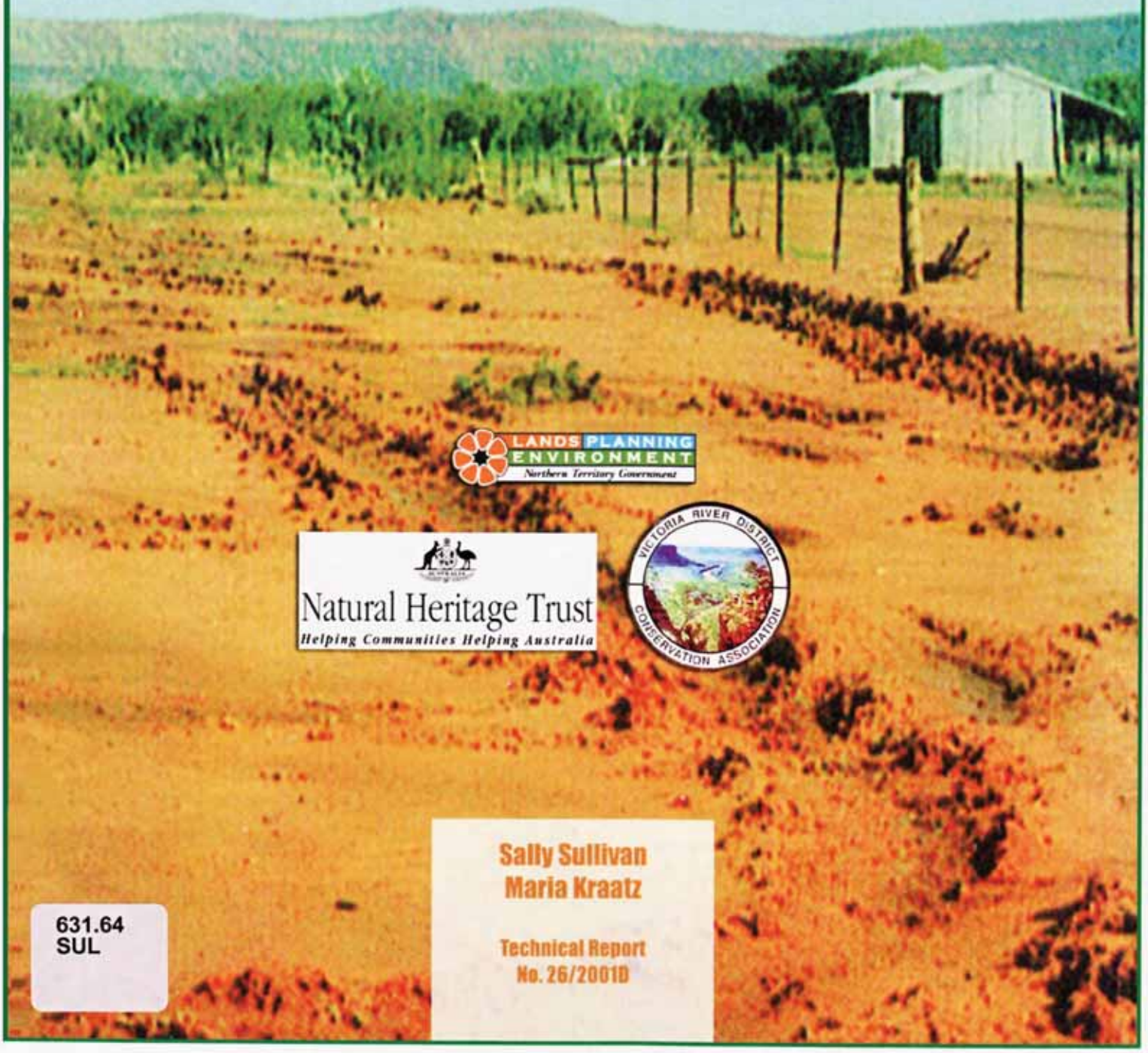
Pastoral Land Rehabilitation

in the

Semi-Arid Tropics

of the Northern Territory

1946-1996



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Northern Territory Government

Natural Heritage Trust
Helping Communities Helping Australia

VICTORIA RIVER DISTRICT CONSERVATION ASSOCIATION

Sally Sullivan
Maria Kraatz

Technical Report
No. 26/2001D

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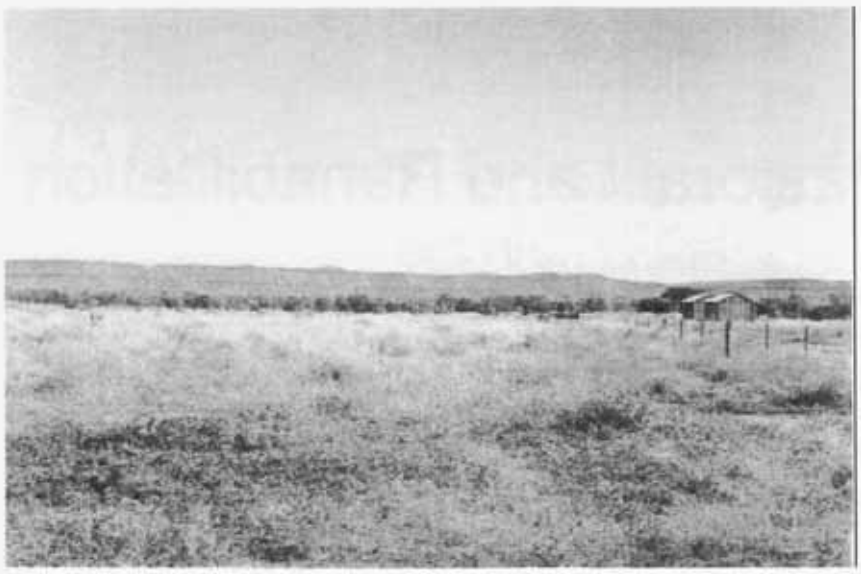

Rehabilitated pastures on Auvergne Station in February 1993.
This photo was taken three months after the photo featured on the cover.

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The information in this publication is, to the best of the authors' knowledge, correct at the time of writing. However, neither the Department of Lands, Planning and Environment nor the authors accept responsibility or liability for the consequences of using this information.

Cover: *Check furrow and pitter cultivation on bare, scalded levee soils near the Auvergne homestead in December 1992.*

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Dedication

To the late Mr Pieter J Walter (1917 – 1983), the first soil conservation officer in the Northern Territory, whose written records, energetic pursuit of his work and dedication to soil conservation and his clientele, should serve as an example and inspiration to landholders and public servants alike.

Contents

Preface

This report is the culmination of work undertaken between 1992 and 1995 with a grant provided by the National Soil Conservation Program, a precursor to the National Landcare Program and Natural Heritage Trust. Interest and funding from the Victoria River District Conservation Association prompted the long overdue publication of this document. The Department of Lands, Planning and Environment provided funds for printing.

The information presented in this document was gathered from Commonwealth and NT Government records, oral history records and anecdotal evidence. Government records included departmental annual and monthly reports and Northern Territory annual reports. This information was not always complete and as a result, the success of some trials and rehabilitation techniques was difficult to ascertain. Other trials, however, were fully documented and for these, references are provided. While the review focuses on the semi-arid tropics, Alice Springs activities are included in the timeline section.

Information used for this review was mainly collected prior to 1996. Since that time, there has been little mechanical rehabilitation activity, though Greening Australia NT has recommenced native revegetation trials in the Katherine region.

The extent of rehabilitation activity on a station should not be interpreted as reflecting the amount of degradation on that property, but rather the motivation of the producer to rehabilitate degraded country.

The names of people involved in rehabilitation activities have been used where possible to assist readers to identify the work discussed and seek further information.

Metric conversions of imperial measurements have been made. A conversion table is provided on page ix.

Descriptions of plough types, including the advantages and limitations of their use, are provided in Appendix A. As this is not a scientific report, common plant names are mainly used instead of scientific names, although in some cases these may be the same. Scientific names are provided in Appendix B. The history of soil conservation in the public service is provided in Appendix C and contacts for advice and assistance are provided on the last page.

Finally, while the intention was to produce an exhaustive history of mechanical rehabilitation in the semi-arid tropics of the Northern Territory, some information may have evaded the authors.

Acknowledgements

The authors gratefully acknowledge the assistance of Fergal O'Gara, Mike Clark, Rod Applegate, Darryl Hill, Liz Brown, Roslyn Howse, Vance Fulton, Tom Stockwell, Scott Wauchope, Steve Petty, Jane Jackson, Rohan Sullivan, Angus Cameron, Barbara Sullivan, David West and finally Philip Sullivan (for his perfect timing).

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Glossary*

Absorption bank

A level bank with a turn-up at each end designed to pond water to a pre-determined depth.

Annual plant

A plant completing its life cycle, from seed germination to death, within a single season.

Awn

A fine, hair-like protrusion from some part of the grass spikelet.

Contour

An imaginary line on the earth's surface connecting points of the same height.

Coated seed

Seed which has been coated with a clay or lime based product which may have fertiliser, fungicide or insecticide added. Coated legume seed may have an inoculant added. Fluffy or small seed can be easier to calibrate, mix and distribute when coated.

Cover

The proportion of the ground surface covered by plants, litter, mulch etc., usually expressed as a percentage. Cover can be one of the most important factors in reducing erosion.

Degradation

The decline in the quality or productive potential of natural resources commonly caused by human activities.

Ephemeral plant

A plant with a short life cycle, having several generations in one year.

Exclosure

An area of land from which domestic and/or native animals are excluded for the purpose of studying the effects of no grazing on vegetation. Such an area may range in size from a few square metres to hundreds of hectares.

Gap spreader bank

A level bank constructed to allow water to be spread by a series of gaps in the bank. Excavation from below creates a level channel into which water flows through the gaps, and from which it spreads over land downslope.

Gully

An open incised erosion channel greater than 30 cm deep. Gullies mostly form as a result of concentrated surface water flow.

Mechanical rehabilitation

Rehabilitation in which machinery, in particular cultivation implements, are used.

Perennial plant

A plant whose life cycle continues for more than 2 years and continues to live from year to year.

Perenniate

To grow from existing rootstock or stems, as opposed to growing from seed.

Reclamation

The repair of land from a degraded state to one where its productive potential is improved (eg. waterponding on scalds).

Regeneration

Often used interchangeably with rehabilitation. Strictly speaking, regeneration is the re-establishment of native pastures by natural self-seeding and growth, encouraged by practices such as the exclusion of stock.

Rehabilitation

The treatment of degraded land to achieve an agreed level of stability, preferably at least equal to that prior to degradation or disturbance.

Rill

A small gully, less than 30 cm deep that can be crossed by vehicles and cultivation implements.

Scald

A bare area produced by the removal of sandy topsoil by wind and/or water. The result is the exposure of a more clayey subsoil which is not very permeable to water.

Self-mulching soil

A heavy clay soil in which the surface layer forms a shallow mulch of loose soil aggregates when dry. The type of clays present cause the soil to swell when wetted and shrink with drying. Any tendency to crust and seal under the impact of rain is counteracted by shrinkage and cracking, thus producing a mulch effect as the soil dries out. Tillage when wet may appear to destroy the surface mulch which, however, will reform upon drying.

Semi-arid tropics

Areas characterised by a distinct hot, summer "wet" season and mild winter "dry" season. Rainfall can be very variable both within the wet season and between years, with average rainfalls ranging from 500 mm in the south to 1000 mm in the north. Vegetation consists largely of open eucalypt woodlands, with an understorey of tussock grasses, on a diverse range of soils.

Sheeting

The removal of a uniform layer of soil from the land surface by wind and/or water. No channels are formed. Bare areas may be prone to sheeting.

Shotgun mix

A mixture of several types of seed.

Sodic soils

Soils containing sufficient exchangeable sodium to adversely affect soil stability, plant growth and/or land use. These soils are dispersible and easily eroded.

Stolon

A branch or stem growing along the ground, rooting at intervals.

Waterponding

A technique for reclamation of scalded land. Small, U-shaped earth banks are constructed to hold water. By forcing water to infiltrate instead of running off, soil structure, chemistry and moisture are improved, creating a favourable environment for plant growth.

Wheelpoint apparatus

A device for identifying the type of ground cover at a series of individual sites. The device consists of a rimless spoked wheel and handle. Points are located by contact with the ground by specified spokes.

Windrow

A longitudinal accumulation of straw, timber, soil or other material, stacked or piled up by mechanical means.

* *Most definitions are from Houghton PD and Charman PEV (1986),* Glossary of Terms used in Soil Conservation, *Soil Conservation Service of NSW.*

Abbreviations

BTEC	Brucellosis and Tuberculosis Eradication Campaign
CCNT	Conservation Commission of the Northern Territory
CLMA	Centralian Land Management Association
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DLPE	Department of Lands, Planning and Environment
DONT	Department of the Northern Territory
DPIF	Department of Primary Industry and Fisheries (formerly DPP)
DPP	Department of Primary Production
GANT	Greening Australia Northern Territory
KEF	Katherine Experimental Farm
KRS	Katherine Research Station
NSCP	National Soil Conservation Program
NTA	Northern Territory Administration
VRD	Victoria River Downs Station
VRDCA	Victoria River District Conservation Association
WADA	Western Australian Department of Agriculture
WAG	Western Australian Government

Conversions

Metric to imperial

10 millimetres	0.39 inch
1 metre	1.09 yards
1 kilometre	0.62 miles
1 hectare	2.47 acres
1 square kilometre	0.39 square miles
1 kilogram	2.21 pounds
1 kilogram/hectare	0.89 pounds/acre

Imperial to metric

1 acre	0.41 hectares
1 inch	25.4 millimetres
1 foot	0.30 metres
1 yard	0.91 metres
1 chain (66 feet)	20.1 metres
1 pound/acre	1.1 kg/ha
1 hundred weight/acre	125.4 kg/ha
100 points (1 inch) rain	25.4 millimetres

INTRODUCTION

"All the little kings in their grass castles, Mary, and the wind and the water sweeping them away. The gullies are creeping up about the house, my dear"

Patsy Durack 1898 (*in* Durack 1985).

This review draws together for the first time all land rehabilitation projects undertaken between 1946 and 1996 on pastoral lands in the semi-arid tropics of the Northern Territory (NT). The area covered includes the Victoria River, Katherine, Gulf and Barkly districts (Figures 1 – 3).

The semi-arid tropics are characterised by a distinct hot summer "wet" season and mild winter "dry" season. Rainfall can be variable both within the wet season and between years, with average rainfalls ranging from 500 mm to 1000 mm. Vegetation consists largely of open eucalypt woodlands, with an understorey of tussock grasses, on a diverse range of soils.

Argyle Station lies immediately to the west of Mistake Creek across the Western Australian (WA) border. Work undertaken on that station has been included due to its proximity and relevance to the NT. Extensive Ord catchment rehabilitation research and activity by the Western Australian Department of Agriculture (WADA) is also of particular relevance, and has been documented by that organisation (Fitzgerald 1967; 1968; 1982, Ryan 1979, Tunbridge 1987, Watson 1989, Petty 1990, Pratchett 1990, Williams 1990).

Historical stocking levels, natural regeneration and the circumstances under which land rehabilitation may be warranted are briefly discussed to provide a background to the timeline and station by station details of land rehabilitation.

The timeline of land rehabilitation activities includes references to Central Australian activities integral to the development of soil conservation in the NT.

Station by station activities are outlined from page 21. The extent of rehabilitation activity on a station should not be interpreted as reflecting the amount of degradation, but rather the motivation of the producer to rehabilitate degraded country.

The success of land rehabilitation depends on a number of factors discussed in the final section of this report (page 107). A decision tree introduces the main factors to be considered when determining appropriate management of degraded areas. These factors include soil type, severity of degradation, cultivation methods, planting and cost/benefits. Future research possibilities are identified.

The review illustrates that the success of land rehabilitation is far from guaranteed and identifies the factors which enhance the chance of success. There are times when rehabilitation is not an appropriate option and other forms of management, such as spelling, are required.

HISTORICAL STOCKING

Inspired by the reports of explorers such as Alexander Forrest, of well-watered fine grassy plains in the Ord River area, European settlement and stocking of the NT and the Kimberleys (WA) occurred in the mid to late 1800's. Increasing numbers of uncontrolled livestock grazed the river frontages and by the mid-1920's few bores had been sunk.

Areas of pasture degradation and erosion were recorded in the early 1900's in the Kimberleys, and an erosion survey of the Ord River valley was undertaken in the 1940's. The NT administration did not appear to become concerned about soil erosion until the early 1960's, when a prolonged drought in central Australia (1956-65) and high stock numbers had significant impacts on land stability.

Historical stocking levels and patterns, in combination with seasonal variation and extreme climatic events, emerge as the most likely cause of erosion in the NT and Kimberleys. For example, it is estimated that in 1936, after several particularly dry years, 80,000 cattle were grazing the frontages of the Wickham and Victoria Rivers on Victoria River Downs Station (VRD)(Makin 1983). This was followed by 550 mm of rain in 3 weeks and a record flood. Similarly extreme climatic events, in combination with high stock concentrations, occurred in the Ord River catchment (Pratchett 1990). Conditions such as these must have accelerated erosion.

By 1986, an erosion survey estimated that over 1,100 km^2 in the upper catchment of the Victoria River were affected by scalding and sheet and gully erosion (Condon 1986). Streambank erosion and tunnelling were also found to be severe, but limited in extent. A strong relationship between soil type and erosion was identified. Most significant erosion had occurred on calcareous red earths which are sandy and sodic and therefore inherently erodible. Such soils are often associated with watercourses and alluvial plains, tend to support preferred pastures and have historically been heavily grazed.

NATURAL REGENERATION

Photographic and anecdotal evidence over the past 30 years indicate that many areas of the Victoria River District which were very bare and often eroding, have shown considerable natural regeneration.

This could be attributed to several factors including:

- better control of stock through increased fencing;
- increases in the number of watering points which has spread the impact of stock;
- decreases in stock numbers with the Brucellosis and Tuberculosis Eradication Campaign (BTEC) of the 1980's; and
- increasing awareness of land conservation principles and practices.

Natural regeneration will only occur where:

- paddocks are spelled at least over wet seasons;
- seasons are favourable;
- some topsoil is intact;
- soil seed banks are viable or seed sources are nearby;
- there are places for seeds to lodge (such as hollows or sandy patches or near sticks or stones); and

- surface sealing and crusting does not impede water infiltration or prevent emergence of germinating seedlings.

In some cases, however, areas can show few signs of recovery, even with light stocking or spelling. In these situations, mechanical intervention may be required to initiate the process of rehabilitation.

LAND REHABILITATION

Land rehabilitation may be warranted on areas which show little sign of natural regeneration particularly if:

- erosion is affecting roads, fences, or other infrastructure;
- the area is required for production;
- runoff from bare areas is exacerbating erosion downslope;
- seed banks are depleted;
- dust is a problem (for example, in homestead or community areas);
- sedimentation is a problem (as in Lake Argyle); or
- the area is highly visible.

Rehabilitation can ensure that water infiltration is maximised, runoff is minimised and controlled and a suitable environment is provided for pasture establishment.

The following review includes many instances across the semi-arid tropics of the NT where land rehabilitation was considered to be an appropriate course of action.

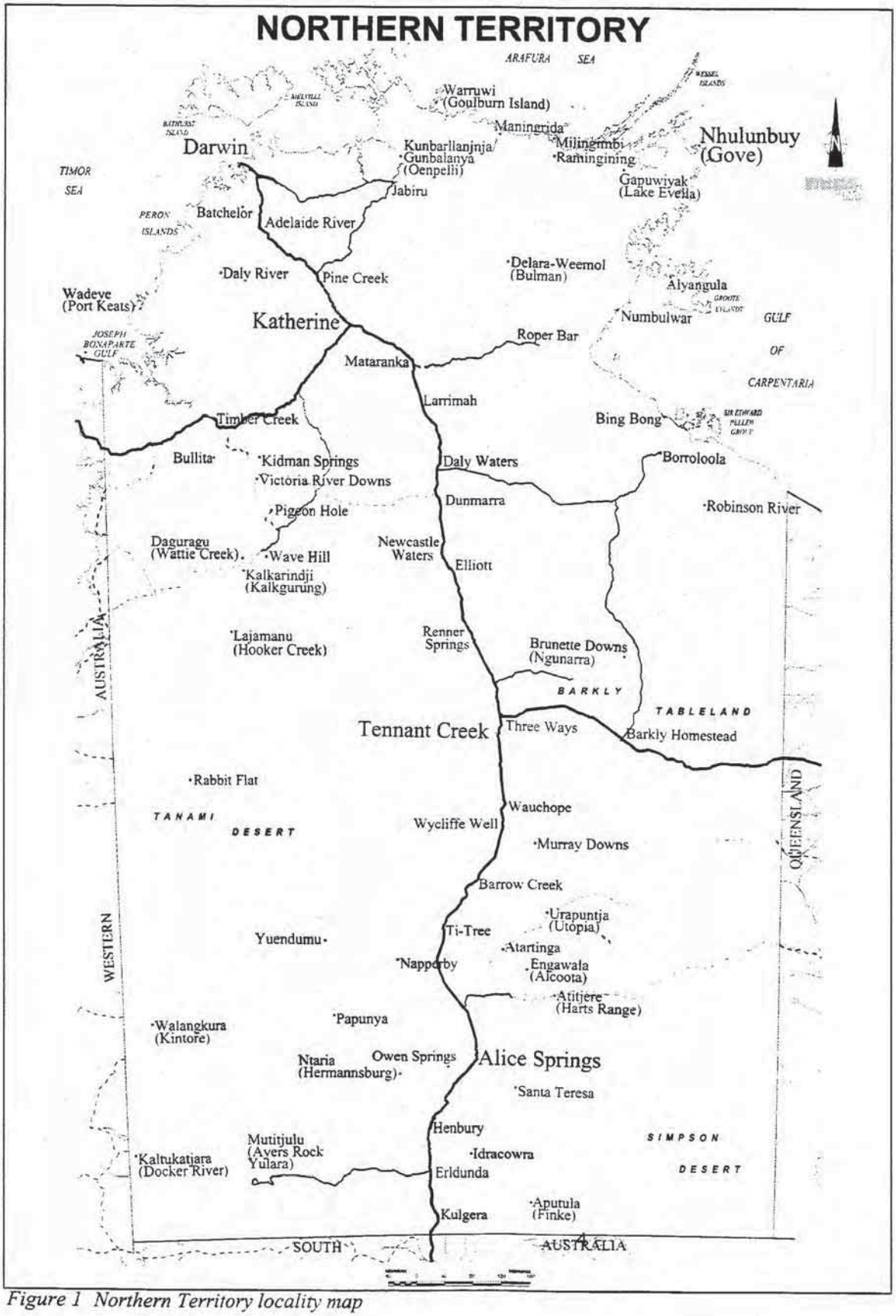


Figure 1 Northern Territory locality map

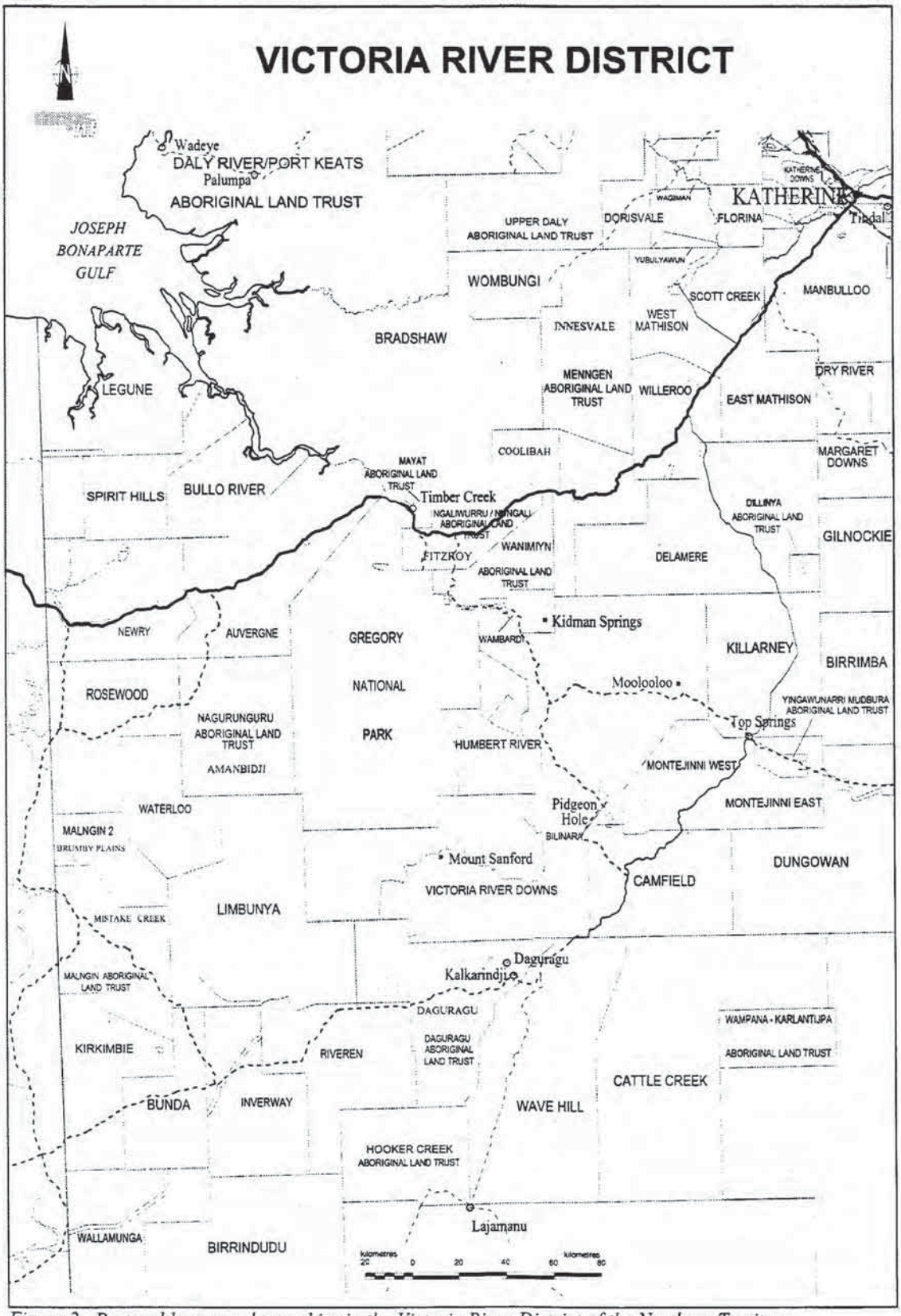


Figure 2 Pastoral leases and townships in the Victoria River District of the Northern Territory

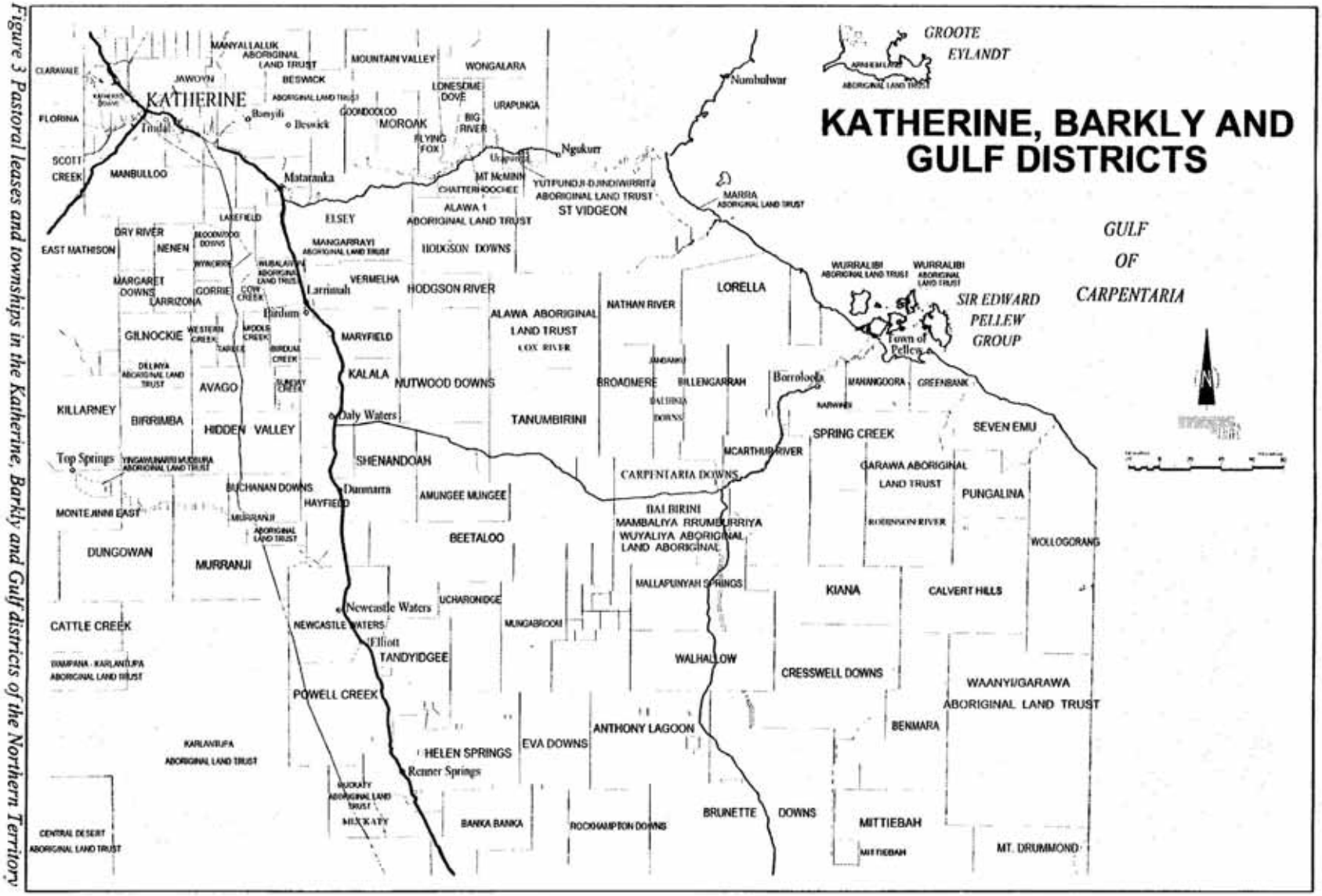


Figure 3 Pastoral leases and townships in the Katherine, Barkly and Gulf districts of the Northern Territory

LAND REHABILITATION TIMELINE

1948

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) established the Katherine Research Station.

