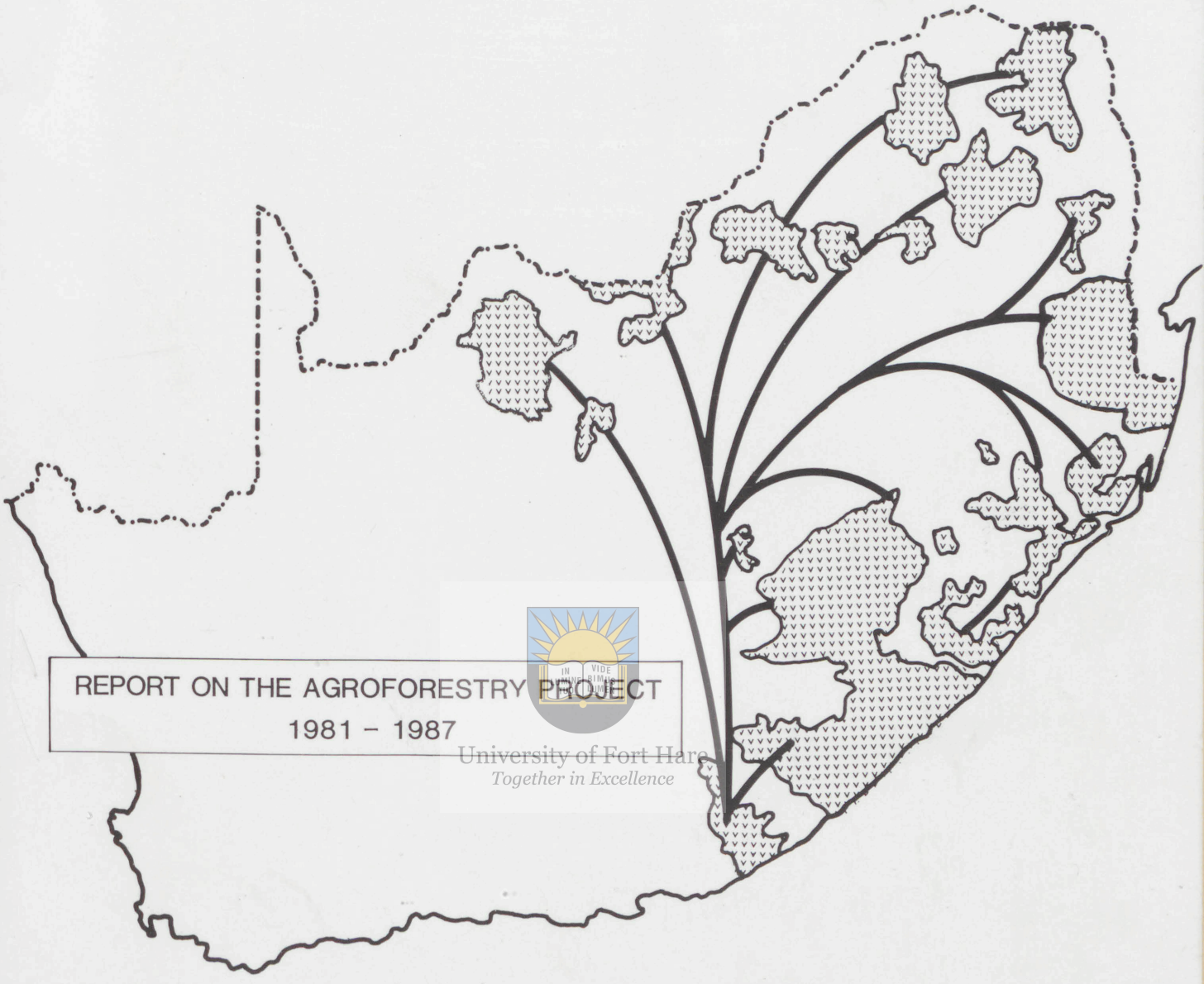
ARDRI



REPORT ON THE AGROFORESTRY PROJECT
1981 – 1987

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J G H DE VILLIERS

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THE AGRICULTURAL AND RURAL DEVELOPMENT RESEARCH INSTITUTE

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The many persons who served on the project's Steering Committee over the years, and especially those who travelled considerable distances to meetings, are thanked for their interest and valued contributions to the study, as are Messrs P E Adams and M Underwood, successive Project Leaders, and Mr A S Marsh, Horticulturist.

Mr J H G de Villiers provided the information for this report and Ms C Harris and Mrs J Matthews prepared the manuscript.

CONTENTS

TABLES

SUMMARY

Background and objectives (Section I)

This report reviews the progress, problems and attainments of the agroforestry project over the seven years since its commencement. The project is one of several programmes conducted by the Agricultural and Rural Development Research Institute (ARDRI) of the University of Fort Hare to help meet some of the technical needs of small farmers. The concept of agroforestry includes trees as an integral part of the farming system for their direct contribution to the production of food and industrial crops, and indirectly to improve the microclimate by providing shade and wind breaks for adjacent crops or fodder for animals. By virtue of their deep roots, trees are more drought resistant than other plants, they help recycle nutrients and enhance soil stability and structure. Leguminous trees also fix nitrogen.

At the inception of the project in 1981 there was virtually no information available on the role of agroforestry in Southern Africa, nor generally in areas where rainfall is limited in amount and distribution. Rural residents of Ciskei and similar areas could be expected to benefit from an increase in the production of food, fuel, fodder and fibre, but information was lacking on i) human preferences and needs in regard to trees; ii) suitable tree and crop species and cultivars, and of their culture; and, iii) the integration of trees, crops and livestock into sustainable systems of production where inputs are low. It follows that the primary objective of the project was to increase the biomass available for human use by the integration of woody species into agricultural production systems. The first steps towards this long-term goal were to:

1. enquire as to the attitude of rural households likely to benefit from agroforestry;
2. obtain seeds of a wide range of woody species and cultivars, including indigenous, and of industrial and food crops not well known agronomically, with a view to screening trials in a wide range of ecological conditions.

These aspects form the substance of the report.

Trees, human needs and attitudes (Section II)

Advantage was taken of two studies commissioned by ARDRI and undertaken by the Institute of Social and Economic Research of Rhodes University in which 1510 households in the Amatola Basin and two adjacent districts were surveyed. Sixtyfive percent of households had food-bearing trees, principally peach trees, located in their vegetable gardens to which they had individual tenure as part of their allocation of arable land.

In view of the villagers knowledge of, and preferences for deciduous fruit, the conclusion was drawn that any tree farming project should develop on the basis of local knowledge and preferences. The investigation also concluded that yields from any tree farming project would continue to be seen as supplementary to the main source of income from outside the rural areas where employment opportunities were much better and with less risk than in rural areas.

Two of three districts surveyed had urgent need of firewood, the normal source of this being communally held grazing areas to which all residents enjoyed free access. The growing of trees in response to the need for fuelwood therefore could only be undertaken with full support of the community/ Tribal Authority because of the communal tenure of grazing areas.

Screening trials of species and cultivars (Sections III and IV)

The preparation, establishment and results from screening a wide range of (mainly) utilitarian woody species and a few crops make-up the main body of the report. Preparation for screening included the acquisition and classification of reference information, and approximately 300 seed introductions from 50 sources were made. A nursery was established at the University where the introductions were propagated and distributed to three main testing sites which were broadly representative of the range of climates in Ciskei. The agroforestry nursery has since become an accepted channel for the introduction of a wide variety of plant material into Ciskei.

First, it is anticipated that ARDRI's major research and development interest of small farm systems will move to an on-farm implementation phase in association with Ciskei agricultural extension staff, in which the farmer will be the central figure. As trees - in the first instance, those in gardens - will be included in on-farm programmes, it is logical that their introduction be in response to felt needs of the individual farmer and be integrated through the small farm research systems and extension (SFRS/E) approach. Similarly, should the community be in need of firewood, the plants and their establishment in the grazing area can be negotiated between the community/Tribal Authority and the SFRS/E team. An important subsequent aspect will be that once the research personnel move to a second community, the extension staff at the original site will be in a position to continue to offer appropriate advice on the care of the respective tree types.

