Management and Performance of *Eucalyptus camaldulensis* in the Murewa and Mutoko Districts of Zimbabwe

by

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ABSTRACT

The standards of management achieved by eucalypt growers in Zimbabwe's rural areas affect the performance of the woodlots. Several woodlot achievement indicators - basal area growth, height growth, survival rates and estimates of mean annual increment were recorded and related to levels of management. Management inputs in eucalypt woodlots in Murewa and Mutoko districts are low. Resource constrained tree-growers operate below technical optima. Consequently, the performance of their woodlots is poor. The mean annual increments of woodlots in the two districts are well below the standards achieved under commercial silvicultural conditions and projections made for the Rural Afforestation Programme. The use of these lower mean annual increments in cost-benefit analyses weakens the economic justification of massive expansion of eucalypt plantings. The estimated mean annual increments of eucalypt woodlots in the two districts were similar to those for local indigenous woodland. This level of performance does not justify the clearing of natural woodlands for establishment of eucalypt woodlots. Current and future social forestry programmes must continue to emphasize a much broader approach linking a multiple species planting strategy to satisfy a wider set of smallholder needs with a more intense management of existing indigenous woodland.

ACKNOWLEDGEMENTS

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INTRODUCTION

Zimbabwe used eucalyptus as the major tree in its Rural Afforestation Programme. This World Bank sponsored programme was by far the biggest post-independence rural development initiative in the forestry sector. Government adopted the programme in response to the worsening woodland resource deficit in communal areas (Furness 1981; Whitlow 1980; Munasirei 1988). Given the perceived need to come up with a speedy solution to rural deforestation, policy makers recommended the establishment of eucalypt nurseries and block plantations mainly for the provision of fuelwood (Whitsun Foundation 1981). Forestry planners premised their choice of eucalypts (for the rural woodlot programme) on two major considerations. First the high productivity of the species and second, their adaptability to a wide range of environmental conditions (Furness 1981; Whitsun Foundation 1981). Indigenous species had a supposed lack of genetic plasticity and slow growth rates (Banks 1981).

Evaluators have subsequently examined the policy objectives of the programme. They asked: - (a) did the programme affect the rate of deforestation; and (b) did the programme effectively equip the implementing agency (Forestry Commission) to carry out social forestry interventions? These two objectives were essentially not achieved. The major reasons for failure were the top-down conceptions of the programme and the poor understanding of the needs of rural communities (Muir and Casey 1989; Dewees 1992).

However, information on the physical performance of the trees in the rural woodlot programme is scarce. Equally, there is little understanding of the management practised by tree growers and how this relates to performance. Optimizing appropriate silvicultural techniques (tillage, weeding, fencing, spacing, watering) is a necessity for good performance in planted eucalypts (Poynton 1965; Schonau 1970; May 1975; FAO 1979). But smallholder incomes are low and agricultural inputs are scarce. Low levels of inputs are likely (Riddell 1981; Jackson 1989; Muchena 1989; Cousins et al. 1992; Coudere and Marijesse 1993). A broader set of information is required to assess the above issues, i.e. eucalypt performance across management, ecological, institutional and technical settings. The paper, (a) explores variations in the quality of management across ownership categories (of eucalypt woodlots) and biophysical factors; (b) identifies the relationship between woodlot management practices and the degree of deforestation in each area, and (c) explores how woodlot-specific management and biophysical variables influence performance (basal area growth, height growth, survival rate and mean annual increment) in Eucalyptus camaldulensis.

STUDY AREA

The study was based in the Murewa and Mutoko districts in Mashonaland East province in north-eastern Zimbabwe. This represents a total land area of over seven-thousand-five-hundred square kilometres, spanning three natural regions (Natural Regions II, III and IV). Rainfall decreases from the southern parts of Murewa district in Natural Region II (932 mm mean annual rainfall), to northern parts of Mutoko district that lie in Natural Region IV (650 mm). Generally temperatures also increase from the southern parts of Murewa district (18°C mean annual temperature), to north-eastern parts of the Mutoko district (22.5°C) (Brin 1986, 1987).