1952

The Agriculture Section of the Lands and Survey Branch of the Northern Territory Administration (NTA) was created. The Katherine Experimental Farm (KEF) (now the NT Rural College site) was established. The main objective of the experimental farm was to investigate the prospects for various crops and pastures.

1957-58

Improved pastures, most significantly, buffel grass and Townsville stylo, were established on KEF. Pieter Walter, a pastures field officer, was stationed in Katherine and made 120 extension visits (of which 68 were to pastoral properties). Advice was given on pasture introduction, fodder conservation, water conservation and utilisation, soil conservation and general agricultural matters. Experimental work in pasture establishment and plant introduction on several pastoral properties began.

Seven trials using 4 buffel grass strains were established on sandy to sandy loam soils in different rainfall zones of the NT. Poor germination and establishment were attributed to dry spells during the wet season. Nurseries of about 20 *Cenchrus* species strains were established, mainly between Pine Creek and Elliott, the western edge of the Gulf of Carpentaria and the Western Australian border.

The NTA field officer considered that overgrazing or pasture destruction only became serious along stock routes and in areas that were either burnt almost every year or fenced. Some soil erosion remedial work was done at Wattie Creek and Timber Creek Police Station, for example, drawing attention to the problem. Several requests for advice were received.

1958-59

The pastures field officer covered all regions of the NT giving advice on agricultural and pastoral holdings, mission stations and government settlements (Plate 1). Some experimental work was carried out including soil conservation measures in the vicinity of the Roper Bar Police Station.

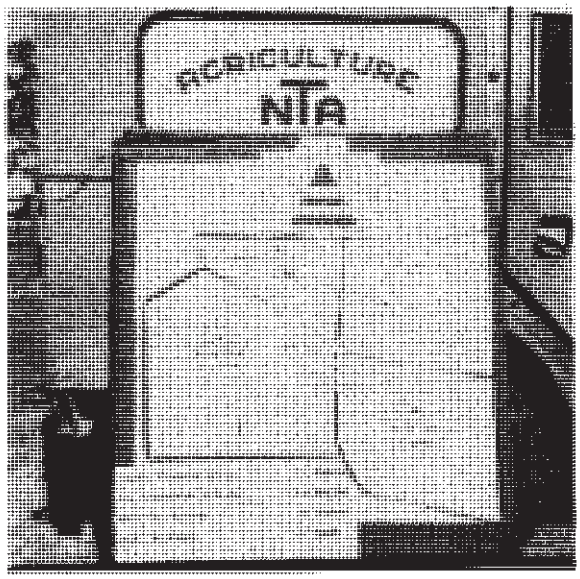


Plate 1 *A map of the "dry monsoonal region" of the Northern Territory at a late 1950's demonstration day showing the area over which extension services were being provided.*

Pasture demonstrations and experiments were conducted on several properties (Plate 2). Buffel and birdwood grass species were not found to be very successful under open range conditions because of various factors including phosphate deficiencies in the soil, competition from native species, removal of seed by ants, destruction of young plants by wallabies, and, in arid and semi-arid regions, high soil temperatures affecting germination. Some land preparation was considered necessary.

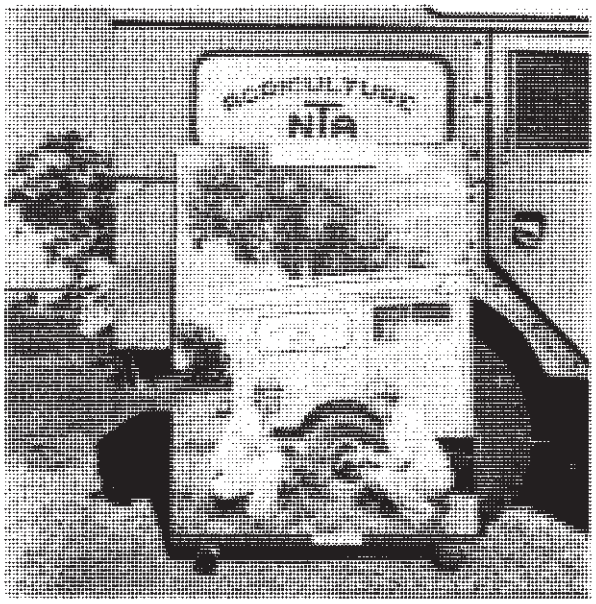


Plate 2 *Pasture demonstrations and experiments were conducted as early as 1958 by the Agriculture Section of the Lands and Survey Branch of the Northern Territory Administration (NTA).*

Kapok bush showed promise for use in low rainfall areas and on soils too poor for buffel. Kapok introduced into the western Victoria River District in about 1956 was well established.

Requests for advice on erosion problems increased, and attention was given to airstrip stabilisation to prevent wind and water erosion.

1959-60

Forty-five pastoral holdings were visited by field officers. In most cases, management showed interest in pasture improvement and soil conservation.

Most experimental work on pastures was undertaken on Manbulloo Station (Figure 4). Trials began with buffel, birdwood, para, sabi and gamba grasses, and with some guinea grass on Auvergne and Newry Stations and Roper River Mission. Problems were sometimes discussed over the radio and several evening meetings were held at station homesteads and stock camps discussing general pasture improvement problems and including slide shows. A total of 150 people attended these meetings.

Erosion control and rehabilitation work commenced around Wave Hill Police Station.

In pastoral areas, inadequate watering facilities were thought to result in overgrazing around watering points during the dry season. The exact nature and extent of these inadequacies were not detailed. The field officer considered he was making progress in assisting pastoralists and farmers to plan their activities on the basis of sound conservation principles.

1960-61

Extension officers were now based in Darwin, Katherine and Alice Springs. A total of 150 visits to pastoral properties were undertaken for general extension work and to conduct field trials and demonstrations. There was a marked increase in interest in pasture improvement, which was becoming part of routine activities on some stations.

Soil conservation work continued on agricultural leases and experimental farms in higher rainfall areas. Higher costs in pastoral regions, however, limited activity to small-scale operations around homesteads, watering points and roads. Investigations continued into the possibility of large-scale.

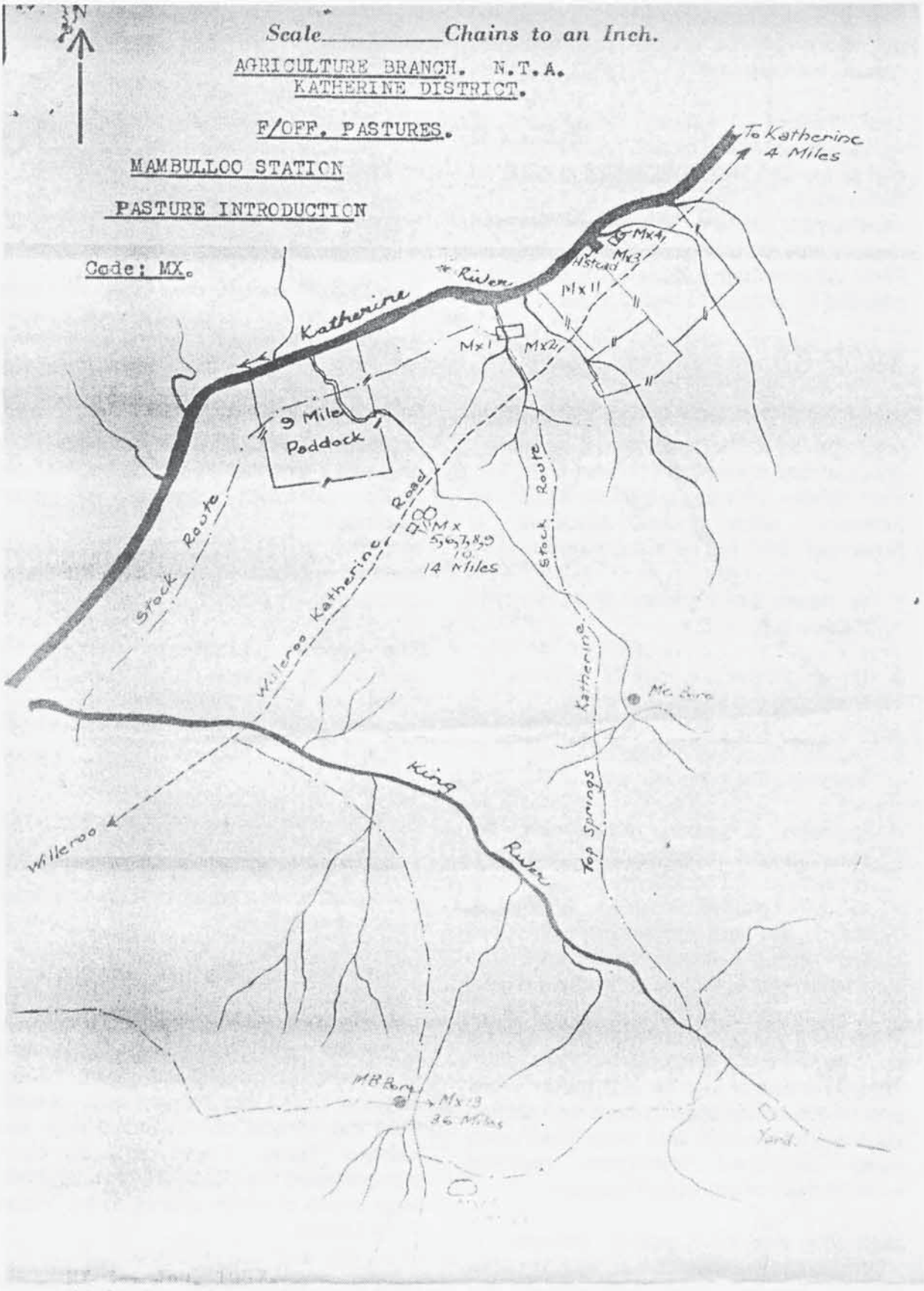


Figure 4 *Most experimental work on pasture introduction in 1959 to 1960 was undertaken at Manbulloo Station, just south of Katherine. This work had been established in 1957.*

erosion control measures in pastoral country by means of fire control and improved grazing management

The Western Australian Department of Agriculture (WADA) began regeneration of part of the Ord River catchment in 1960 on both sides of the NT/WA border. The development of the Ord River Scheme necessitated treatment of some of the Ord River catchment to reduce erosion and the potential for siltation of Lake Argyle.

1962-63

Extensive and increasing soil conservation problems led to the appointment of the first specialist soil conservation officer in the NT. Pieter Walter, who was previously a pastures extension officer, was appointed in November 1962. His initial tasks were:

- assessment of the extent and severity of erosion in the NT;
- the production of a map of the entire NT illustrating the above (Figure 5);
- detailed mapping of erosion in the most severely affected areas; and
- provision of general advice and the planning and implementation of erosion prevention and control measures. Areas to be covered included agricultural leases and land surrounding both public and private buildings, roads and other investments in remote parts of the NT.

In previous years, extension activities in the arid zone had concentrated on small irrigated areas of lucerne and fodder crops and on the reclamation of bare and eroded country. Reclamation was undertaken using newly developed techniques involving establishment of introduced species.

Emphasis was now turning, however, to improving the management of existing native pasture species. This field offered the greatest scope in preventing further deterioration of arid zone pastures and improving the ability of pastoral operations to withstand severe and often prolonged drought conditions.

The first rehabilitation demonstration area in the Territory was established on 40 ha of country just east of Centre Camp on VRD.

1963-64

New pasture species were introduced to dry land trials on 7 stations, but severe dry spells restricted germination. With no follow-up rain, the young seedlings died off quickly. Observations on these and earlier introduction or reclamation trials were hampered by drought. Nevertheless, buffel grass was demonstrated to be superior over native perennial grasses in general hardiness, drought resistance, time of response to small amounts of rain, level of seed production and ability to remain green during long dry periods.

The second rehabilitation demonstration area was established on VRD near Kidman Yards.

1964-65

A soil erosion survey of just under 13,000 km^2 in the Victoria River District, centring on VRD, was completed (Plate 3). Land units were mapped and erosion details were superimposed.

Outstanding progress was achieved in the regeneration of native vegetation and establishment of introduced species continued on the land reclamation demonstration on Victoria River frontage country. Useful results were also obtained from the second demonstration area near Kidman Yards. These projects clearly demonstrated the possibility of rehabilitating large areas of similar country in the Victoria River District.

Airstrip rehabilitation and pasture introduction trials commenced at Borroloola.

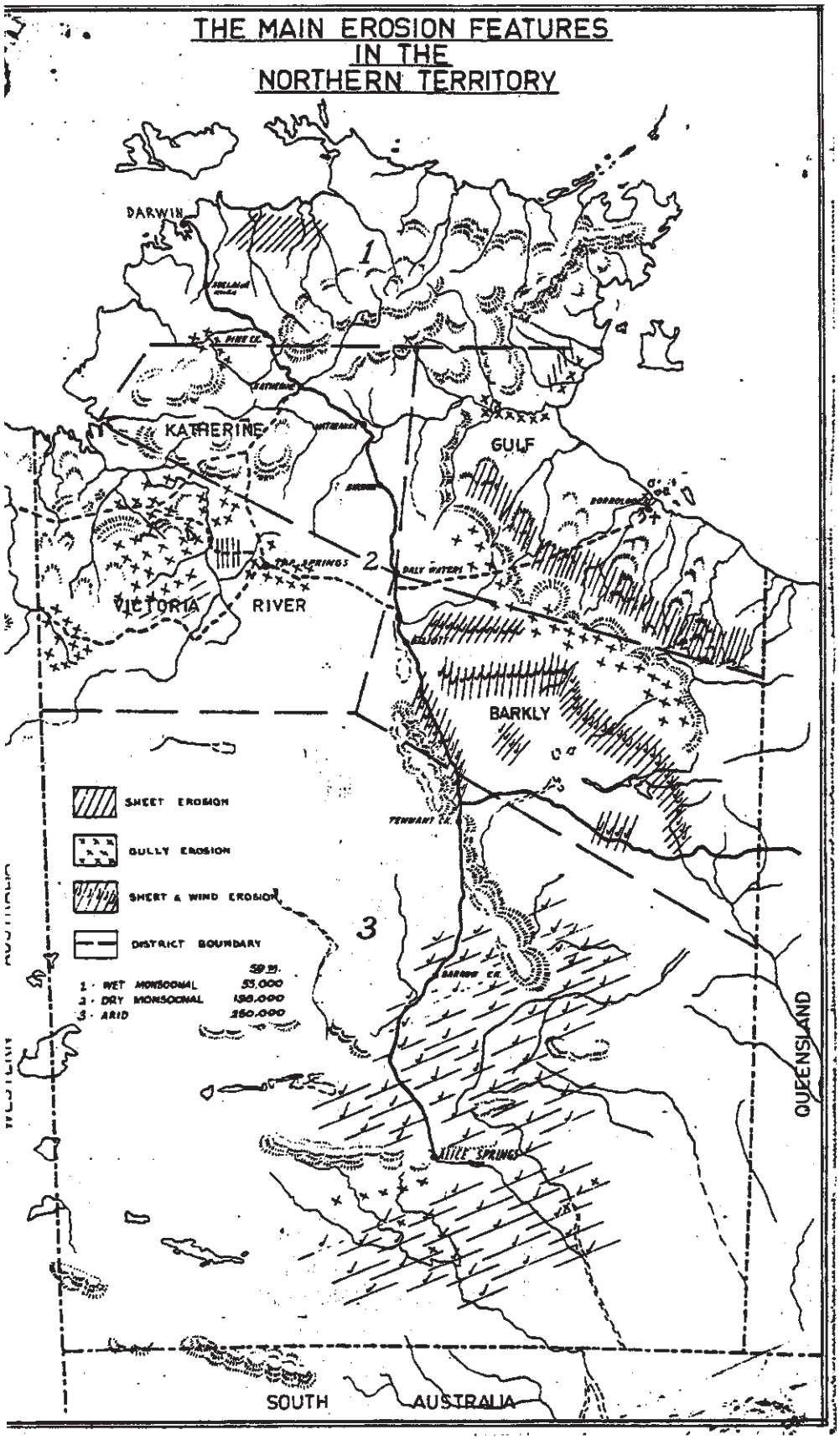


Figure 5 *The main erosion features of the Northern Territory as mapped by Pieter Walter in the early 1960's.*

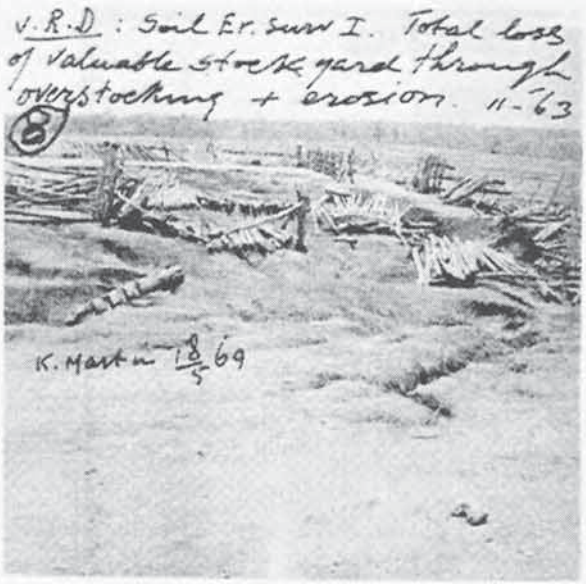


Plate 3 *A soil erosion survey on just under 13,000km^2 in the Victoria River District was completed between 1963 and 1964.*

1966-67

Another detailed soil erosion survey of just under 800 km^2 of grazing lands in the Victoria River District was completed. As a result, recommendations for improved resource conservation were made.

Investigations into methods of stabilising earth walls (turkey nests) by vegetative cover continued and illustrated the value of jute netting. Further pasture improvement trials were conducted in the district.

Three areas in the Victoria River District, totalling just over 400 ha, were treated using improved pasture and soil rehabilitation techniques. Germination was good and establishment encouraging. There were 4 major and 4 minor demonstration areas. Recovery of native pastures was excellent where demonstrations were fenced. Establishment of introduced species could be disappointing in the first year or two and most success was seen where follow-up soil conservation techniques were employed.

1967-68

Erosion surveying continued in the Victoria River District and included Kidman Springs (the Victoria River Research Station).

Investigations were made into the value of materials such as fibreglass blankets, jute netting and "Colas" bitumen to stabilise earth walls and discharge points. Jute netted earth walls were found to be successful where protected from stock.

Three areas in the district underwent pasture and soil rehabilitation work. Initial establishment was good.

Rehabilitation work commenced on Manbulloo.

1969

The Department of the Northern Territory (DONT) took over the NT side of the Ord Catchment Regeneration Project from WADA. Rosewood, Mistake Creek, Inverway and Waterloo pastoral leases lay within the catchment. Soil conservation and pasture rehabilitation work commenced on Montejinni Station.

1971-72

Recommendations on soil and land conservation measures for the NT were to be made by an appointed Soil Conservation Advisory Committee.

Conservation projects designed to halt erosion in the Ord River catchment and parts of the Daly River Basin were under way.

1972-73

In June 1972, a land conservation office opened in Katherine to cover work in the lower Daly Basin, southern Arnhem Land, Victoria River District and Ord River. Major activities were conservation planning in the Scott Creek/Willeroo cropping area, the

provision of roadside stabilisation advice, inspection of grazing license areas and the conduct of scientific studies in the Ord River catchment.

Mechanical rehabilitation had been carried out on over 4,000 ha of the Ord catchment. Most of this was essential follow-up to the original WA Government work. This program was due to be completed by 1977.

Other activities in the Ord catchment included:

- mustering;
- donkey eradication;
- the establishment of an experimental program to determine criteria for range assessment in the semi-arid tropics; and
- the development of a "control catchment" using gabion weirs and groynes to establish baseline run-off and sedimentation figures for use in evaluating reclamation work.

A dust mitigation project involving cultivation and re-seeding began in the Alice Springs airport vicinity in 1972. This was reported by Keetch (1981).

1974-77

A summary report of the first 4 years of Ord River catchment work was produced by Ian Melville (1974). Work in the catchment continued.

1977-78

As a reflection of depressed rural industries, there was little demand for soil conservation advice or planning.

Regeneration of the Ord River catchment continued with a further 7,300 ha receiving an initial treatment of ploughing, pitting and seeding with buffel grass. Above average rainfall for the year, combined with excellent seasonal distribution, resulted in rapid establishment of grass on treated areas. In April 1978, all land on the NT side of the catchment was declared an area of erosion hazard under the *Soil Conservation and Land Utilization Ordaninance*.

1978-79

A co-operative ploughing and seeding project was undertaken in areas of the Victoria River District using staff and equipment from Nelson Springs which was the NT base for the Ord Catchment Regeneration Project. Doug Blandford established exclosure sites for routine monitoring.

1979-80

Research into the effectiveness of Ord regeneration work continued with the assistance of a North Australian Research Unit grant. A preliminary analysis of results indicated that the program had been very effective in reducing erosion.

Nelson Springs was mustered to destock paddocks and routine monitoring of exclosures continued. John Leys, an Honours student from the University of New England, was sponsored to investigate the effectiveness of land treatments on erosion control.

More of the Alice Springs dust control project was sown and a trial of rangeland reclamation techniques was established on Idracowra Station. The latter involved seeding with WA and US buffel, tine pitting and opposed disc ploughing. The effectiveness of the trial was to be evaluated over time using indicators such as pit stability, effectiveness and persistence and seed germination.

1980-81

Stock exclosures were maintained in paddocks undergoing rehabilitation on Mistake Creek and Waterloo pastoral leases. Measurements of plant growth and projected foliage cover were carried out during the wet

season. The effect of maintaining paddocks stock-free was reflected in an improvement of vegetative cover outside the exclosures.

Revegetation of degraded lands continued at Alice Springs and Nelson Springs. Two thousand kilograms of buffel grass seed was harvested on Nelson Springs for use in further rehabilitation work.

1981-82

On Nelson Springs, maintenance of 400 km of fencing and cultivation and seeding of over 9,800 ha was to be completed by late 1982. On the Alice Springs dust control project, 400 kg of buffel seed was harvested for sowing on the dust control area and pastoral leases. At Owen Springs, for example, 350 ha were sown. The regeneration trial on Idracowra Station was re-evaluated and the low success rate attributed to poor 1979/80 and 1980/81 summer rains. Cost-sharing regeneration trials began on pastoral stations in the Alice Springs region. This included a total of 50 ha on 9 sites at Indiana and Woodgreen Stations.

1982-83

The NT side of the Ord Regeneration Project cultivation and seeding program, which commenced in 1964, was completed. The base camp at Nelson Springs was decommissioned and staff were relocated. Negotiations commenced on the proposal for a phased re-introduction of grazing under controlled conditions.

Activities in the Alice Springs region included the maintenance of the dust control project, re-seeding of 40 ha of scalds and old quarries and cost-sharing rangeland rehabilitation projects on Murray Downs, Alcoota, Muckety and Woodgreen Stations. Nine further requests were outstanding. On Alcoota 100 kg of Mitchell grass was harvested for use in the 1983/84 rehabilitation establishment trials.

1983-84

Reclamation work, pitter ploughing and seeding were undertaken in a cost-sharing arrangement on 3 Alice Springs properties. Trials on waterponding for para grass were conducted at Muckety.

1984-85

The Alice Springs rangeland reclamation program continued with advisory visits to 16 Alice Springs and Barkly properties. Five properties participated in cost-sharing programs. Maintenance of the dust control program was undertaken with re-seeding of 50 ha and construction of 2 waterponding banks.

A reconnaissance erosion survey of the Victoria River District was undertaken by Dick (RW) Condon.

1985-86

Interest in rangeland reclamation programs increased. In the Alice Springs region, 6 properties participated in cost-sharing rangeland reclamation projects and a further 12 indicated a desire to participate. Similar work took place on 2 Katherine region stations.

1986-87

Rangeland conservation work was carried out on Kidman Springs, involving gully control, reseeding, inspections and assessments, and revegetation trials.

1987-88

The Victoria River District Conservation Association (VRDCA) was formed. A Soil Conservation Officer from the Conservation Commission of the NT (CCNT) was stationed at Timber Creek (Darryl Hill). National Soil Conservation Program (NSCP) funding allowed for the appointment of another Soil Conservation Officer (Sally

Sullivan) to investigate techniques for land rehabilitation in the Victoria River District.

1988-89

The Centralian Land Management Association was formed in 1988 to cover 400,000km^2 of pastoral leases in Central Australia.

Rehabilitation trials in the Victoria River District commenced on VRD. Cost-sharing rangeland reclamation projects continued in the Alice Springs region with an increase in requests. NSCP funding was granted for investigation into the use of native and introduced pasture species for rangeland reclamation in the Barkly and Alice Springs regions.

A survey of landholder perceptions of land degradation in the Victoria River District was conducted by Dick Condon and a Land Conservation Strategy for the district was later produced by the CCNT (1990).

1989-90

Landcare NT, a committee comprised of mainly community representatives, was formed to provide direction for landcare in the NT.

A broad scale erosion survey of the western Victoria River District using Landsat imagery and ground truthing was commenced by Maria Kraatz and Phil McCleod of the CCNT. Rangeland reclamation research began on Camfield and Bullo River Stations involving species and implement trials (Plate 4). Waterponding trials on scalded areas on Kidman Springs were undertaken.

The Barkly and Gulf Landcare and Conservation Association formed in 1989.

Plate 4 *Rangeland reclamation trials funded by the CCNT and NSCP began at Bullo River Station in 1990.*

1990-91

Further rehabilitation work in the Victoria River District included cultivation and seeding on Riveren Station, an implement comparison demonstration and further waterponding on Kidman Springs and waterponding on Auvergne Station.

1991-92

Rangeland rehabilitation projects commenced in 1989/90 in the Victoria River District were largely completed and documented by 1992. Cost-sharing rangeland reclamation work continued on 6 Alice Springs stations and at Warburton, WA. The first "Landcare on Pastoral Land" competition was held in conjunction with the 1991 Katherine and District Show.

1992-93

A survey of landholder perceptions of land degradation in the Gulf district was conducted by Sarah Kerin of the CCNT. Rehabilitation activities on stations in the Alice Springs region and Victoria River District were becoming more widespread and landholder driven.

Native grass seed harvesting and revegetation trials were commenced by Mike Clark of Greening Australia NT (GANT) on the Barkly Tablelands.

1993-94

A Land Conservation Officer for the Gulf district (Sarah Kerin) was appointed by the CCNT.

1994-95

The Roper River Landcare Group formed. Four landholders from the group tried the "Crocodile", a tractor-pulled rehabilitation implement. The implement was shaped in the form of a roller with fins that left pits in the ground.

GANT's native grass seed trials were extended to the Victoria River District. Approximately 4 tonnes of seed had been collected by mid 1995, involving over 22 properties.

GANT and the VRDCA received NHT funding to employ a Rangelands Revegetation Coordinator. Between 1995 and 1997, native grass trials were undertaken on Moolooloo, Montejinni, Camfield, Rosewood, Kidman Springs, Humbert River and Mount Sandford.

1996

After a period of inactivity, the Barkly and Gulf Landcare and Conservation Association became incorporated as the Barkly Landcare and Conservation Association.

TIMELINE SUMMARY

Katherine Research Station established by the CSIRO	1948	
	1952	The Katherine Experimental Farm (now the NT Rural College site) established.
Overgrazing or pasture destruction thought to only become serious along stock routes and in areas burnt almost every year.	1957	Improved pastures sown on the KEF. Experimental work on pasture introduction began on many properties.
Requests for advice on erosion problems increased.	1958	Experimental soil conservation work conducted.
Inadequate watering facilities in pastoral areas thought to result in overgrazing around watering points in the dry season.	1959	
Large scale erosion control measures such as improved grazing management investigated. Regeneration of the Ord River catchment began.	1960	Pastures extension officers based in Darwin, Katherine and Alice Springs. Interest in pasture improvement increased markedly.
Improved management of existing native pastures considered to offer the greatest scope in preventing further deterioration of arid zone pastures.	1962	First specialist soil conservation officer appointed in the NT. The Territory's first rehabilitation demonstration area established near Centre Camp on VRD.
Buffel grass demonstrated to be superior to native perennial grasses in general hardiness and drought resistance etc.	1963	The second rehabilitation demonstration area established on VRD around Kidman Yards.
Soil conservation survey completed on just under 13,000 km^2 in the Victoria River District.	1964	
Demonstrations in the Victoria River District showed recovery of native pastures to be excellent in fenced areas.	1966	Another soil conservation survey undertaken in the Victoria River District. Recommendations for improved resource conservation made.
	1967	Three areas in the Victoria River District underwent pasture and soil rehabilitation work.
The DONT took over the NT side of the Ord Catchment Regeneration Project from WADA.	1969	
	1971	Recommendations for soil and land conservation measures to be made by a newly established Soil Conservation Advisory Committee.
A land conservation office opened in Katherine. A dust mitigation project around the Alice Springs airport began.	1972	Mechanical rehabilitation had been carried out on over 4,000 ha of the Ord catchment.

	1974	Summary report of the Ord catchment work produced
Low demand for soil conservation advice or planning thought to be a reflection of depressed rural industries.	1977	
	1978	Cooperative rehabilitation project undertaken in the Victoria River District using staff and equipment from the Ord catchment area.
Demonstration of rangeland reclamation techniques established on Idracowra Station.	1979	Research indicated that the Ord Catchment Regeneration Project had been effective in reducing erosion.
Stock exclosures on Mistake Creek used to demonstrate the effectiveness of excluding stock during rehabilitation.	1980	
	1981	Cost-sharing rangeland reclamation projects undertaken in the Alice Springs region.
NT side of the Ord Catchment Regeneration Project completed.	1982	
	1983	
Reconnaisance erosion survey undertaken in the Victoria River District.	1984	
	1985	Interest in rangeland reclamation programs increased in Central Australia.
Rangeland conservation work carried out on Kidman Springs.	1986	
	1987	The VRDCA formed. Techniques for land rehabilitation in the Victoria River District investigated.
The CLMA formed. Survey of landholder perceptions of land degradation in the Victoria River District conducted	1988	Projects examining the use of native and introduced pasture species for rangeland reclamation in the Barkly and Alice Springs regions commenced.
	1989	Landcare NT formed. The Barkly and Gulf Landcare and Conservation Association formed.
Rehabilitation activities in Alice Springs and the Victoria River District became more landholder driven.	1992	Survey of landholder perceptions of land degradation conducted in the Gulf district.
Land Conservation Officer for the Gulf district appointed.	1993	Native seed harvesting project began on the Barkly Tablelands.
	1994	The Roper River Landcare Group formed.
GANT's native seed harvesting project extended to the Victoria River District.	1995	A Rangeland Rehabilitation Coordinator started work in the Katherine area through a joint GANT/VRDCA project.
	1996	The Barkly and Gulf Landcare and Conservation Association became the Barkly Landcare and Conservation Association.