The second area is that associated with special crops, including woody species, studies on which and related breeding work would form part of the research undertaken by the University's Department of Crop Science. Once their cultural requirements are understood, these special crops should also be channelled through the SFRS/E linkage to farmers. The continued monitoring of existing screening work would also be undertaken by the special crops team.

Nursery operations would need to continue, together with the training of nursery staff for Ciskei. Small farm development and community need of trees, together with the propagation of some specialised crops, all require this important support facility.

THE AGROFORESTRY PROJECT

(formerly Forest Farming Project)

A report for the period 1981-1987

I. Introduction

Though proposed as an approach to land use half a century ago, forest farming, or agroforestry, has only recently started to attract attention. Energy, population and food crises coupled with growing unemployment over much of the world have led to a search for more productive uses of marginal lands.

Only 13% of South Africa is arable. The remaining 87% is used chiefly as rough grazing although much of this area comprises deep, and sometimes fertile subsoils. Trees, because of their deeper roots, are better able to withstand drought than field crops, promote soil stability and improvement of soil structure and allow the recycling of nutrients. Leguminous trees fix atmospheric nitrogen. Planting of marginal areas with trees, therefore, may directly contribute to the production of food and industrial crops in the form of fruit, nuts, berries, beans or fibre, and, in addition, may improve adjacent field crops through providing shade, wind-breaks and soil amelioration. These benefits may be obtained without detriment to grazing or the provision of firewood, while secondary activities such as beekeeping and gum harvesting are catered for. Alley cropping, in which crops are planted between rows of trees is a development of this agroforestry concept. The choice or development of suitable trees or shrubs and compatible crops may enable the cropping of marginal soils.

The use of trees in the production of biomass other than timber, or those more traditional products associated with plantations or forests has, in the past decade attracted considerable interest, culminating in the establishment of the International Council for Research in Agroforestry (ICRAF) in Nairobi, Kenya in 1977. This event occurred at about the same time similar interest arose among staff of the Agricultural and Rural Development

Research Institute (ARDRI) at the University of Fort Hare (UFH). The existence of ICRAF only came to the attention of these workers in 1982, when the Journal, Agroforestry Systems, appeared for the first time. Much of the early work of the Institute was, therefore, of an exploratory and developmental nature, as those involved were attempting to initiate research for which there was little or no precedent.

1.1 The problem

Rural residents of Ciskei (and of other similar areas) could be expected to benefit from an increase in the production of food, fuel, fodder, fibre and from more varied diets. However, knowledge of the following interrelated aspects essential to the success of an agroforestry programme was minimal:

1) human preferences and needs in regard to trees and constraints imposed by land tenure system;

2) suitable tree and crop species and their cultivars, and of their culture in marginal conditions;

3) the integration of trees, crops and livestock into sustainable systems of production where inputs are limited.

1.2 Objectives of the project.

It follows that the primary objective of the project was to increase the biomass available for direct human utilisation (or indirect use where direct consumption was impractical) by the integration of trees and shrubs into agricultural production systems either singly, or in association with animals, crops or both. The first steps towards this long-term goal were to:

1) enquire as to the attitude of those most likely to benefit from such a project;

Settlements are a feature of the undulating Ciskeian landscape. Note the near-treeless surrounding countryside.

2) obtain seeds of as many cultivars of promising species as possible from sources such as the International Tree Crops Institute, for testing in a wide range of ecological conditions. Industrial and food crops that were not well known agronomically, and promising indigenous species were to be included. The testing was to comprise -

(i) screening of selected species and cultivars for vigour, yield and acceptability of product.

(ii) the development of techniques and, where necessary, equipment for the handling of seeds, seedlings, trees and their products, up to the time of harvest.

These aspects form the substance of this report.

II. Trees, Human Needs and Attitudes

As little was known about the attitudes and perceptions of the people who stood to gain from the agroforestry project the acquisition of such information was of major importance. Use was therefore made of two studies commissioned by ARDRI (one specifically for the project) and undertaken by the Institute of Social and Economic Research of Rhodes University (Bekker, de Wet and Manona, 1981a,b), in which 1510 rural households in the Amatola Basin and adjacent areas were surveyed. These workers defined the general aims of agroforestry as "the growing of trees, shrubs or other perennials for their yields of food and fodder such as fruits, nuts, berries, pods or seeds, or for other products such as fibres, oils or chemicals or for fuel or shelter".

2.1. Socio-economic survey

From the agroforestry viewpoint the socio-economic survey had two aims. The first was to identify the extent to which villagers had already participated in agroforestry or related activities, specifically with regard to the production of food from trees. The second was to speculate, on the basis of

the researchers' knowledge of the communities, on possible community responses to the introduction of agroforestry.

The surveyed areas were characterised by a high degree of dependency on money coming into the community from outside in the form of pensions and remittances, a demographic imbalance whereby the resident community consisted mainly of women, children and pensioners, and by the low status of agriculture which functioned primarily as a supplementary food source. However, a majority (85%) of the households had gardens, most of which were cropped to provide mealies and vegetables. Labour for the gardens was supplied mainly by women, and more attention was paid to gardens than to fields, as the former were smaller, and the fields were often situated at considerable distance from the homestead (Bekker et al. 1981a).

2.2 Acquisition and care of trees, sale of fruit

Virtually all trees in evidence were grown either in people's gardens or around their houses rather than in the fields. Though some were grown for shade, most trees were grown for their fruit and 65 percent of households had food bearing trees (Table 1). Most households had one to five trees, with only one percent of households having more than 20 trees (Table 2). One-third of the households surveyed had no trees. More than 80% of the trees were peaches (Table 3).

Trees were not purchased. Seeds were planted, and when these had sprouted, they were planted out in the gardens. Their maintenance was not regarded as work-demanding. Commonly, the trees received some manure when about 300mm high. Fertilizers and insecticides were not used. Yields were unknown and fruit was not normally sold, except by a few of the households that possessed larger numbers of trees. One such household in Cata (which had 63

TABLE 1 Presence and types of trees in rural households of the Amatola Basin, Cata and Burnshill (Bekker, de Wet & Manona, 1981a)

	Amatola Basin	Cata	Burnshill
Percentage of households growing food bearing trees	68%	70%	52%
n=	(415)	(767)	(328)
Peach trees as percentage of food bearing trees	82%	84%	87%
n=	(1 503)	(2 050)	(740)
Average number of food bearing trees per household growing trees	5,3	3,8	4,3

TABLE 2 Distribution of food bearing trees

	Amatola Basin	Cata	Burnshill
Households without trees	32%	30%	48%
Household with 1-5 trees	47	NR*	40
6-10 trees	13	NR	8
11-20 trees	6	NR	3
> 20 trees	1	NR	1
n=	(415)	(767)	(328)

* NR = not recorded

TABLE 3 Distribution of types of food bearing trees (Peaches only recorded at Cata)

	Amatola Basin	Cata	Burnshill
Peach	82%	84%	87%
Fig	6	-	2
Apple	5	-	0
Prickly pear	0	-	2
Grape vines	0	-	2
Other	7	-	2
n=	(1 503)	(2050)	(740)

peach trees growing in a securely fenced garden) claimed to sell peaches locally and in Keiskammahoek village.

2.3 Associations between tree-growing and agriculture

Bekker et. al., (1981a,) found no correlations between either the planting of trees or the number of trees and: access to arable lands, cultivation of arable lands, cultivation of gardens, household demography, or household income.

2.4. Conclusions and recommendations

Two general conclusions were drawn from this subsidiary research project. The first related to the extent to which villagers already had knowledge of, and preferences for, deciduous fruit grown in their gardens. Deciduous fruit was well-known and produced by a majority of households. By virtue of this there was an articulated preference for this type of supplementary food. Therefore any tree farming project should develop from knowledge of and food preferences existing in the areas under consideration.

The second major conclusion related to the extent of economic dependence on sources of cash income outside the rural areas, and the concomitant extent of adult emigration. Since this trend was likely to remain a dominant feature of the study areas in the foreseeable future:

(i) the yields from any tree farming project would continue to be seen as supplementary to the main source of cash income from outside the rural areas;

(ii) labour intensive projects would only succeed under exceptional circumstances since most labour would migrate to urban areas in search of better employment opportunities.

The researchers stressed that any exotic tree or shrub introduction should be actioned only after lengthy and full deliberations with the community

involved and their advisors; such introductions, moreover, should be shown to be successful by way of demonstration plots, and, if possible, by entrepreneurs in the area itself.