Much of the study area is underlain by granitic rocks of the Basement Complex with scattered and localized intrusions of dolerite (Stagman 1978). Sandy nutrient-poor soils of granitic origin are the most widespread in the two districts and these are mainly used for dryland cropping of maize and to a lesser extent groundnuts and sunflowers. Much of the vegetation in the study area has been cleared for cultivation except on steep and rocky areas which are not amenable to cultivation (Brinn 1986, 1987). In 1992 the two districts had a population of 274 794 people (Central Statistical Office 1992). Population density is higher in Murewa district than in Mutoko district.

METHODS

The study stratified the area into two regions - Stratum One (Natural Region II) and Stratum Two (Natural Regions III and IV). Twelve sampling sites, (of sixteen square kilometres each) were randomly selected in each of the strata (Fig 1). Within each of the sampling sites, all woodlots were located and then five per site were randomly selected. A woodlot was considered to be any area planted (with Eucalyptus camaldulensis), that had at least fifteen trees, with the trees planted in at least three rows with an average spacing not exceeding 10 m by 10 m.

For each of the woodlots selected, a person (or persons) who established the woodlot was identified and a short questionnaire was administered to them. Management operations included in the questionnaire survey were ploughing of the site, termite treatment, protection against fire, watering, blanking (replacing dead seedlings), fencing, weeding, choice of planting season and adding organic matter to planting stations. Two management indices were used, one derived from a principal component analysis (index 1) and the other an additive index of all the management operations (index 2). Index 1 largely reflects management related to weeding, blanking, spacing of seedlings and choice of planting season.

Natural woodland cover around each woodlot was assessed using the most recent (1986) aerial photographs (1: 25 000). A circle of diameter 4 cm (equivalent to a distance of 1 km on the ground), was engraved onto a transparent template and 48 sampling dots were marked within the circle in such a way that they were equidistant from each other. Centring the overlay on the woodlot, relative cover was assessed by determining the percentage of dots overlying natural woodlands. (For subsequent statistical analysis, each sample area was classified into one of two woodland cover categories, i.e., heavily deforested, with 0-15% woodland cover, and less heavily deforested, with 16-33% cover).

For each woodlot measurements determined an average basal area and an average height. Subsequent analyses calculated a standardized growth performance index (adjusting for different ages of woodlots). Survival rates in the woodlots were also assessed. Allometric equations (assuming a quadratic paraboloid form function) (after Phillips 1983) were used to translate basal areas and heights of each woodlot into stand volumes while adjusting for density and mortality in each woodlot. Mean annual increment was derived by dividing the stand volume for each woodlot by the age of the woodlot.

RESULTS

The main findings of the study are:

1. The most frequently occurring woodlots were those under individual ownership (63% of the 120 woodlots sampled), followed by woodlots under school ownership (30%). Cooperatively-owned woodlots were the least frequent (7%). Most of the eucalypt growers had planted the trees for poles (83%) and not for fuelwood (11%).

2. The most commonly reported management operations were - ploughing and weeding. The least practised operations were -adding organic matter to planting holes, blanking, termite control and watering (Table 1). Management operations practised by tree growers were not different across different ecological locations. Most of the management operations did not differ significantly across ownership categories. Individual tree growers ploughed more frequently. Schools added organic matter to planting stations more frequently (Table 1). Management indices reflected no statistically significant difference in management across ownership categories but schools reflected higher management and cooperative woodlots reflected lower management (Table 2).

3. Poverty and lack of inputs are the major reasons why most operations are not done. Moreover, tree-growers allocate scarce resources across competing enterprises (Table 3).

4. Management indices reflected no differences across woodland cover classes (Table 4). Scarcity of woodland appears not to affect management (Table 4).

5. Management does improve growth. A stratified analysis comparing mean annual increment of woodlots under differing levels of management suggests a positive effect on growth (Table 5).

6. Nonetheless growth of woodlots in the study area was pathetic. It was far below standards achieved under commercial silvicultural conditions and projections for the Rural Afforestation Programme (World Bank 1991) (Table 7).

7. Management has strong influence on eucalypt performance (Fig 2), but because most of the management operations were not practised, performance was sub-optimal.