STATION BY STATION LAND REHABILITATION

Land rehabilitation activities are summarised for the following stations in the VRD, Katherine, Barkly and Gulf Districts. Argyle Station in Western Australia is included because of its proximity and relevance to work in the NT.

Station	District
Amanbidgi	VRD
Argyle	WA
Auvergne	VRD
Balbarini	Gulf
Barkly Tablelands	Barkly
Eva Downs	
Helen Springs	
Mallapunyah Springs	
Muckaty	
Philip Creek	
Tunumbirini	
Walhallow	
Bauhinia Downs	Gulf
Bing Bong	Gulf
Borroloola	Gulf
Bradshaw	VRD
Broadmere	Gulf
Bunda	VRD
Calvert Hills	Gulf
Camfield	VRD
Cattle Creek	VRD
Daly Waters	
Elsey	Katherine
Eva Valley	Katherine
Fitzroy	VRD
Goondooloo	Katherine

Station	District
Hogdson River	Gulf
Humbert River	VRD
Inverway	VRD
Katherine	Katherine
Kiana	Gulf
Kidman Springs	VRD
Killarney	VRD
Legune	VRD
Manbulloo	Katherine
Manyallaluk	Katherine
Mistake Creek	VRD
Montejinni	VRD
Mooloolooo	VRD
Mount Sanford	VRD
Newry	VRD
Ngukurr	Gulf
Riveren	VRD
Robinson River	Gulf
Roper Bar	Gulf
Rosewood	VRD
Scott Creek	VRD
Spirit Hills	VRD
Timber Creek	VRD
Victoria River Downs	VRD
Waterloo	VRD
Wave Hill	VRD
Wave Hill settlement	VRD

AMANBIDGI (Kildurk)

There is no record of rehabilitation activities on Amanbidgi Station. Some verano stylo was established by Reg Durack with a chisel plough on red soil, southwest of the homestead.

ARGYLE (1990-94)

Prior to 1990 Rod McColm, the manager of Argyle Station, had tried several techniques for rehabilitation. These included ripping, pitting, scarifying and small banks, all of which were seeded. Short-lived annuals responded, but perennial species did not establish.

REHABILITATION TRIALS

Steve Petty of WADA carried out some rehabilitation trials on Argyle in 1990/91. Treatments included:

- staggered opposed disc furrows with deep ripping on the contour (Plate 5);
- 2 sizes of scallop-shaped opposed disc runs to pond 2.5 and 5 cm of water (Plate 6); and
- deep ripping alone.

The cultivation was seeded with birdwood, Gayndah and WA buffel, and coated verano and amiga stylos. Kapok was also sown, of which half was treated by freezing. Three rates of fertiliser were applied but there was no significant response. Most of the introduced species established well.

Exclosures were fenced and establishment inside was considerably better than outside, illustrating the importance of protecting rehabilitation work from grazing.

In 1991, some strips were re-scarified (but not re-seeded) and kapok established in those lines. The positive effect of ponding in scalloped furrows was evident from the good establishment of pastures where water had been ponded. Establishment on ripping was poor, relative to that on opposed disc hills.

SIDELINE BORE

About 40 ha of sloping red soil in the Sideline Bore area was treated in December 1991. The area, bare with sheet erosion and terracing, was fenced and covered with staggered opposed disc furrows. Furrows 10 m long were placed along the contour and spaced 2 m apart. Silk sorghum, Gayndah buffel and birdwood were sown and no fertiliser was applied. Establishment was fair but disappointing in the first year and was noticeably better in the upslope runs which intercepted more runoff. In September 1992 after early storm rains, there was reshooting of old plants and some establishment of new plants. Establishment after the better 1992/93 wet season was very good.

OTHER AREAS

In December 1991, a small area of black soil in a homestead holding paddock was also chisel ploughed and sown to Gayndah buffel. Little establishment resulted.

In late November 1992, a further 65 ha was cultivated using the WA "Agrow" opposed disc plough. Another opposed disc plough was used on about 20 ha east of Sideline Bore with pitting between opposed disc runs. Buffel establishment on both the opposed disc runs and the pitting was fair after early rains in December, however, little birdwood established.

Pitting between opposed disc runs appeared to be effective for achieving better coverage of the treated area with planted pastures. Silk sorghum planted in 1991 was persisting in January 1994.

Plate 5

Rehabilitation trial on Argyle Station. Staggered opposed discing and deep ripping were carried out on the contour. Establishment following a poor wet season was better in the upslope furrows, which intercepted more runoff (18 September 1992).

Plate 6

Inside one of rehabilitation trial exclosures on Argyle Station. The background area was treated with scallop-shaped opposed disc runs. The bare area in the foreground was not treated. (18 September 1992).

AUVERGNE (1959-94)

Rehabilitation activities on Auvergne Station have been significant and largely centred around 2 periods from 1959 to 1965 and since 1990.

1959 - 1965

In 1959, pasture introduction and improvement were considered desirable for the station and imperative for the control of serious and active erosion. A small disc plough belonging to the station was used for initial pasture introduction work in a number of areas including Airstrip paddock, the levee west of the East Baines River, Horse and Stockyard Paddocks, a nursery area and an irrigation block. Other issues included a rubber bush infestation and the rehabilitation of Police Hole Paddock.

Airstrip Paddock

In this paddock south of the airstrip, just over 16 ha of bare red-brown earth were covered by parallel, alternate double and single ploughed strips spaced 4.5 m apart.

Levee west of the East Baines River

On the sloping levee to the west of the East Baines River, 2 ha were covered with contour strips spaced 3 m apart. Single ploughed checkerboard strips spaced at 6 m covered 2.4 ha on the western levee

and 2 ha on the eastern levee. Such strips are placed at right angles to each other. Double ploughed spirals with single ploughed cross-strips covered 0.2 ha of a bare and sheet eroded area.

Horse Paddock
In Horse Paddock, which was not grazed bare but carried only inferior annual species, just over 12 ha were covered with alternate double and single contour strips with 5.5 m spacing.

Stockyard Paddock
In Stockyard Paddock, 0.2 ha of bare ground was covered with alternate double and single contour strips at 2.7 m spacing.

Results of the rehabilitation work at these sites in Auvergne are not detailed. Stocking of these areas probably continued either then or in later years. These areas were bare in the late 1980's, leading to further rehabilitation attempts in 1991-92. Thick stands of buffel and kapok may remain from 1959 work in protected areas around the homestead.

Nursery area
A nursery area of 0.2 ha with rows 0.9 m apart was planted to 23 *Cenchrus* cultivars (buffel and birdwood), kapok, sabi grass, sorghum alum and bulrush millet. Townsville stylo was also planted between some rows.

Irrigation block
A block of 3 0.2 ha bays was ploughed and levelled with a grader ditcher. Sorghum alum and blue pea were sown at 4.5 kg/ha before the area was raked and fertilised with superphosphate at a rate of 125.4 kg/ha. The area was to be flooded with 100 mm of water per week for 3 weeks and then not irrigated until March. An area of 0.4 ha on the riverside of the paddock was ploughed for buffel propagation with single strips at 1.2 m spacing and with no irrigation.

In February 1960, Lloyd Fogarty the owner of Auvergne, reported: "On the buffel blocks, heavy storms closed all drains, knocked down the earth and one would hardly know it had been ploughed". Mr Fogarty was of the opinion that seed has to be sown when the ground is ploughed after good rain and when more rain is imminent (that is, in late December or January). The nursery area was a 100% failure as it couldn't be irrigated. Sorghum was over 2 m high, thick and seeding, while blue pea was present but wasn't particularly healthy. The sorghum was cut in March and regrowth occurred after a further 230 mm of rain. In September that year, sorghum alum was still growing well without water.

Townsville lucerne was sown in late January/early February of 1960. There was good germination, but it did not flower and burnt off. Kapok, birdwood, poona pea, sabi grass and bulrush millet were going well in trial plots. Rainfall received was:

- December 1959 381 mm;
- January 1960 38 mm;
- February 1960 203 mm; and
- March 1960 38 mm.

There were plans to sow buffel and Townsville lucerne in late 1961. Tea tree country was being cleared for Townsville lucerne.

In a letter dated September 28 1964, John Edey, the District Agronomist, indicated that the irrigation trials were showing promise. The species being tested included sudax (a sorghum-sudan grass hybrid), maize, bulrush millet, guinea grass and siratro.

Rubber bush and riverbank erosion
In May 1965, the Soil Conservation Officer, Pieter Walter, reported a rubber bush infestation and active riverbank erosion between the homestead and the main road crossing and from the homestead north.

Police Hole Paddock
In June 1965, the planting of buffel and birdwood in Police Hole Paddock on Newry was discussed, as the seed was available from the Native Welfare Department in Port Hedland. This work did not proceed. Rehabilitation in the area was again discussed in the early 1990's.

1990 - 1994

Rehabilitation work on Auvergne between 1990 and 1994 centred on pasture evaluation sites in King Billabong Paddock and a number of scald rehabilitation sites near Saddle Creek, the airstrip and the homestead.

Pasture evaluation sites
In January 1990, 2 pasture evaluation sites in King Billabong Paddock were established by Reg Andison of DPIF. One was on black soil in good condition and another on degraded red soil which was semi-scalded and covered by annual grasses. Four treatments on each soil type were:

- cultivated only;
- cultivated and fertilised;
- fertilised only; and
- not cultivated or fertilised (control).

A small offset disc plough was used for cultivation.

On the red soil, species planted were Indian couch (coated and uncoated), verano stylo, wynn cassia (coated and uncoated), Gayndah buffel, birdwood, seca stylo, gamba grass (coated), cavalcade and bundey centros, Glenn jointvetch and Kazungula setaria. The soil was low in phosphorus but other nutrients were adequate for pasture growth.

In early April, no germination of any species was recorded on the uncultivated treatments. Plant counts on cultivated treatments showed Indian couch to be most prominent, followed by Gayndah buffel, wynn cassia, bundey (centro), verano (stylo), cavalcade (centro), seca (stylo) and birdwood. In general, establishment was patchy, little seed was set and plants were small. In April 1991, some verano plants had perenniated and there were a few buffel plants and very scattered Indian couch. Wynn cassia plants were dead.

On the black soil, nothing established on the uncultivated plot. Indian couch, Biloela and Nunbank buffel, Glenn jointvetch, seca stylo, purple pigeon grass, creeping couches (Hatch and Bissett), and gamba grass were present on the cultivated plots. Indian couch and Biloela and Nunbank buffels were quite good, though grazed. The buffels had seeded and Glenn jointvetch established well in the hollows. Most of the other species were present but only as small or scattered plants.

In April 1991, Indian couch was spreading quite well by stolons and even better on the fertilised plot. Buffel and Glenn jointvetch plants were small but had increased in number, and a good stand of seca stylo had established.

Scald rehabilitation – Saddle Creek
In September 1990, a series of shallow waterponds were constructed with a grader on a scalded flat near Saddle Creek on the Victoria Highway (Plate 7). This work was undertaken by Sally Sullivan and Darryl Hill of the CCNT.

Many ponds were sown to improved pastures by drum seeding over grader rip-lines or opposed disc hills. The establishment of introduced species such as forage sorghum, buffel and sabi grass was very encouraging in the first year. Buffel grass and sabi have persisted well.

Self-sown native pasture species increased each year in the proportion of perennial species and in yield and cover (Plate 8). Native millet established dense swards in some ponds, accompanied by rice grass, wandarrie grass and lovegrass. Several breaches occurred during the first wet as a result of high intensity rainfall events and design shortcomings (Plate 9). Remedial earthworks and some repositioning of banks in 1991 were successful and few breaches occurred in the next few years.

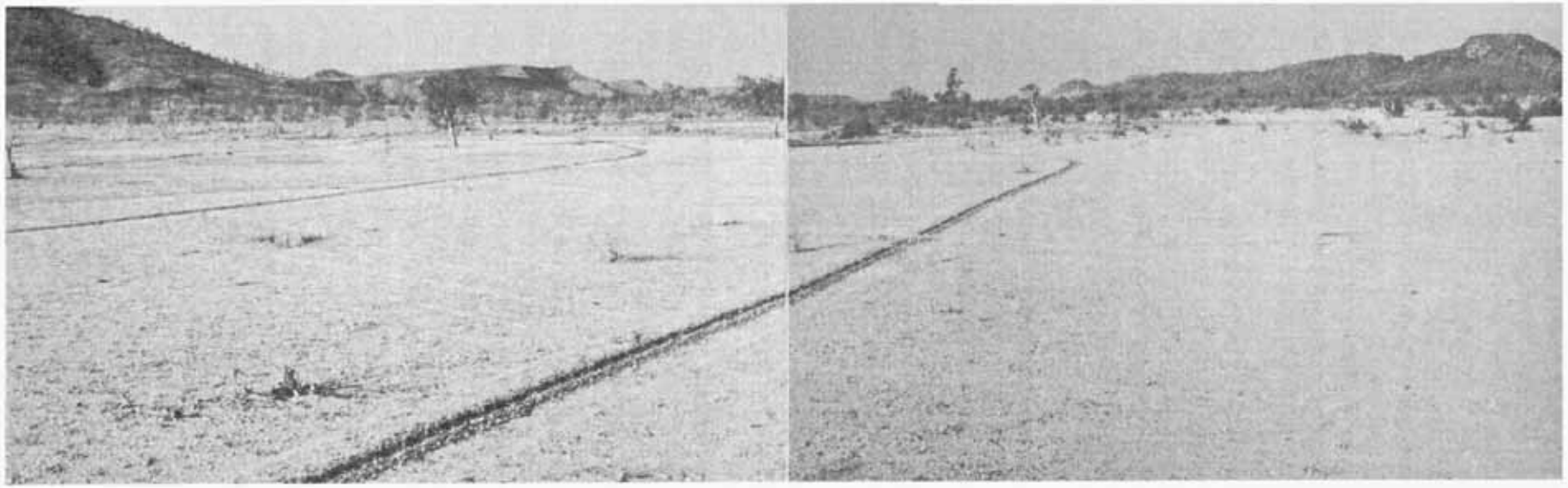


Plate 7 *Riplines mark planned ponding bank positions on the Saddle Creek scald, Auvergne Station (27 September 1990).*

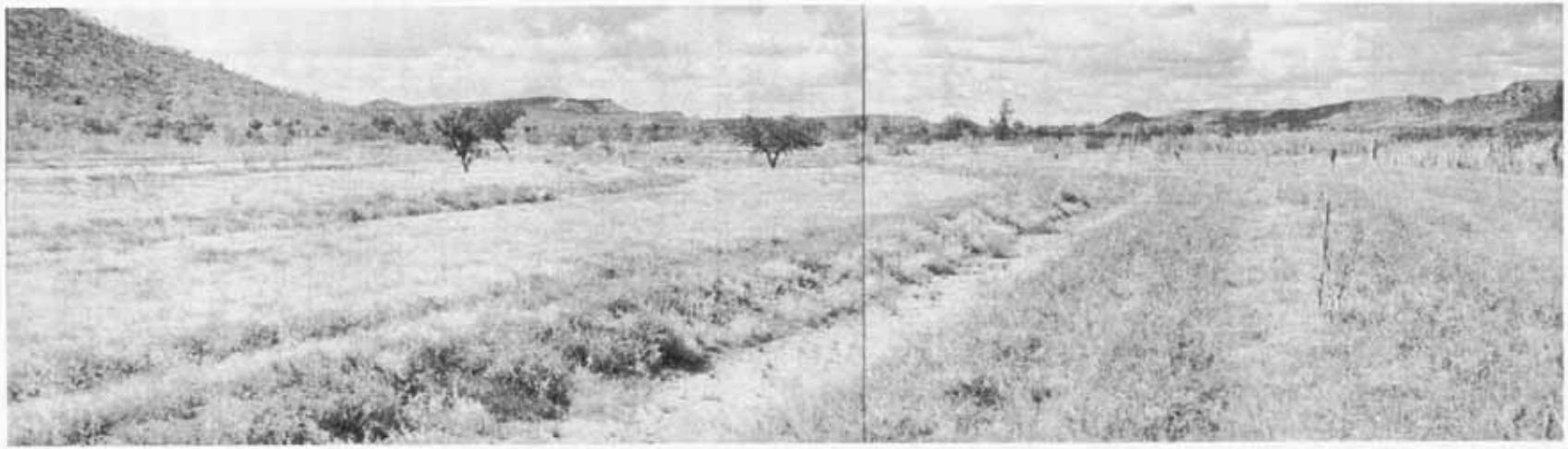


Plate 8 *The Saddle Creek scald in April 1991. Self-sown native pastures established in ripped ponds (left) and sabi grass (centre) and forage sorghum (right) grew well.*

A full report on the design, layout, construction and plantings on the Saddle Creek waterponding area was compiled (Sullivan 1992a).

Scald rehabilitation south of the airstrip
In mid to late December 1991, an opposed disc plough was used by Darryl Hill (CCNT) and Allan Andrews (station manager) to create staggered furrows on a small scalded red soil area about 1 km west of the homestead at the southern end of the airstrip. The cultivation was hand-sown to buffel, seca and verano stylo and silk sorghum. Several small areas around King Billabong were also ploughed and planted to Gayndah buffel. Little buffel established after a poor wet. Some red soil areas were too hard for the opposed disc plough to penetrate and a tined implement was suggested for use on those areas. On some heavier soil in No. 1 Paddock, a chisel plough was used and Glenn jointvetch planted. No establishment was observed.

Scald rehabilitation – homestead area
In late November 1992, further work was undertaken to suppress dust and rehabilitate bare, levee soils around the homestead.

A Paech pitter and check furrow machine were used to cultivate along the contour (Plate 10, cover plate). Buffel and birdwood grasses and Townsville stylo were planted by hand into furrows between November and December 1992. Establishment of all planted species was good, particularly in the furrows, while pitting between the furrows provided better overall cover (Plate 11, cover page). Between furrows where there was no cultivation, native couch and roly poly dominated.

The success of these works was demonstrated by a noticeable reduction in storm runoff in the furrowed area between the house and yards. Rain from almost any storm event would previously result in runoff. Following rehabilitation, runoff only left the area after 3 good storms.

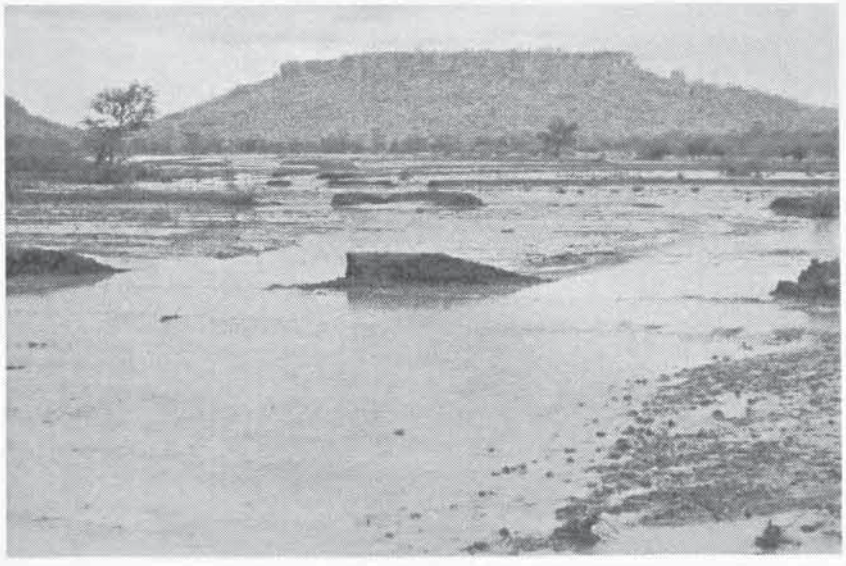


Plate 9
Breaches in ponding banks on the Saddle Creek scald resulted from high intensity rainfall and design flaws that were later rectified (10 December 1990).

Plate 10

A check furrow machine and pitter planter were used to cultivate bare levee soils near the Auvergne homestead (December 1992).

Plate 11

By February 1993, establishment of both sown and native pastures was good on the area shown earlier in Plate 10.

BALBIRINI

Considerable testing of verano and seca stylos was undertaken with varying success by Reg Andison of DPIF.

Poor results were obtained from buffel and para grass plantings.

BARKLY TABLELANDS (1993-94)

Native seed harvesting and revegetation activities were undertaken in the Barkly Tablelands by Mike Clark of GANT in 1993. Most work was done on Walhallow and Anthony Lagoon Stations on black soil country depleted of desirable perennial grasses.

Species harvested included barley, weeping (hoop) and bull Mitchell grasses, Flinders grass and native millet. A portable rotating brush harvester was towed by a 4WD vehicle. Seed collected was then used in revegetation trials.

Bull and weeping Mitchell tended to establish better than barley Mitchell. In 1996, conclusive results were not available regarding the effects of cultivation, threshing of seed and the rainfall events necessary for good establishment. At the time of publication, information from these trials is being reviewed.

EVA DOWNS 1994

Three revegetation sites were established. A 2 ha cultivated site around the homestead yard was sown to a bull and barley Mitchell mix at 20 kg/ha. This site was on a denuded black soil area where dust was a problem. Two other fenced sites of 1 and 2 ha were similarly sown on cracking clay soils. Encouraging numbers of seedlings were recorded, mainly on the downwind (north-westerly) side of the plots. Numbers of plants counted were a little less outside fenced plots than inside, which could be attributed to wind or stock.

HELEN SPRINGS 1994

A 2 ha site was fenced in a horse paddock on black soil and was cultivated and sown to barley Mitchell at 20 kg/ha. A 1 ha site in Home Paddock was also cultivated and sown to bull and barley Mitchell at 20 kg/ha.

MALLAPUNYAH 1993

Seed was hand sown at 20 kg/ha inside and outside an existing fenced area of about 40 m by 40 m. Results were promising after the following wet season with about 20% coverage of newly emerged seedlings. About 3 km from a bore, 4 runs 100 m apart and 1 km long were also sown.

MALLAPUNYAH 1994

Four 1 ha fenced trials were established on 4 sites. A mix of bull and barley Mitchell was sown on all sites. Cultivated and uncultivated plots were sown.

MUCKATY 1993

A large area of black soil near Government Bore was sown by the CCNT to barley Mitchell using an opposed disc plough.

MUCKATY 1994

In the same area as above, a 2 ha site was sown to a bull/barley Mitchell mix at 20 kg/ha and cultivated.

Further trials were set up in the VRD in 1995/96 on Mooloolloo, Montejinni, Camfield and Rosewood. (See individual station entries).

PHILLIP CREEK 1994

A revegetation area was established at Bullock Hole Holding Yard on a scalded site where a clay subsoil was exposed. The already fenced site was cultivated with a 3-tine chisel plough and sown to bull and barley Mitchell at 10 kg/ha. Little success was apparent in the first year. On a scalded Warrego Dam site, barley Mitchell and native millet were precision seeded with an opposed disc plough behind shallow waterponding banks. Establishment was very good, with 100% cover along plough lines. Native millet was dominant over barley Mitchell.

TANUMBIRINI 1994

A trial was established on a 2 ha black soil site of which half was fenced. A seed mix of bull, barley and weeping Mitchell grasses, Flinders grass and native panic was sown. Treatments were cultivated versus uncultivated, and threshed versus unthreshed seed.

WALHALLOW 1993

Bull and barley Mitchell were sown at 5 and 10 kg/ha on fenced 12 ha plots and unfenced 4 ha plots. All plots were further divided into 1 ha sections. Seed was sown straight onto the soil surface.

WALHALLOW 1994

Bull Mitchell and barley Mitchell were sown at 10 and 20 kg/ha on fenced 12 ha plots and unfenced 6 ha plots. Plots were further divided into 1 ha sections. Seed was sown straight onto the soil surface and cultivated with a chisel plough. Assessment after the first wet season showed promising results.

Bull and barley Mitchell were also sown in 1 km strips, 400 m apart, on a site 3 km from a bore.

Approximately 3 tonnes of native seed were harvested from Walhallow and Anthony Lagoon Stations.

BAUHINIA DOWNS (1992)

In 1992, a scalded area near the access road to the homestead was ripped with a dozer. Buffel grass was hand sown into riplines and stock were excluded. Buffel establishment, though a bit patchy, was very encouraging.

BING BONG (1965)

Some plots of buffel were planted in 1964/65 and were doing well in September 1965. No further details were located.

BORROLOOLA (1963-65)

Erosion around Borroloola and the airstrip was mapped in 1963. Erosion at the airstrip was active with some gullies progressing between 1 m and 2 m over the wet season. Tunnel erosion was also occurring. Goats were removed and small water mitigating and diversion earthworks were constructed.

A significant amount of work was also undertaken on pasture introduction blocks.

PASTURE INTRODUCTION BLOCKS

Pasture introduction blocks were established in 1963/64 on sandy and clay soils by Pieter Walter.

On the sandy block, only sabi grass establishment was considered to be satisfactory in July 1964, however, a few introduced pastures had established on areas of tall kerosene grass (Plate 12). It was thought that this grass had established after the original vegetation deteriorated along old roads and with grazing and fire impacts. Where the sandy block was better grassed, introduced species established well. The seed viability of the sabi grass was very good and poorer than expected establishment was therefore attributed to the sowing method. Birdwood establishment

was poor and dried off indicating dry soil. Some Townsville lucerne established but it was generally poor. Other species tested were makarikari panic, guinea grass, molasses grass, birdwood and WA buffel. Bulrush millet and sorghum alum establishment was fair. A recommendation was made to furrow plough some of the area, oversow with guar, buffel and sabi and fertilise half the area sowed.

In July of the following year, sabi was the best of 3 main introduced species, having withstood 2 fires and heavy grazing by stock and marsupials. Townsville lucerne establishment was generally unsatisfactory. Some birdwood was present, but was being dug out by marsupials.

In July 1964, native species present on the clay block were golden beard grass, silky browntop and bluegrass (Plate13). Cultivation didn't eliminate the golden beard grass. Townsville lucerne was well established in a small area, while phasey bean was poorly established. Insignificant annual grasses and weeds were thriving on ploughed areas.

In the strip trial introduction area, only Townsville lucerne establishment was fair. A little phasey bean had also established, but nothing else was successful. A recommendation was made to re-plough the area, introduce sorghum alum and blue pea (no guar), and introduce stylo in strips to a non-cultivated area.

By July 1965, Townsville lucerne was well developed on the clay block in one area where there was either less intense fire or superphosphate, instead of rock phosphate, applied. Severe fires destroyed the golden beard grass. Golden beard grass drainage plains were known for poor quality pastures and the introduction of Townsville lucerne into swards was considered desirable.

Rehabilitation of denuded cracking clay soils was considered to be extremely difficult.

Plate 12 *Sabi grass planted on a sandy block at Borroloola (4 August 1964).*

Plate 13 *Ploughed (left of man) and unploughed strips of introduced pastures on a clay block at Borroloola (4 August 1964).*

BRADSHAW (1993-95)

In January 1994, an hydraulic "Kimseed" pitter plough was used by the station owner (Ian McBean) to sow buffel grass onto patches of scalded river levee (Plate 14). No fertiliser was applied. While results were a bit disappointing after a fair wet season, some establishment did occur and cattle were hanging on the area in May. As the buffel seed was fairly fresh, germination rates may have improved in time. Buffel plants were small and establishment was patchy. Native annuals were more prevalent on the area after treatment than before.

Plate 14 *Ian, Kay and Sam McBean on pitted levee soils on Bradshaw Station (7 July 1994).*

BROADMERE (1991-93)

In December 1991, pasture introduction trials were undertaken by Reg Andison of DPIF on black and sandy soils. The black soils near the laneway were planted in strips of seca stylo and Biloela buffel and fertilised with superphosphate at a rate of 75 kg/ha.

Establishment was not encouraging after a poor wet season. Seca mostly occurred around depressions, while buffel was sparse. After being locked up for the 1992/93 wet season, there was little change in the introduced pastures. The recovery of native species, however, such as native millet, golden beard grass, Flinders grass, silky browntop and bluegrass was dramatic.

This showed that spelling black soil pastures may be more effective than introducing improved pasture species.

At the time of planting, the sandy soil site near the main yards only supported insubstantial native annual species. USA, Cloncurry and Gayndah buffels and Indian couch were planted at 3 kg/ha, while amiga and verano stylos were planted at 6 kg/ha. Single superphosphate was applied at 150 kg/ha.

Results were generally poor. Stylo establishment was fair with about twice as many verano plants as amiga plants. Only a few buffel plants were found overall. Tickweed, native *Sida* species, rattlepod, native couch and comet grass established. There was much evidence of marsupial and/or grasshopper activity on the area. After a reasonable 1992/93 wet season, native pasture presence was fair and again there had been significant marsupial and/or grasshopper activity. Stylos had persisted and improved and buffel was still very sparse.

BULLO RIVER (1989-91)

Rehabilitation work on Bullo River Station centred on rehabilitation of bare country in Bulrush and Bush Paddocks and saltbush trials.

MECHANICAL REHABILITATION

In late 1989, 2 plough types were used by Sally Sullivan and Darryl Hill of the CCNT to rehabilitate bare areas in Bulrush and Bush Paddocks. A chisel plough and offset discs were used to introduce 8 pasture species on 2 soil types (Plate 15).

The grassland site in Bulrush Paddock had alkaline, yellow massive earths with little ground cover, a dominance of introduced sida species and an active erosion terrace at the interface between grassland and saline breakaways.

The woodland site in Bush Paddock had a pale, loam levee soil, was also dominated by sida, and had some evidence of sheet erosion. Trial areas were fenced. Species sown included Gayndah and Nunbank buffel, Indian and creeping couch, gamba and sabi grass, verano stylo and calopo.

The establishment of introduced pasture species was encouraging. **From a land conservation perspective, however, the dramatic recovery of native grasses with the exclusion of stock was the most significant result.** In the Bulrush exclosure, kangaroo grass was dominant, while native millet and bluegrass species also established. In the Bush Paddock exclosure, native couch was most common, while black speargrass and golden beard grass were also present.