Since the short-term strategy recommended by Bekker, de Wet & Manona (1981a) was one based upon residential gardens, any project which aimed at utilising either arable or communal (non-arable) land should take into account the formal and informal rights and duties pertaining to the land tenure. In the light of the role which stock, and cattle in particular, play in the lives and activities of villagers, any extensive forestry project on communal pasture land would probably have to contend with initial village opposition, confusion regarding individual and group benefits, and petty theft of produce.

The availability of firewood was found to be a basic issue, affecting both light and heating and was identified as deserving urgent attention. Though dead wood was still freely available in the Amatola Basin, this was not the case in the adjacent areas of Burnshill and Cata where green wood was gathered and dried. Under the latter circumstances, wood - which together with water was viewed by the communities as a collective resource freely available to all residents - would rapidly diminish. Tree growing to stabilise the supply of fuel wood was recommended.

Although those findings of Bekker et al (1981a,b) concerning off-farm income, household demography and the low status afforded agriculture have been confirmed by a number of subsequent ARDRI studies (reviewed by Rose and Williams, 1988), the latter did not cover tree growing activities.

III. Screening: Preparatory Phase

This section outlines the work carried out and in preparation for the field screening and testing of plant species and cultivars.

3.1 Acquisition and classification of reference material

The first exercise was to receive literature and to contact individuals and organisations with an interest in agroforestry, development or related subjects, both locally and abroad. A large amount of written information was acquired, classified, indexed and filed, to produce a comprehensive and useful reference source. This collection proved to be invaluable in the selection of material for inclusion in the various trials and in developing processes and techniques associated with them. In the course of the first five years of the project approximately 300 seed introductions were obtained from 50 sources.

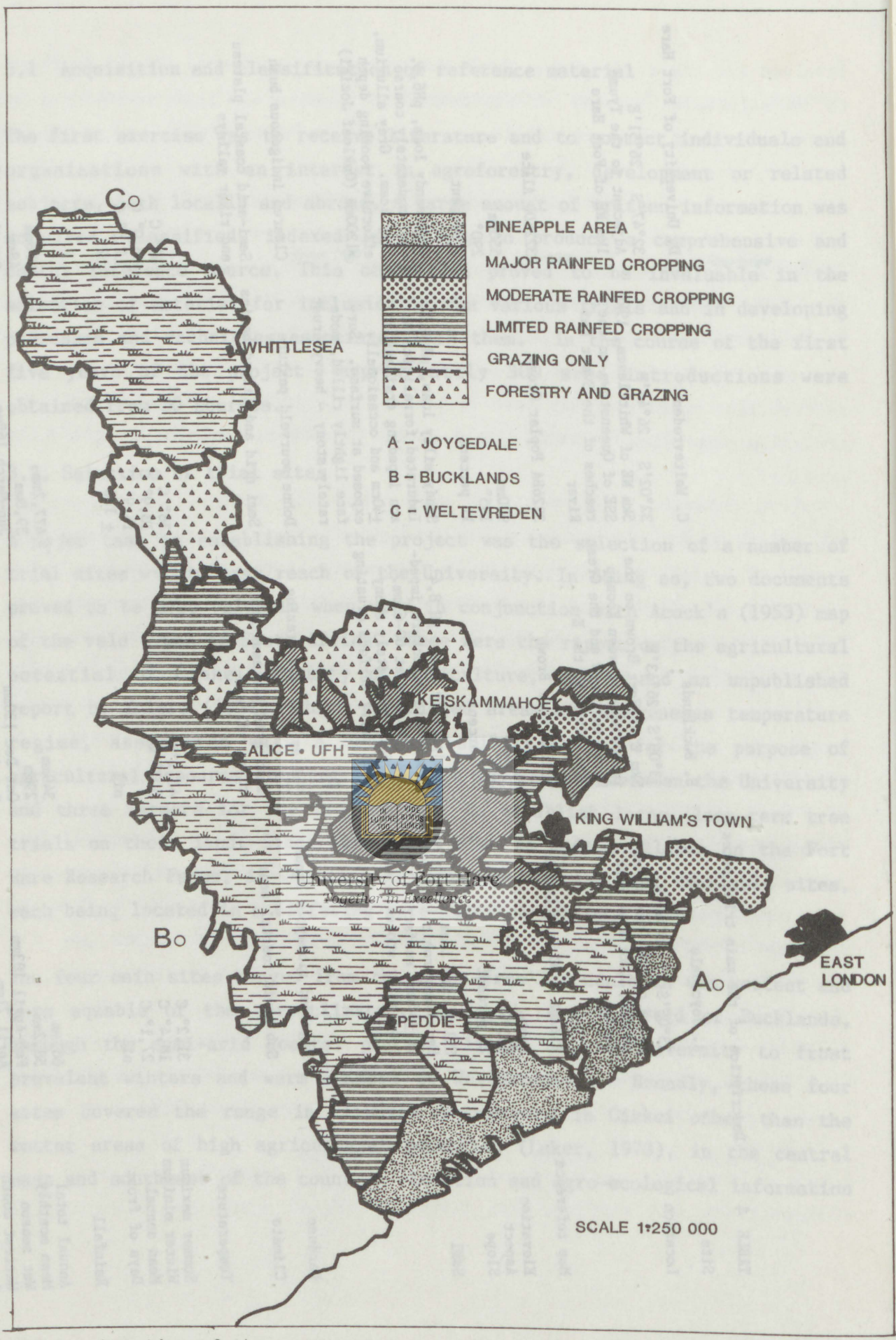
3.2. Selection of trial sites

A major task in establishing the project was the selection of a number of trial sites within easy reach of the University. In doing so, two documents proved to be most valuable when used in conjunction with Acock's (1953) map of the veld types of South Africa. These were the report on the agricultural potential of Ciskei (Faculty of Agriculture, 1978), and an unpublished report by Ehlers (1974), which classified areas of homogeneous temperature regime, associated with a crop suitability chart, for the purpose of agricultural resource planning. Agreement was reached between the University and three farmers for the project team to establish large, long-term tree trials on their land. Since land could also be made available on the Fort Hare Research Farms, it was decided to proceed on the four available sites, each being located in a differing agro-climatic region.

The four main sites ranged from the frost-free Joycedale in the wettest and more equable of the agro-climates, the arid, dry bushveld of Bucklands, through the semi-arid coastal plateau climate of the University to frost prevalent winters and warm summers at Weltevreden. Broadly, these four sites covered the range in climates encountered in Ciskei other than the wetter areas of high agricultural potential (Laker, 1978), in the central east and southeast of the country. Location and agro-ecological information

TABLE 4 Description of the main trial sites

Site	A. Joycedale	B. Bucklands	C. Weltevreden	D. University of Fort Hare
Location	33°05'S 27°40'E 5km N of the Gulu river mouth, 25km W of East London	33°09'S 26°43'E 5km E of Fort Brown on the interfluve between Koonap River to the W and the Great Fish River in the E	32°02'S 26°44'E 5km NE of Whittlesea, 19km SSE of Queenstown on the reaches of the Swart Kei River	32°47'S 26°51'E Adjacent to the Tyume 1km NE of Fort Hare
Map reference	3327BA & BC East London	3326BA Fort Brown	3226BA Poplar Grove	3226DD Alice
Elevation	±300m	±500m	900mm	550mm
Aspect	040°	023°	195°	290°
Slope	27 percent	11 percent	11 percent	2 percent
Soil	Silty clay loam, pH 5,9 Heavy anaerobic clay horizon at ±45cm, surface rilled, subangular stones common	Sandy silty loam, pH 8,4 Pisolithic structure impeding drainage at 60-65mm. Surface moderately stony with heavy surface crusting	Sandy silty loam, pH 6,3 Indurated ferralitice horizon impeding drainage at ±40cm and occasionally exposed at surface. Surface lightly rilled, moderately stony - heavy crust	Fine sandy loam, pH6,5, over moderately coarse clay loam. Grey allurium, effective rooting depth >1200mm (Oakleaf Jozini)
Landuse	Degraded pineapple lands	Valley bushveld grazing	Dohne sourveld pasture	Cleared indigenous bush
Climate	Sub humid coastal zone	Semi-arid plateaux and river valleys	Semi arid and inland basins	Semi-arid coastal plateau and river valleys
Temperature				
Summer maximum	31,2° C	45,2°C	38° C	42° C
Winter minimum	18,4° C	6,7° C	13,9° C	-6,0° C
Mean annual	27,1° C		16,9° C	12,5° C
Days of frost	nil	nil	± 120	12
Rainfall				
Annual total	661mm	349mm	477,2mm	576mm
Mean monthly	58,2mm	29mm	39,8mm	48mm
Wet season	Feb-April 183mm	Oct-Dec 120mm	Jan-March 168mm	Oct-March 377mm
Wettest month	April 71mm	Oct 49mm	March 68mm	March 71mm
Dry season	July-Sept 117mm	May-June 45mm	May-July 75mm	April - Sept 199mm
Driest month	Dec 13mm	May 14mm	June 18mm	June 23mm



MAP 1. Location of the major trial sites in relation to Ciskei Consolidated Production Potentials (after Laker, 1978)

for the sites are given in Table 4 and their geographical locations are shown on Map 1.

