by sheep grazing and vigorous introduced pasture species (Duggin *et al.*, 1986).

Dieback on the Northern Tablelands therefore, has been a consequence of a process. Clearing and pasture improvement, and the changes arising from them, have increased stress on trees from weather, stock and humans, resulting in greatly increased attack from insects above and below ground level and increasing disease and parasitism of the trees. All this has been coupled with reduced replacement of trees. Favourable seasons for insect defoliators further exacerbate the situation and each time these favourable seasons recur, dieback has been worse.

Rural dieback is not unique to the Northern Tablelands as already mentioned. However little work seems to have been done to try and explain why rural dieback occurs in some cleared regions and not in others (eg. on Western Slopes or the coast). One possibility is that dieback on the Tablelands is worse because the harshness of the winters place the trees under more stress and prevent them from recovering from heavy insect defoliation. In warmer areas this does not happen to the same extent. A worrying prospect is that dieback seems to be spreading through the higher rainfall parts of Australia.

The challenge now is for people to reduce the impact of our induced changes, to look after the

health of retained trees and, above all, to grow additional trees on the cleared land – trees that will live and thrive, and restore elements such as landscape, shelter, habitat, and soil stability (Grose, 1980).

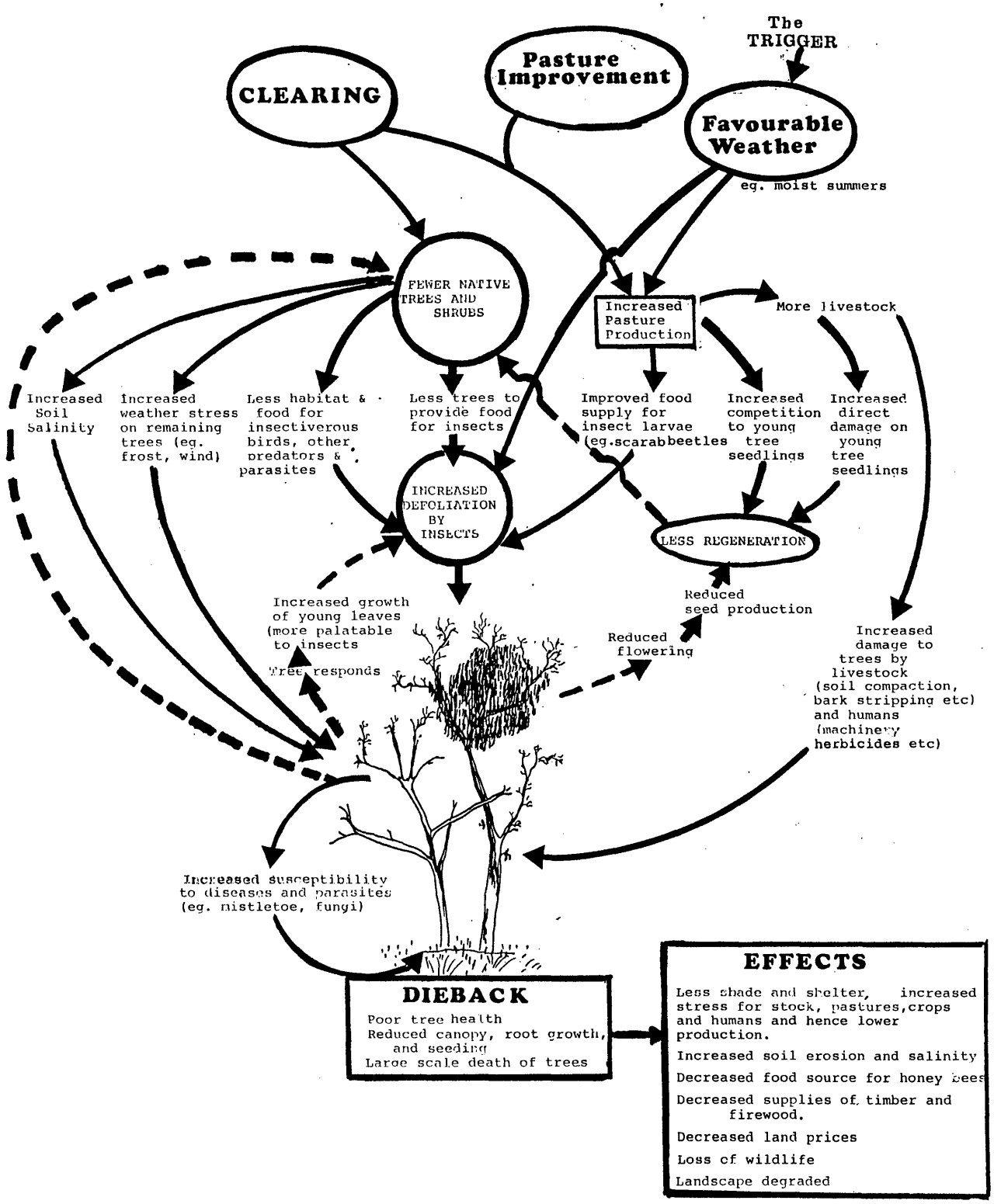


Figure 3.1: Summary of New England dieback - causes and effects

Chapter 4

Value of Trees on Farms

> "As eucalypts are most valuable trees, whether considered in an industrial, medicinal, or hygenic point of view, it is highly important to prevent their indiscriminate removal. They furnish, and by judicous management they may continue to furnish, some of the strongest and most durable of timber. They afford in their resins, their barks, and their volatile oils many substances useful for economic and therapeutic purposes, whilst it is a fact that those who live in the country and inhale the gases emanating from their leaves can bear testimony to their sanitary properties." (Wools, 1891)

Given that tree removal was necessary to establish the grazing and farming industries it is possible to identify a great many benefits trees and native vegetation, strategically placed, can provide in rural areas and on farms – benefits which provide a justification for re-establishment of trees in many areas.

Most of these benefits have long been recognized in Australia by some individuals, community groups and government organizations. For example, in the 1880s sugar gum plantations were established throughout south-western Victoria by many farmers to give shelter to stock (Jamieson, 1947). Various governments have initiated programmes such as Arbor Day (begun in the 1890s) to educate school children on the importance of trees, and Soil Conservation Services to correct poor land management (Reid, 1980). Significant publications have emanated from government departments, such as those by Anderson (1936; 1945), on the value of trees on farms. Community groups have formed over the years to combat tree decline, eg. the Save the Trees movement (1940s and 1950s in Victoria and Queensland); Natural Resources Conservation League (1951 in Victoria); Western Australian Tree Society (1956 - Western Australia); Men of the Land (1954 - N.S.W.); the Gould League; Field Naturalists clubs and many others (Reid, 1980).