The best establishment in the Bulrush exclosure was buffel grasses on disc cultivation. Patchy but promising verano establishment also occurred along with kangaroo grass and other native grass species (Plate 16). Some unsown introduced legumes also established including phasey bean, centro and buffalo clover. Buffels and sabi were the most promising introduced species in Bush Paddock, with slightly better results on chisel ploughing than discing (Plate 17).

SALTBUSH TRIALS

As Bullo River has some saline, unproductive areas, the suitability of old man saltbush was investigated. Thirty-two seedlings were planted in December 1989 in another exclosure in Bulrush Paddock, on and behind graded windrows (Plate 18). By April 1990, 10 remained alive, mostly upslope of the windrows. These plants did not receive the prescribed post-planting waterings and by April 1991, only 2 saltbushes remained. While 1 of these seemed well established and vigorous, neither of the plants survived.

Sullivan (1991b) provides a full report on the rehabilitation trials summarised above.

Plate 15

Offset and chisel ploughing in the Bush Paddock pasture rehabilitation site, Bullo River (13 December 1989).

Plate 16

Patches of verano established well in the Bulrush Paddock exclosure on Bullo River, along with kangaroo grass and other native pasture species (16 April, 1991).

Plate 17

Buffel predominated over native species and sida on chisel ploughing in Bush Paddock, Bullo River (16 April 1991).

Plate 18

One of the saltbushes planted in Bulrush Paddock on Bullo River (16 April 1991).

BUNDA (1988-1994)

Rehabilitation has been undertaken in a number of areas on Bunda Station mainly in small paddocks near the homestead. This work has involved chisel ploughing and seeding of red soils, the use of saltbush seed and "speedlings", and water ponding on both black and red soils.

HOMESTEAD AREA - RED SOILS

1988
In December 1988, purple pigeon grass, birdwood and Gayndah buffel were sown at about 2 kg/ha each in a bare red soil paddock near the homestead. A 4-tine chisel plough and approximately 50 kg/ha of N:P:K (15:13:10) fertiliser was broadcast. This work was undertaken by Kit Jolley and Darryl Hill of the CCNT and station owner Reg Underwood. Establishment of all species, especially birdwood and buffel, was encouraging.

Buffel was also sown in Horse Paddock and established well. The first 30 m of seed was coated, while the remainder was uncoated. Purple pigeon grass planted in a corner of a saltbush trial area did not establish.

1990/91
Sabi grass, buffel and silk sorghum were planted with a chisel plough. Following a fairly favourable wet season, establishment was very impressive and 700 bales of hay were cut from the area. An area of irrigated para grass and old man saltbush was similarly impressive in April 1991.

In November 1991, an opposed disc plough was used for regeneration of some bare red soil patches.

1991/92
Another area of bare red soil was planted by Reg Underwood with a chisel plough to sabi and buffel and very good establishment resulted (Plate 19).

1993
A bare red soil area near the airstrip was chisel ploughed in January and seeded with buffel and sabi grass, and stylos. Establishment of introduced pastures and recovery of native pastures on some heavier soil patches were good.

Establishment was so successful following the wet season that stud cattle on the pastures were well prepared for sales and shows. Grazed plants were still vigorous and green in June as a result of late rains. The season was above average in terms of both the rainfall received and duration of the growing season. After a couple of years seca stylo dominated this area, possibly as a result of grazing strategies.

SALTBUSH TRIALS

In 1989, old man saltbush failed to establish from seed. Transplants (or "speedlings") were then planted at numerous turkey nests and also nearer the homestead where some were irrigated. "Gro cones" were used on half of the 40 plants in a trial area. Stock did not show much interest in the plants on a pond bank near the homestead.

WATERPONDING

Shallow waterponds were constructed with a grader on degraded black soil areas northwest of the homestead and on a sloping scalded area of bare and possibly sodic red gravelly clay. Opposed disc runs were not sown. Native annuals established on the hills but bare ground remained between. Several introduced pasture grasses and legumes including lablab, amiga and verano stylos, cavalcade centro, silk sorghum and sabi grass, were sown behind the ponding banks with a chisel plough.

After the wet season, little had established on ponded black soils apart from native couch which might have established anyway. There was a small area of Rhodes grass and some patches of sabi and silk sorghum. Several ponds breached due to tunnelling which is not uncommon for small

earthworks on black soil. These black soil banks were levelled out in December 1993.

On a scalded area northwest of the homestead many ponds were breached. This was a result of the large catchment and insufficient protection of banks from above, where water concentrated down an old road.

Despite breaches, the positive effect of ponding on vegetation was obvious (Plate 20). Growth of native grasses and some introduced pastures was quite good in ponding channels and where ponding depth was greatest. Germination of bundey and cavalcade centros was good in the channels, however plants were small and had not seeded and regeneration was unlikely the following year. Establishment of other planted species was poor or patchy, however by 1995, a very good stand of seca stylo had established.

Native annuals established on unseeded opposed disc hills above the ponding area. In time, verano became well established and the pasture cover across the area was good. There was no growth on chisel ploughed scald areas above, between, or below the ponds, except where water had ponded. Before the next wet, the ponds were repaired and more diversion banks were constructed across the old road above. The top bank breached again in the 1992/93 wet but other banks held up well. Another diversion bank was constructed in December 1993 and more opposed discing carried out.

Plate 19

Buffel established well on chisel ploughing in bare red soil paddocks near the Bunda homestead (4 March 1992).

Plate 20

The beneficial effect of waterponding can be seen on this scalded area on Bunda Station (4 March 1992).

CALVERT HILLS (1960)

Prior to 1960, kapok, birdwood, WA buffel and sabi grass were introduced to 4 sites on Calvert Hills Station. Pieter Walter noted these as Station Lookout Rock, Kangaroo Creek land, Black Rock land and Gorge Desert Rocks. In September 1961, the occasional buffel clump was evident.

CAMFIELD (1989-94)

In the 1989/90 wet season, land rehabilitation trials were established on 4 "degraded" areas by the CCNT (Sally Sullivan and Darryl Hill). These were:

- the black cracking clay soil in Dry Paddock;
- a mixture of black cracking clay and red non-cracking clays in Wyalong Paddock;
- a watersheeted calcareous earth in Trap Paddock; and
- a rocky red earth in Sisters Paddock.

The areas in Trap and Sisters Paddocks supported very little vegetation while the black soil sites only supported native annuals and weeds.

Species planted were Gayndah buffel, Nunbank buffel, purple pigeon grass, creeping couch, Indian couch, gamba grass, verano stylo and silk sorghum. In Sisters and Trap Paddocks, the opposed disc plough, pitter planter and chisel plough were used. Only the opposed disc and chisel ploughs were used in Wyalong and Dry Paddocks.

The 1989/90 wet was very poor. Germination only occurred in the top furrow of chisel plough runs which intercepted what little run-off occurred.

DRY PADDOCK

In Dry Paddock, the occasional Gayndah and Nunbank buffel plant established on each cultivation type. After a better 1990/91 wet season, native pastures, especially Flinders grass, recovered well (Plates 21, 22). This indicated that mechanical rehabilitation of this black cracking clay was not necessary in this case, and that the use of native pasture seed should be considered if seed stocks are depleted. The exclosure fence in Dry Paddock was pulled down when the highway was fenced in 1992.

WYALONG PADDOCK

In Wyalong paddock, some Nunbank and Gayndah buffel established in upslope chisel plough runs and a little on opposed disc hills (Plate 23). These plants were still persisting in 1992. Verano increased slightly but was generally poor. Native pasture growth was also poor on this site, even after 3 years spelling and a couple of quite good wet seasons. Little fenceline effect was evident (Plate 24).

In 1992, barley Mitchell grass and native millet were also planted into the Wyalong exclosure with no initial success. By 1994, however, Mitchell Grass was evident.

SISTERS PADDOCK

Nunbank buffel was not planted in this paddock. Some Gayndah buffel and a few verano plants established on all plough types and persisted. No purple pigeon grass or gamba grass established. Some creeping couch established on pitter and opposed disc ploughing but did not persist. Indian couch also established in 1990/91 but did not persist (Plates 25, 26, 27).

By mid-1993, some buffel and wiregrass had died. The cultivated runs were still very evident, supporting some limestone grass and wiregrass, as well as native couch, fairy grass and tickweed, the main species surrounding the site. Native annuals were

more widespread after the good 1990/91 wet and the cultivated strips less prominent.

In January 1992, verano and amiga stylos were planted on the Sisters Bore road by Reg Andison of DPIF. Seed was spread onto cultivated and uncultivated strips with 25 kg/ha of superphosphate. A poor wet season yielded no establishment.

TRAP PADDOCK

A few Gayndah and Nunbank buffel plants were found on each cultivation type, but establishment of introduced species was otherwise poor on all plough types (Plates 28, 29, 30). A couple of "dead" grass butts regenerated and were identified as bull Mitchell grass.

In late 1990, much of the area on the Trap Paddock flat was pitted and sown to a shotgun mix of introduced species. After a reasonable wet season in which the area was flooded, a good cover of native annuals established. Few of the sown species established.

In 1992, annuals were only established in the bottom of pits, reflecting the poor wet. In 1993,however, there was a good cover of native annuals across the area. Mitchell grass increased significantly both inside and outside the trial exclosure.

A full report on the rehabilitation trials summarised above can be found in Sullivan (1991c).

FARQUARSONS PADDOCK (1992)

In December 1992, Darryl Hill of the CCNT used a chisel plough to reintroduce pasture onto weed infested black soils in the northeast corner of Farquarsons Paddock.

Several pasture species were hand-planted including silk sorghum, amiga stylo, native millet and Mitchell grass. Despite quite a good season, few introduced species established apart from silk sorghum. Ploughing had an obvious effect in encouraging native couch and reducing weed growth. It was considered that the growing season may have been insufficient for the germination and survival of Mitchell grass, given that Mitchell grass planted in a similar fashion had germinated on Mount Sanford which had more rain and a longer growing season.

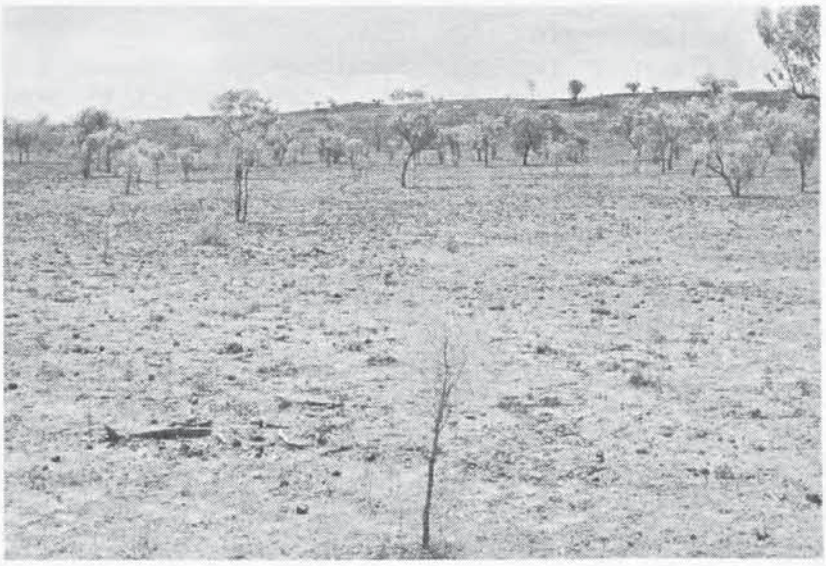


Plate 21

The site of a rehabilitation trial on black, cracking clay soils in Dry Paddock, Camfield Station (4 January 1990).

Plate 22

The Dry Paddock rehabilitation site showed significant natural regeneration after the 1990/91 wet season (18 April 1991).

Plate 23

Opposed discing on the Wyalong Paddock trial site on Camfield Station (4 January 1990).

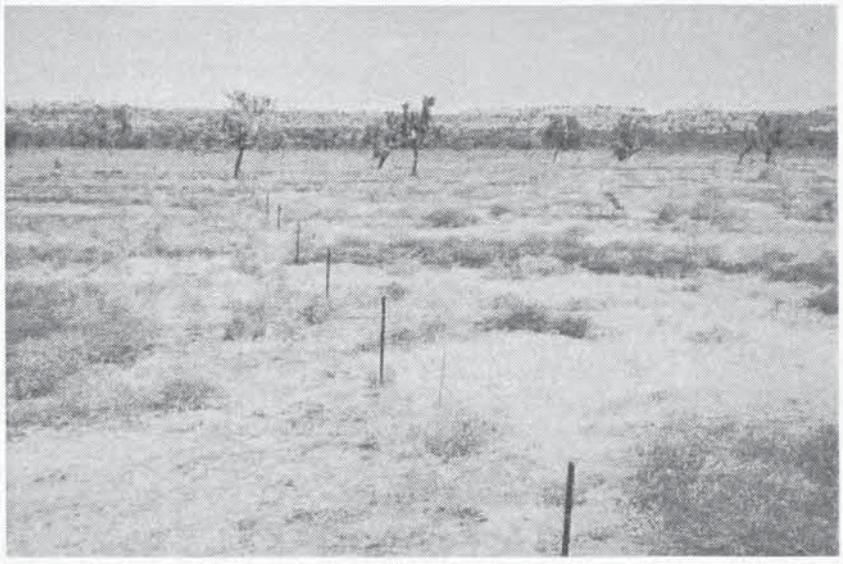


Plate 24

Sown pasture establishment was poor and native pasture recovery slow in the Wyalong exclosure, Camfield Station (18 April 1991).

Plate 25

Rehabilitation trial site in Sisters Paddock, Camfield Station (5 January 1990).

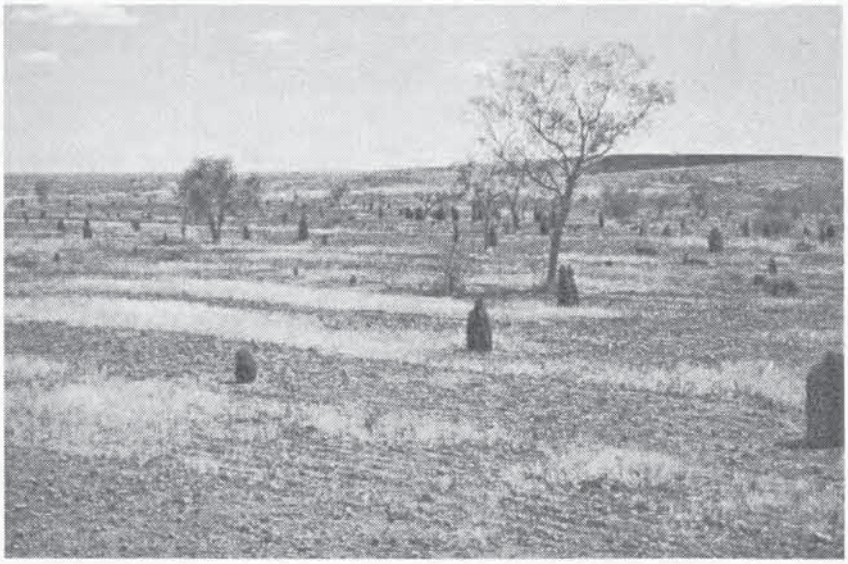


Plate 26

Sown pasture establishment in Sisters Paddock was sparse, with mainly insubstantial native annuals growing on plough lines (April 1990).

Plate 27

Native annual pastures dominating the Sisters Paddock exclosure on Camfield were still thickest in the cultivated lines.

Plate 28

Chisel ploughing on the calcareous earth in Trap Paddock, Camfield Station (3 January 1990).

Plate 29

Only native annuals emerged in Trap Paddock after the poor 1989/90 wet season and then only on cultivated areas (April 1990).

Plate 30

By April 1991, native annual grass cover was improving in Trap Paddock, Camfield..

CATTLE CREEK (1991-93)

In November 1991, about 7.5 ha of regeneration work was carried out above a badly eroded area near Kelman's Bore. This work was conducted by Kit Jolley and Darryl Hill of the CCNT.

The area was lightly fertilised and an opposed disc plough used to make staggered furrows and sow a shotgun mix of Gayndah buffel, sabi grass, verano stylo and Rhodes grass. Two other short runs were hand-seeded with only native millet and barley Mitchell grass. The area was fenced on the contour and a very poor wet season followed.

By early April 1992, no introduced pasture species (except perhaps some Rhodes grass) could be identified. Several barley Mitchell plants had established and seeded. Some forage sorghum was planted near the homestead and germinated well, but did not receive follow-up rain and subsequently burnt off.

COOLIBAH (1964)

Prior to 1964, some areas were planted with buffel and guar. Grazing, poor quality seed and a poor season were considered to be the main factors leading to an unsuccessful result.

In 1964, regeneration work was proposed in an area near the homestead. Townsville lucerne was considered suitable for this area, for small paddocks near the yards and for other red levee soils. No further record of this work was found.

DALY WATERS (1991)

A bare and watersheeted area at the Daly Waters rodeo ground was ploughed with offset discs and planted in January 1991. Cultivation was only shallow and 6 kg/ha each of USA buffel, Cloncurry buffel and Indian couch were planted.

By May 1991, sparse native annuals had established, particularly on the cultivated area. No USA buffel established, and only a few Cloncurry buffel and Indian couch plants were found.

In 1992 and 1993, the occasional Cloncurry buffel plant remained and a patch of Indian couch appeared to be diminishing. By March 1995, however, this patch was persisting and had possibly increased.

ELSEY (1968)

In January 1968, 162 ha of land near the homestead were cleared for cultivation. It was noted that the riverbanks were in need of reclamation. Buffel seed was provided to experiment with, and to demonstrate the soil conservation value of the grass on riverbanks.

No record of results was found, however, buffel is now well established on the banks and levee of the Roper River in the vicinity of the homestead.

EVA VALLEY

(see Manyalluluk)

FITZROY (1987-88)

In December 1987, a small area was planted to buffel grass with a chisel plough. Establishment was fair.

GOONDOOLOO

In 1990/91 Kit Jolley and Darryl Hill of the CCNT conducted rehabilitation work on a gravelly area near the airstrip and towards the river from the homestead. A chisel plough was used to sow a mixture of buffel, birdwood and purple pigeon grasses and verano and seca stylos. Some buffel, birdwood and verano established, though the results were not spectacular. The positive effect of cultivation on vegetative cover was very evident (Plate 31).

Small earthworks were also constructed around active gully heads in black soil just east of the homestead and sabi grass was planted upslope. This met with limited success.

Plate 31 *Some buffel, birdwood and verano established on chisel ploughing near the airstrip on Goondooloo (5 July 1991).*

HODGSON RIVER (1987-93)

In 1987, an opposed disc plough was used on some bare red slopes northeast of the airstrip. Success was limited. Closer adherence to the contour and the use of staggered and discontinuous runs may have improved the outcome.

In about 1983 contour banks had been constructed on another area of red soil nearer the airstrip to prevent sheet and rill erosion. While successful in preventing erosion, the banks robbed the area of water and bare areas developed. Weeds and annual grasses dominated growth along the banks and some rilling was evident where the banks discharged. A dam was constructed in 1992 which spills out near the area.

In January 1993, a system of water spreading banks or "gap spreaders" was constructed to catch and spread water across the red soil area nearest the airstrip, enabling the re-establishment of pasture without causing erosion. The banks were constructed along the contour with a front-end tractor blade which pushed from below. Gaps in the banks were left to enable water to go through, run along the bottom channel of the bank and then spill evenly out across the area to the next bank (Plate 32).

Areas between banks were chisel ploughed and fertilised and buffel, sabi grass, Indian couch and stylo were broadcast.

The banks were successful in safely controlling water. Pasture establishment was quite good and of significant grazing value. The season was above average and the earthworks withstood some early high intensity storms.

Plate 32 *Gap spreader banks were constructed to safely spread runoff and prevent erosion of a sloping bare area on Hodgson River Station (12 January 1993).*

HUMBERT RIVER (1994)

In 1942 Charlie Schultz planted birdwood seed from Ayr in Queensland in the vegetable garden on Humbert River Station. Within 2 years the grass had taken over. Charlie harvested the seed and planted about a hectare around the run, and considered that "it was a marvellous grass for erosion" (NT Records Service 226 TS 481). He later planted buffel grass from near Toowoomba and fertilised it with superphosphate. This established quite well, especially where the seed had been sown on ploughed earth and thick stands persist.

In December 1994, an opposed disc plough was used by Darryl Hill of the CCNT to sow buffel grass on bare red soil in the Williams Dam area. A small exclosure was erected in the same area, and an opposed disc plough and check furrow plough used to plant buffel grass, birdwood and silk sorghum. Establishment was very good and exclosures were covered almost completely by buffel and birdwood.

Native grass seed trials were conducted by Frank Marshall of GANT in 1996.

INVERWAY (1967)

In August 1967, the Maud Plain drainage area was seriously eroded as a result of drought, a good wet season with high intensity rainfall, and stock pressures. Gullying was present but not very active owing to a fairly stable sub-soil. The affected area was fenced and subsequent recovery of the grass plains was impressive. Pieter Walter considered that further "runoff damage" was unlikely to occur for at least another 2 years.

KATHERINE AREA (1963-)

Numerous soil conservation and land rehabilitation works have been undertaken on freehold blocks in the Katherine area. Rehabilitation of eroding river levees has been of concern since at least the early 1960's and small earthworks and pasture introductions have been used in rehabilitation attempts.

For example in 1963/64, short furrows of substantial cross-section were made to establish strips of pasture on degraded and eroding levee country on Morrison's Farm. In 1967, these were considered successful, however, gullies remained active as stock continued to water at the river.

KIANA (1989-93)

Pasture introduction trials were commenced on Kiana Station in 1989 and 1991 by Reg Andison of DPIF.

1989 PASTURE TRIALS

Pasture introduction trials were planted on 2 sites on Kiana Station in December 1989. Treatments were:

- cultivated only;
- cultivated and fertilised;
- fertilised only; and
- not cultivated or fertilised (control).

The red soil site near the laneway was very bare and hard with a sandy veneer. The black soil site in House Paddock was also bare except for native *Sida* stems and native couch. Jumbo and silk sorghums, cavalcade and bundey centros, gamba grass (coated and uncoated), Indian couch (coated and uncoated), verano and seca stylos, Gayndah buffel, birdwood and wynn cassia were planted.

In May 1990, after a poor wet season, only wynn cassia was found on the red soil site. Competition from native annuals, such as armgrass, button grass, flannel weed and native *Sida* species may have been significant on cultivated areas. On the black soil, there was only sparse native couch and native *Sida* species. No introduced pasture species established over the following wet.

1991 PASTURE TRIALS

In January 1991, a sandy soil site near the main yards was planted to amiga, seca and verano stylos, USA, Cloncurry and Gayndah buffels and Indian couch. Seed was sown at a rate of 1 kg/ha each and was then fertilised with 50 kg/ha superphosphate and 25 kg/ha muriate of potash. A shotgun mix of Indian couch, Cloncurry buffel, seca and amiga stylos at 2 kg/ha each, was also planted.

In May 1991, despite having been heavily grazed to less than 5 cm high, establishment of all introduced species was fair to good. Verano and amiga stylos and Gayndah buffel were the best established. In May 1993, after being locked up for the wet, a good stand of pasture had established in the shotgun mix area and 4 t/ha of dry matter was measured. About half of this was introduced species, particularly Cloncurry buffel and amiga and seca stylos.

KIDMAN SPRINGS (1968-1992)

Kidman Springs has operated as the Victoria River Research Station since 1968. Between 1968 and 1992 several rehabilitation attempts were made using various techniques and with varying degrees of success. Soil conservation work was conducted in the homestead area in 1968 and early scald reclamation work was done in Bull, Acacia and Supplejack Paddocks in 1972. Other later work included:

- scald reclamation trials using cultivation between 1981 and 1990;
- waterponding trials for scald reclamation between 1985 and 1990;
- a plough type comparison in 1991; and
- pasture introduction trials on degraded red soils in 1990/91.

Native grass revegetation trials were conducted by GANT in 1996.

HOMESTEAD AREA (1968)

In 1968 soil conservation works were undertaken by Pieter Walter with the establishment of the homestead area. Contour furrows were constructed with a grader at about 11 m intervals around the hill with stops at every 10 to 20 metres. The areas between the banks were ripped by the grader to increase water absorption. These areas were then seeded with buffel, kapok and guar. A diversion bank was also constructed above the airstrip.

Buffel and kapok have persisted and spread around the homestead area.

BULL, ACACIA & SUPPLEJACK PADDOCKS (1972)

In about 1972, the manager Brian Hill used a Paech pitter plough on bare red soils in Bull Paddock in the vicinity of the 1991 implement trial described later.

Buffel and birdwood were sown after cultivation with a drum seeder. Establishment of introduced grasses was only fair to poor, while native grasses (in particular limestone grass) established very well. At the same time, pitting was done on the Acacia Paddock scald, which was not successful, and on the softer scalded areas in Supplejack Paddock where buffel, birdwood and native grasses did establish.

SCALD RECLAMATION BY CULTIVATION (1981 – 1990)

In 1981/82, a Paech pitter plough was used by Max Saunders of the DPP to create staggered pits along the contour on the Acacia Paddock scald. The cultivation was seeded with Gayndah buffel, birdwood and verano stylo using a drum seeder.

The pitter had difficulty penetrating to maximum depth on the hard scald. The cultivation was washed flat and did not hold sufficient water long enough for germination (Saunders 1985).

A 4-tine chisel plough was also used by Max Saunders in 1981 to cultivate and seed some areas. Again, sufficient penetration of the tines could not be achieved and the cultivation was flattened by rainfall. Some rilling occurred along the furrows as water concentrated in areas where the contour was not precisely followed.

In 1984/85, an opposed disc plough was used to create a series of staggered hills. Again, as for the other plough types, little germination resulted.

In 1985, the Tom Stockwell of the DPP and Malcolm Letts of the CCNT undertook a study to compare destocking with various methods of revegetation. This study

focused on scalded areas in Acacia Paddock and Supplejack Paddock on the Coolibah fenceline.

Gayndah buffel, birdwood, Bowen bluegrass and verano stylo were sown onto opposed disc and chisel plough cultivation and fertilised with superphosphate. Observations were that the *Cenchrus* species (buffel and birdwood) were better suited to the conditions on the scald than Bowen bluegrass. Although establishment of *Cenchrus* species on chisel ploughing was good, plant vigour was greater on opposed disc cultivation. Both cultivation types had levelled out after the wet season.

Pasture establishment on the cultivation was not successful in the long term. Cultivation marks were still discernible in 1989, however no vegetation was present, except where seed had washed or blown into drainage lines. In February 1990, black wattle and silk sorghum were planted into riplines on the Supplejack scald with some gypsum application. Riplines quickly sealed over and establishment was very poor.

In late 1990, the soft loamy scald in Guttapercha Paddock along Sundown Creek was completely cultivated. The pitter plough was used over much of the area with some opposed discing on harder and steeper areas. Buffel grass germinated in the bottom of the pits, but did not establish well enough to persist. Limestone grass and fairy grass established on the cultivated area. Buffel grass established quite well on some of the opposed discing in the first year, but gradually died out as the hills subsided (Plate 33).

WATERPONDING FOR SCALD RECLAMATION

1985-1987

Max Saunders noted that runoff occurred on scalds after only a few millimetres of rain and that water only penetrated to a depth of 3 to 4 mm. To trap and hold rainfall, he constructed a series of circular and semi-circular banks with an opposed disc plough in 1984/85 (Figure 6). For circular ponds, areas of 6 m diameter were ripped to a depth of 0.5 m with a D4 bulldozer. A bank about 0.3 m high was constructed around the ripped area with the opposed disc plough. Semi-circular ponds were similarly constructed (Plate 34). Ponds were seeded with buffels, birdwood and verano stylo.

Some ponds overflowed and breached and pieces of polythene pipe were later inserted in the walls to prevent overtopping. Germination of planted pastures (especially buffel and verano) in the pond areas was very encouraging and vegetative cover good. Some native pastures also germinated.

In 1985, 2 larger circles approximately 10 m in diameter were constructed with a grader. The area inside one of the circles was ripped with a D4 dozer. Further grader-built circular ponds were constructed in 1986 and 1987. The response of native couch and feathertop was good in all grader-built circles, especially on the downslope side. A spiral bank was constructed in 1987 with an opposed disc plough. The plough had difficulty digging in and the cultivation and native pasture establishment were short-lived.

While ponds showed the most promise of all rehabilitation techniques on the scalded areas, pasture was not spreading from these areas. Runoff and wind erosion were causing the ponds' gradual decline. The life of the ponds may have been prolonged if construction had started at the top of the catchment. By 1989, some ponds (both circular and semi-circular) had almost disappeared and only dead buffel stalks remained.

1989

In late 1989, 43 U-shaped banks were constructed to cover 15 ha of the Acacia Paddock scald (Figure 6, Plate 35). The banks were surveyed and constructed in accordance with specifications developed in western NSW. Banks were designed to hold a maximum depth of 10 cm of water before overflowing around each end into ponds below. Banks were 0.45 m high and 1.8 m wide at the base and were constructed with a 130G grader.

Numerous pasture grass and legume species were planted in ponded areas to gauge their ability to withstand the ponding environment. Species included 3 buffels, birdwood, Indian couch, creeping bluegrass, sabi, gamba and Rhodes grass, silk sorghum, verano and seca stylos and bundey and cavalcade centros. The effect of fertiliser and gypsum applications was also investigated. Species were planted into riplines and onto opposed disc hills.

The most dramatic effect of ponding was the establishment of self-sown native pastures, particularly where pond areas were ripped (Plates 36, 37). This was possible through significant improvements in soil moisture and water infiltration rates. Soil chemistry also improved under ponding with decreases in salinity and sodicity (Sullivan 1992c).

The most promising improved pasture species were buffels (Plate 38), silk sorghum, sabi grass, Rhodes grass and Indian couch. Indian couch and Rhodes grass were the only species to spread much from sown rows. Rhodes grass and para grass were the only introduced species to establish well in bank channels.

The relative suitability of sowing pastures into opposed disc hills or riplines could not be determined. Opposed disc hills may have been advantageous in wetter years given their greater height. It was determined that the use of gypsum was not warranted and that fertiliser greatly improved establishment of most pastures.

Bank maintenance was necessary after a couple of wet seasons.

1990

A further 15 ha of scald was waterponded in Acacia Paddock and whole ponds were planted to buffel grasses, forage sorghum hybrids, sabi grass and Indian couch. Some banks were also constructed in the stocked Boab Paddock. These held up surprisingly well to the stock traffic, breaching only after 3 wet seasons. The stocking pressure did, however, inhibit the establishment of native pastures in the ponds. The opposed disc plough was tested for bank construction on softer scalded areas but could not raise a bank high enough to be effective in long term.