On occasion, other sites have been used for testing plant materials and these include Old Womans River, Bathurst, Tainton, Kalbaskraal and Oudtshoorn.

3.3 Nursery

The agroforestry nursery was established near the main campus of the University and equipped with two tunnels, a shade house and simple ancilliary facilities. Under the control of the project's horticulturist, Mr A S Marsh, the nursery has played an integral role in the programme with the propagation of seedlings, and virtually all trees screened have been planted out from it.

In the course of the project, a demand for tree seedlings by small farmers led to requests for vegetable seedlings, the production of which commenced in 1985. Since then, 50 - 60 000 vegetable plants have been sold annually. This response to a felt need has brought an official request from the Ciskei Government for assistance in establishing seven district nurseries and the training of the relevant staff. The first of these nurseries has been established.

This aspect of the agroforestry programme therefore provides an established channel for the introduction of new plants into the region.

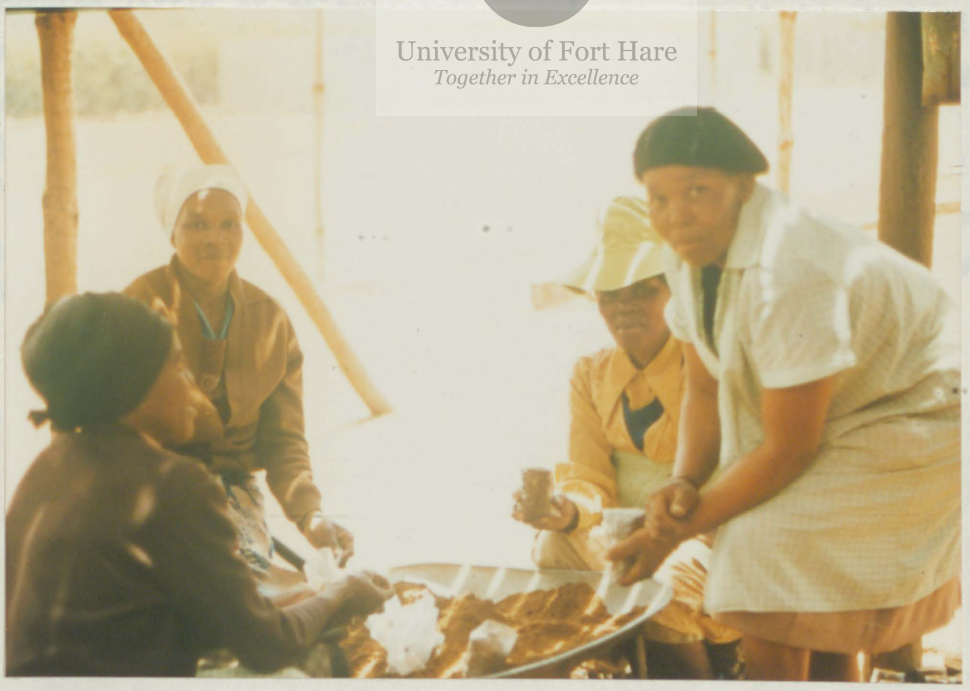
IV. Screening Trials of Species and Cultivars

By June 1981, the principles which were to be applied in the selection of trees for inclusion in the agroforestry programme had been established. Implicit in the choice of species and cultivars for their utility and contribution to ecological balance was that competition between tree and understory vegetation be minimal. Among other things, trees chosen for

Seed pricking

Originally established to propogate trees for the Agroforestry project, the ARDRI nursery has extended its activities to the production of vegetable seedlings in response to felt needs

Potting



agroforesty should have relatively thin crowns to allow as much sunlight as possible to reach the plants nearer the ground.

Central to the concept of agroforestry is the inclusion of exotic plants together with traditional crop, orchard or forestry plants in integrated systems. A recurring problem when new plants are included in artificially constituted management systems is that the plants are invariably neither adapted to their new environment nor do they produce at the levels expected of them. Thus screening of introductions (and the subsequent genetic improvement of selected material) is essential. The initial phases of a project such as agroforestry are necessarily concerned with the time consuming evaluation and selection of plants which are suited to the systems envisaged.

Screening and the introduction of plant material was well established by Mr P D Adams, the first project leader, before he left Fort Hare, in 1982. Although plants subsequently continued to be introduced from time to time, the appointment of Mr M Underwood as project leader in 1984 brought redirection of emphasis to the evaluation of Leucaena species, and in particular, Leucaena leucocephala, as the major component of the project.

For reasons of brevity and convenience, the screening information is given in tabular form. Table 5 describes trials with utilitarian species whose products require little or no processing, and more detailed information is given regarding two of the most promising species, Eucalyptus and Leucaena in the following sections 4.1-4.4. Section 4.5 (Table 10) deals with woody species grown for their industrial products; and Section 4.6 (Table 11) is concerned with food crops. In view of the findings and recommendations of Bekker et. al. (1981a), a somewhat surprising omission from the screening trials were fruit trees.

TABLE 5 Utilitarian trees and shrubs

Name(s)	Origin, habit, reputed characteristics, use	Test site	Result
Albizia andrianthifolia (Flat crown)	Warm, moist S.A.; Tall spreading tree, moderately drought tolerant; Shade, medicinal	Bucklands	Survived one winter only
Antidesma venosum (Tassle berry)	Indigenous; shrub 4-5m; medicinal	Joycedale	Successful, but growth poor
		Bucklands, Weltevreden	Failed
Aspalanthus contaminatus (Rooibos tea)	Indigenous to W.Cape; Small shrub; Well known herbal beverage	Joycedale, Bucklands, Weltevreden	Failed- difficult to raise in field, better direct sown
Carissa macrocarpa (Noem-noem, Amatungulu, Natal plum)	Indigenous; Spiny small shrub; Fleshy fruit used in jam-making	Joycedale	Successful, satisfactory growth
		Bucklands	Failed, too dry
		Weltevreden	Failed, very suseptible to frost
Ceratonia siliqua (Carob)	Mediterranean; Pod-bearing leguminous tree, drought and frost resistant; pod, high sugar content. Direct human and animal food, confectionary, alcohol	Joycedale	Grows well but slowly
		Bucklands, Weltevreden	Failed
		Tainton	As for Joycedale
Crataegus pubeseens (Hawthorn, Doringappeltjie, Mexican hawthorn, Skaapvrug)	Central America; Frost resistant. Fruit ripens autumn-winter, rich in carbohydrates, pectin and vitamins A & C; Leaves and fruit, fodder. Dried fruit ground into mean for humans and stock	Joycedale, Bucklands, Weltevreden	Failed to survive prolonged droughts; growth poor even at Joycedale, no seed production; out of environment

TABLE 5 (CONT.)