DISCUSSION

At what institutional level should there be agroforestry interventions in Zimbabwe's communal areas? This issue continues to be debated. Concerning growth and survival indicators, this study suggests that differing ownership arrangements are of little import. More woodlots fell under individual ownership than under cooperative ownership. If this were a sign of rural smallholder preferences, then the individual or household could be the institutional framework on which to base future tree planting initiatives. Several reports highlight the breakdown of cooperative tree growing initiatives (Forestry Commission 1992; Coopibo 1992). Complex tenure arrangements and leadership problems are the common causes for failure of the cooperatives. This would appear to suggest that tree planting based on the individual household level, is a more practical option. This suggestion goes against the original focus of the Rural Afforestation Programme, i.e. community woodlots.

Do smallholders devote scarce resources to eucalypt growing? Yes they do. However, a low level of management was the main feature of most woodlots. Variations in management operations across different ownership categories are explained by patterns of resource availability. Individual tree growers keep cattle and there was a higher incidence of ploughing in individually-owned woodlots. Schools have a greater supply of labour. Schools therefore weeded and added organic amendments to planting holes more frequently. Tree-growers establish trees (suggesting a will) but have highly limited means. Labour and financial constraints were frequently mentioned as the major reasons for not undertaking management operations. Those management operations requiring some financial input were the least practised e.g. blanking and addition of termiticides. Because of resource constraints, tree growers operate below the technical optimum. An assessment of the marginal net-benefits at these extremely low levels of management (and other inputs) requires future research.

Low levels of management suggest the need for financial support and more effective extension. There is greater need for such support in the establishment phase, where costs are considerably higher (World Bank 1991). However, financing social forestry through financial aid packages would appear paternalistic besides fostering situations whereby viability is conditional upon external aid money. It is also contrary to the current national trend to remove subsidies. A possible option, therefore, would be to start savings clubs to raise funds from which tree growers can borrow, as reported by COOPIBO (1992). Furthermore, financial incentives are unlikely to solve the shortages of labour.

Levels of management in schools were generally high. Schools should play a bigger role in future social forestry programmes. Conceivable strategies would be to use the few forestry extension officers available to impart the skills to teachers, who would in turn impart it to the young tree growers. Such an extension structure would have the following strengths: ensuring greater extension density, equipping pupils with survival skills and giving forestry extension workers more time for monitoring progress.

Quality of management at woodlots is little affected by the relative abundance of woodland resources in the surrounding areas. It seems that relative woodland cover does not influence people's management of woodlots. Estimates of biomass and cover done by other researchers reflect scarcity of woodland resources in some provinces (Mashonaland East included) (Furness 1981; Whitlow 1980). Physical scarcity may, therefore, not have reached the point where it translates into perceptual scarcity. Alternatively, resource constraints may limit tree growers from allocating scarce resources to eucalypt growing, even in the face of scarcity. In other words, farmers may recognize scarcity but it is not great enough to cause shifts in priorities.

The mean annual increments of Eucalyptus camaldulensis, were much lower than World Bank projections (World Bank 1991). The use of these lower mean annual increments in cost-benefit analyses weakens the economic justification of massive expansion of eucalypt plantings. The estimated mean annual increments for the two districts were similar to those for local indigenous woodland. This level of performance does not justify the clearing of natural woodlands for establishment of eucalypt woodlots, as happened in a few areas (Mcgregor 1991; World Bank 1991). Current and future social forestry programmes must continue to emphasize a much broader approach linking a multiple species planting strategy to satisfy a wider set of smallholder needs with a more intense management of existing indigenous woodland.

* **NOTE**: This paper is a summary of the major findings in an Msc dissertation by Alois Mandondo to which Jeremy Jackson was a supervisor. More detailed descriptions of the methods and results can be found in Mandondo (1993).

REFERENCES

Banks, P.F. (1981) 'The planting of woodlots for fuelwood requirements of the TTL populations in Zimbabwe-Rhodesia: A review of past and future development,' in: South African Forestry Journal, **117**, 13-15.

Barret, R.L. and D.T. Carter (1976) '*Eucalyptus camaldulensis* provenance trials in Rhodesia (Later results),' in: The Rhodesia Bulletin of Forestry Research, **2**, 1-38.

Brinn, P.J. (1986) "Communal land physical resource inventory. Mutoko district." Harare: Chemistry and Soil Research Institute. - Report No. A524, pp. 1-89.

Brinn, P.J. (1987) "Communal land physical resource inventory. Murewa District." Harare: Chemistry and Soil Research Institute. - Report No. A540, pp. 1-44.