Very good stands of improved pastures were established in the ponds on Two Tree Flat and showed potential for recovering the costs of ponding if used for hay, seed production, or stocking (Plates 39 – 40).

Full reports on the survey, construction, pastures, treatments, results and costs associated with the waterponding work in 1989 and 1990 can be found in Sullivan (1992c, d).

PLOUGH TYPE COMPARISON (1991)

A bare red soil site in Bull Paddock was used by Sally Sullivan to test the effectiveness of various plough types for establishment of improved pastures in late January 1991. Small plots were cultivated with an:

- opposed disc plough;
- pitter planter;
- offset disc plough; and
- one-way disc plough.

Buffel grass, seca stylo and superphosphate were broadcast across the plots.

Timely rainfall and good growing conditions resulted in good germination of buffel and a little seca on all plots. By mid to late March, the vigour and growth of plants differed greatly between plough types (Sullivan 1992e)(Table 1, Plates 41 – 46).

Table 1 *Relationship between plough types and plant vigour in the Kidman Springs implement comparison trial (1991).*

Implement	Buffel condition
Opposed disc	Largest and most vigorous plants in trial.
Pitter planter	Grew and seeded well, but not as vigorously as above.
One way disc plough	Plants slightly better than in the offset disc area.

Several hectares near the comparison site were direct seeded with the pitter planter. Establishment was very poor, especially compared to the plot where seed had been broadcast. This was probably because the pitter planter placed seed at the bottom of the pits where it may have drowned or been prevented from emerging by surface sealing. Broadcasting seed appeared to be a better option.

Sullivan (1992e) provides a full report on the plough type comparison.

PASTURE INTRODUCTION TRIALS (1990/91)

In 1990/91, Aidan Kerr of CSIRO established a pasture introduction trial on a degraded calcareous red soil site in Box Paddock. The main objective was to identify grasses able to regenerate degraded areas or stabilise areas threatened with degradation.

A small area was fenced, and pastures were planted inside and outside on rotary hoe cultivation. Sabi grass, Bowen and Medway varieties of Indian couch, black speargrass, and amiga, verano and seca stylos were planted. Treatments applied were with and without:

- grazing;
- stylos (verano, amiga and seca); and
- fertiliser (single superphosphate).

Germination of most species was quite good. Under drier conditions, however, only those plants in drainage lines or deposition zones survived. Sabi grass, then buffel, were the most productive species, while few stylos grew. Fertiliser improved grass survival, seed panicle production, ground cover and yields. Only small patches of sabi and buffel regenerated in the second wet season.

Continuous grazing outside the fenced area eventually resulted in the demise of all surviving plants, including speargrass.

David Tongway of CSIRO Canberra visited the site in August 1992 and noted that the soil lacked structural integrity and its surface was slaked. Rain infiltration would therefore have been poor and runoff high. He suggested that cultivation with a rotary hoe might have exacerbated this problem.

More information on this work can be found in Kerr (1992) and Kerr and Jones (Draft).

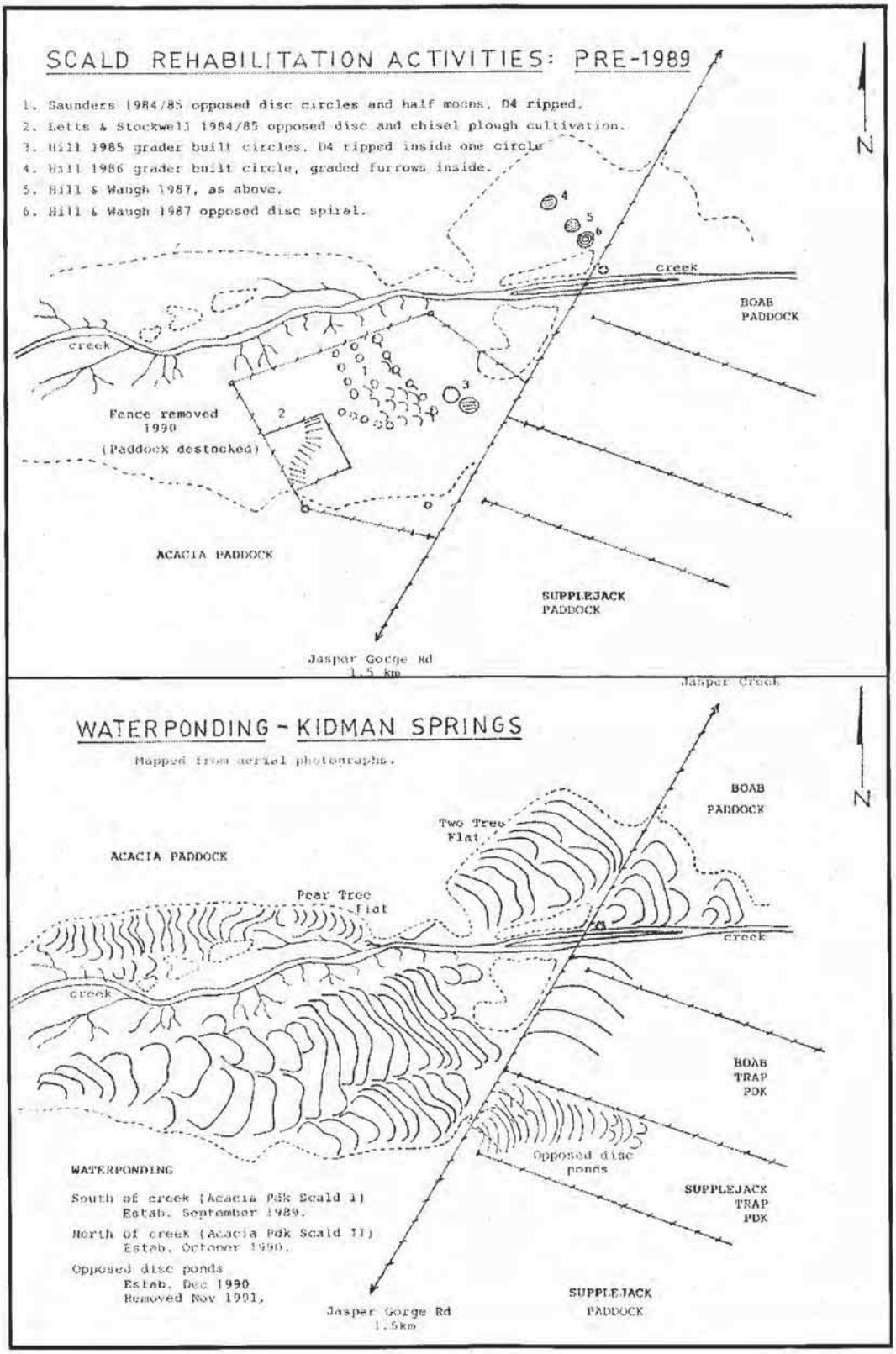


Figure 6 *The location of scald reclamation activities prior to 1989 and waterponding activities between 1989 and 1991 on Kidman Springs (approximate scale 1:11,000).*

Plate 33

Buffel grass established on opposed discing on a soft loamy scald in Guttapercha Paddock, Kidman Springs. Hills and plants did not, however, persist beyond a few years (May 1991).

Plate 34

After 8 years, chisel plough marks could still be seen on the Acacia Paddock scald at Kidman Springs. Semi-circular opposed disc plough banks succeeded in supporting some buffel grass, but gradually disappeared (September 1989).

Plate 35

Riplines marking proposed ponding banks on Acacia Paddock scald, Kidman Springs (7 September 1989).

Plate 36

Self-sown native pastures flourished in ripped ponds on the Acacia Paddock scald, Kidman Springs (18 March, 1991).

Plate 37

An aerial view of the Acacia Paddock scald at Kidman Springs demonstrates the improvement in vegetative cover under waterponding (14 March 1990)

Plate 38

Nunbank buffel on opposed disc hills on the first ponding area in Acacia Paddock, Kidman Springs (14 January 1990).

Plate 39

An aerial view of dense stands of buffel, sabi grass and silk and jumbo sorghums illustrates an opportunity for cost recovery on ponded areas at Kidman Springs (February/March 1991).

Plate 40

Sabi and buffel grass (foreground) and jumbo sorghum (background) on the Two Tree Flat ponding area, Kidman Springs (February/March 1991).

Plate 41

Opposed disc cultivation in the plough type comparison in Bull Paddock, Kidman Springs (29 January 1991).

Plate 42

Pitter planter cultivation in Bull Paddock, Kidman Springs (29 January 1991).

Plate 43

Offset disc cultivation in Bull Paddock, Kidman Springs (29 January 1991).

Plate 44

Opposed disc hills provided the best environment for vigorous buffel growth in the plough type comparison at Kidman Springs (11 March 1991).

Plate 45

Many buffel plants in the pitted plot shown in Plate 42 seeded and persisted (11 March 1991).

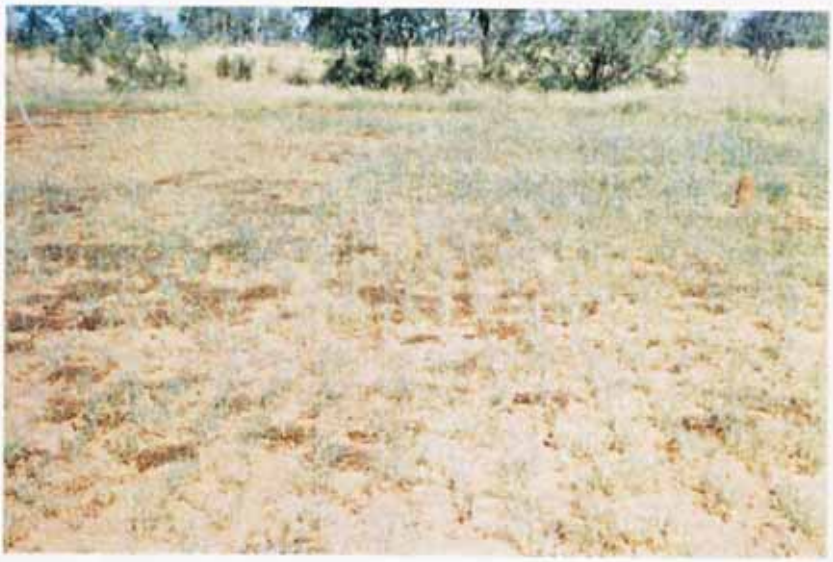


Plate 46

Small, stressed buffel plants grew on the offset disc cultivation (Plate 43) and did not persist (11 March 1991).

KILDURK (see Amanbidgi)

KILLARNEY (1988)

In December 1988, some rehabilitation work was undertaken by Darryl Hill of the CCNT on bare red soils in small paddocks near the homestead. Purple pigeon grass, birdwood and Gayndah buffel were sown with a 4-tine chisel plough and fertilised with N:P:K 15:13:10 at 50 kg/ha. No purple pigeon grass and only small areas of buffel established. Poor results were attributed to little rainfall and fresh seed which has a lower germination rate than if it has been stored for a year.

LEGUNE

In about 1990 Bevan Gitcham erected 2 50 m by 50 m exclosures and planted para grass and buffel on disc harrow cultivation.

Requests for government assistance to rehabilitate saltwater intruded country were followed up after 1996.

MANBULLOO (1968-1992)

Major rehabilitation work on Manbulloo Station was undertaken in 1968 on Horse Paddock. Some pasture introduction strips were established earlier in 1957-59 but details were not located (Figure 4).

Rehabilitation of bare areas commenced in 1992 using fencing and a rotational grazing regime.

HORSE PADDOCK - LAND REHABILITATION AND EROSION CONTROL (1968)

In January 1968, Pieter Walter proposed that just over 200 ha of bare and eroding country in Horse Paddock be treated over 3 years. Erosion on the 1 to 2 % slope was thought to date back to the early war years or before. Runoff areas were bare with little soil and calcareous rock was surfacing in places. Gullies resulting from stock and vehicle tracks were cutting upslope on lower areas, reaching bedrock at a depth of 60 to 90 cm.

Small 0.5 m high absorption banks with 0.3 m furrow banks in between were constructed on gently sloping areas. Breaks in furrows were recommended at every 30 m. Diversion banks 0.6 m high were constructed above the gullies, with space in between for follow up work that was planned for at least another 2 years. WA buffel and Townsville lucerne were planted. Sabi grass was unavailable. Seed and 125 kg/ha of superphosphate was hand broadcast from a vehicle.

A D4 dozer with a blade and ripper was used for bank construction. As a wheel tractor and 3-disc plough could not produce the required furrows, angle blading with the dozer was considered. This too proved unsatisfactory and a ripper was to be used in the second season.

In the first year, 5.5 km of absorption banks, 3.7 km of furrows and 0.7 km of diversion banks were proposed. By May 1968, only half the program had been completed as a result of a late start, and a proposal was made to continue the program in the following wet season.

Those structures which had been completed in the first season handled the runoff well and this was particularly the case with the absorption banks. There was little evidence, however, of seed introduced on any earth structures. The importance of introducing seed onto freshly opened earth was subsequently recognised. Buffel grass was recommended for planting on

absorption furrows, however Townsville lucerne was considered too risky on a reclamation project. This was possibly because its germination and perenniation were not as reliable as buffel grass.

Maps of the project showing sheet and gully erosion and the areas treated were drafted but were not found in records.

SCALD RECLAMATION (1992)

In 1992, the station manager Harry McNought used a combination of fencing and rotational grazing practices to regenerate pastures and allow recovery of bare, red soil areas.

Some pasture improvement had been undertaken in the past on some of the area and continuous utilisation had resulted in deterioration of both native and improved pastures. Ten paddock areas were fenced and a rotational grazing regime planned to allow pasture recovery. The length of the grazing and spelling times took account of the length of the growing season during the wet and the limited potential for growth or recovery during the latter half of the dry season.

The recovery of native perennial and improved pastures over the wet was substantial compared to areas which carried cattle continuously. This was more attributed to wet season spelling than to rotational grazing regimes. Rotational **spelling** was practised in larger paddocks with similarly encouraging results.

MANYALLALUK (1993)

(formerly Eva Valley)

In December 1993, several pasture species were planted near the station access road by Reg Andison of DPIF. The plots were in burnt spinifex country on poor siliceous and earthy sands. Superphosphate was applied at planting on some of the plots at 200 kg/ha. A further 150 kg/ha of urea was added in February 1994. Some plots were also cultivated.

Seca and amiga stylo establishments were poor. Wynn cassia establishment was poor on uncultivated plots, but good on cultivated plots. Cloncurry, Gayndah and USA buffel were only sown on cultivated plots and established well. Establishment of buffel was also better on fertilised plots. Post-establishment performance was very poor and the addition of urea had no effect.

MISTAKE CREEK (1969-93)

WADA undertook regeneration work in the Ord River catchment from the early 1960's. This was to reduce erosion and the potential for accelerated siltation of Lake Argyle, which had been constructed to service the Ord River Irrigation Scheme. The catchment included Mistake Creek Station in the Northern Territory.

Rehabilitation work on these stations was taken over from WADA by DONT in 1969 and regeneration techniques already developed were largely adopted (Plates 47 – 56). About 8,900 ha on Mistake Creek were rehabilitated between 1969 and 1973. By the completion of the project, an area in the order of 10,000 ha had been rehabilitated. Cultivation techniques were described in reviews of the project undertaken by Ian Melville in 1974 and Doug Blandford in 1979. An early map of areas treated in Morton's Paddock is shown in Figure 7, while the total area treated on Mistake Creek up to 1982 is shown in Figure 8.

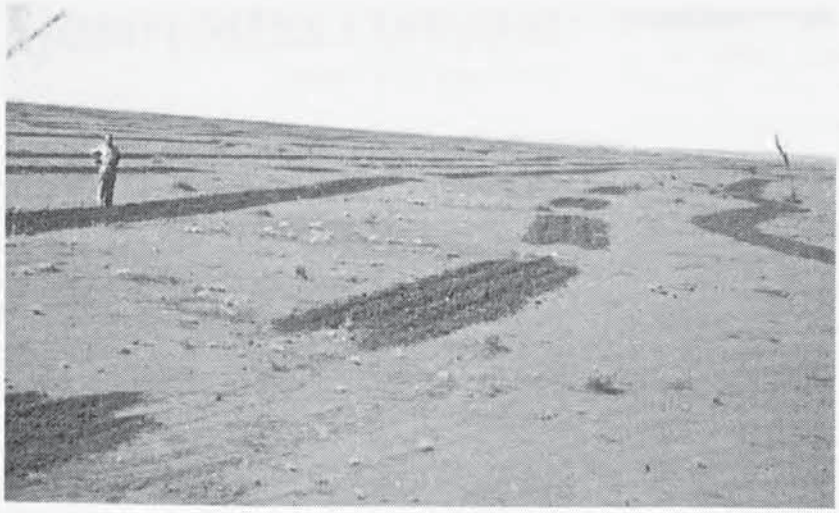


Plate 47

Cultivation on Mistake Creek in the late 1960's.

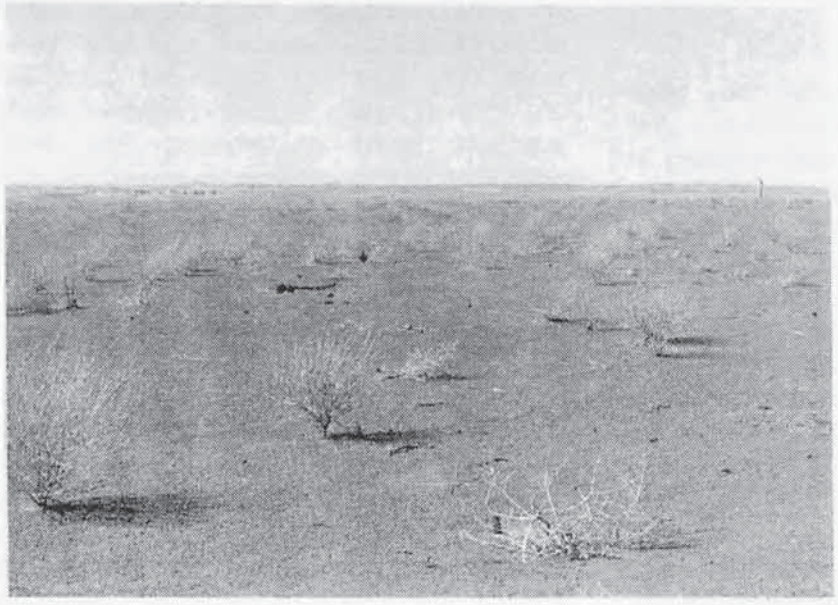


Plate 48

Kapok bush and roly poly on land to be rehabilitated on Mistake Creek in the early 1970's.

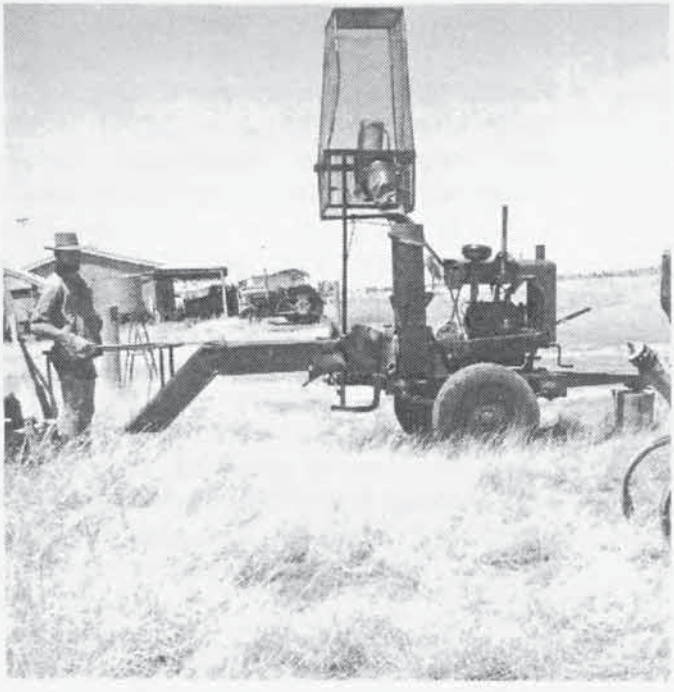


Plate 49

A kapok harvester used in the Ord Catchment Regeneration Project (1969).

Plate 50

Contour lines for cultivation were marked with a hose level and single tine (circa *1968).*

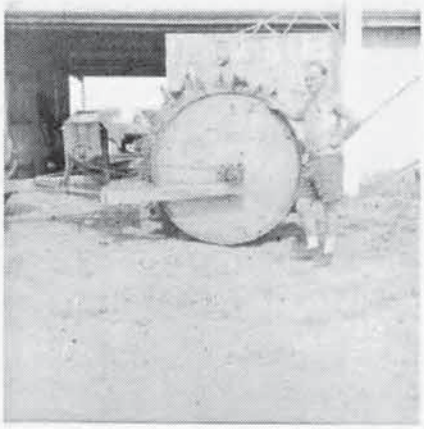


Plate 51

Numerous machines were tested for rehabilitation potential, including this spiked roller (Ord River Research Station, WA, 1968).

Plate 52

The Holt Clod Breaker or 'sod buster' was used unsuccessfully in the hard fingers of gullies (early 1960's).

Plate 53

Buffel seed was sown with an axle driven seedbox and chisel plough (circa *1968).*

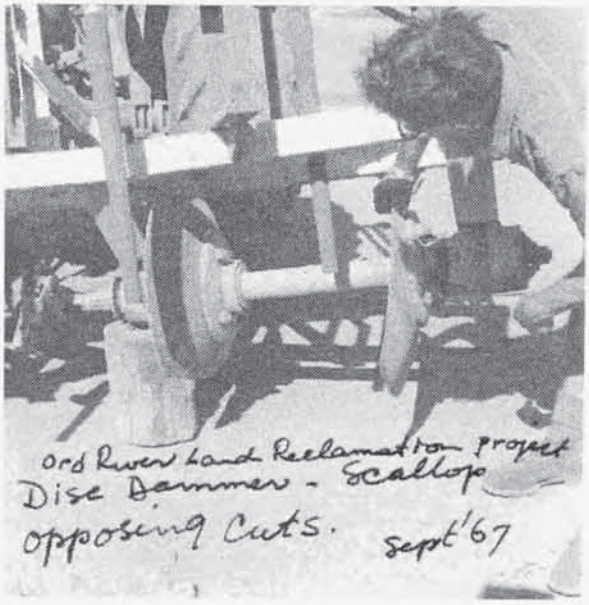


Plate 54

Scalloped discs on the 'disc dammer' (1967).

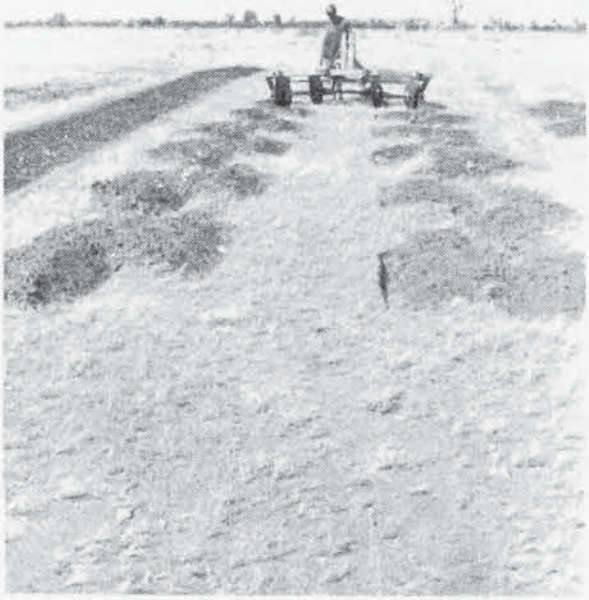


Plate 55

Cultivation of the 'disc dammer' with discs mounted to face outwards.

Plate 56

Pieter Walter sowing guar on 'disc dammer' cultivation, New Chums Paddock, Mistake Creek (1969).

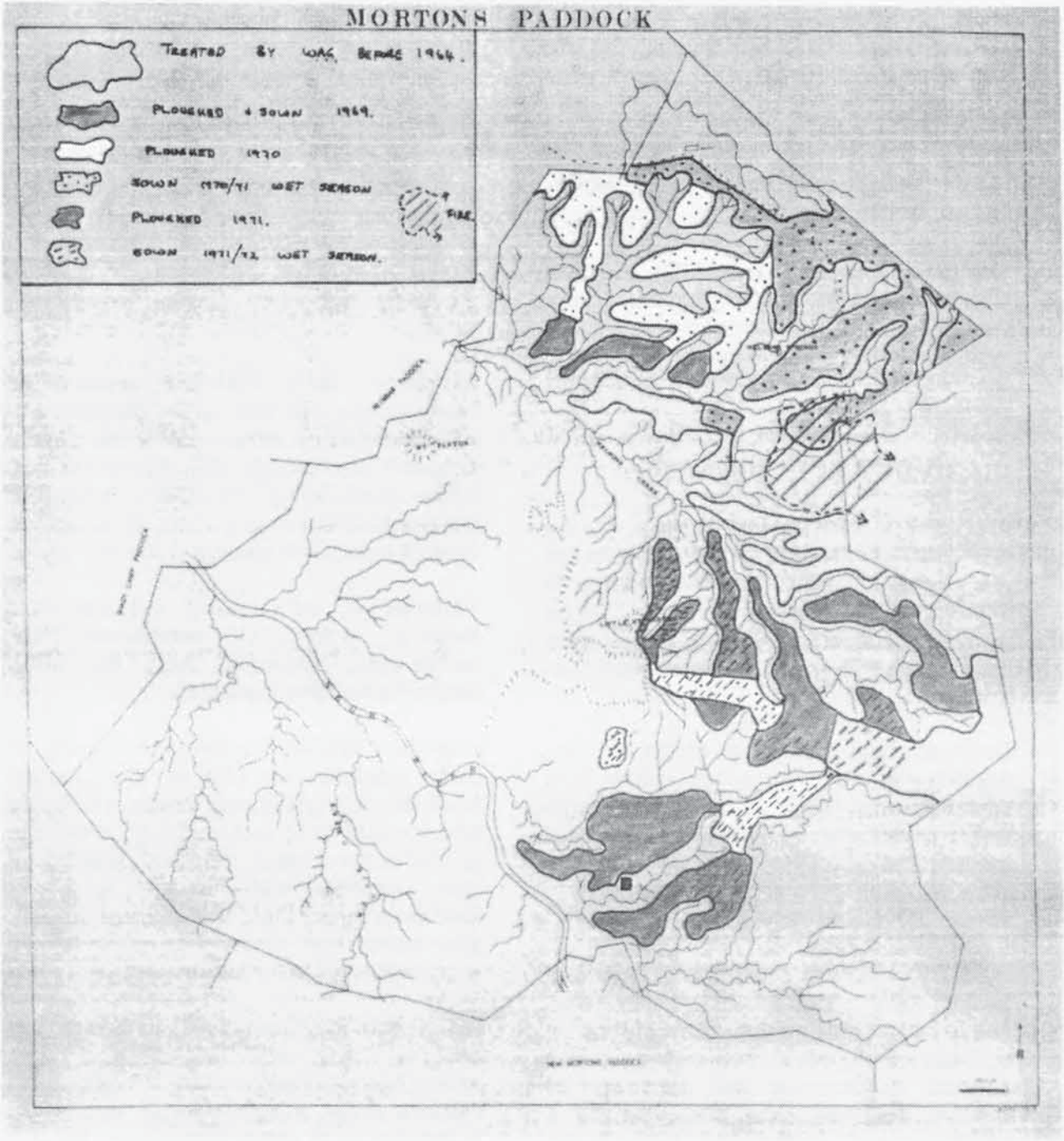


Figure 7 *Areas treated in Morton's Paddock on Mistake Creek prior to 1972.*

Numerous projects and trials were undertaken on Mistake Creek in order to gauge the success of various treatments and pasture species, and to provide information useful for rehabilitation in other parts of the Territory. The aims, methodologies and results of these projects are summarised in Table 2. (Plates 57 – 71). Project locations are shown in Figure 9.

Mistake Creek work programs suffered from isolation, poor accessibility, communication difficulties, lack of resources, high staff turnover rates and changing political influences. These problems, coupled with droughts, floods, vermin and later, fires, made working in the area very challenging. Despite all of these adverse conditions, significant successes were achieved.

CULTIVATION TECHNIQUES

According to Melville (1974), work on the NT side of the Ord River Catchment Regeneration Project initially consisted of follow-up ploughing between strips previously cultivated by WADA. Cultivation was generally confined to slopes less than 2 %.

Opposed disc ploughing continued, but seeding in the same operation was discontinued in 1969. An improved plough, which constructed a higher hill, was also brought into use. Plough runs were 9 m long, with 6 m gaps in between, and were about 40 m apart (Plate 72).

By 1973, much of the 1969/70 opposed discing was losing its effectiveness. Revegetation was not as successful as on cultivation using the improved plough. In an attempt to improve the longevity of opposed disc hills, chisel ploughing with a seedbox was carried out immediately above the hills. Germination was often poor and the cultivation silted up very quickly, rendering it ineffective. On low slopes, however, results could be quite good (Plate 73).

Pitter ploughing with a Paech pitter was also carried out between opposed disc runs. Responses of sown species were variable, but in general, native limestone grass and bunched kerosene grass established well.

Cultivation was sometimes carried out during the dry season, while seeding was carried out in a separate operation closer to, or actually during, the wet season. Rats were reported as being a problem on treated areas in the late 1960's and early 70's and presumably this late seeding regime reduced seed predation. It also enabled cultivation to proceed over a longer time, rather than being restricted to the early wet when access became an issue.

Blandford (1979) describes seeding as being carried out with chisel seeders and pitter ploughs on either side of the original opposed disc plough line. Ploughing and follow-up ploughing and seeding operations were carried out over 3 years as insurance against a poor wet season in the first year.

Varieties of buffel used included WA, Gayndah, colopo, US and Biloela. **WA buffel and birdwood were the most easily established grasses.**

Blandford identified premature grazing of buffel pastures as one of the greatest hazards for regenerating areas. Trampling was considered to reduce the effectiveness of cultivation, while repeated grazing of new seedlings was thought to either destroy or inhibit their development. It was also noted that removal of cover would expose the soil to further erosion.

Mechanical rehabilitation continued on Mistake Creek until 1982/83 and cattle were re-introduced in 1985. Photographic records show a considerable decline in buffel stands in some paddocks in the late 1980's. This decline may have been due to stock, fires and/or poor seasons (Plates 74 – 79).