However in southern Australia, and the Northern Tablelands is no exception, practical appreciation of the value of trees over the last century has been confined to relatively few, and has been reflected mostly in scattered windbreak and amenity plantations of exotic trees. This attitude has begun to change in the last two decades as concern about tree decline has spread and a greater proportion of the community has come to recognize the value of trees on farms. On the Northern Tablelands this concern was evidenced in the late 1970s by the raising of $80,000 by the community for the Eucalypt Dieback Research Fund Appeal.

In Victoria tree re-establishment on over-cleared farmland has become widespread in the last 10 years (Curtis and Reeve, 1988a) and consequently much of the recent literature on the value

of trees on farms is Victorian in origin (in particular the reviews by Bird). Nevertheless much of this work is of relevance to the local situation.

ENVIRONMENTAL BENEFITS OF TREES

Shelter. Properly designed shelterbelts can reduce windspeeds by up to 70% (Bird, 1984), and the effect of the shelter can be measured to a distance of 25 times the height of the trees or more. Reducing windspeeds benefits plant growth by reducing evapotranspiration and by reducing direct mechanical damage caused by the wind. Consequently net improvements of 5-50% have been measured in pasture growth, where shelter has been provided, and crop yields have been enhanced by 20-100% (Oates, 1983; Bird, 1984). Plant growth is inhibited close to a shelter belt but further away plant growth is improved, giving an overall net increase in yield (Bird, 1984).

Sheltered stock suffer much less stress than unsheltered stock. Their growth is improved, as is meat and wool production, and they eat less to produce that improved growth (Bird, 1984; Bird *et al.*, 1984). Stock losses, particularly of newly shorn sheep or lambs, can also be reduced by up to 50% or more by providing shelter (Squires, 1983; Bird, 1984).

An unexpected effect of reducing windspeed has been observed in western Victoria where the speed of grass fires was greatly reduced by shelterbelts (Bird, 1981). This was observed in the Ash Wednesday fires of Western Victoria in 1983 where areas and livestock behind shelterbelts remained unburned (Bird, 1984).

Shade. By protecting stock from heat stress, trees can increase growth, fertility, and survival of livestock (Squires, 1983; Bird, 1984). Trees with a spreading crown (such as *Angophora floribunda* or *Brachychiton populneum*) offer better shade for sheep than more elongated trees and consequently are favoured by them for daytime sheep camps on the Tablelands (Taylor and Hedges, 1984). Having scattered shade trees in a pasture encourages stock to range more freely over a paddock and so use it more effectively.

The optimal density of trees in a pasture is a matter of some debate. Combined evaporation from pasture and trees is increased the more densely trees are growing (Eastham *et al.*, 1988;), as trees transpire much greater amounts of water than pasture plants. However there are indications that by reducing desiccation and evaporation from the soil through shading and reduced wind speeds and by reducing frost damage, trees may increase pasture growth (Eastham, 1988). This effect was measured by Cameron *et al.* (1989) who found that trees 10-11 m high spaced 6.5 m or more apart (ie. 300 trees/hectare) did not interfere significantly with pasture growth.