Chidumayo, E.N. (1988) 'A survey of woodstocks for charcoal production in the miombo woodlands of Zambia,' in: Forest Ecology and Management, **20**, 59-66.

COOPIBO (1992) "Community based tree nursery groups in the Mutoko Communal Lands of Zimbabwe." Seminar paper for Participatory Extension Methods and Sustainable Agriculture, Mutoko, Zimbabwe. pp. 1-8.

Cousins, B., D. Weiner and N. Amin (1992) 'Social differentiation in the communal lands of Zimbabwe,' in: Review of African Political Economy, **53**, 5-24.

Coudere, H. and S. Marijsse (1988) Rich and poor in Mutoko Communal Area. Zimbabwe Journal of Ecomonics, **2**, 1-25.

Dewees, P.A. (1992) Household economy, trees and woodland resources in communal areas of Zimbabwe. Oxford: ? pp. 31-51.

Food and Agriculture Organization, (1979) Eucalypts for Planting. Rome: Food and Agriculture Organization (FAO). pp. 146-180.

Forestry Commission, (1992) "Forestry Extension Division Annual Report". Harare: Forestry Commission. pp. 1-15.

Furness, C.K. (1981) 'Estimating indigenous resources for fuelwood and poles and plantation requirements in the Tribal Trust Lands of Zimbabwe,' in: Forestry Journal, **117**, 5-9.

Jackson, J.C. (1989) 'Exploring livestock incomes in Zimbabwe's communal lands,' in: People, Land and Livestock in the communal lands of Zimbabwe. Ed. by B. Cousins. Proceedings of a workshop on the socio-economic dimensions of livestock production in communal lands of Zimbabwe. University of Zimbabwe: GTZ and the Centre for Applied Social Sciences. pp. 183-210.

Mandondo, A. (1993) "Management and growth and survival of Eucalyptus camaldulensis in Murewa and Mutoko districts of Zimbabwe". Unpublished MSc thesis, University of Zimbabwe.

May, E.D. (1975) "Forest plantation establishment in Malawi". Paper presented at the 5th Meeting of the Standing Committee of SARCCUS, October 13-16. Pretoria.

McGregor, J. (1991) Woodland resources: Ecology, Policy and Ideology. An historical case study of woodland use in Shurugwi Communal Area, Zimbabwe. PhD thesis, Loughborough University of Technology. pp. 25-69.

Muchena, M. (1989) 'The effect of ox-sharing arrangements on the supply and use of draught animals in communal areas of Zimbabwe-preliminary findings,' in: People, Land and Livestock Production in the Communal Lands of Zimbabwe. Ed. by B. Cousins. Harare: GTZ and the Centre for Applied Social Sciences, University of Zimbabwe. pp. 253-277.

Muir, K. and J. Casey (1989) 'Institutional responsibility of social forestry in Africa: Lessons for Zimbabwe,' in: Journal of Social Development in Africa, 4, 27-37.

Munasirei, D.K. (1988) 'Woodfuel harvesting and soil erosion in Zimbabwe,' in: Energy Environment and Development in Africa II. Ed. by R.H. Hosier. Stockholm: Beijer Institute. pp. 185-198.

Phillips, M.S. (1983) Measuring Trees and Forests: A Textbook Written for Students in Africa. University of Daresalaam. pp. 20-60.

Poynton, R.J. (1965) 'Research on the silviculture of Eucalyptus grandis (saligna) in Northern Transvaal,' in: South African Forestry Journal, 55, 10-20.

Riddell, R.C. (1981) "Report on the Commission of Inquiry into Income, Prices and Conditions of Service". Salisbury. pp. 77-83.

Stagman, G. (1978) An Outline of the Geology of Rhodesia. Salisbury: Government Printer. pp. 3-24.

Whitsun Foundation, (1981) "Rural Afforestation Study. Project No. 3.22". Salisbury: Whitsun Foundation. pp. 29-81.

World Bank, (1991) "Project Completion Report: Zimbabwe Rural Afforestation Project". Report No. 9562. Washington D.C.: World Bank. pp. 1-17.

APPENDIX 1

Table 1 : Management operations as practised in woodlots owned by schools and individuals. Significant differences, as indicated by X^2 analyses, are shown. The overall column includes cooperatively-owned woodlots.