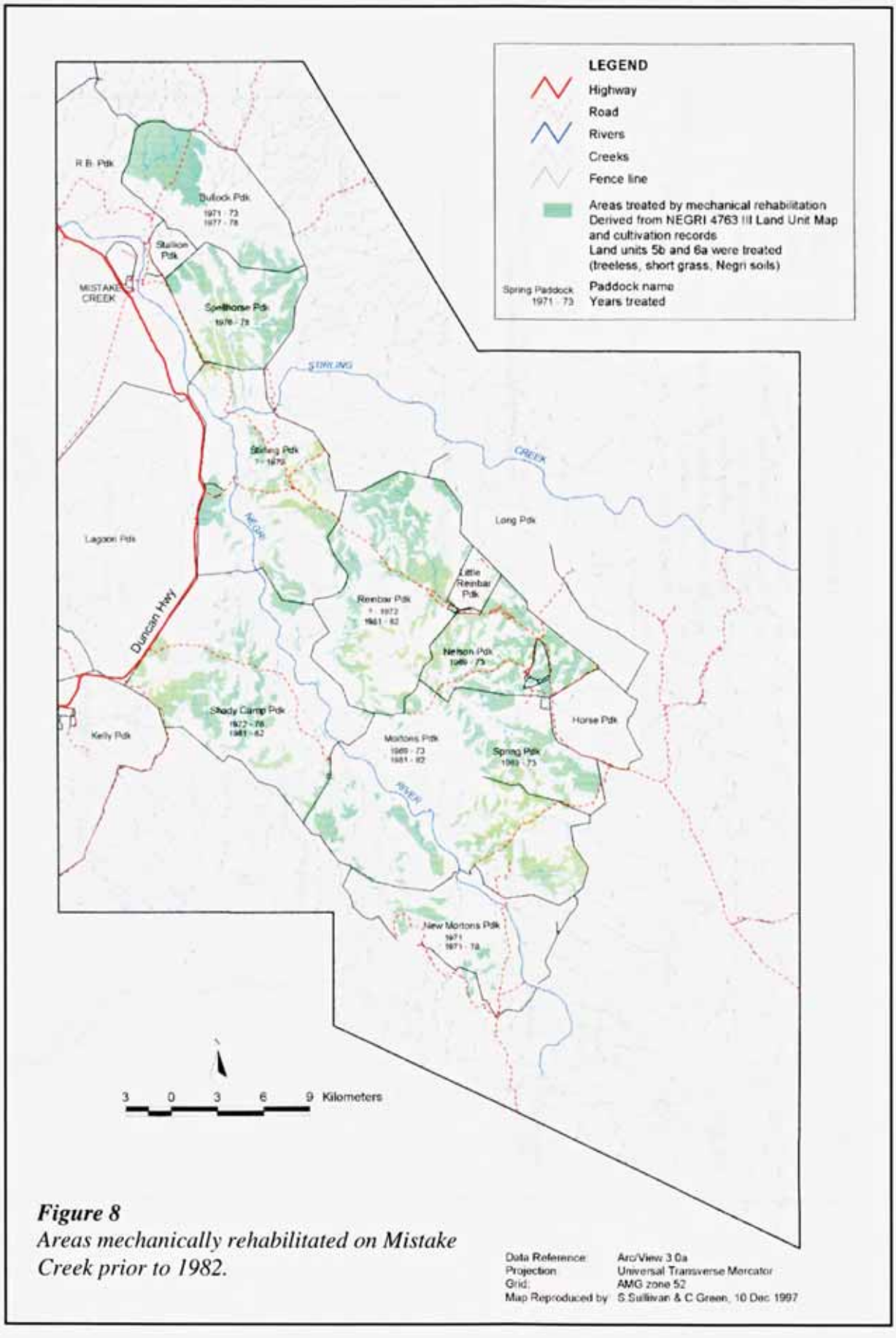
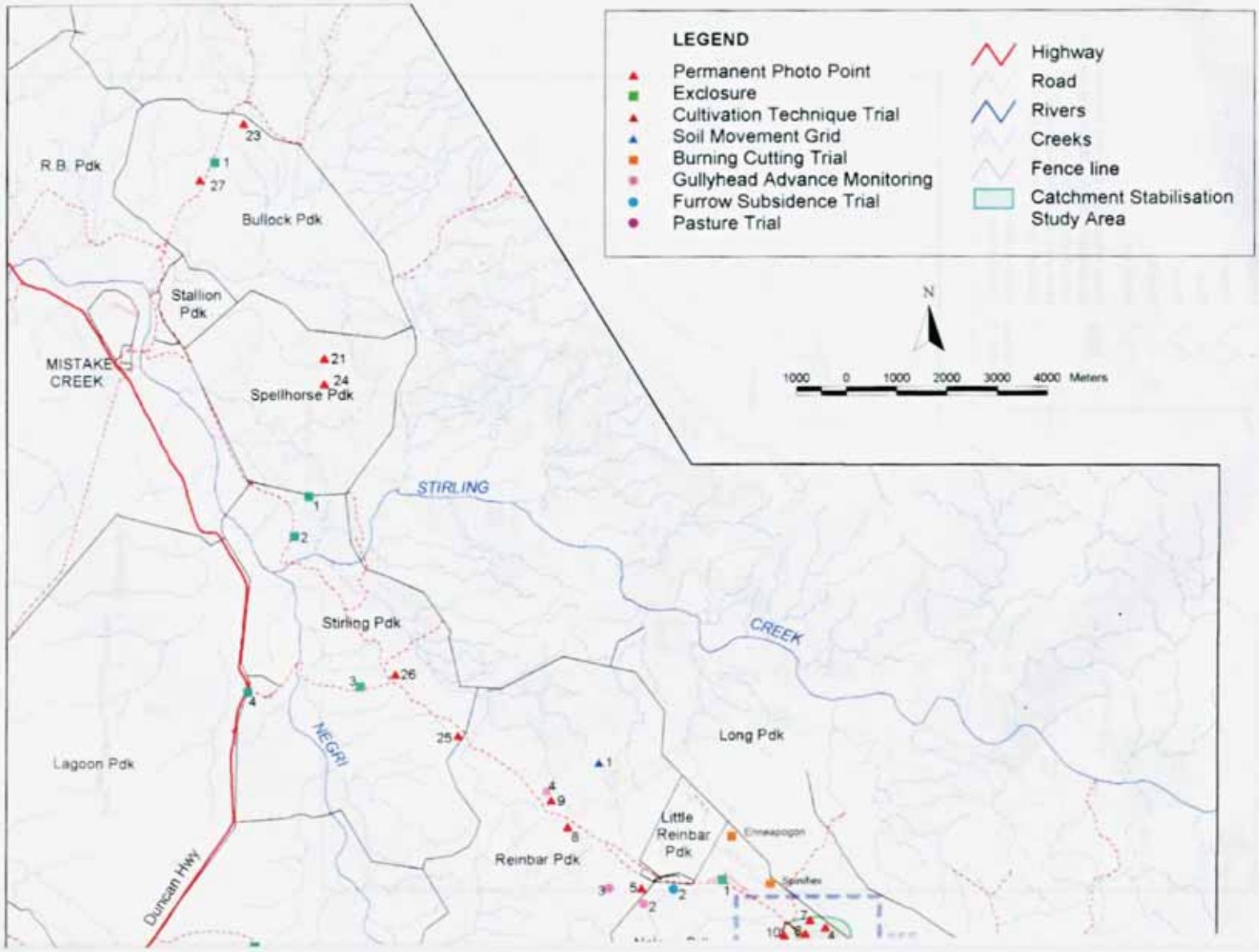


Figure 8
Areas mechanically rehabilitated on Mistake Creek prior to 1982.

Data Reference: Arc/View 3.0a
Projection: Universal Transverse Mercator
Grid: AMG zone 52
Map Reproduced by: S.Sullivan & C.Green, 10 Dec 1997


LEGEND
Permanent Photo Point
Exclosure
Cultivation Technique Trial
Soil Movement Grid
Burning Cutting Trial
Gullyhead Advance Monitoring
Furrow Subsidence Trial
Pasture Trial
Highway
Road
Rivers
Creeks
Fence line
Catchment Stabilisation Study Area
N
1000 0 1000 2000 3000 4000 Meters
R.B. Pdk
Bullock Pdk
Stallion Pdk
MISTAKE CREEK
Spellhorse Pdk
STIRLING
CREEK
Stirling Pdk
NEGRI
Lagoon Pdk
Long Pdk
Little Reinbar Pdk
Reinbar Pdk
Duncan Hwy

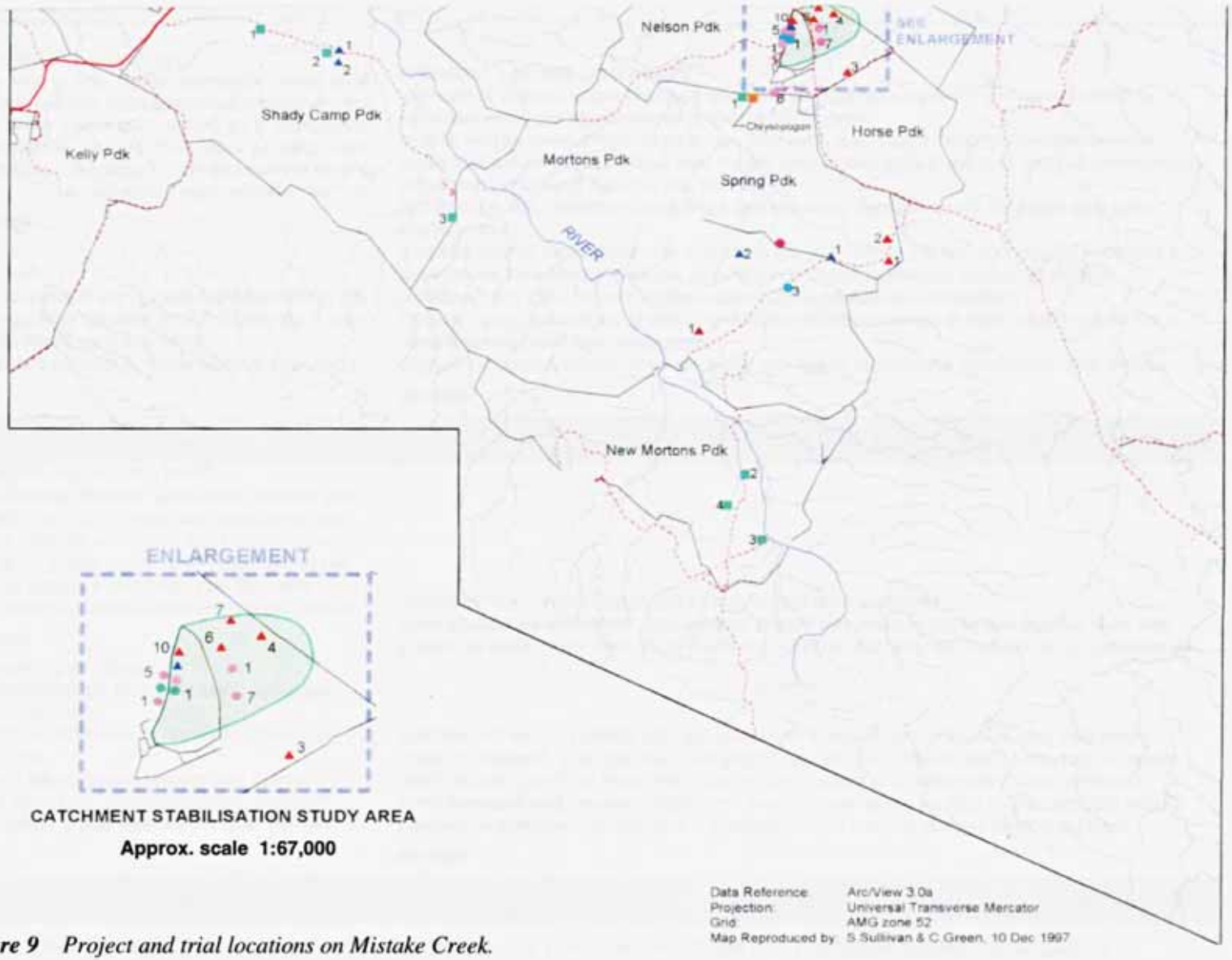


Figure 9 *Project and trial locations on Mistake Creek.*

Table 2 *Summary of trials and projects conducted on Mistake Creeke as part of the Ord Catchment Regeneration Project.*

Pasture establishment plots — **Established: 1969/70 wet season by Stuart MacNish**

Aims

(a) Evaluate 6 new pasture species: 3 buffel varieties from central/southern Australia, giant panic, native verbine and annual verbine.
(b) Plant a large area of guar and if possible, harvest seed.
(c) Investigate the time of planting of a buffel, birdwood and guar mix.

Methods

The 6 pasture species were planted on Airstrip Ridge in Morton's Paddock. The guar was planted on 7-mile Ridge. Two replicates of the pasture species evaluation were planted on 17 January 1970 on shallow, red calcareous soils with a gravelly surface. Plots were seeded after 2 cultivations with a chisel plough.

Results

Pasture evaluation: No results are available for the pasture species evaluation plots.
Guar planting and harvest: Initial guar germinations died from lack of rain and rats eating many shoots. The guar area was to be re-sown. There is no evidence of that occurring.
Time of planting: This trial was thwarted by rats and ants taking seed, poor/patchy rainfall and planting errors. Despite this, the November planting was reportedly very successful.

Further to these trials, seed of 36 grass and legume species was provided by P. Harrison of Alice Springs for evaluation. Germination testing and establishment of a nursery area was commenced in January 1972. No further details were recorded.

Furrow subsidence trial — **Established: November 1970 by Stuart MacN**

Aims

(a) Record the rate of subsidence of opposed disc banks on 3 soil types.
(b) Investigate different furrow types with a view to increasing the life and effectiveness of the banks.

Methods

An 11.2 km transect was chosen to run downslope, intersecting 10 furrows on an area of cultivation. In October and May of each year, levels were taken and related to a benchmark. The sites chosen were Nelsons Paddock, Airstrip Ridge and 7-mile Ridge. Readings were taken from May 1971 to May 1975.

Results

MacNish reports that from early readings, the rate of subsidence decreased when a more narrow-based bank was constructed.
Herbert (1983) mentioned Western Australian experiences with a wide setting in their early ploughing, but does not say whether those experiences were successful.
Subsidence averaged 3.6 cm per year and was found to bear no relation to rainfall.
Average annual subsidence was highest in the first year at 4.8 cm, as might be expected of newer banks.
Subsidence was detected over the dry season on all areas and was generally less than subsidence occurring over the wet season.
Several of the recorded heights rose on the Nelson and Airstrip furrows, making interpretation difficult and throwing some doubt on the accuracy of methods used. No comments were recorded about the effectiveness of the banks in 1975.
The rate of siltation of the opposed disc furrow would also influence the effectiveness of cultivation. This was not recorded.

Permanent photopoints — Established: November 1970 by Stuart MacNish

Aims

Record vegetation changes at fixed sites over time with photographs and plant counts.

Methods

Photopoints were selected and marked with a picket and the photo direction specified.
Plant counts were made in a 0.6 m x 0.6 m quadrat at 0, 10, 20, 30, 40 and 50 paces from the picket in the direction of the photo. Counts were made at least once a year for most years from November 1970 until December 1979 and then again in 1993.

** Results from interpretation of photos, paddock histories, rainfall records and plant counts by Sally Sullivan.*

Results (Plates 57-68)*

Fire did not have a significant adverse effect on established buffel grass regeneration areas, when followed by a fair wet season.
Heavy stocking between 1987 and 1989 followed by at least one below average wet season led to significant *Cenchrus* mortality, and not uncommonly, to the permanent loss of considerable stands.
Below average wet seasons, in the absence of heavy grazing, did not lead to any *Cenchrus* mortality.
Heavy stocking or trampling, followed by below average wet seasons led to the demise of black speargrass patches which did not return after several wet seasons.
Trees and shrubs increased significantly. Many appeared to establish or grow vigorously after good wet seasons in the mid-1970's.
Roly poly bursts appeared to be more related to season than to site condition. Annual native grass and forb species occupied the inter-tussock areas of *Cenchrus*-dominant pastures after above average wet seasons and in the absence of stock. Otherwise, the inter-tussock areas were bare.
Significant bare patches were covered after one exceptionally good wet season. That cover was maintained until heavy stocking or very poor wet seasons occurred.

Cultivation Technique Trial (CTT) — Established: November 1970 by Stuart MacNish

Aims

(a) Determine the most successful method of cultivation to arrest the activity of erosion steps (terracing) on slopes.
(b) Determine whether any treatment at all is advisable.

Erosion of steps is due to soil loss from the downslope face by slumping or cutting away. Soil loss may therefore be prevented by catching soil immediately below the face, or by preventing water flow over the face.

Results

Opposed disc runs: The best establishment of sown pastures was consistently on the uphill furrow of opposed disc runs. Treatments involving opposed discing above or below the step tended to be most effective. Presumably, erosion would be best controlled by using both.
Some opposed disc hills and furrows persisted to 1993 and supported vigorous native and introduced pastures.
Chisel and pitter ploughs: The chisel plough and pitter alone (above or below the step) were least effective. Pits and chisel ploughing filled in and by 1993 did not support much more vegetation than uncultivated areas (Plates 69-71).

CONTINUED OVER PAGE

Table 2 Continued

Cultivation Technique Trial (continued)

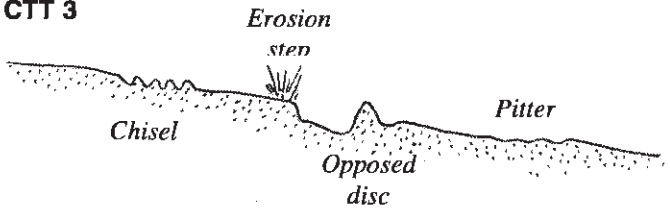
Methods

Opposed disc, chisel and pitter ploughs were used in 10 combinations above and below erosion steps to ascertain the most effective combination (see diagrams below). All furrows were hand seeded with a 1:1:1 mix of WA buffel, birdwood and guar at approximately 22 kg/ha.
The trial was undertaken on skeletal, calcareous red soils in Morton's Paddock on 7-mile Ridge (pH 8.5, light clay on weathered shale).
The area was fenced in 1971 and assessed in January, April and November 1971 and June 1993.

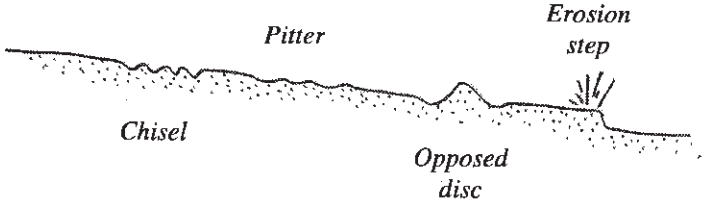
Results (continued)

Seeding: Guar germinated and often seeded, but failed to persist. Buffel generally performed better than birdwood.
Photographs from 1993 show buffel distribution to be very similar to that in 1972. In 1993, buffel and birdwood plant mortalities were evident and new plants were not likely to establish. Native vegetation cover on the area was better in 1993 than in 1970/71.
Larger scale cultivation trials were undertaken on 7-mile Ridge by Alan Payne of WADA in 1964/65. The treatments used were signposted, but no record of results could be found. The trial area was not discernible in 1993.

CTT 3



CTT 9



Soil movement grids

Established: May 1971 by Stuart MacNish

Aims

Measure the amount of soil lost or deposited from an area and relate to other catchment areas and soil types.

Methods

Six 30.5 m x 30.5 m grids were established on 3 soil types. Grid points were surveyed at every 3 m. Results at each of the 121 points per grid were averaged to give total soil loss or gain. Grids were surveyed in May to detect soil loss by water erosion, and in October to detect soil loss by wind erosion. Readings continued until 1975.

Results

After the first 2 wet seasons, 2 grids showed a loss of 12 mm.
Final results were that 5 sites lost up to 21 mm of soil. One site gained 6 mm.
Site heights rose and fell within the 4 years of monitoring. Reasons for this were not documented.

Burning, cutting and regrowth

Established: May 1971 by Stuart MacNish

Aim

Gather more information on the effect of fire and grazing on limestone grass, golden beard grass and spinifex pastures.

Methods

Three 0.05 ha plots of each pasture type were fenced and used as cutting, burning and control plots. No cutting treatment was used for spinifex. Dry matter per acre was calculated for cut plots and the number of plants per acre calculated for burnt plots.
Plots were burnt in October 1971 and November 1972, and assessed in November 1973 and May and October 1974.

Results

The 1971/72 and 1972/73 wet seasons were below average but not "drought" years. 1973/74 was a very good wet season with 1163 mm of rainfall, which is nearly twice the average. Nelsons Springs recorded 73 mm of rain in September 1974 and 163 mm in October 1974. Results are difficult to interpret and initial plant counts prior to each treatment were not located.
Limestone grass: Decreased in density on all treatments between November 1973 and October 1974. Recruitment was greatest on the burnt plot after the October 1974 rain. The density of plants was always greatest on the cut treatment.
Golden beard grass: Density didn't change significantly on any treatments. Recruitment was highest on the control plot and least on the burnt plot after the October 1974 rains. The density of plants was always greatest on the cut treatment.
Spinifex: In November 1973 and May 1974, the burnt plot supported fewer plants than the control. By October 1974, however, plant density was the same on each treatment, though ground cover was significantly less on the burnt plot.
In January 1982 there was no visible difference between any of the treatments on the 3 trial areas (Herbert 1983).

Catchment control project

Established: June 1972 by Stuart MacNish

Aims

Completely stabilise a sub-catchment of Nelson's Creek by mechanical and vegetative means and record vegetation changes and silt loads over 5 years.

Methods

Suitable areas were ploughed and seeded. Diversion banks were to be constructed above the 2 main gullies in the defined area. The use of weirs and gabions for gully control was also to be tested.

Results

In June 1972, 2 weirs and 3 groynes were constructed out of logs and rocks. No results or further details of this project could be located.

Table 2 Continued

Gully advance trial	Established: October 1970 by Stuart MacNish
Aim Record the rate of advance of gullies and relate to annual rainfall, expected flow over gully heads, and soil type or parent material. **Methods** Five gullies were selected in 1970. Two of those silted up in1971 and alternative gullies were selected.	**Results** After initial readings, 2 more readings were taken prior to May 1972. From the very limited data collected it was determined that gully advance did not relate to rainfall. An increase in the rate of advance of one gully was attributed to new road drains.
PVA infiltration trial	**Established: Stuart MacNish**
Aims Assess the application of PVA (poly vinyl alcohol) to the soil surface to reduce surface sealing and so improve infiltration. *Note: PVA acts as a glue when wet and it was thought that it would bind soil aggregates.* **Methods** PVA was applied at 0.01% w/w to the top 19 mm of soil. Infiltration rings were installed on treated and untreated areas.	**Results** Recordings of infiltration and soil moisture were made twice. The results were inconclusive and the trial discontinued.

Revegetation, runoff and suspended sediment trial

Established: 1979/80 by John Leys

Aim

Determine the effectiveness of revegetation in controlling runoff rates and suspended sediment loads.

Methods

Two comparable catchments, one revegetated and the other partially denuded, were monitored over the 1979/80 wet season. Vegetation cover, type, distribution and infiltration rates were examined for each catchment and used to explain differences in runoff rates and suspended sediment load. The catchments chosen were near the degraded Nelson Springs airstrip.

Results

The comparison of 2 catchments over 10 rainfall events led to the general conclusions that revegetation:

(i) increased the infiltration rate of the soil;
(ii) reduced the runoff volume;
(iii) reduced the suspended sediment loss; and
(iv) decreased catchment response time.

The latter is an anomalous result and is difficult to explain.

Note: A hydrological study by Kate Duggan of the CCNT (unpublished) on Mistake Creek over the 1978/79 wet season indicated that major sources of sediment were drainage lines and adjacent bare areas. Duggan (pers comm in *Leys 1980) hypothesised that the cleaner runoff from revegetated upper slopes of catchments had an increased capacity to erode lower slopes and drainage lines.*

Ground cover variation assessment

Established: October 1978 by Doug Blandford

Aims

Monitor ground cover in order to assess the ability of the land to resist rainfall erosivity.

Methods

Eleven 200 m x 200 m exclosures were erected in treated and untreated areas. A wheel point apparatus was used to record ground cover features every 1.5 m for 1000 points, inside and outside each exclosure. Each "strike" was recorded as bare ground, basal cover, projected foliage cover, litter, rock outcrop, rock floaters or erosion in the form of sheet erosion, rilling and minor or major gullying. The nearest species to each strike was also recorded. Survey runs every March, July and November were planned. Data was actually recorded in July and November 1978, January and May 1979 and January 1981. Sally Sullivan and Darryl Hill repeated the assessments in May 1993.

Results

Data from 1978 to 1981 were located in 1993. No analysis of results was found. The percentage of bare ground increased significantly in an exclosure between July and November 1978 and decreased again by March 1979. A decrease in litter cover accounted for much of the increase in bare ground. Poor paddock histories of fires, stocking or rehabilitation work made interpretation of results difficult.

Bullock Paddock: Between 1979 and 1993, cover decreased, litter increased and buffel increased significantly inside the exclosure. In 1993, there was more cover and much more litter and buffel inside the exclosure than outside (Plates 74-79).

Stirling No. 1: A small increase in cover was recorded between 1979 and 1993. Limestone grass decreased and small annuals like fairy grass increased. In 1979, cover was slightly better inside. In 1993, cover was similar in/outside, however limestone grass cover was greater inside.

Stirling No. 2: Between 1979 and 1993, cover increased, buffel decreased and limestone grass increased. In 1979 and 1993, cover was similar in/outside. In 1993, more birdwood was inside than outside, limestone grass was similar in/outside.

Stirling No. 4: A large decrease in birdwood and increase in limestone grass was recorded between 1979 and 1993.

April 1971

June 1974

June 1979

April 1987

May 1988

May 1989

Plates 57 – 68 *Photo point 10 on Mistake Creek between April 1971 and May 1995. Refer to captions on opposite pages for interpretation. The photo point lies in Nelson Paddock. Photos are taken from the top of Nelsons Ridge looking towards Mount Panton. Rainfall figures from 1971 to 1978 were taken from Nelson Springs and Mistake Creek records. Following 1978, Mistake Creek rainfall was inferred from Rosewood Station records. Average wet season rainfall for Mistake Creek is about 610 mm.*

Plate 57

Strips of mainly kapok and limestone grass are growing, probably along cultivated lines, and bare areas can be seen in between. This scene remained virtually unchanged after 2 below average wet seasons (519 mm and 417 mm).

Plate 58

The 1973/74 wet season was exceptionally good (1193 mm), with good rains beginning in November and continuing until March. January and February both received 250 mm, March and April both received 75 mm and a further 29 mm fell in May. Cover established on bare patches, and was dominated by roly poly, limestone grass, wiregrasses and fairy grass.

Plate 59

The area was still well covered in 1979. Cenchrus *had become dominant and trees and shrubs were regenerating.* Cenchrus *became most obvious in the photographs after the 1977/78 wet season of 546 mm, though some appeared in plant counts after the 1976/77 wet season. It is uncertain when or where this was planted.*

Plate 60

Tree and shrub cover continued to increase. Cenchrus *pasture was in good order. Black speargrass in the foreground appeared in 1983. Some bare ground was evident between grass tussocks.*

Plate 61

In October 1987, stock had been in the area. The 1986/87 wet season may have been below average. Inter-tussock areas were bare and the black speargrass appeared to be grazed down. Cenchrus *tussocks had not recovered.*

Plate 62

The 1988/89 wet season was only slightly below average. Black speargrass and Cenchrus *tussocks had not recovered.*

October 1989

March 1990

May 1991

May 1992

May 1994

May 1995

Plates 57 – 68 *Continued.*

Plate 63

Stock activity in the area had been considerable. Annual ground cover had been destroyed and some limestone grass tussocks heavily grazed.

Plate 64

The 1989/90 wet season was only fair (525 mm), with most rain falling in December and January. Annuals had not established on the bare ground and many tussocks had not regenerated over the wet.

Plate 65

The 1990/91 wet season was quite good (720 mm), although the growing season may not have been very continuous. Good rain fell in February (350 mm) but there was very little rain after that. Cover looked reasonable but consisted only of fairy grass. Perennial grasses had been lost in the foreground area. By October 1991, bare ground was again prominent.

Plate 66

The 1991/92 wet season was about average. Small fairy grass plants were growing in bare patches. Old, dead perennial grass tussocks can be seen. The black speargrass from 1988 had not regenerated.

Plate 67

After 2 average wet seasons, large roly poly plants occupied the bare patch with some small kapok bushes and annual grasses. Cenchrus *growth in the middle-ground looked quite good. By October 1994, the roly poly and annuals had largely been broken up, possibly by stock.*

Plate 68

Cover improved on the bare area after an above average wet season (800 mm). Many limestone grass tussocks established. It appeared that Cenchrus *tussocks were not going to be replaced. By October 1995, stock activity had again reduced cover significantly in the foreground. Tree and shrub cover had increased markedly compared to the 1970's.*

Plate 69

Cultivation technique trial No. 10, showing from the left, an opposed disc ridge, pitting and chisel ploughing (2 November 1970).

Plate 70

Cultivation technique trial No. 10 in May 1972. Cenchrus *and roly poly dominate the opposed disc ridge. Limestone grass and some* Cenchrus *plants have established on pitting and chisel ploughing.*

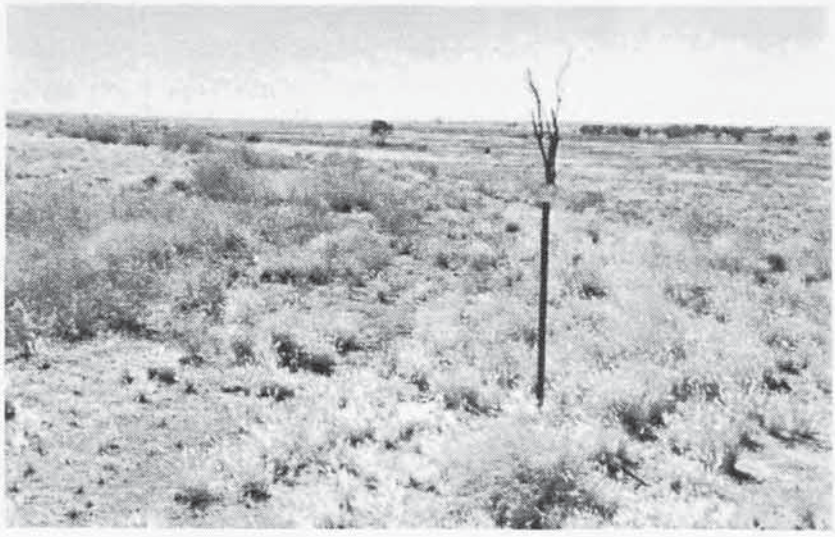


Plate 71

Cenchrus *continues to dominate the opposed disc ridge in cultivation technique trial No. 10. Some* Cenchrus *and kapok bush, along with native annuals, remain on the other cultivation types. The uncultivated area to the right of the chisel ploughing mainly supports small native annuals.*

Plate 72

A discontinuous opposed disc bank with pitter ploughing downslope (to the left of the bank), and chisel ploughing upslope (early 1970's).

