Initial Effects of Deforestation on Herbaceous Species Composition in Grassy Woodlands of the Northern Tablelands, NSW Australia

Chris R. Chilcott
Department of Natural Resources, Australia

N. Reid
University of New England, Australia

R. D. B. Whalley
University of New England, Australia

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INITIAL EFFECTS OF DEFORESTATION ON HERBACEOUS SPECIES COMPOSITION IN GRASSY WOODLANDS OF THE NORTHERN TABLELANDS, NSW AUSTRALIA

C.R. Chilcott[12], N. Reid[2] and R.D.B. Whalley[2]

[1]Department of Natural Resources, PO Box 318, Toowoomba, Queensland 4350,
Chris.Chilcott@dnr.qld.gov.au.

[2] School of Rural and Natural Resources, University of New England, Armidale, New South Wales, 2350.

Abstract

Limited information on the initial effects of clearing and thinning on herbaceous vegetation of grassy temperate eucalyptus forests exists. The aim of this investigation is to study the initial changes in species composition following clearing and thinning. A deforestation experiment was established where clearing, thinning of 50% of canopy cover and control treatments were established. In the open-forests, patterns in herbaceous species composition were strongly influenced by the presence of trees, with weeping wheat grass (*Microlaena stipoides*) dominant, whereas wiregrass (*Aristida ramosa*) dominated interspaces and canopy gaps. Immediately following clearing, significant changes in the herbaceous species composition were observed, with 26 new species recorded. The original vegetation pattern was lost, being replaced by Cyperaceae and Juncaceae, and a large number of invasive ruderal species. A state and transition model that describes the changes in composition is presented.

Keywords: Clearing, thinning, herbaceous species, state and transition model

Introduction

Patterns in herbaceous botanical composition are strongly influenced by the presence of trees (Taylor and Hedges, 1984; Walker *et al*., 1986, Scanlan and Burrows, 1990; Heard, 1996) and stringybark (*Eucalyptus laevopinea*) grassy open forests are no exception. However, detailed information about the effects of clearing on the herbaceous vegetation is lacking. This study investigated the initial effect of clearing and thinning of a grassy forest on herbaceous species composition.

Material and Methods

A long-term deforestation experiment was established at Newholme Field Laboratory (latitude 30^{o} 31’S , longitude 151^{o} 40’E, elevation 980m) on the Northern Tablelands, 10 km North of Armidale, New South Wales. The experiment involved eight paddocks each of 3-6 ha in stringybark (*E. laevopinea*) grassy open forests. The climate is cool temperate with a mean annual rainfall of 793 mm, a majority falling in the summer months (Bureau of Meteorology, 1988). Mean air temperatures range from 0-13°C in winter to 13-26°C in summer, with over 100 frost days a year (George *et al*., 1977). Soils were gradational yellow podzolics, overlying Mount Duval adamellite granite (Neilson, 1970). The experimental design consisted of four treatments (two replicates of each):

1. clearfelled with fertiliser (250 $kgha^{-1}$ of single superphosphate) and clover (1 $kgha^{-1}$ of white clover and 2 $kgha^{-1}$ sub-clover) amendment
2. thinned forest (50% canopy cover removed) with fertiliser and clover amendment;
3. existing forest cover with fertiliser and clover amendment (amended control) and ;
4. existing forest with no fertiliser and clover amendment (unamended control)

Paddocks were stocked at between 3.0 to 5.3 sheep ha^{-1} with Merino wethers, in April 1996 following timber clearing (November 1994- June 1995), and burning (April 1996).

Herbaceous botanical composition and mass were assessed using BOTANAL (Tothill *et al.*, 1978). Pasture assessments were conducted in 42 sites (50 x 10 m): 18 sites in interspaces (large naturally occurring canopy gaps) and 24 sites beneath trees (areas with more or less continuous canopy cover). Sites were studied in (1) April-May 1994, prior to clearing (baseline), (2) following initial clearing works in April-May 1996 and (3) again after fertiliser and clover amendment in January 1997.

Results and Discussion

There was a clear relationship between the presence of canopy cover and pasture composition before clearing and thinning. Shade tolerant grasses (*Microlaena stipoides*, *Danthonia racemosa*, and *Poa sieberiana*) dominated the beneath-zone and accounted for 78% of the herbage mass. The limited light and soil water beneath trees may have limited the occurrence of *Aristida ramosa*. *Aristida* is a C4 plant that is especially well adapted to high light intensities and high temperatures. It dominates interspaces and small canopy gaps, as well as long-cleared unfertilised pastures in the region (Chilcott, 1998, Gibbs *et al*., 1998).