Name(s)	Origin, habit, reputed characteristics; use	Test site:	Result
Cytisus sp. Tagasaste or lucerne tree	Central Europe, Canary Islands; Large leguminous shrub drought tolerant, frost resistant; Protein rich fodder	U F H	Currently under observation- promising
Canjanus cajan (or C. indica) (Dahl, Pigeon Pea	Africa ?; Short-lived perennial, leguminous shrub 1-4m. Extensively grown in India; Seeds - food, green-raw; dried- cooked plant- fodder, green manure, cover, shade crop	Joycedale	40 cultivars tested, 6 selected for further testing
		U F H	Drought killed first test, testing thereafter abandoned for work with Leucaena
Dovyalis caffra (Kei apple)	Indigenous; Thorny shrub, slow growth, drought tolerant; Ripe fruit - jam, compote, marmalade; unripe- jelly. Protective hedges	Joycedale	Grows well- no fruit to-date
		Bucklands Weltevreden	Failed
Eucalyptus sp. Gum trees	Australia; Trees, widely grown in SA (120 sp). fast growing, frost & drought resistant, aggressive; Timber, fuel, wind breaks, swamp reclamation	U F H	13 species sown, only E. punctata failed & the remaining 12sp planted out at the three sites.
		Joycedale	12 species grew well, 2,5-3,5m at 18m. (see section 4.1.1)
		Bucklands	E. caldocalyx only survived 2 years
		Weltevreden	E. paniculata, & E. cornuta (an additional sp.) and E. diversicolor established, with respective ratings good, fair, poor; all have grown slowly. Other sp. failed. Further work abandoned for

TABLE 5 (CONT.)

Name(s)	Origin, habit, reputed characteristics: use	Test site:	Result
Harpephyllum caffrum (Kaffir plum, Essenhout, Cape ash)	Indigenous; medium size tree; Edible drupe, table jelly, timber, furniture, landscaping	Joycedale	Successful
		Bucklands	Established but short-lived
		Weltevreden	Failed
Leucaena leucocephala	Central America; Many types- leguminous, with high N-fixing ability, naturally coppicing, drought resistant, grows rapidly, invasive. Browse contains mimosin and can be toxic to livestock; Fuel, timber, browse, wind & soil ameolioration	Joycedale	9 cultivars: all successful (see section 4.1.2)
		Bucklands	3 cultivars survive
		Weltevreden	Two screening trials failed due to frost and dryness
		Tainton	3 Nelder fans established satisfactorily, browsed by buck.
Leucaena paniculata	Central America; Similar to L. leucocephala but less invasive due to limited seed set.	U F H	Successful introduction of Mexican cultivar ±2m high and ±8cm girth at 18 months
Melia azedarach (Bead tree, syringa)	India/Burma; Fast growing, deciduous tree with light wood, widespread in southern Africa, flowers and seed poisonous; Fuel	Joycedale	Successful, fast growth
		Bucklands, Weltevreden	Failed, due to very hot and dry conditions
Pinus radiata	N. America; Frost tolerant, rapid growth where moisture is adequate; Timber - widely versatile, fuel	Bucklands	Failed - out of environment

TABLE 5 (CONT.)

Name(s)	Origin, habit, reputed characteristics; use	Test site:	Result
Pithecellobium saman (syn. Pithecolobium) (Indian rain tree)	Venezuela; Tall spreading leguminous tree; Coffee & cocoa shade tree; timber, furniture	Joycedale	Limited, poor growth
Prunus amygdalis (Almond)	China; Nut-bearing; Kernels widely used as confectionary nuts, baking, oil-flavouring	Joycedale	Partially successful
		Bucklands, Weltevreden	Failed, scion dieback
Ricinodendron rautanenii (Manketti tree)	Botswana; Slow growing, drought resistant; Dried fruit porridge, stockfeed	Bucklands	Healthy, slow growth
Sesbania bispinosia	Indigenous; Shortlived perennial small, leguminous shrub; Grazing & fodder, nets	Joycedale	Successfull, vigorous, freeseeding, invasive

Two other woody leguminous species were considered for the programme but excluded because of their tendency to spread in an uncontrolled manner. They were Acacia mearnsii (Black wattle) from Australia and Prosopsis juliflora (Mesquite) from the arid areas of the SW United States and Mexico.

Grevillea robusta (silky or silver oak), a tall drought resistant Australian tree suitable for timber and windbreaks was not grown in the programme although common in Fort Beaufort. Olea capensis (wild olive, olienhout) a small indigenous tree with hard dense wood used for props, poles and cabinet making, and suitable as a rootstock to the domestic olive (O. europaea), was also not screened. In this instance the local people repeatedly destroyed grafted material.

4.1 Growth of *Eucalyptus* spp. at Joycedale

Gum trees are well known throughout the sub-continent and 120 species are known in South Africa. Resistance to the use of eucalyptus in agricultural systems is common because of their aggressive competition with other species. Nevertheless they were included in the project because of the known utility of the timber for structural purposes as well as for firewood.

Owing to the shift in emphasis in the project to *Leucaena*, no measurements of growth were taken until 14 July 1987, when the amount of standing wood in the Joycedale trial was estimated by the formula of James (1982) to obtain an approximate comparision of species yields:

$$\text{Yield } (m^3) = \frac{\{(DBH/2)^2 \times 3.14\} \times H}{10000}$$

where DBH = diameter at breast height (cm) (taken as 1,2m above ground level), and H = height (m). The results are summarised in Table 6.

No yield estimate was made of *E. lehmannii*, since it is a multistemmed species.

TABLE 6 Mean[1] dimensions and estimated yield of eleven Eucalyptus spp. planted at Joycedale late September 1983 and measured mid-July 1987

Species	Girth (cm)	Height (m)	Estimated yield (m^3)
E. camaldulensis	43,0	11,4	,17
E. cladocalyx	44,5	6,9	,11
E.diversicolor	40,0	8,3	,11
E.maculata	39,3	8,1	,10
E.grandis	39,8	7,9	,10
E.paniculata	37,3	6,1	,07
E.microcorys	35,5	5,4	,05
E.tereticornis	27,8	8,1	,05
E.polyanthemos	30,3	6,0	,04
E.sideroxylon	29,8	4,5	,03
E.ficifolia	23,7	6,4	,03
E.lehmanii	-	5,5	-

1. n=8

The most notable feature of Table 6 is the outstanding performance of E.camaldulensis, whose estimated yield of timber exceeded the two second-ranked species 1,5 times and those of the lower-ranked species over five times, in this environment.

4.2 Leucaena spp.

As stated in the introduction to this section work of the project was concentrated on Leucaena leucocephala from 1984 to 1986. This species had an established international reputation for its utility and was considered to be the most promising of all the tree species that had been screened for the agroforestry project.

L. leucocephala is a legume reputed to fix 100 to 200 kg/ha nitrogen annually, it is rapid growing, drought resistant and moderately frost tolerant. A long tap root allows successful establishment of the plant on steep slopes so that it is regarded as useful in combating soil erosion and as a windbreak. It is an excellent fuelwood, one particularly suited to rural demands as its bushy growth habit provides several stems which are easy to break and small enough to start a fire. It coppices readily. The calorific value of the wood is between 4200 and 4600 kcal/kg, sufficient to sustain a boiling pot.

Leucaena foliage is rich in protein and vitamin A content and can either be browsed, cut and carried to penned livestock or dried to make a meal similar to lucerne meal. Branches 50 to 150 cm in length are cut and sun dried. After 24 to 48 hours the leaves are sufficiently dry to be either shaken or beaten off and collected. Dried leaves are readily ground into a meal that has a high protein content (25-30 percent), a very high vitamin A content (up to 5 times that of lucerne meal), is low (±10 percent) in fibre, and contains about 2,5 percent calcium (Oliver and Topps 1978).

These impressive attributes of L.leucocephala must be weighted by two important reservations. The first concerns the invasive potential of the species. Where grown in favourable rainfall conditions L. leucocephala's free-seeding nature enables the rapid colonisation of adjacent areas in the absence of competition, especially on disturbed ground. This is of concern where the tree is not subject to ecological or human controls. The second area for concern relates to the amino acid, mimosine, present in leaves of L.leucocephala, which may cause unthriftyness, loss of hair, infertility or even death, in animals feeding upon it. For these reasons, pig and poultry diets should not contain more than 10 percent of the Leucaena leaf meal, while ruminants should not be given a diet solely of Leucaena. Australian evidence indicates that this problem may be overcome in cattle by the introduction of suitable microflora into the rumen (Jones, Megarrity, LeFeurve & Freeman , 1986). Importantly, the position in respect of fibre-bearing ruminants is not clear.

A more detailed review of L.leucocephala in South Africa was prepared for the agroforestry project by Underwood (1987).