Other Microclimatic Effects. In addition to their shade and shelter effects, trees can favourably influence the microclimate of stock, pasture and people by reducing frost severity. Trees planted near buildings can also reduce energy consumption, particularly through shading in summer and by providing wind protection in the winter.

Climate. Trees can modify climate on a more regional or global scale. Forest clearing worldwide in combination with pollution is said to be contributing to the greenhouse effect (World Watch Institute, 1988). It is also often suggested that clearing forest reduces regional

rainfall (eg. Bachelard *et al.*, 1985). The suggested mechanism for this is that trees cool the atmosphere both near the ground and around their canopy with their shade and with evaporative cooling. This cooler air leads to increased humidity amongst and above the trees which may be precipated as extra rain. Evidence for this is hard to collect however and much is anecdotal. On the Tablelands there is no evidence that tree decline has altered rainfall patterns although in the 1890s many people blamed the major drought of the time on the widespread ringbarking (Ch 2). Trees can increase effective rainfall locally by condensing fog on their leaves. This benefits the trees themselves and epiphytes but not other plants to any great extent.

Soil erosion. Injudicious tree clearing has contributed substantially to huge soil and land degradation problems in Australia. The Federal Government's soil conservation document estimated that some 51% of the total area used for agriculture and pastoral purposes in Australia needed some form of soil conservation treatment (Dept. Arts, Heritage and the Environment, 1986). The Northern Tablelands is not divorced from the national trend and there are many areas locally which have bad erosion problems. In most cases these are correlated to clearing or cultivation practices (Blandford, 1977).

Tree retention and re-establishment on upper slopes, steep land, and along drainage lines are important for any long term solution to soil erosion. Trees and shrubs moderate rainfall intensity, increase water infiltration, maintain organic content in the soil, and bind the soil. The result is that there is reduced water runoff, soil and nutrient loss, sedimentation and flooding, and improved land stability and long term production (Mullen, 1976; Houghton, 1984; Bachelard *et al.*, 1985).

Water quality. Water pollution caused by nutrient runoff, sedimentation and salinity is also substantially reduced where catchments have good tree cover (Hartley, 1983; Hartley *et al.*, 1984; Chittleborough ca. 1983).

Soil salinity. The clearing of trees from catchments and the resultant rises in watertables have been responsible for an increasing soil salinity problem, which is costing Victoria alone about $40 m per annum in lost productivity (Salinity Committee, 1984) and is affecting some 19,000 km^2 across Australia (Bird, 1984). On the Tablelands over 1,000 ha has been salt affected in the Inverell district (Country Leader, 11.7.88) and patches of salting have been observed in the Armidale and Walcha areas (Enders, Gentle, Barnet, Croft pers. comm.). This could get worse if the Victorian situation is any indication. Re-establishment of trees in combination with other techniques have been used throughout Australia to reverse both dryland and irrigation induced salting.

Mineral cycling. Trees make an important contribution to soil fertility by bringing nutrients such as potassium, calcium, magnesium and nitrogen from deep in the subsoil to the topsoil through the processes of root growth and litter fall (Bird, 1984). In addition many Australian trees are important nitrogen fixers (eg. *Casuarina* and *Acacia* spp.)(Bowen, 1983).

Soil acidification. Trees may be useful in remedying soil acidification associated with the use of superphosphate and improved pastures (Bachelard *et al.*, 1985) although research has yet

to provide hard data.

Biological control and habitat for wildlife. Native trees and shrubs are important in providing shelter and food for a diverse array of birds, insects and other wildlife which control pests of pastures, crops and trees. Encouragement of habitat allows a corresponding decrease in the need to use chemical pesticides (Davidson, 1980, 1982 a,b, 1984 a,b; Breckwoldt, 1984).

Beneficial wildlife can be encouraged through retention of timbered areas, protection of stream bank communities, establishment of shelterbelts and woodlots, promotion of vegetation around dams and streams, provision of additional water areas and retention of dead trees and logs. All these have added spinoffs to the farm eg. in providing stock shelter etc. (Bachelard *et al.*, 1985).

Pollution. Trees are valuable in reducing noise levels, in absorbing or filtering dust particles from the air and in absorbing some air pollutants (Bachelard *et al.*, 1985).

ON FARM USES

Different species of trees contribute a great number of products useful on the farm or to sell. All of these have application on the Northern Tablelands.

Honey. A great number of local eucalypts and native shrubs have great value in producing honey and it is possible to have local native trees and shrubs flowering much of the year for honey bees (Clemson, 1985).