There was little variation in the dominant species in unamended control sites over the study period. In amended control beneath tree sites, there was a slight increase ($p= 0.276$) in the contribution of the dominant species *M. stipoides*, with an equivalent decline in *D. racemosa*. Beneath trees, *A. ramosa* declined following fertiliser and clover addition, while *Elymus scaber* was lost. The interspace dominant *A. ramosa* declined significantly ($p = 0.028$) following fertiliser and clover addition, but remained dominant and with *Eragrostis* accounted for 70% of herbage mass.

Soil profiles remained near saturated for 12 months following clearing, prior to and during the 1996 data collection. Conditions dried before the 1997 data were collected. Immediately following clearing, significant changes in the species composition were observed. In the 1996 survey, 26 species previously unobserved in clearfell sites were found, accounting for 60% of herbage mass. The new species were predominately Cyperaceae (five species) and Juncaceae (four species), and a large number of invasive ruderal species (Grime, 1979). Increases in *Hypochaeris* spp. (ruderal species) were significant (p= 0.004) in both former beneath tree and interspace sites. *Juncus subsecundus* became dominant in clearfell interspaces, with a significant (p= 0.028) decline in the occurrence of *A. ramosa* (56.6% in 1993 to 5.8% in 1997). *Eragrostis* spp. increased in dominance in clearfell interspaces between 1993 (3.5%) and 1997 (15.2 %). *Cyperus sanguinolentus* became the second most abundant species in former beneath tree sites, and the most abundant species in the former interspace sites. This species had not previously been observed in the baseline surveys. The new dominants replaced those native herbaceous species intolerant to severe exogenous disturbances that tended to be habitat specialists (e.g., beneath-tree species *Danthonia* and *Pimelea*)

C. sanguinolentus became dominant in areas where overland flow and waterlogging were observed after clearing. *C. sanguinolentus* is found in swamps, roadsides and streambanks throughout its range (Wilson, 1993). The ephemeral habits of this species meant it was absent in the sward in 1997 as soil profiles dried. A pulse of recruitment of new species should occur with the demise of *C. sanguinolentus*, as resources previously captured by this ephemeral species and other ruderal species are released.

A state and transition model describing the initial changes in species composition following clearing was developed (Figure 1), following Westoby *et al*. (1989). These models describe vegetation as a catalogue of alternative states. A particular set of changes in environmental factors must occur in order for a transition to occur (Whalley, 1994).

State 1 is *Eucalyptus laevopinea* dominated open-forest, with stand age a function of past logging. Naturally occurring canopy gaps were dominated by *Aristida ramosa*, *Sporobolus creber* and *Eragrostis* spp. Beneath the canopy yearlong green perennial species dominate (*Microlaena, Danthonia* and *Poa sieberiana*) favoured by shaded conditions and moderate grazing pressure. Total standing biomass is low, suppressed by tree competition for water and nutrients. Grazing pressure may be concentrated beneath trees where higher soil fertility, and dominance of more desirable year-long-green species, is favoured by grazing animals. Fluctuation in species composition is minimal and driven by climatic conditions and stocking rate.

The transition from state 1 to state 2 was triggered by the clearfelling, and in our case, coupled with high seasonal rainfall, resulting in waterlogging and surface water flow. Increases in plant available nutrients released from harvest trash and leaf litter, higher soil temperatures, increased soil moisture and loss of shading result in substantial changes in species composition. The reverse transition from State 2 to 1 would be slow, with tree regrowth and seedling regeneration probable at moderate grazing pressure, with favourable climatic conditions and in the absence of fires. A shift back to the original herbaceous composition is probable, given that herbaceous botanical composition in the controls reflects past logging practices.

As well as increased soil moisture, destruction of established plants facilitated the clearing-induced shift in botanical composition to species of Juncaceae and Cyperaceae. Consequently, species favoured by the changed soil moisture and that can successfully establish from seed quickly were favoured in areas where significant soil disturbance occurred. Dominants included *Microlaena* (a remnant from the previous vegetation), *Cyperus sanguinolentus*, and a variety of other Cyperaceae and Juncaceae. Thus the original vegetation pattern remained, with initial clearing-induced species changes be represented. In highly disturbed areas (ashbeds and where topsoil had been removed), invasive species dominated

(*Hypochaeris* and *Conyza albida*), with the suite of species not represented in any other location.