Plate 73

Successful rehabilitation following destocking, cultivation and sowing with kapok, buffel and birdwood in the early 1970's.

May 1988

May 1989

May 1990

May 1991

May 1994

May 1995

Plates 74 – 79 *Bullock Paddock exclosure on Mistake Creek between May 1988 and May 1995. Refer to captions on the opposite page for interpretation.*

Plate 74

Cover outside the exclosure is less than inside, however Cenchrus *tussocks are persisting outside.*

Plate 75

Cover is somewhat less than would be expected after a slightly wetter than average season. Cenchrus *tussocks are still evident and mainly limestone grass has established. Stock have been in the paddock during the wet season.*

Plate 76

Very little wet season growth has occurred. Cenchrus *tussocks do not appear to have much wet season growth, if any. Growth inside the exclosure remains reasonable. The 1989/90 wet season was below average. Bare inter-tussock areas inside probably reflect the poorer wet season.*

Plate 77

Good cover established over the slightly above average 1990/91 wet season. Cover was, however, mainly comprised of fairy grass and tickweed which were not likely to persist through to the end of the dry.

Plate 78

Continued stocking pressures led to poor cover outside the exclosure following an average wet season. Cover consisted mainly of small fairy grass plants. Roly poly established within the exclosure but not outside.

Plate 79

The above average 1994/95 wet season resulted in little other than fairy grass and tickweed growth outside the exclosure. Perennial grass tussocks were lost from outside the exclosure but still thrived within. Stocking pressures alone appeared to be responsible for the demise of perennial grass tussocks in this area.

MONTEJINNI (1968-1992)

Several rehabilitation trials have been undertaken on Montejinni dating back to late 1968. This has included work at sites in Dry Paddock, near Gorey's Bore and the station entrance road. Some verano and amiga stylo trials were undertaken in 1992 and native grass revegetation trials were conducted by Frank Marshall of GANT in 1995.

In December 1968, soil erosion on Montejinni was not considered serious. Land degradation was evident only where stock were worked and on some frontage country. Active erosion was recorded in a few paddocks around the station. The owner/manager Brian Crowson was interested in soil conservation and pasture rehabilitation and decided to undertake regeneration work.

Staggered furrows were constructed using a station tractor and a government owned opposed disc plough on an area not far from the homestead. This was sown with a seed mix including birdwood, buffel, guar and kapok. Stock were to be kept out for at least 1 year, however if a good wet season developed, it was agreed that a short grazing period in the late dry would be allowed. More staggered furrows were then to be constructed between the previous runs in later stages.

In February 1969, 4.9 ha of Dry Paddock were to be treated with staggered furrows no more than 20.1 m long, with a gap between furrows of 6.7 m. A 7-point chisel plough was to be used on the upper sides of furrows to encourage absorption of water and to mitigate runoff.

In June 1969 furrow lines were ripped in a dry paddock crossed by the access road about 3.2 km from the homestead. October 1968 photographs show the areas to be treated and riplines marking contours. In August 1969, treatment was started from a low hill in the northeastern portion of the paddock (Plate 80).

Plate 80 *Opposed disc hills, Montejinni, September 1969.*

In early 1971, buffel establishment in most opposed disc furrows was good, although the area had been grazed contrary to an agreement. An inspection later that year revealed little evidence of buffel growth or furrows. Photographs from 1972, however, show remnants of rows and plants some years after the work was done (Plate 81). In 1993, there were no signs of rows or buffel in that area, though limestone and fairy grasses and native forb cover had vastly improved on what was apparent in the 1972 photographs (Plate 82). Kapok was prevalent and there was a distinct fenceline effect, with little kapok in a neighbouring paddock.

GOREY'S BORE (1988)

In December 1988, Darryl Hill of the CCNT conducted some pasture introduction work on black soils near the Gorey's Bore turnoff on the Buchanan Highway. Purple pigeon grass, Gayndah buffel and birdwood were sown with a 4-tine chisel plough and N:P:K 15:13:10 fertiliser. The area was fenced and a small area outside was also sown. Reasonable germination of buffel and birdwood was observed and was far better inside the fenced area than outside. No purple pigeon grass established. Bull Mitchell grass regenerated in the northeast corner of the fenced area.

Plate 81 *Remnants of rows and plants remained some years after cultivation on Montejinni (16 October 1972).*

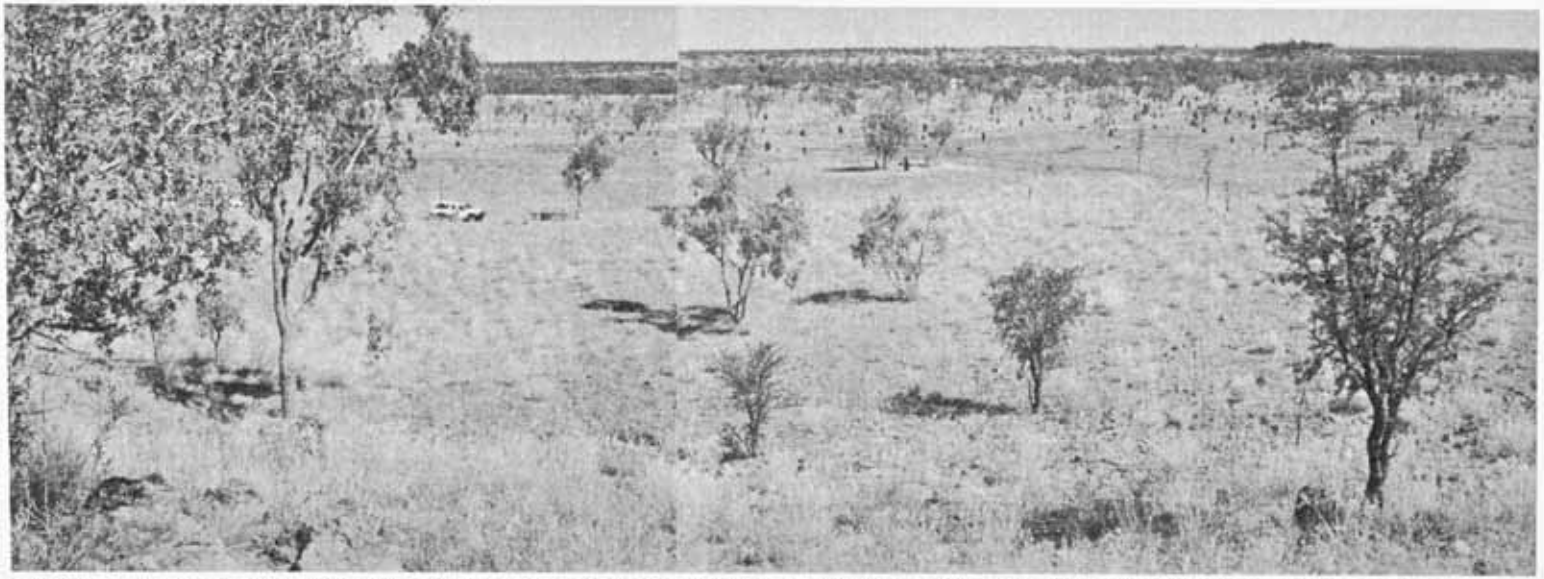


Plate 82 *In June 1993, no evidence of prior workings could be discerned in the area shown in Plate 81. Kapok bushes across the area may have been introduced during the 1960's rehabilitation attempts.*

STATION ENTRANCE SITES (1990)

In March 1990, Darryl Hill of the CCNT used a chisel plough to plant 3 sites near the entrance to the station. Coated and uncoated buffel and birdwood grasses were sown.

The best results were obtained on the better-drained soils and buffel grass was dominant. In 1993, buffel establishments were persisting well with no evidence of mortalities. Little birdwood was evident.

A very good stand of buffel had established in the corner of a paddock near the highway up to the foot of a rocky hill. This was probably the result of buffel hand planted from a small chisel plough by station staff in 1991.

STYLO TRIALS (1992)

In January 1992, verano and amiga stylos were planted onto cultivated and uncultivated strips by Reg Andison of DPIF. While verano establishment was superior, both stylos established well despite a poor wet season. There was little difference between cultivated and uncultivated plots.

MOOLOOLOO

Native grass revegetation trials were undertaken by Frank Marshall of GANT in 1995 and 1997. There are no records of any other rehabilitation activities on Moolooloo.

MOUNT SANFORD (1989-97)

Regeneration work has only been undertaken on Mount Sanford in more recent years and has focused on areas around the homestead, and in Lochart and Donkey Paddocks. Native grass seed trials were also undertaken by Frank Marshall of GANT in 1996 and 1997.

HOMESTEAD AREA (1989 – 1992)

In 1989/90, buffel grass was hand broadcast onto unploughed red and black soils in the homestead area with very little success.

In 1992, a chisel plough was used to regenerate pastures on bare red soils around the homestead and airstrip which had been heavily used. Buffel and birdwood grasses were hand-seeded into ploughing above the airstrip and good establishment resulted. This work was conducted jointly by Paul Stone, the station manager, and Darryl Hill of the CCNT.

LOCHART PADDOCK (1992)

Regeneration of a black soil area in Lochart Paddock not far from No. 3 Bore was attempted in 1992. This area had previously only supported weeds and annual grasses. Nunbank buffel, silk sorghum, Lee jointvetch, calopo, Mitchell grass and native millet were hand-seeded onto chisel ploughing.

Establishment of good native pasture species such as Mitchell grass was encouraging, particularly within an exclosure (Plate 83). Silk sorghum established well and some Nunbank buffel plants were evident. This success was no doubt aided by above average rainfall and a long growing season.

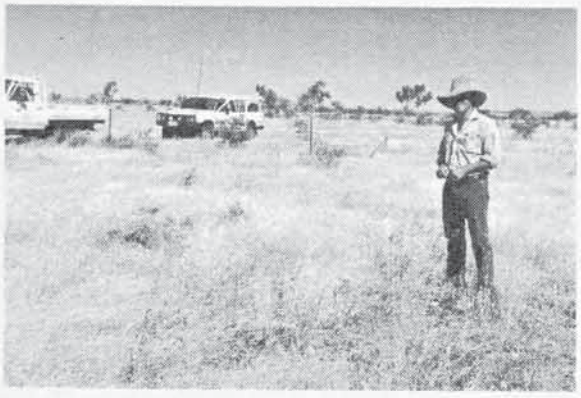


Plate 83 *Paul Stone standing next to a Mitchell grass tussock in an exclosure near No. 3 bore, Mount Sanford (June 1993).*

After the 1993/94 wet season, Mitchell grass establishment inside the exclosure had increased 4-fold, however, plants remained within the original rows. In 1995 all Mitchell grass in these exclosures had died, however self-sown Mitchell grass outside the exclosure was persisting.

DONKEY PADDOCK (1992)

Red soils in spinifex country were chisel ploughed and sown to Nunbank buffel and silk sorghum. An area of grey soil below Snake Hill was ploughed and seeded to barley Mitchell, native millet, buffel and silk sorghum. Only buffel achieved a fair rate of establishment.

NEWRY (1959-91)

Most rehabilitation work on Newry occurred in 1959, 1960 and 1991.

1959 - 1960

In November 1959, the manager of Newry (Keith Lansdowne) used a disc plough for pasture introduction and regeneration work on the red-brown earths in Home Paddock. This 10 ha paddock was bare and sheet eroded and conditions at the time of work were dry, but workable.

Alternate double and single strips of contour ploughing spaced at 1.8 to 3.7 m were constructed with a twin disc plough. Locally harvested buffel (WA purple) and 2 year old kapok seed were sown in strips after the onset of wet season at a rate of 2.2 kg/ha.

A *Cenchrus* nursery similar to that on Auvergne was established with numerous strains including 5 birdwood grasses, and Gayndah, Biloela and Cloncurry buffels, with a sprinkle of superphosphate.

Numerous pasture introductions were made in the vicinity of the homestead.

A sorghum alum and bluepea seed mix was sown at 3.4 kg/ha each, with 125.4 kg/ha of superphosphate. Seed was covered with a rake.

Another small block north of the homestead was ploughed for sorghum and blue pea and fertilised with blood and bone. At 12 locations within 16 km of the homestead on sandy loamy soils, 3 single ploughed strips 40 m long were each prepared and immediately sown with local buffel, WA purple buffel and kapok respectively.

Single and double ploughed strips were prepared and sown with WA purple buffel and kapok in a 4 ha stock paddock, just over 24 km from the homestead.

Two 0.4 ha blocks near the homestead received checkerboard ploughing and contour double ploughed strips. Seed was sown at the onset of the wet. No fertiliser was used for bush introductions. The Peel River Company, the owner of Newry, had encouraging results with this method on sister places in WA.

All of these pasture introductions were well established in May 1960. Success was attributed to the manager who personally sowed areas and kept stock out where possible. Not much kapok established, but more was expected the next year. Home Paddock, which had previously been completely bare, became covered in buffel.

1991

In December 1991, Darryl Hill of the CCNT attempted regeneration of several areas using an opposed disc plough and seeding with Gayndah buffel and birdwood. The areas included a scald and a small, light black soil area in East Keep Paddock, and an area 1 km south of Ballinger bore. A couple of small areas close to the highway were too hard for the opposed disc plough, but all areas successfully disturbed were seeded.

Chisel ploughing and seeding were also undertaken near the station to thicken existing stands of buffel in Mill Paddock, and in another area about 11 km north of the station on sandier soils.

Generally poor results for this 1991 work were attributed to the poor wet season.

NGUKURR

(formerly Roper River Mission)

The establishment of seed nursery areas is the only rehabilitation activity recorded at the Roper River Mission.

In 1959-61, however, a nursery area with 22 strains of birdwood and buffel was established. A second area, which could be irrigated, was also established.

The seed, which was only 10 months old and may have been too fresh, did not do well in either the irrigated or non-irrigated areas.

Townsville lucerne, *Panicums* and blue pea planted in the garden area in February established, however wallabies were a problem. Sorghum alum and Townsville lucerne proliferated.

RIVEREN (1988-93)

MUCKA PADDOCK (1988)

In late 1988, Kit Jolley and Darryl Hill of the CCNT used a chisel plough to introduce buffel, birdwood and purple pigeon grass into an area of Mucka Paddock near the laneway. No establishment resulted, which could have been a consequence of the poor season, heavy soils and/or stocking.

OBSERVATION PADDOCK (1990)

In 1990, an area near Mucka Waterhole was fenced with GANT funding and named "Observation Paddock". This is referred to as "Research Paddock" in the trial report by Sullivan (1992d).

Mechanical rehabilitation of red soil ridges and slopes (transition areas between spinifex hills and black soils) was undertaken in December 1990 by Sally Sullivan of the CCNT (Plate 84). Areas were ploughed using an opposed disc plough, pitter planter and scarifiers mounted on a grader (Plates 85, 86). A shotgun mix of Indian couch, Nunbank and Gayndah buffel, silk sorghum and seca stylo was sown onto all of the ploughed areas, except the grader scarifying. All plantings were fertilised with superphosphate broadcast at 50 kg/ha.

Results of the mechanical rehabilitation were generally poor, despite quite a good wet season (Plates 87, 88). This was partly attributed to the concentration of a few stock on the cultivated area when plants were establishing. In addition, while the soils were non-cracking red clays, some areas exhibited the surface characteristics of black soils, which tend to dry rapidly.

Some buffel, Indian couch, silk sorghum and seca plants could be found, but insubstantial native annual grasses and forbs dominated and cover was still poor. Cover on the grader scarified areas was at least as good as that on pitted and opposed disced areas. Natural

regeneration of perennial grasses on the black soil areas of the paddock was good.

By June 1993, Indian couch had not persisted, stylos had increased a little and established buffel plants were persisting. Native grass and forb cover had improved considerably and consisted mainly of annuals, although perennial wiregrass plants had increased. Cover was poorer on opposed disc hills than between runs, indicating that opposed disc cultivation was not suitable for this soil type.

Plate 84

Cultivation on red soil ridges in Observation Paddock, Riveren (December 1990).

Plate 85

Grader scarifying was one of the treatments used in Observation Paddock, Riveren (December 1990).

Plate 86

Opposed disc and pitter ploughing in Observation Paddock, Riveren (December 1990).

Plate 87

The Observation Paddock rehabilitation area in April 1991. Cultivation had little effect on regeneration after the wet season.

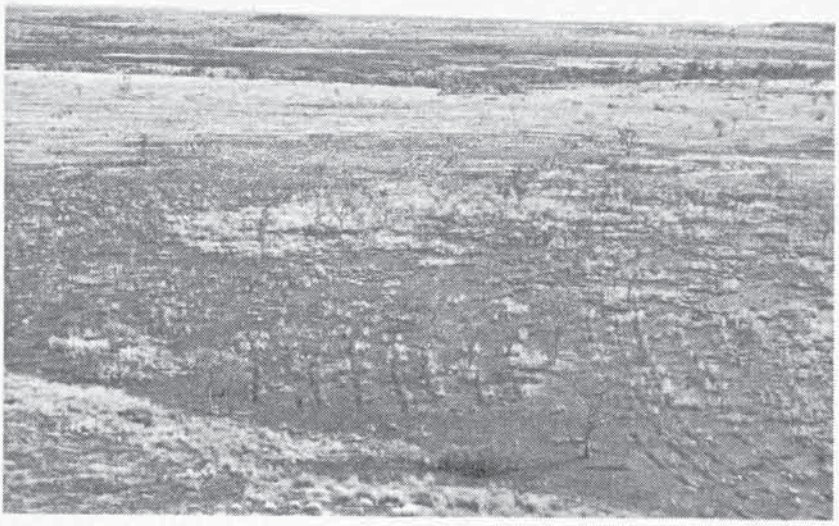


Plate 88

Some perennial grasses lined these opposed disc runs in Observation Paddock, however by May 1992, cover and establishment on the area was generally poor.

ROBINSON RIVER (1960-61)

Records indicate that buffel grass must have been introduced to Robinson River prior to 1960, when the manager mentioned its presence. In the poor wet season of February 1961 buffel was reported to be growing well.

In 1960, the planting of Gayndah and Cloncurry buffel, birdwood, kapok, Townsville lucerne, Rhodes grass, blue panic, green panic, centro and sorghum alum was considered. Fodder crops such as millet, sabi and Sudan grass, sorghum alum, buffel or birdwood and blue pea were also later considered.

Further details could not be located and as 1961 was a particularly dry year, the planting may not have gone ahead, or if it did, may have failed.

ROPER BAR (1958-62)

In 1958, all land within 1.6 km of the Roper Bar Police Station was seriously affected by gully erosion.

Absorption furrows were laid out at vertical intervals of 15 cm to head off gullies. No safe disposal points for diversion banks could be found. Treatment of 1.2 ha consisted of fencing to keep out goats, and oversowing with WA and Gayndah buffel at 2.2 kg/ha each. Seed was to be sown by hand just before or during monsoonal storms. Between furrows, 1.5 m strips were ripped to provide a seedbed and improve absorption. A sketch of the planned rehabilitation was made.

In May 1959, the constable at Roper Bar reported 358 mm of rain from October 1958 to March 1959. Contour banks were repaired when necessary and an area was rock filled. Continual maintenance was required on the furrows. Native grass growth was good on contoured areas.

Seed was only planted on March 9 and 10 and didn't get much follow up rain. Some germination occurred, but at only 3 cm to 4 cm high, the plants were not particularly healthy. Planting had no doubt been carried out too late in the season.

It was recommended that:

- furrows and riplines be re-opened;
- stops be placed in furrows;
- more buffel, birdwood and Townsville lucerne be provided; and
- the area be properly fenced.

Seed was planted mainly in riplines and furrows on 24 December 1959. Furrows were holding fairly well and were repaired when washed out, but there was no sign of germination. Erosion in gullies was continuing but was largely prevented by furrows. Some hedge plants from around the police station were planted on one of the worst sections and more seed was sown in February.

On March 29 1960, buffel germination was estimated to be only 17%. By April 11, no further germination had occurred. Grasshoppers were bad and erosion was continuing. Furrows next to the house were okay. Watering the furrows was suggested to encourage growth before the next wet season.

In July 1960, further mechanical treatment was not recommended, and more WA buffel and birdwood seed was required.

By January 1962, Pieter Walter considered the erosion to be uncontrollable and mechanical treatment uneconomical. The erosion was endangering infrastructure and it was considered that the entire area should be fenced and all land use ceased. Some of the more stable red sandy clay soils could then be treated.

In 1965-66, a new police station site was recommended.

ROPER RIVER MISSION

(see Ngukurr)

ROSEWOOD (1991-92)

A black soil paddock, which was almost bare and supported only poor native annual species, was lightly stocked and periodically spelled for 10 years. By 1991, significant patches of bull Mitchell grass and Flinders grass had established. **This demonstrated the benefits of spelling black soil instead of introducing pastures** (Plate 89).

DUCKHOLE TRAP PADDOCK (1991)

In December 1991, 2 small areas on black basalt and heavy red basalt soils in Duckhole Trap Paddock were ploughed using an opposed disc, and seeded with Gayndah buffel and birdwood grasses by Darryl Hill of the CCNT. Fertiliser was not applied. A small sloping scald on the access road was also treated.

A poor wet season yielded disappointing results. By 1994, some buffel had established on the heavy red soils in Duckhole Trap Paddock.

BLACK SOIL NATURAL REGENERATION (1993)

In 1993 Darryl Hill of the CCNT and Clive Stone (the station manager), constructed an exclosure on black soil for observation of natural regeneration. Two more exclosures were constructed in 1994 and round native hay bales were rolled out in one of these. Short-term results were not promising.

Lablab, stylos, Mitchell grass and sorghum were planted both inside and outside the exclosures in 1994 but little had established after the wet season.

NATIVE PASTURE TRIALS (1995)

Native grass establishment trials commenced in late 1995 in conjunction with Frank Marshall of GANT.

Plate 89

Clive Stone in a Mitchell grass regeneration paddock on Rosewood Station (May 1992).

SCOTT CREEK

There is no record of rehabilitation activities on Scott Creek. However, fairly extensive areas of improved pastures have been established on cleared land using conventional methods.

SPIRIT HILLS

There is no record of rehabilitation activities on Spirit Hills.

Some improved pastures have been introduced in conjunction with DPIF.

TIMBER CREEK (1958)

In 1958, the country surrounding Timber Creek Police Station was fenced and sown to buffel grass and kapok. A netting fence had to be constructed to keep wallabies off the area. Some gullies were filled and pasture furrows introduced.

Pasture establishment was good and improved with time and vastly improved cover on the area. Gullies were still active in 1995, however, and further earthworks were proposed.

VICTORIA RIVER DOWNS (1962-93)

Many land rehabilitation demonstrations and trials have been undertaken on VRD and date back to the early 1960's. Major demonstrations were established near Centre Camp and near Kidman Yards in 1962. Other smaller trials were conducted in various paddocks throughout the 1960's, from which Pieter Walter was able to draw a number of conclusions. Rehabilitation was recommenced in the late 1980's and early 1990's, with trials conducted on 4 soil types.

DEMONSTRATION NO. 1 (Near Centre Camp)

1962

In December 1962 "Demonstration 1" was established in a 40.5 ha paddock just east of Centre Camp. This is the same paddock in which the rubbish dump was located in 1993. Soils included:

- cracking clays;
- red sandy clay-loams (topsoil remnants and levee soils);
- exposed sandy clay subsoils; and
- grey sandy clays (drainage alluvia).

Furrows were made on the contour with a 3-disc plough and planted with guar, Cloncurry and WA buffel, birdwood and Mitchell grass seed. In December 1962, a batch of seed was sent to VRD presumably to sow in the demonstration area. The batch included 1 bag each of Mitchell grass, WA (short) and Cloncurry buffel, birdwood, kapok, guar, lucerne and a shotgun mix, and 2 bags of WA buffel.

An agreement was made that the Soil Conservation Officer control the area for 5 years and that any stocking required his approval. The fence was to be maintained and breaks in furrows repaired by the station. The 1962/63 wet season was beneficial for the demonstration, with most of the 508 mm of rain falling in the hotter part of the season. There were no high intensity storms and good follow up rain fell in February.

1963

Guar establishment was dense on red soil furrows, but only a few plants were evident on cracking clay soils. Buffel and birdwood established on the 30 cm deep sandy clay loam remnants of the original topsoil, however establishment was poor on the exposed sandy clay sub-soils. There was a good stand of guar on these sandy clays.

Where present outside the fence, buffel and birdwood were grazed down, while only the top part of guar was browsed. The guar was seeding prolifically.

Only guar was well established on red sandy clay-loam levee soils (Plate 90). Isolated buffel and birdwood stands were evident but these occurred mainly under trees. On drainage alluvia (grey sandy clays), there was poor establishment of introduced grasses, but promising regeneration of native grasses and bauhinia. Off-levee red sandy clays were bare and upper areas resembled clay pans. Buffel and birdwood established on lower (more loamy) areas, but there was poor establishment upslope.

Plate 90 *Dense guar stubble and regrowth in furrows. VRD Demonstration No. 1 (November 1963).*

1964

By 1964, buffel grass was more dominant than guar (Plate 91). Furrows on drainage plains had disappeared, but spelling brought the vegetation back (Plate 92). **Pieter Walter commented that furrowing and pasture introduction on problem (black) soils was a waste of time.**

Plate 91 *After guar, buffel grass and other vegetation grew along furrows. VRD Demonstration No. 1 (May 1964).*

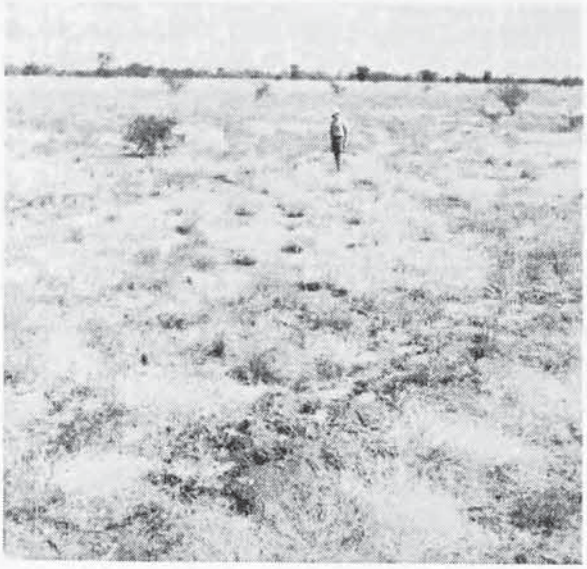


Plate 92 *Natural regeneration occurred on heavier clay soils making mechanical rehabilitation unnecessary (May 1964).*

1965

In April 1965, rehabilitation on Demonstration No. 1 was progressing satisfactorily. Mitchell and golden beard grasses were returning, especially on friable light brown cracking clays. Rehabilitation was much slower on yellow-red clay earth areas where soil was compacted and hard, or where there were claypan type features.

Rehabilitation between furrows was unsatisfactory, but growth within furrows was generally dense (Plate 93). Furrows on cracking clay areas, however, had not contributed significantly to rehabilitation and were causing tunnelling. **Furrowing those soils was subsequently not recommended, given that resting and management alone was thought to enable rehabilitation.**

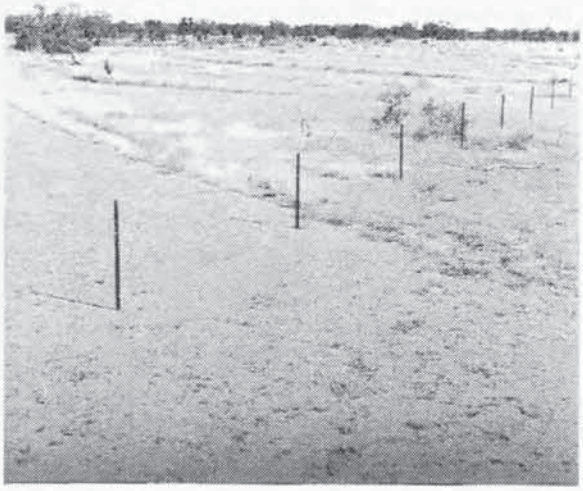


Plate 93 *While pastures were well established on furrows, bare areas remained in between. VRD Demonstration No. 1 (May 1965).*

Shrubs and trees either returning to the area or recovering included bauhinia, conkerberry, whitewood and prickly acacia.

Buffel establishment improved significantly after the 1964/65 wet but was confined to yellow-red clay areas and mainly within furrows. Only a few buffels and thick couch were present in between furrows. No kapok established. Guar was used as a pioneer for buffel establishment and was well distributed throughout furrows for the first 2 years, but little remained after the 1964/65 wet.

The demonstration area was used for holding small numbers of horses on a few occasions. It was planned to stock 500 beasts on the area for 2 weeks in the late dry and to rip areas between furrows with a grader prior to the wet season.

1966 - 1972

In 1966, ant activity and the reluctance of buffel to spread away from furrows were noted. In 1967, the area had reportedly been "well stocked" (Plate 94). By 1972, there were remnants of *Cenchrus* species, and Mitchell grass was returning to the cracking clay soils (Plates 95, 96). "Yellow weed" (roly poly) was still prevalent on black soils.