Timber. A great number of important timber species can be grown on the farm. On the Tablelands the list is not as long as elsewhere but includes various eucalypts, conifers, and deciduous species (New England Trees on Farms, ca 1986; Forestry Commission of N.S.W., 1988). Many species can provide timber for on farm use as fence posts, in shed and yard construction, etc. Unfortunately due to tree decline, natural sources of timber for these purposes have become quite scarce in many places on the Tablelands.

Agroforestry, where timber and pasture production are combined, is becoming increasingly popular in Australia, particularly Victoria, and could have application locally (Bachelard *et al.*, 1985; Oates and Clarke, 1987).

Firewood. Armidale alone probably uses in excess of 18,000 mature trees in firewood each winter. It is not surprising then that good firewood is becoming increasingly scarce on the Tablelands and firewood carters travel long distances to collect wood. Ironically the widespread death of trees from dieback has not changed this situation significantly as a large proportion of the trees killed by dieback were not particularly good for firewood (eg. *E. nova-anglica*, *E. viminalis*). Consequently landholders who plant species for firewood could recoup a good return in years to come. Johnson (1983) estimated a possible return of $200-$400 per hectare every 5-7 years in areas with a similar rainfall to the Tablelands and based on 1983 firewood prices. Many of the local *Eucalyptus, Acacia* and *Casuarina* species are useful for firewood and can be established in plantations and harvested on a rotation. Alternatively firewood trees can be included as part of windbreaks, woodlots, or regeneration areas.

Fuel. Trees can provide fuel for machinery. One farmer in New Zealand has converted his

truck to run on wood gas produced by heating wood chips in an air tight container (Dengate, 1983), and there are reports of one local farmer at least who has done the same thing (N. Cobcroft, pers. comm. 1989).

Eucalyptus oil. The eucalytus oil industry in Australia is growing again after a long decline and there is some scope locally to harvest eucalypts for oil (Clifford, 1978; Mc Donald, 1980; Abbott, ca 1985). Some local landholders are harvesting *E. youmanii* for the export trade while one landholder has established a small scale plantation near Armidale of *E. australiana* to harvest oil (A.Coates, pers. comm. 1988).

Fodder. The foliage of some local native trees (eg. some species of *Casuarina, Eucalyptus, Angophora* and some exotic species) is useful as fodder for stock in time of drought (New England Trees on Farms, ca 1986).

Few studies have been carried out to quantify the value of trees on farms. The best to date in Australia have possibly been by Bird (Bird, 1981; 1984; 1988; Bird *et al.*, 1984). Basing his calculations on the demonstrable benefits of shelter belts to pasture and stock yields, he estimated that about 10%, and in some situations up to 20%, of a farm can be timbered without affecting productivity. Indeed with substantial reductions in stock losses, increased pasture and stock production, biological control of pests, reduced soil erosion and salting, timber and firewood production and various crops such as honey, he suggests that retention or establishment of timbered areas may be able to provide a landholder with increased income in the medium to long term.

The only study to examine the economic effect of dieback on the Tablelands has been by Sinden and Jones who asserted that dieback has been worth $1.7 million per year to the Armidale, Uralla and Walcha region by effectively clearing areas and making them more productive (Sinden *et al.*, 1983; Sinden and Jones, 1985). However these researchers did not cost any of the values of trees listed above. Nor did they take into account the fact that dieback usually occurs in more fertile, highly improved areas (Chapter 3), so while they assumed that dieback was *causing* the land to be more productive, it was more likely that dieback was a *consequence* of greater productivity already inherent in the land.

The value of trees on farms can be reflected by property values and land prices. One property in an almost completely cleared part of western Victoria had two similar 130 ha pieces of the property valued by an independant valuer. The area with good shelter belts was valued at $900 per hectare while the unsheltered paddock was valued at $790 per hectare (Usher, 1984). By surveying real estate agents, Riggs (1983) found that property values in urban areas were increased by at least 5% by the presence of trees, although in rural areas the position was less clear. On the tablelands it is possible that presence of healthy trees might improve the value of a property, particularly in the wake of dieback, but there have been no published studies.

Recognizing the value of trees in ameliorating land degradation, the Federal Government removed tax incentives for land clearing in 1983 and tree establishment in connection with soil conservation is now 100% tax deductible in the year of expenditure (Roberts, 1988). Agroforestry

plantings and shelter plantings may also be tax deductible although the tax laws are less clear on this aspect (Bachelard *et al.*, 1985).

Decisions about the ideal tree species, density, and distribution for a particular situation are not easy to make and many variables must be considered. Increasingly whole farm planning is encompassing tree establishment and retention as a component of good land management for a sustainable Australian agriculture (Houghton, 1984b; Oates and Clarke, 1987; Campbell, 1988).