The transition from State 2 to 3 will occur with either grazing management that prevents seedling regeneration or chemical control of seedling and sucker regrowth. Without fertiliser and clover addition *Microlaena* and white clover will be lost from the sward. Transition from state 3 to 1 will only occur with grazing management and climatic conditions that allow seedling regeneration, or tree planting. However, transition from state 3 to 2 will not occur as the conditions of high soil moisture and soil disturbance will only follow clearing of a forest. Whilst thinning caused similar changes in the species composition to the clearfell operation, the effect was not as extensive. The shift in the species composition was more marked in beneath tree sites compared to interspaces. This was expected as a majority of the disturbance associated with tree removal will occur in the beneath tree sites. Moderate grazing without fertiliser inputs and in the absence of tree regeneration may cause a shift towards a pasture community dominated by *Aristida* and *Sporobolus*, so evident in long cleared paddocks in the region.

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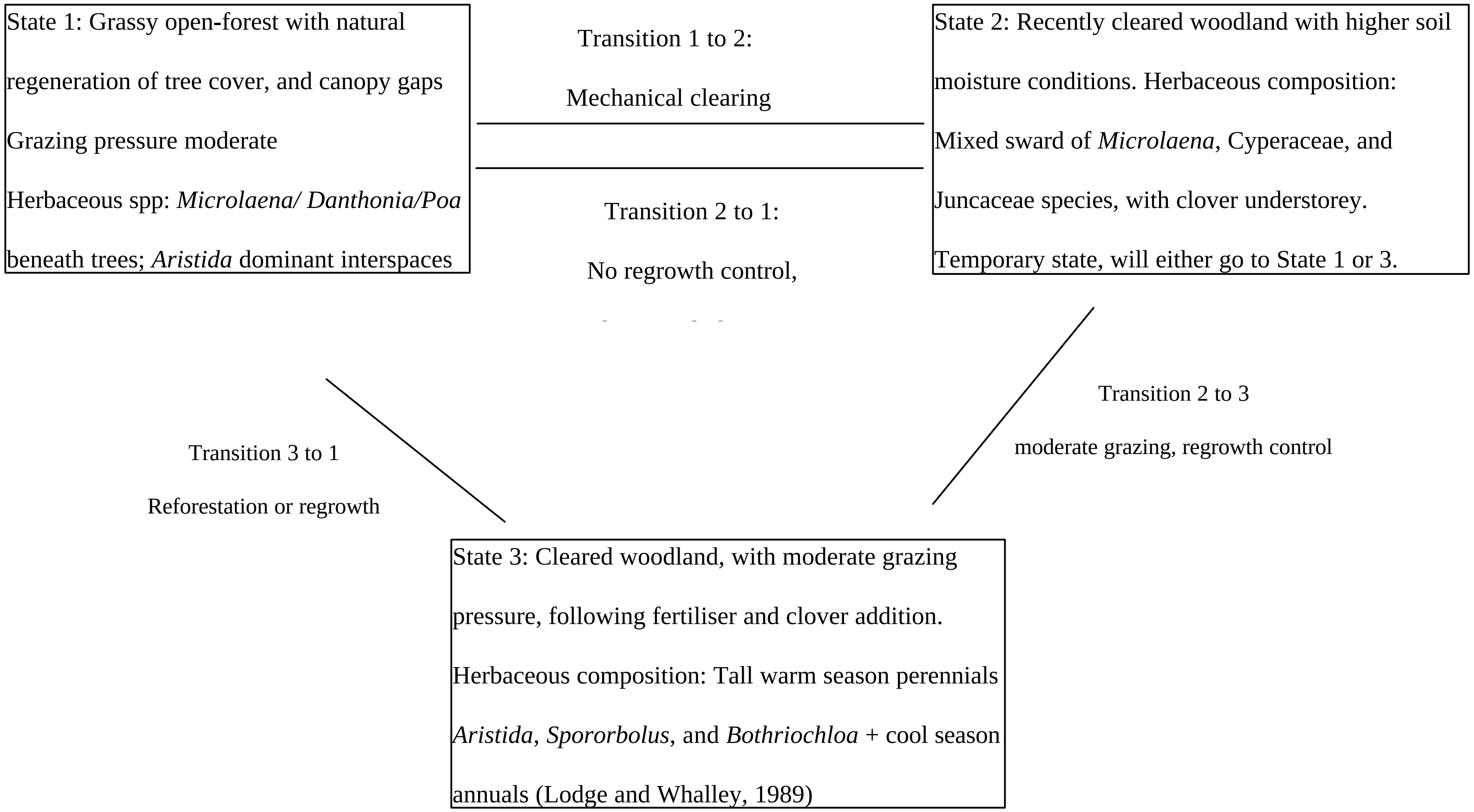

Figure 1- State and transition model for the Eucalyptus laevopinea open-forest.