	Overall (n=120)	School (n=36)	Individual (n=76)	Sig.
% ploughed	62	28	75	***
% with organic matter applied at planting	28	44	24	*
% weeded at least once	86	92	84	n.s.
% blanked	39	44	38	n.s.
% protected from fire or with no risk	90	89	91	n.s.
% treated against termites or with no risk	35	36	34	n.s.
% watered at least at establishment	37	50	33	n.s.
% fenced	53	44	59	n.s.

d.f. = 1 in all cases
n.s. = $p > 0.05$
* = $p < 0.05$
*** = $p < 0.001$

APPENDIX 2

Table 2 : Quality of management across ownership categories (high values of the management indices reflect good management, while low values reflect poor management).

	Management index 1		Management index 2		
Owner	**Mean**	**Std dev**	**Mean**	**Std dev**	**n**
School	0.52	1.04	5.30	1.31	36
Individual	-0.20	0.89	5.21	1.30	76
Cooperative	-0.43	0.96	4.55	1.75	8

APPENDIX 3

Table 3 : Reasons why certain management operations are not done. (Percentage of all eucalypt growers for choice of planting season and percentages of eucalypt growers not doing particular management operations for the remaining variables)

		Ownership category		
	Overall	**School**	**Individual**	**Coop**
Reasons why ploughing was not done:	(n=48)	(n=27)	(n=20)	(n=1)
Lack of draught power	75	88	55	0
Thought it was not necessary	25	12	45	100
Reasons why blanking was not done:	(n=72)	(n=19)	(n=47)	(n=6)
Lack of finance	70	40	79	100
Seedlings not available	27	60	17	0
Survival high enough	3	0	4	0
Reasons why protecting from fire was not done:	(n=93)	(n=26)	(n=61)	(n=6)
No risk	87	85	89	83
Never thought of it	9	11	7	17
Other overriding labour commitments	4	4	5	0
Reasons why treating for termites was not done:	(n=98)	(n=30)	(n=62)	(n=6)
Lack of finance	78	77	77	83
No risk	22	23	23	17
Reasons why watering was not done:	(n=60)	(n=13)	(n=42)	(n=5)
During rainy season	87	85	91	60
Other overriding labour commitments	13	15	9	40
Reasons why weeding was not done:	(n=17)	(n=3)	(n=12)	(n=2)
Other overriding labour committments	77	67	83	50
No reason	23	33	17	50
Reasons for choice of planting season:	(n=120)	(n=36)	(n=76)	(n=8)
Availability of rain	68	67	70	62
Availability of labour	24	22	25	13
Availability of seedlings	8	11	5	25

APPENDIX 4

Table 4 : Indices of management as they relate to natural woodland cover. Significant differences as indicated by the Mann-Whitney U-test are shown. (High values of the management indices reflect good management, while low values reflect poor management).

	Relative woodland cover		
	Heavily deforested (n=67)	Less heavily deforested (n=53)	Sig.
Management index 1			
Mean	0.11	-0.31	n.s.
Standard deviation	1.45	0.92	
Management index 2			
Mean	4.12	3.76	n.s.
Standard deviation	0.98	1.08	

n.s. = $p > 0.05$

APPENDIX 5

Table 5 : Mean annual increment of Eucalyptus camaldulensis for woodlots where all management operations were done in relation to those where all operations were not done.

	Mean MAI $m^3\ ha^{-1}\ yr^{-1}$	Standard Deviation	n	n as % of whole sample
Woodlots where all management operations done	1.67	1.33	18	15
Woodlots where all management operations not done	0.36	0.65	38	33

APPENDIX 6

Table 6 : Mean annual increment (MAI) for sampled Eucalyptus camaldulensis woodlots in the present study area in relation to those from other studies.