The following information describes ARDRI's studies of L. leucocephala. The nutritive value of browse (Table 7) and yields of browse and firewood (Table 8), obtained at Joycedale, are presented. Growth measurments of cultivar K8 grown in Rayi location are given in Table 9, and in section 4.3 a trial in which cattle were offered L. leucocephala is briefly considered.

TABLE 7 Proximate analysis (% of DM), estimated total digestible nutrients (% of DM), metabolisable energy (MJ/kg DM) and mimosine (% of DM) of first year browse[1] of Leucaena leucocephala at Joycedale, sampled on 3 May 1983.

	Mean[2]	S E
Crude protein	20,5	1,48
Crude fibre	26,2	1,11
Ether extract	3,3	0,65
Nitrogen-free extract	42,0	6,10
TDN	62,8	1,76
Ash	7,4	0,55
M.E.	9,5	0,19
Mimosine[3]	6,1	0,50

1. Four trees of each of nine cultivars were sampled. Browse taken from the top, middle and lower portions of each tree comprised shoots 6mm diameter or smaller and the accompanying leaves and pods. The four samples per cultivar were bulked for chemical analysis.
2. n= 9 (cultivars)
3. Mimosine content estimated from duplicate browse samples to those used in the proximate analysis.

These nutritive values are in the range of those given lucerne meal by Topps and Oliver (1978) except for ether extract and ash content, which are higher and lower than those of lucerne, respectively.

TABLE 8 Means[1] and standard errors for yields (kg, DM) of browse[2] and firewood[2] of trees of Leucaena leucocephala grown at Joycedale and cut at approximately 15, 25 and 38 months of age.

Age (months)	Date cut	Browse Mean	Browse S E	Firewood Mean	Firewood S E
15	3/5/83	1,9	0,46	2,4	0,88
25	1/3/84	5,2	2,30	3,2	2,01
38	11/4/85	2,6	1,31	6,8	3,38

1. n=9 (cultivars). One representative tree of each cultivar was sawn 30cm above ground level on each date.

2. Browse comprised shoots 6mm diameter or smaller and the accompanying leaves and pods. The remainder of the tree was the firewood component.

Average browse yield varied with age and physiological state of tree which were confounded with season and date of cutting. There was a three-fold increase in firewood between 1983/84 and 1984/85. Knowledge of age and growth characteristics of trees is needed to formulate optimal cutting programmes.

It is clear from Table 8 that variability of both browse and firewood production was high, part of which was due to large differences in yield between the cultivars. Three varieties, K6, K8 and K66 produced approximately 13kg DM, 1,5-2 times more browse and firewood than the next four-ranked (K29, V1, K500, K67) and three times more than the two lowest producing varieties, (K341 and Peru). The indications were that future use of the more successful cultivars at this site could bring marked benefits in increased supplies of fuel-wood, browse or both.

Invasion: However, in August 1987, it was noted that Leucaena leucocephala was spreading in an uphill direction and against the wind at the rate of 10

m annually at Joycedale. Since the site is on previously cultivated land and adjacent to existing commercial pineapple fields, this species can no longer be recommended for use at this site.

TABLE 9 Means and standard errors for height and diameter of a random sample[1] of Leucaena leucocephala cultivar K8 trees in the Rayi location woodlot[2], at approximately 1, 2 and 3 years of age[3].

Year	Age	Height(cm)		Diameter (mm)	
		Mean	S E	Mean	S E
1985	1	73	29	13	7,2
1986	2	104	58	22	12,9
1987	3	123	61	23	13,4

1. n=20
2. 5km west of King Williams Town on the road to Grahamstown; soil, fertile sandy loam (Oakleaf form)
3. Planting date: 12 March 1984

As was the case with the Joycedale yield data (Table 8) age of the tree and seasonal influences are confounded. Again, wide variability in the two dimensions is evident, but in the present case, within a particular cultivar, indicating that selective improvement may be possible. As the measurements reported were not common to both Rayi and Joycedale, no site comparison is possible. It is hoped that yield sampling may be possible in future and any spread of the cultivar monitored.

Importantly, however, the present trial was the only one to be sited in a Tribal Authority area, and the only trial specifically directed at meeting a major felt need. All parties involved were able to agree to the establishment and to satisfactory maintenance arrangements.

Community involvement: planting the woodlot of L. leucocephala in Tribal Authority Area at Rayi Location.

More information is needed regarding the effect of Leucaena browse on goat and sheep production.

4.3 Health of growing steers offered Leucaena browse

In view of possible toxic influences of the mimosine content in Leucaena browse on livestock health and performance, a small trial was established in which 18 month steers were offered a predominantly Leucaena leucocephala diet. The site made available by the Transkei Agricultural Corporation was at Ntsimbini, 30 kms inland from Port St Johns in the lower Umgazi river valley. A well established L. leucocephala stand was cleared of all other vegetation and the Leucaena cut back and burnt to stimulate new regrowth at browsable height.

Two groups of three Afrikaner x Brahman tollies were used. One group was confined to the regrowth area, the other (control) was assigned to nearby valley bushveld. At the end of the 90 day experimental period in December 1986, there was no evidence of deleterious effects on the group confined to Leucaena leucocephala or differences in liveweight gains, relative to their controls.

Clearly, these results from a short-term study with a few non-breeding cattle require confirmation from a much stronger body of data before they can be generally accepted. Moreover, the trial failed to address key questions affecting the introduction of L.leucocephala, namely its invasive capacity and its effect on goats and sheep. Regarding the first of these issues, the species was originally introduced to Ntsimbini as a coffee shade tree and had taken-over the site.

4.4 Species of promise

As indicated in the previous sections Leucaena and Eucalyptus fall into this category. The invasive nature of Leucaena leucocephala restricts its use in favourable agroclimates, but this may not be the case elsewhere. Furthermore, there are many species and types of Leucaena that may warrant assessment, some of which may have the desirable characteristics of L. leucocephala but with limited seeding capacity and of low mimosine content. L.

paniculata shows considerable promise at UFH and todate has shown little tendency to seed freely, but requires further assessment. Eucalyptus spp. on the other hand show wider environmental tolerance without the invasive nature of Leucaena. Where timber and fuel-wood are the prime needs, eucalypts warrant serious consideration.

Other utilitarian species under observation which show promise are Cytisus and Prunus amygdalis. Those fruits already cultivated by households must be taken to be adequately assessed for use in their respective localities, and additional fruit species and cultivars need to be screened.

4.5 Cash crop trees and shrubs

Under this heading are included those trees and shrubs which might be of value in an integrated agroforestry system and whose products require industrial processing before use, thereby generating a cash income for the grower.

Final assessment of the woody species has yet to be made, but there is a continuing need to introduce material of a special crops nature so that advantage can be taken of promising species while unsuitable material can be characterised and discarded. Whether or not work of this nature should be within the compass of an agroforestry programme is arguable, but certainly such introductions fall within the ambit of ARDRI supported research.

4.6 Locally adapted crop plants

Southern Africa does not directly benefit from the work of international organisations such as CIMMYT or ICRISAT. These agencies have built up huge germ plasm collections of wheat, maize, sorghums and millets which their scientists use in breeding cultivars aimed at increasing food sufficiency in developing countries. There is recognition too that high yielding commercial hybrids are not necessarily appropriate to the small farmer. Open pollinated varieties may be of lower risk in marginal conditions where this

TABLE 10 Tree crops whose products require industrial processing

Name(s)	Origin, habit, reputed characteristics; use	Test site:	Result
Aleurites fordii (Tung oil tree)	China; Euphorbia, prefers acid soil; Seeds - oil for paints and varnishes	Joycedale	Successfully established, but growth < 1m in 3 years
		Bucklands, Weltevreden	Failed
Cinammomm camphora (Camphor wood)	Far east; Timber, camphor extraction	Joycedale	Growth vigorous
		Bucklands, Weltevreden	Failed
Parthenium argentatum (Guayule)	SW USA; Drought and frost tolerant perennial shrub; Only alternative commercial natural rubber source to Hevea sp. known. Possible strategic value - in CSIR Renewable Feedstock Program.	U F H	Cuttings successfully rooted: 3 culitvars x 2 spacings trial in progress; survival trials at 5 sites in Ciskei. Rubber yields not yet known. Observations on 2 cultivars in progress.
Simmondsia chinensis (Syn. S. californica) Jojoba, Pignut, goat nut	California, Mexico; Shrub, adapted to arid climates; Seeds: food, either parched, raw, ground roasted. Important alternative oil source to sperm whale for non-drying lubricants, and used in cosmetics, pharmaceuticals, printing and other industries	Kalbaskraal, Oudtshoorn	Observation and fertiliser trials, yield and oil extraction data awaited

TABLE 11 Food crops.

Three crop species not in wide agronomic use have been grown

Name(s)	Origin, habit, reputed characteristics; use	Test site:	Result
Amaranthus sp. (Grain amaranths)	Peru; Wild form common- tall (1-2m) vegatative growth, rather fibrous cf. cabbage; high potential yield. Seed - small edible grain; Leaves - widely used vegetable in Africa.	U F H	Grain variety trial 1981/2: highest yield of five cultivars 0,23 t/ha
Cucurbita foetidissima (Buffalo gourd)	Mexico SW USA; Arid-zone perenial with fruiting ability and very large deep root; Seed, oil & protein rich; root, starch, bitter (glycosides); seed, food	Joycedale Bucklands Weltevreden U F H	Killed by fungus Survives, does not fruit Failed Thrives, bulking in progress
Voandzeia subterranea (Bambara nut)	Tropical Africa; Wide spread legume, but little known of its potential; Alternate to groundnut;	Old Womans River	9-10 accessions screened and multiplied 1986/87, 1987/88

attribute is more desirable than high yield potential with its concomitant high input requirements, high cost and high risk. Similarly, rural households without modern domestic appliances prefer vegetables with extended bearing or fruiting periods to those in commercial use so that small quantities of fresh material is available over long periods.

A component of the agroforestry programme has the aim of collecting, characterising, breeding and preserving locally adapted strains of plants to contribute to a gene pool representative of such material in the subcontinent. To date a selection has been made of "Thonwana" maize, a drought resistant strain from Venda. In addition, 17 inbred lines of maize which flower after ±60 days growth have been isolated at Fort Hare, with a view to developing very short season cultivars.

There is need for breeding work directed at the management needs of rural households, and socio-economic information (Rose and Williams, 1988; Williams, 1988) suggests that vegetables, including green mealies, should have priority in this regard. As in the case of cash crop trees (section 4.2) it is moot whether work of this nature should be included in an agroforestry programme but ARDRI's commitment to small farm systems reseach demands that greater attention paid to horticulture.

V. Technology related to Agroforestry tempeh production

From the inception of the project, emphasis was placed on the use of leguminous trees, shrubs or food plants, because of the many desirable properties which are associated with the Leguminosae family. They play an important role in fixing atmospheric nitrogen in the soil by their association with rhizobial bacteria and are themselves rich in protein.

While the seeds of virtually all legumes are usable as food, many of them are extremely hard, or contain harmful substances so that they cannot be used without considerable preliminary preparation. A case in point is the extremely valuable soybean (Glycine max). A range of traditional methods for the domestic processing of the beans have their origin in the Far East. A

simple method for producing a palatable product was that used in the preparation of Indonesian Tempeh, which involves the fungus Rhizopus oligosporus, grown on a substrate such as partly cooked and dehulled soybeans (Figure 1). The fungal mycelium penetrates the beans of the substrate, produces an enzyme which causes a partial breakdown of their cells, thereby making them more palatable, and imparting a meat-like flavour to the beans. These can then be further prepared for eating by, for example, deep frying. The fungus was reported also to have been successfully used on wheat, rice and peanut press-cake. When used on soybeans, the product, or Tempeh, contains about 42% protein.

The production of Tempeh from legumes or legume-cereal mixtures had the potential, like yoghurt, of being done at home for individual use, or as a cottage industry, or of being developed into a industrial process.

5.1 Experiments on the production of Tempeh

During June and July 1981, Dr J P Mildenhall, of the Department of Genetics and Plant Protection of the University of Fort Hare and Prof B A Prior, of the Department of Microbiology at the University of the Orange Free State, were contacted for help with the production of Tempeh. Prof Prior proposed that a standard fungal culture, which could be freeze dried and supplied to users for sprinkling on to suitable substrates in the form of a dry powder, be prepared. Towards this end Dr Mildenhall visited Dr K Steinkraus, of the New York Agricultural Research Station, and obtained the necessary information as well as cultures of Rhizopus oligosporus. This material was then used by him and Prof Prior in a series of experiments to produce Tempeh from a variety of substrates.

Using the preparation of the protein rich, highly digestible Indonesian soybean Tempeh as an example, several locally available beans were investigated for their suitability as replacements for soybeans. Prepared samples of the beans were inoculated with a pure culture of Rhizopus oligosporus and firm mycelial cakes allowed to develop. Slices of the cake were then deep-fried, salted or flavoured and eaten as snacks. Unfried slices of cake were

Whole, clean soybeans

⇩

Soak overnight (or 24 hours) to hydrate soybeans and allow bacterial fermentation and acidification

⇩

Dehull by hand or by passing through machine to loosen hulls

⇩

Remove hulls by flotation on water

⇩

Boil cotyledons for 60 minutes

⇩

Drain and cool and allow surface moisture to evaporate

⇩

Inoculate with tempeh mould

⇩

Ferment small packets of inoculated soybeans wrapped in banana leaves or in clean shallow covered pans

⇩

Incubate at a temperature of 30° - 35°C until soybeans are completely covered with mould mycelium (generally 24 to 36 hours)

⇩

Tempeh cakes can be sold on the market or used in home by slicing thin strips and deep frying or cutting into chunks and cooking in soups

FIGURE 1. Indonesian Tempeh fermentation (National Academy of Sciences, 1979)

also used as a substitute for meat in soups. The end-products were then evaluated for taste, palatability and odour, by two panels of participants, one white and one non-white.

The preparation and processing which was required by the different beans was compared. Before and after fermentation stereo-microscopic investigation was done on each sample to determine the degree of penetration of the mycelium into the beans, as well as the cellular decomposition which resulted. With soybeans as a control, Mesquite (Prosopis) pods, honey locust (Gleditsia) seeds in three forms (whole, cracked, milled), samp, sugar beans, haricot beans, kidney beans and cowpeas were used in the trials.

For practical home use, tempeh fermentation must be simple and rapid. It is therefore essential that the Rhizopus inoculum should be pure and that spores should germinate readily. This fungus is propagated mainly by the rapidly growing mycelium. To prevent contamination by undesirable micro-organisms and to simplify storing, a four day long fermented inoculum on sterile rice was prepared, followed by freeze drying.

The samples of beans were prepared by being precooked in slightly acidified water, obtained by the addition of acetic acid, in order to lower the pH sufficiently to inhibit growth of undesirable bacteria, but not the growth of the mould. One half of each sample was passed through a meat grinder, without a blade, to break up the seeds, after pre-cooking.

5.2 Results obtained with Tempeh production

Except for the samp and milled honey locust, which did not require dehulling, and the cracked honey locust, of which the hulls floated, the other samples required a time-consuming dehulling. Passage through the meat grinder did not break the hulls of whole honey locust or mesquite and dehulling by hand was impossible. The other samples of broken seeds were easier to clean. Dehulling of the cowpeas (2h/kg) and soybeans (1,5h/kg) required relatively hard work, while the haricot-, sugar- and kidney beans required less effort (0,5-1h).

After inoculation, some samples were incubated in dishes covered with unpierced aluminum foil while the remainder were covered with foil pierced with holes ± 3 cm apart. A dish of water was placed in the incubator together with the latter, to increase the humidity. Better results were obtained from the samples with unpierced covers. The time required to produce adequate mould growth varied between the different beans. In practice the incubation period was limited to a maximum of 48 hours to prevent souring, and the samples were then stored in a refrigerator (Table 5.1).