	Age (months)	Stocking (stems ha^{-1})	MAI $m^3\ ha^{-1}\ yr^{-1}$	n
Eucalypt woodlots:				
Kadoma[a]	41	2501	6.70	
Mtao[a]	41	1716	3.01	
Kadoma[a]	130	1730	3.90	
Study area[b]	2-20	2497	1.05	21
	21-50	2767	1.59	44
	51-80	2154	0.90	40
	81-159	2619	0.99	15
Estimates for Rural Afforestation programme[c]:				
Projections in appraisal report			10-15	
Project completion estimate			2-5	
Indigenous woodlands:				
Miombo woodland (Furness 1981)			0.84	
Regrowth miombo woodland (Chidumayo 1988)			1.93	

Note:

[a] Represents results from Barret and Carter (1976)

[b] Figures of stocking and mean annual increment for the study area represent an average associated with woodlots of that age.

[c] Represents results from World Bank (1991).

APPENDIX 7

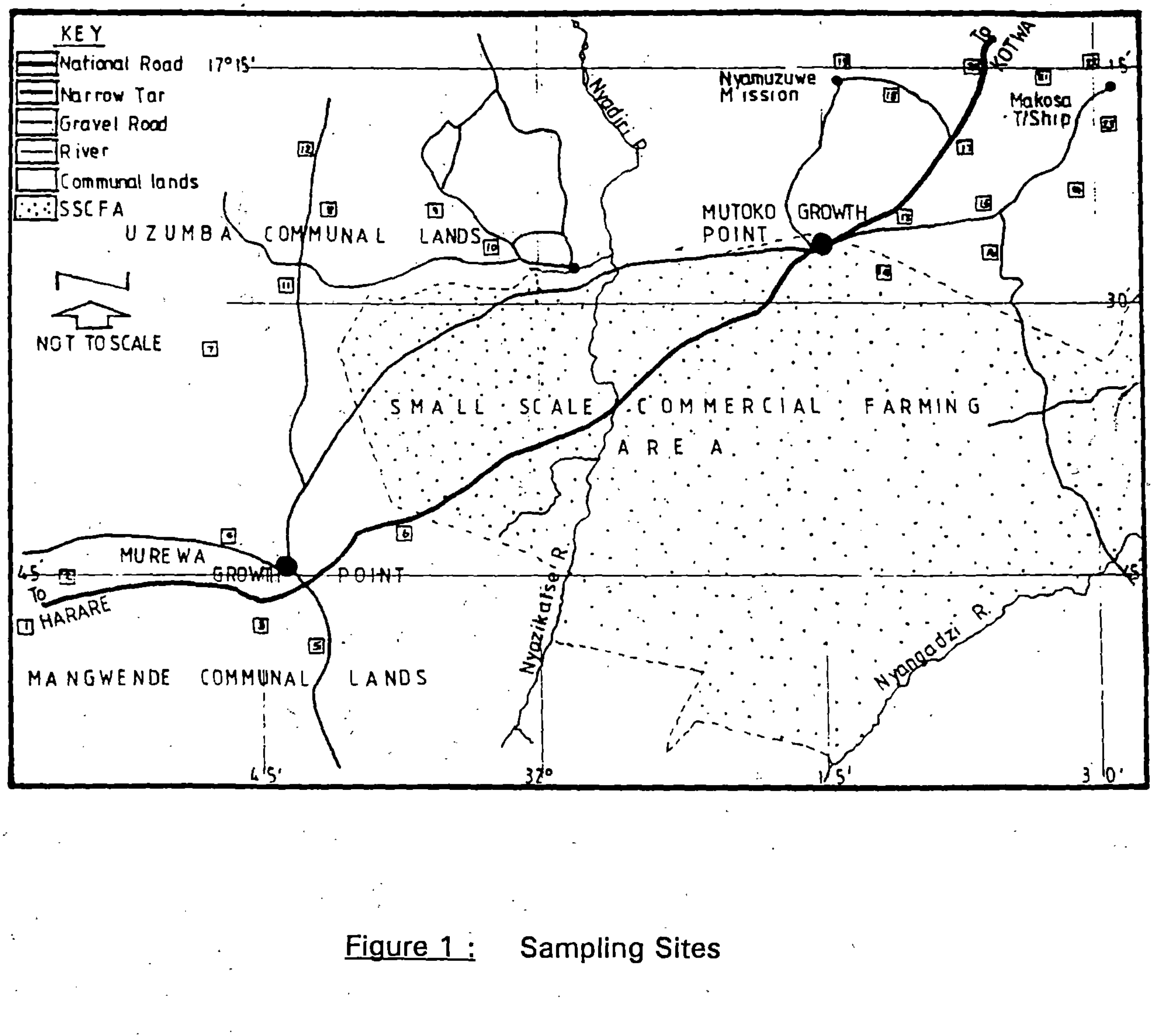

Figure 1 : Sampling Sites

APPENDIX 8

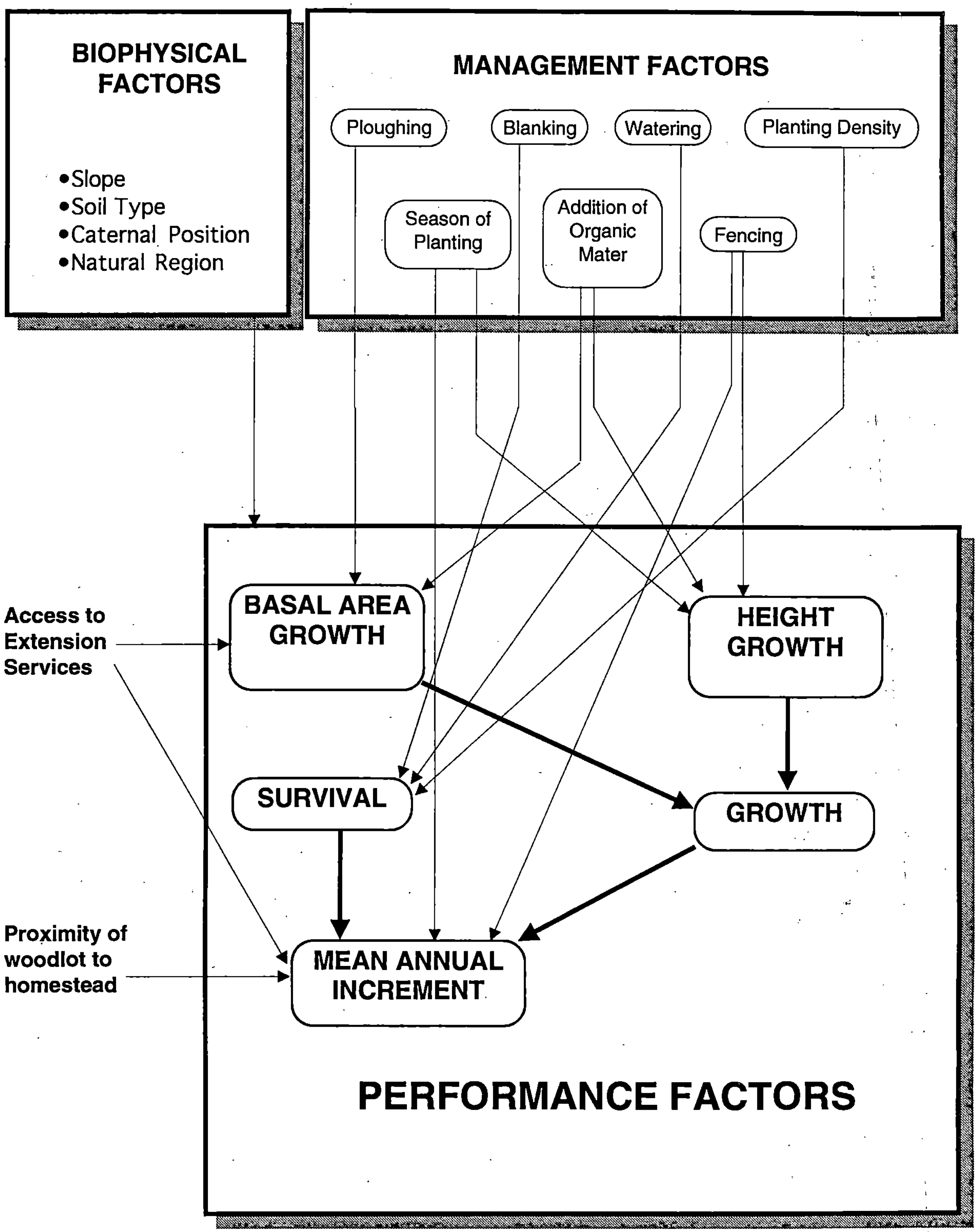

Figure 2 Summary of Factors influencing performance in Eucalyptus camaldulensis