TABLE 12 Growth of Rhizopus oligosporus on various types of beans

	Growth characteristics of fungal cake	
Cake	After 24 hours	After 48 hours
Soya bean	Very good. Slight sporulation	Not observed
Sugar bean	Very good. With sporulation	Very good. With
	Poor on broken beans	sporulation also on
		broken beans
Cowpeas	Slight growth	Very good. Slight
		sporulation
Haricot beans	Reasonable. Slight sporulation	Not observed
Kidney beans	No growth	No growth
Mesquite	Slight growth	Slight growth with
		sporulation
Honey locust:		
whole	No growth	Slight growth
broken	Good growth	Very good. With
		sporulation
ground	No growth	No growth
Samp	No growth	Not observed

Observations on the general quality of the mycelial cake made under stereo-microscope are summarised in Table 13.

TABLE 13 Characteristics of Tempeh (visual and stereo-microscopic)

Bean	Physical qualities of mycelial cake
Soya bean, whole & broken	Good mycelial penetration; good cake, white colour
Sugar bean, whole	Good mycelial penetration; solid cake; soft texture
Cowpeas, broken	Good mycelial penetration; solid cake; soft texture
Haricot bean	Good mycelial penetration; solid cake; rough texture. Broken Haricot similar to whole, but not so solid
Kidney bean	Poor mycelial penetration; loose cake; difficult to handle when frying
Mesquite	Poor mycelial penetration; no cake formation
Honey locust:	
whole	Poor mycelial penetration of beans; mycelium does not bind husks together
broken	Mycelial penetration of beans; jellylike texture

On a scale 0 (inedible) to 100 (completely acceptable) Blacks rated soya, sugar and haricot bean Tempeh as completely acceptable; Whites rated soya as very good and sugar and haricot Tempeh as edible. Both panels regarded whole and broken honey locust and mesquite inedible.

The production of fermentation products such as Tempeh from legume and cereal seeds showed definite promise. The processes involved were sufficiently uncomplicated to be conducted in the home, without need of sophisticated or expensive equipment. In order to retain the inoculum of R. oligosporus for future work samples of the culture were lyophilised and stored.

VI. Evaluation

6.1 Resumé

Information has been presented on the results of two related socio-economic surveys of Ciskei household activities, attitudes and needs in relation to trees. Most farmers had planted fruit trees in their vegetable gardens to

which they had individual tenure as part of their arable allocation. Two of the three districts surveyed had urgent need of firewood, the normal source of this being communally-held grazing areas to which all residents traditionally enjoyed free access. The main body of the report deals with the establishment of, and the results from screening a wide range of (mainly) utilitarian woody species and a few crops. Of 193 site x species/cultivar observations initiated, the more promising species were Eucalyptus and Leucaena, with others still being assessed. The work with Leucaena is discussed more fully in view of the emphasis given L. leucocephala for three years. Finally, an account is given of the development of a microbiological technique to widen the use, acceptability and improve the nutritional value of locally available legume seeds through Tempeh production.

6.2 Appraisal

Embracing nearly all disciplines of the agricultural sciences, agroforestry in essence is a concept of land use in which people, trees, crops, pastures, animals interact among themselves and with climate and soils. Unless adequate prior knowledge exists of the appropriate tree(s) and crop(s) and their integration, agroforestry is a very long-term development and for this reason the research component is costly, both in time and money and returns are slow to accumulate. This is especially true in areas with limited rainfall. Seven years is quite an inadequate time span in which to have obtained comprehensive information on the integration of trees x crops where the trees required introduction.

The real value of the agroforestry programme lies in the fund of information available from the site x species/cultivar screening trials and in related issues. Interventions in existing agricultural programmes or accurate development planning are dependent on what is possible, and the many failures of woody species noted in this report provide positive information as do those species and cultivars that succeeded.

It has already been noted that fruit trees were being grown by the communities surveyed by Bekker et al. (1981a,b). The failure to build on this

preference is seen in the hindsight possible with the now well documented base-line and felt needs surveys of rural households carried out since the inception of the agroforestry project (reviewed by Rose and Williams, 1988). As a result future on-farm research and development programmes will be much better aware, among other things, of the importance of gardens, of fruit and of vegetables, and the role women play in rural households.

While fruit trees were not included in the screening programme, several potential fuel-wood species were, and in the case of Rayi location, Leucaena leucocephala was introduced into the woodlot and monitored. Whether or not other Leucaena or Eucalyptus species might usefully have been included, the fact remains that this need of the community was established on communal land and that the community was sufficiently self-disciplined to respect the fencing and the trees. This augers well for other villages in need of trees, and fuel-wood could be used as a means to gain rapport between research/extension staff and the community/Tribal Authority. In these aspects, as in the case of vegetables, the agroforestry nursery has played a vital role and is now an established channel for the introduction of plants to Ciskei.

More generally, there is much better appreciation that what the small farmer does of his or her own volition is the only realistic basis on which to plan change, and that change requires successful demonstration under the relevant conditions and management. The need to include information about trees along with other agricultural particulars in surveys undertaken as part of an on-farm research programme is established.

Regarding Tempeh, it is noted that the success achieved with various cultivated beans needs to be extended to the seed of leguminous trees in the veld, as well as be introduced to domestic science personnel and leaders/advisors of women clubs.

6.3 Whither?

From the foregoing it seems likely that the future of the agroforestry programme lies within two other ARDRI projects thereby facilitating the integration of related activities with stronger professional backing. It is appropriate too that this report is made at a time when changes in ARDRI's small farms systems research programme are being considered.

First, it is anticipated that ARDRI's major research and development interest of small farm systems will move to an on-farm implementation phase in association with Ciskei agricultural extension staff, in which the farmer will be the central figure. As trees - in the first instance, those in gardens - will be included in on-farm programmes, it is logical that their introduction be in response to felt needs of the individual farmer and be integrated through the small farm research systems and extension (SFRS/E) approach. Similarly, should the community be in need of firewood, the plants and their establishment in the grazing area can be negotiated between the community/Tribal Authority and the SFRS/E team. An important subsequent aspect will be that once the research personnel move to a second community, the extension staff at the original site will be in a position to continue to offer appropriate advice on the care of the respective tree types.

The second area is that associated with special crops, including woody species, studies on which and related breeding work would form part of the research undertaken by the University's Department of Crop Science. Once their cultural requirements are understood, these special crops should also be channelled through the SFRS/E linkage to farmers. The continued monitoring of existing screening work would also be undertaken by the special crops team.

REFERENCES

ACOCKS, J.P.H, 1953. Veld types of South Africa Memoirs of the Botanical Survey of South Africa. No 28. Government Printer, Pretoria.

BEKKER, S.B., DE WET, C. and MANONA, C.W., 1981a. Tree farming activities in three Ciskei rural areas. Institute of Social and Economic Research, Rhodes University.

BEKKER, S.B., DE WET, C., and MANONA, C.W., 1981b. A socio-economic survey of Cata location. Institute of Social and Economic Research, Rhodes University.

EHLERS, J.H., 1974. Agro-ekologiese streeksindeling van die Republiek van Suid-Afrika. Unpublished report. Department of Bantu Administration and Development.

FACULTY OF AGRICULTURE, 1978. The agricultural potential of the Ciskei, University of Fort Hare, Alice.

JAMES, N.D.G, 1982. The Foresters Companion (3rd Edition) Blackwell, Oxford, Chapter 9.

JONES, R.J., MEGARRITY, R.G., LEFEURVE, R., and FREEMAN, K.B., 1986. Leucaena toxicity studies. CSIRO Division of tropical crops and pastures. Annual Report 1985-86 p85.

LAKER, M.C., 1978. In: The agricultural potential of the Ciskei. Faculty of Agriculture, University of Fort Hare, Alice.

NATIONAL ACADEMY OF SCIENCES, 1979. Microbial processes: promising technologies for developing countries. Washington, D.C. p32-36.

ROSE, C.J., and WILLIAMS, W., 1988. Small farms systems research - the ARDRI project. Paper presented tot the DBSA seminar "Farm Systems Research", Johannesburg, 25 March.

TOPPS, J.H., and OLIVER, J., 1978. Animal foods of Central Africa. Technical Handbook No2. Rhodesia Agricultural Journal. Government Printer, Harare (Salisbury).

UNDERWOOD, M., 1987. Agroforestry (formerly Forest Farming), Interim Report. ARDRI p35-58.

WILLIAMS, W., 1988. Huistuingroenteproduksie deur landelike gemeenskappe in the Alice-omgewing, Ciskei. Unpublished MSc. Agric Thesis, Department of Agricultural Extension and Rural Development, University of Fort Hare.