Plate 94 *Stock had been on VRD Demonstration No.1 in September 1967.*

Plate 95 *Heavily grazed buffel tussocks persisted along furrows. VRD Demonstration No. 1 (16 October 1972).*

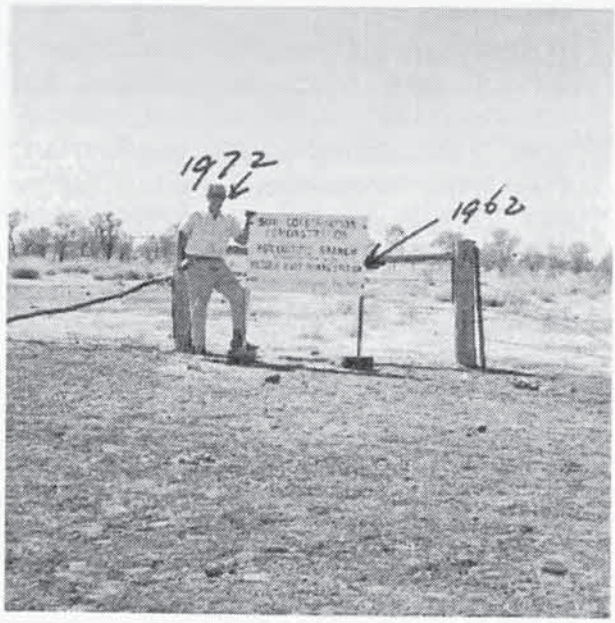


Plate 96 *Pieter Walter at the VRD Demonstration No. 1 site (16 October 1972).*

1993

In 1993, the paddock had only been used for a few horses and was in quite good condition. The furrows, and buffel establishment along them, were still evident in June, particularly so from the air (Plate 97).

Buffel spread between furrows was not great, however good stands had established downslope of the area planted in the northeastern corner of the paddock. This was possibly due to water accumulation. Buffel plants were also scattered along drainage lines, even through heavier soils. Most noticeably, buffel had established under trees along the river levee, again some distance from where it was planted (Plate 98). Buffel was generally restricted, however, to the paddock in which it was originally planted and was not as prominent under trees up or downstream of the demonstration paddock.

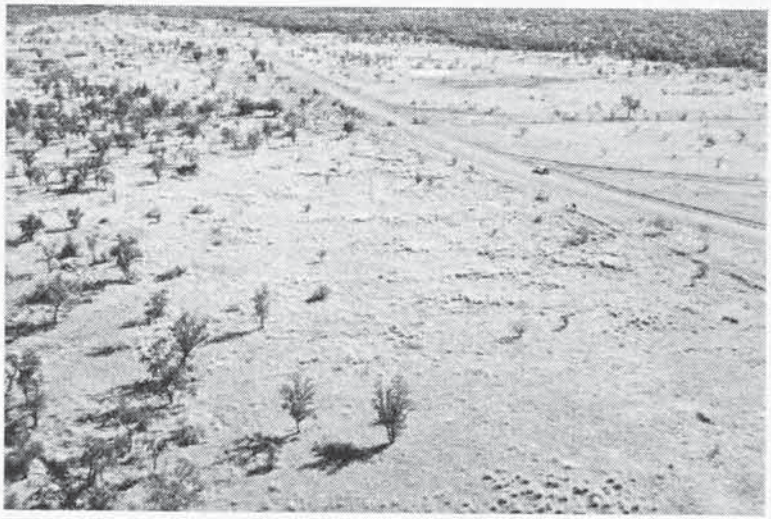


Plate 97

In June 1993, buffel grass was still evident along the furrows where it was planted 30 years earlier.

Plate 98

By June 1993, buffel had spread from VRD Demonstration No. 1 to drainage lines and under trees.

DEMONSTRATION NO. 2 (Near Kidman Yard)

1962-64

In late 1962, 260 ha near Kidman Yards (6.4 km off the Jasper Gorge road), were fenced and some of the area treated. The Kidman Creek area selected was described in 1963 and May 1964 as being scalded with some hummocks. Topsoil had been eroded exposing limestone rubble. Silver leaf box trees were dead, owing to topsoil loss and root exposure. Drainage lines were eroded to bedrock.

Some of the area was treated in November 1963 and all treatment was finished in November of the following year. This consisted mainly of crossed spiral furrowing (Plate 99). Seed was broadcast onto hills and no fertiliser was used. Only Gayndah and Cloncurry buffel and kapok were planted, as birdwood, sabi grass and guar were unavailable.

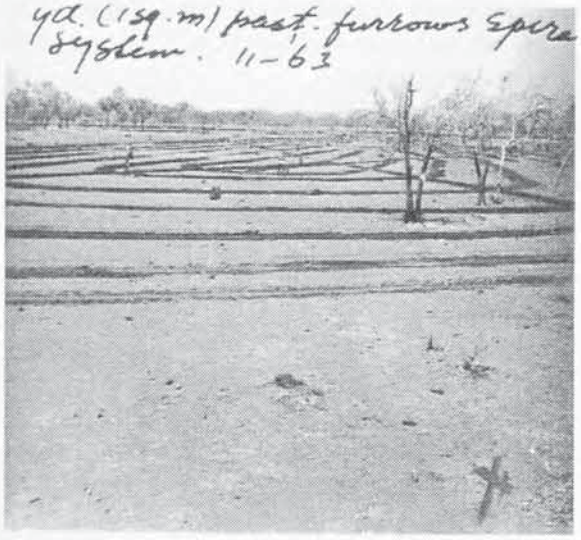


Plate 99 *A spiral system of furrows in VRD Demonstration No. 2, Kidman Yard (November 1963).*

After the 1962/63 and 1963/64 wet seasons, establishment was generally light, with some dense stands in runoff accumulation sites (Plates 100, 101).

Plate 100 *Buffel established well in the furrows of the VRD Demonstration No. 2 (May 1964).*

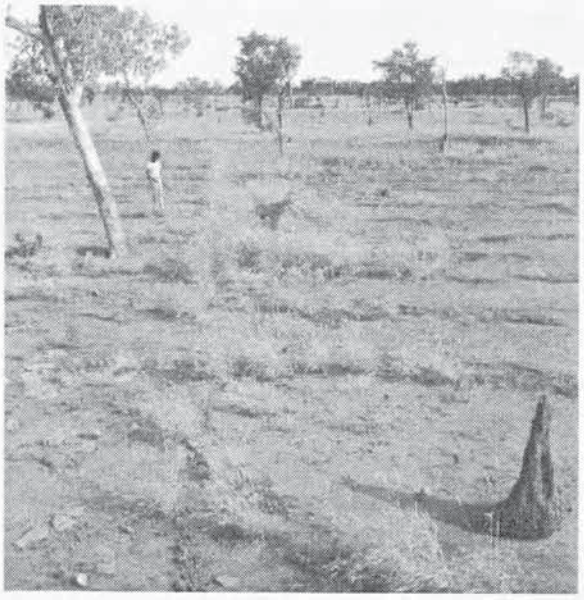


Plate 101 *Pasture stands were more dense along drainage lines or runoff accumulation sites. VRD Demonstration No. 2 (1964).*

In June 1964, successful establishment of buffel was attributed to:

- **viable seed lodging near or in stony material; and**
- **accumulation of moisture in furrows.**

Failures were attributed to:

- **use of the wrong strains;**
- **placement of seed outside furrows;**
- **failure of germination;**
- **death of seedlings after germination;**
- **harvesting of seed by ants; and**
- **destruction of plants by marsupials.**

More intensive treatment with guar and WA buffel was recommended for November 1964.

1965

Good rains in the 1964/65 wet season resulted in wider and more dense establishment and by April the demonstration showed outstanding results.

Plants grew most successfully at the junction of cross and spiral furrows and in yellow-red sandy clays with limestone rubble and bauhinia, nutwood, bloodwood and coolibah trees. Dominant annuals were limestone grass, native couch and pigweed. Sorghum alum, which had only been planted in one area, established in drainage sites.

Dense buffel grew along rows and some plants established throughout the area. Young establishing golden beard grass plants were evident and annuals were invading bare areas (Plate 102). These results led Pieter Walter to comment **"rehabilitation is possible if applied properly and managed well"**.

Nothing established on areas of accelerated erosion or on more sloping or untreated bare areas.

The area was stocked for only a few months late in the 1965 dry season.

Spiral cross furrowing replaced an earlier square checker-board system which was proving unsatisfactory because furrow breaks were common. Vegetation on spirals was quicker to establish and the spirals had a better chance of resisting furrow breaks. Cross furrows were constructed first and spirals were constructed over these. This method was first successfully introduced on Manbulloo in 1959.

Plate 102 *The VRD Demonstration No. 2 site in May 1965.*

1966 – 1993

In 1967, it was noted that while buffel did not spread in some areas, it spread like wildfire in others (Plate 103).

In November 1968, photographs of treated, untreated, controlled and uncontrolled stocking of the Kidman demonstration area were taken. After 8 years, this area had experienced infrequent and brief heavy grazing (Plate 104).

In 1993, Les Humbert of Kidman Springs considered that the area had vastly improved since the early 1980's when it was bare and scalded with dead trees. The area was not grazed much for several years prior to 1990, although cattle have since been re-introduced to the paddock.

In July 1993, there was little evidence of the demonstration area. Fences had been removed and only isolated clumps of buffel were present (along old windrows, for example). Good cover of native annual and

perennial pastures had regenerated and there was little evidence of dead trees and shrubs.

Plate 103 *Buffel had not spread from the furrows in the VRD Demonstration No. 2 site by August 1967.*

Plate 104 *After 8 years of infrequent and brief but heavy grazing, buffel was persisting in furrows and had spread in drainage areas of the VRD Demonstration No. 2 site (16 October 1972).*

OTHER 1960'S REHABILITATION PROJECTS

In the 1960's, several other areas on VRD were furrowed and seeded for rehabilitation. These included areas near:

- Colts Paddock;
- Bluebush Paddock;
- Crystal Paddock;
- Bull's Head Holding Paddock;
- Centre Camp;
- Police Hole; and
- Dry Horse Paddock, Weaner Yard and Dashwood Holding Area (Plate 105).

Plate 105 *Furrowing for rehabilitation in Dashwood Holding Area, VRD Station (November 1966).*

Photographs of other minor soil conservation demonstrations around the station were taken in November 1963. These show guar stubble, furrows constructed above gullies and stops placed in furrows (Plate 106).

Plate 106 *Pasture furrows above gully heads on VRD (November 1963).*

Colts Paddock (1965)

In March 1965, big rains were received and the manager subsequently planted 2 areas of 0.6 ha north of the main road. No fertiliser was used and the area was rolled with a 102 kg roller after sowing. Strips were sown to kapok, buffel, Townsville lucerne, Mitchell grass and guar. The area was not fenced.

Bluebush Paddock (1965)

In May 1965, a drainage plain in Bluebush Paddock was inspected by Pieter Walter at the request of the manager with a view to pasture rehabilitation and soil conservation. The area was a self-mulching clay soil south of the VRD-Top Springs road, 21 km east of Centre Camp, and 1.6 km east of the Bluebush Paddock gate. Little was known about pasture introduction into these soils.

An area of 1.6 ha was to be sown with a disc plough on the contour. Mitchell grass was to be considered and it was thought that buffel, Townsville lucerne and sabi grass may establish given a favourable season. Kapok was considered unsuitable.

Crystal Paddock (1965)

An area of 40.5 ha of black soils in Crystal Paddock near the homestead was selected for the establishment of permanent improved pastures for stud breeders. Strip introductions were recommended in preference to large-scale cultivation.

Kapok had not been successful at other locations on VRD and it was considered that proper establishment of other pastures may take up to 5 years. Most buffel strains had been tried on this soil type with no success, and sabi was not considered suitable. Mitchell grass was recommended and it was thought that millet and sorghum may give mediocre stands in good wets. WA buffel, birdwood and guar (as a pioneer crop) were recommended for the yellow-red earths in that paddock.

While records do not detail what was actually sown, isolated birdwood establishments were recorded.

Bulls Head Holding Paddock (1965)

Pastures were introduced to the Bulls Head Holding Paddock in 1965. By 1966, there was excellent WA buffel establishment, however, stock had damaged the stand (Plate 107).

Centre Camp (1967)

An opposed disc plough was used near Centre Camp in 1967 (Plate 108). Uncontrolled stocking finished off a successfully established grass stand on a spiral. Stock concentration on the treated area was noted.

Police Hole (1967)

In August 1967, the Police Hole project showed good recovery of shrubs and trees, but poor establishment of introduced grasses (Plates 109, 110). Similar methods were used for this project as for Demonstration No. 2.

Plate 107

Excellent stands of WA buffel established in Bull's Head Holding Paddock, however heavy stocking threatened the rehabilitation (August 1967).

Plate 108

Opposed discing near the entrance to Centre Camp on VRD (1967).

Plate 109

Uncontrolled spiral furrowing and pasture introduction in the Police Hole holding area, VRD (November 1966).

Plate 110

Trees, shrubs and native annuals improved, however poor establishment of introduced pasture species occurred. Police Hole holding area, VRD (August 1967).

BUFFEL DISTRIBUTION (1993)

Around the VRD Centre Camp area, buffel and kapok seemed fairly widespread at ground level, although distribution appeared to be more patchy from the air.

Buffel occurred mainly in disturbed or well watered areas such as:

- along windrows and against roads and tabledrains;
- around buildings; or
- in the vicinity of previous planting efforts, (opposite the front grid in the old farm area and in Demonstration 1 Paddock, for example).

The preference of buffel for non-cracking clay soils was very obvious opposite the front grid. Buffel stands were restricted to red soils with a definite cut-off line at black soil patches to the north. The water requirements of buffel were also illustrated on the old farm area. Stands were very thick against old irrigation ditches and bays where some ponding occurred, while bare areas were evident where the ponding effect diminished (Plate 111).

A summary of the findings of these demonstrations was written by Pieter Walter in the late 1960's (Table 3).

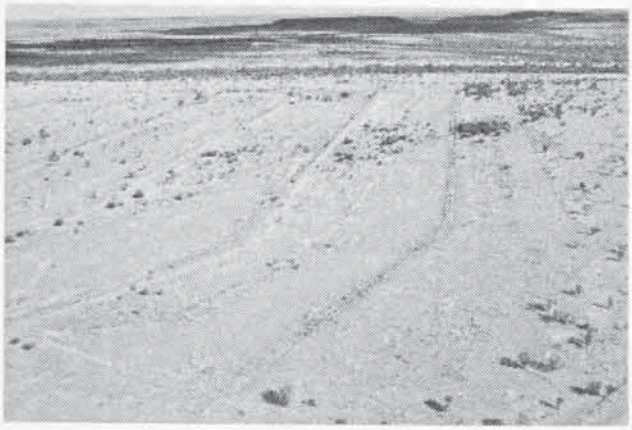


Plate 111

The old farm area near Centre Camp illustrated the importance of water retention for pasture establishment. Buffel (probably self-sown) was well established where water had ponded in and against disused irrigation ditches (2 June 1993).

Table 3 *Findings from soil conservation demonstrations on VRD as summarised by Pieter Walter in the late 1960's.*

Aspect	Findings
Levelling	Levelling was the most time consuming part of rehabilitation work.
Soils	The success of rehabilitation on lighter textured soils was affected by ephemerals out-competing perennials. Regeneration of areas in which topsoil had been lost, or where a surface crust was evident, required breaking of the surface.
Implement	Use of the opposed disc plough was proving successful on sandy and silty soil types.
Seed	Seed placement techniques were open to much improvement. In low rainfall areas, WA buffel, birdwood and kapok were the best species for rehabilitation work. Guar enhanced buffel establishment by 25% to 40%.
Furrows	The establishment of water retaining furrows provides a basis for pasture introduction work on degraded country (Figure 10). The cross-section and depth of furrows was of great importance. The best spacing of furrows was not known, but was usually between 5.5 m and 11 m. Between 124 km and 186 km of furrowing are required per square kilometre treated.
Stocking	Protection from grazing was very important at certain times. Spelling of Mitchell and Flinders grass plains was required as a result of excessive grazing and erosion. Controlled stocking was allowable for short periods during the dry.
Costs	The costs of furrowing and seeding were "80 to100 pounds per square mile(10/- per acre or ½ mile of furrow)". Mechanical work to arrest erosion was beyond the finances of landholders.

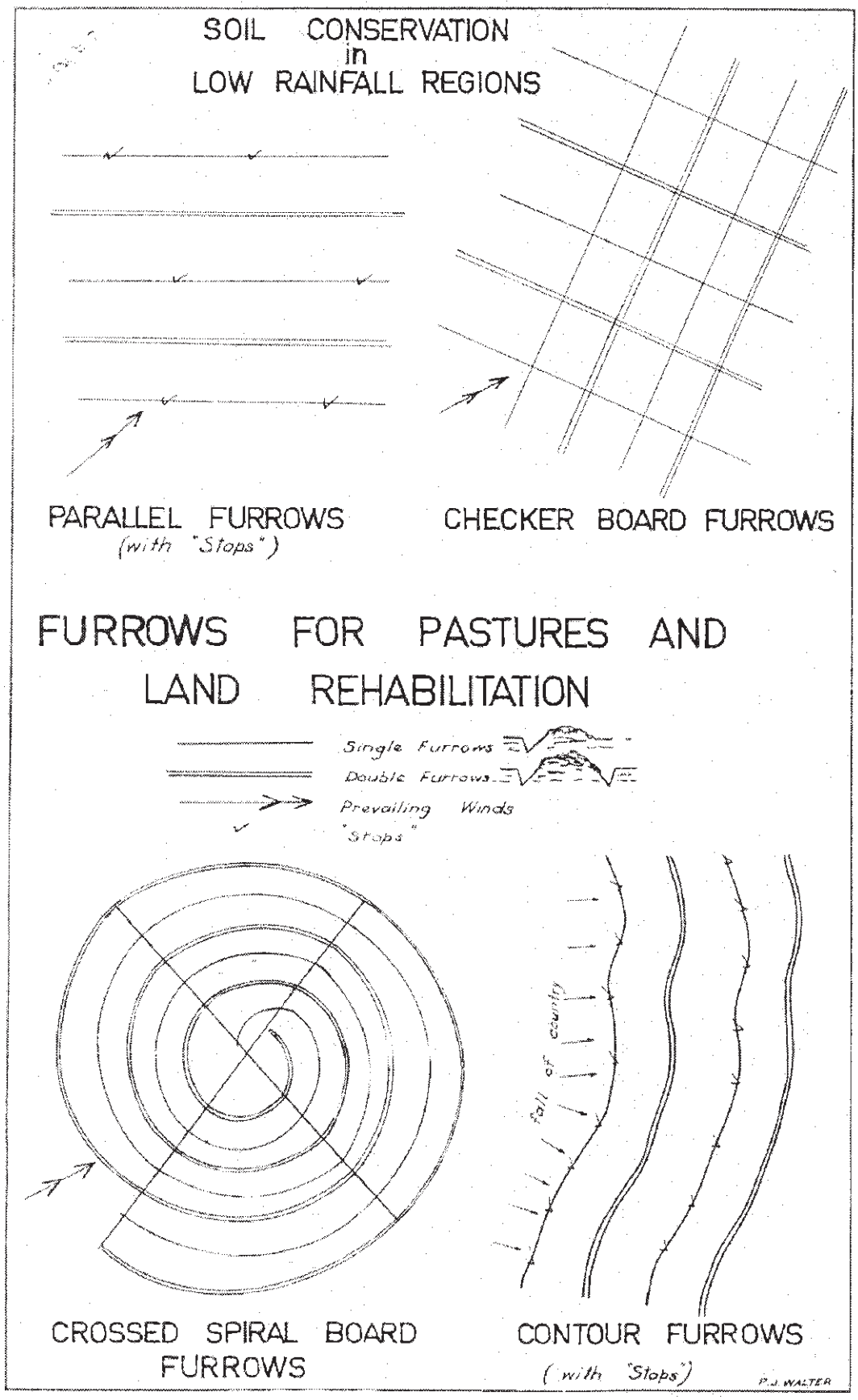


Figure 10 *Cultivation patterns used for rehabilitation on VRD in the 1960's.*

REHABILITATION TRIALS (1989-92)

In February/March 1989, mechanical rehabilitation trials were established on 4 soil types by Kit Jolley of the CCNT. The soils and site locations were:

- cracking brown clays, 1 km south of Dashwood Crossing;
- non-cracking calcareous clays, 3 km east of Centre Camp;
- non-cracking red clays, 1.2 km south of Dashwood Crossing; and
- a stony red earth, 1.8 km south of Dashwood Crossing at the Larry's Lake turnoff.

The plough types used were an:

- opposed disc plough;
- a pitter planter; and a
- chisel plough.

Gayndah buffel, birdwood and purple pigeon grass were planted. All trials were fertilised with 50 kg/ha N:P:K 15:13:10, which was broadcast prior to planting.

Cracking brown clays

The cracking clay soil did not allow establishment of sown species on chisel or opposed disc plough cultivation. The latter, in fact, appeared to inhibit the good natural recovery of native pastures, which occurred with a fair wet season and light stocking (Plates 112, 113). A few buffel plants did establish on opposed disc hills and were large and vigorous in 1993.

Non-cracking calcareous clays

On the grey calcareous clays, establishment of all species was good on opposed discing, fair on pitting and poor on chisel plough cultivation. As on other sites, purple pigeon grass did not persist. Buffel and birdwood persistence was also poor on the pitting, however reasonable establishment and sizeable plants remained on opposed discing in 1993 (Plates 114, 115).

Non-cracking red clays

A chisel plough was used on the red clay soil, where germination of purple pigeon grass and birdwood was quite good. Plants quickly became stressed, however, and persistence was poor. No buffel established and only some small birdwood plants were surviving in 1993.

Stony red earth

On the stony red earth, establishment of all species was good within pits and opposed disc furrows. Plant yield and vigour on opposed disc hills were superior to that on the pitting (Plates 116, 117, 118).

Purple pigeon grass did not persist to the next wet season. Birdwood establishment was more consistent than buffel, but plants were generally smaller.

Opposed discing on stony soils is less than ideal, as the discs tend to ride up onto the stones reducing penetration.

A full report on the location, methods and results of these trials is available in Sullivan (1991e).

East of Centre Camp (1989)

In 1989, several hectares along the Top Springs Road just east of Centre Camp were chisel ploughed and sown with a shotgun mix of buffel, birdwood and purple pigeon grass. Establishment may have been fair, but did not withstand heavy grazing by wallabies.

In late 1991, Jim Coulthard (the manager) undertook a project to rehabilitate an area around a filled rubbish dump.

Loader rippers were used to scarify the bare red country and kapok and birdwood seed were hand sown into riplines. The 1991/92 wet season was below average. There was

some germination, which subsequently burnt off. Establishment of kapok after the 1992/93 wet season was good and probably originated from the sown rather than "naturally" occurring seed.

Plate 112

An area of cracking brown clays or "black soils" on VRD where buffel grass was sown onto opposed disc furrows (23 February 1989).

Plate 113

Natural regeneration on cracking brown clays or "black soils" on VRD showed that mechanical rehabilitation on these soils is often not warranted or successful (29 March 1990).

Plate 114

Discontinuous opposed disc furrows follow the contour on a non-cracking calcareous clay, VRD (13 May 1989).

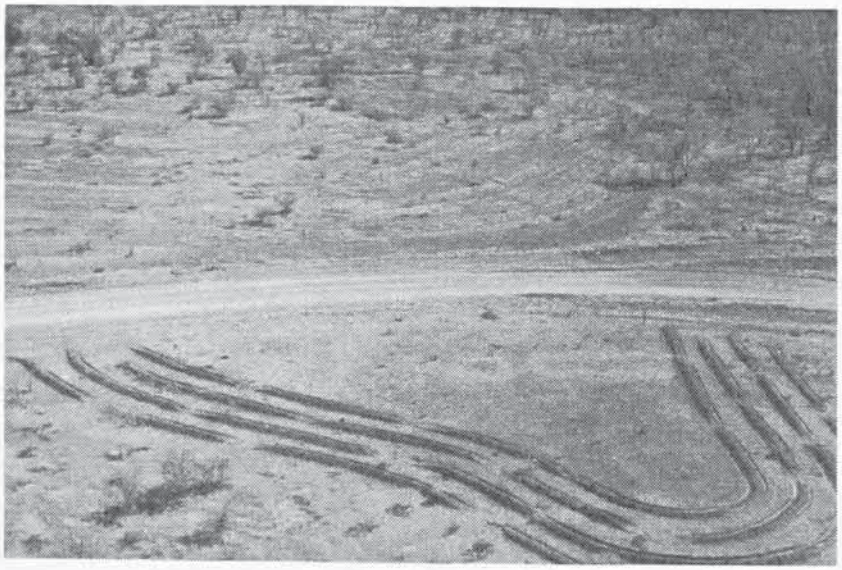


Plate 115

Despite some stocking, buffel established in opposed disc furrows on a non-cracking calcareous clay on VRD. Larger plants established on the uphill side of opposed discing where runoff interception was greatest (13 January 1990).

Plate 116

Pitter ploughing on a stony red earth, VRD (1 March 1989).

Plate 117

Buffel establishment was quite good on the stony red earth shown 2 months earlier in Plate 116 (12 May 1989).

Plate 118

While the size and vigour of buffel plants was greatest on opposed disc hills on the stony red earth, subsidence of the hills and exposure of the plant roots was eventually going to result in plant mortality (14 February 1991).

VICTORIA RIVER RESEARCH STATION

See Kidman Springs.

WATERLOO (1992 - 1993)

Pitting, opposed discing and chisel ploughing were tested by Darryl Hill of the CCNT in 1992 and 1993 to rehabilitate degraded areas along Waterloo Creek and in paddocks near the homestead.

Soil types ranged from gravelly red soils to cracking clay "black" soils. Cultivated areas were hand-seeded in December 1992 with buffel grass and silk sorghum. Heavier soils were also sown with Bermuda couch and Mitchell grass.

The amount of rainfall received was above average, but the growing season was short. Germination of planted species was disappointing on most areas, given the favourable season, although cover of species like kapok and couch improved.

WAVE HILL (Kalkarindji) SETTLEMENT AREA

Soil conservation and rehabilitation work around the Wave Hill settlement area commenced as early in 1957, with the introduction of buffel and birdwood grasses in the Wattie Creek area. Extensive rehabilitation was also required around the police station in the 1960's due to significant gully erosion.

Wattie Creek buffel grass introduction project

In 1957, buffel and birdwood grasses were introduced as a routine part of early extension services in the Wave Hill district.

Kapok and sabi grass were added in the following year to make a shotgun mix for soil conservation purposes.

Establishment was aggressive and in 1960, large areas were covered. At the time it was thought that the spread had reached its limit. Establishment continued, however, on alluvial, colluvial or run-on areas and away from creek frontages. The potential for a seed harvesting industry was recognised.

In September 1967, WA buffel and birdwood from Ord River Station was introduced.

In 1971, a remarkable spread of these grasses around the Wattie Creek levees was reported by Stuart MacNish. Grasses covered a much larger area than that indicated on sketches of the original areas planted, although it was recognised that some areas may have been planted after these sketches were made.

MacNish estimated that 130 ha to 260 ha of grass would be available for seed harvesting.

Wave Hill police station (1960 - 1970)

In 1960, erosion control work in the vicinity of the Wave Hill police station became necessary. Road drainage lines put in by the Works Department required immediate attention with mechanical treatment and revegetation. The slope was 2.5 % and the work required fencing.

The Wave Hill Station chisel plough and tractor were to be used, although Pieter Walter would have preferred a disc or mould-board plough. WA buffel, birdwood and kapok were sown, with some of the buffel seed to be harvested from the Wattie Creek area.

Sketches were made of the area showing gullies, drainage lines, tracks and areas treated.

By May 1963, 305 mm of rain had been received. The general appearance of the vegetation was unsatisfactory. Kapok had been well established in 1962, but its growth was now disappointing. Buffel establishment was also unsatisfactory. Short lived annuals covered the area and there were swarms of grasshoppers.

The fence required some maintenance and the gate was to be kept closed. Planting of exotic trees such as Athel pine, and oleander, which would require watering, was recommended.

In May 1965, comparisons with February photographs (Plate 119) showed that March rains had greatly improved cover. Kapok had spread over much of the previously bare area and buffel had spread, although mainly in drainage lines. Tree planting was considered important for a speedy recovery.

Photographs from May 1967 show recovery of the seriously eroded area, dense kapok and dense stands of buffel within furrows (Plates 120, 121).

By October 1967, the area was an outstanding example of successful rehabilitation under arid conditions. The fence needed repairs, but there was good vegetation cover and gullies were disappearing.

In April 1970, there was an excellent establishment of kapok and good stands of buffel. This was despite the poor condition of the fence and heavy grazing by goats.

Plate 119 *The Wave Hill police station area on 28 February 1965.*

Plate 120 *The Wave Hill police station area in May 1967.*

Plate 121 *Buffel grass established well along furrows and drainage lines in the Wave Hill police station area (May 1967).*

WAVE HILL STATION (1990-91)

Rehabilitation was undertaken by the manager Graeme Fagan at 2 locations and with varying success.

In December 1990, a pitter planter was used to introduce pastures to a bare area between the Camfield River channels.

Cloncurry buffel, seca stylo and purple pigeon grass were planted in one area and USA buffel and seca stylo in the other. Planted areas were fertilised with 75 kg/ha of superphosphate. The soils were similar to the calcareous earths in Trap Paddock on Camfield Station. The wet season was quite good and the area was inundated at least 3 times.

Birdwood, which had grown along the river for years, spread a little into cultivated areas. Establishment of buffel was poor to fair, but best on the pit edges. Native pasture cover was good, but consisted mostly of annual species. There was little growth in the pits which was probably due to waterlogging. Some Mitchell grass regeneration occurred.

In 1989/90 and 1990/91, introduced pastures were sown on an area of black soil a few kilometres southwest of the station turnoff along the Buchanan Highway.

Buffels, stylos and forage sorghum were planted with a chisel plough and fertilised. Some establishment was noted in 1989/90, but plants subsequently burnt off. No establishment occurred in the second year. **Planting onto these black soils may require specialised methods, such as use of presswheels, mulches or planting at depth.**

WILLEROO (1988)

In December 1988, Darryl Hill of the CCNT and Mark Clifford, the station manager, used a chisel plough to cultivate an area on a gravelly red soil ridge running down onto a black soil area about 10 km down the Delamere Road from the Victoria Highway.

Buffel, birdwood and purple pigeon grass were planted and the area was fenced. A poor season followed.

Some buffel was persisting in 1994, however, no purple pigeon grass or birdwood established.

TOWARDS SUCCESSFUL REHABILITATION

The success of land rehabilitation is far from guaranteed. This review identifies the factors which enhance the chances of success. There are times when rehabilitation is not an appropriate option and other forms of management, such as spelling, are required.

The main factors to be considered when determining appropriate management of degraded areas are summarised in a decision tree (Figure 11).

Should mechanical rehabilitation be the appropriate option, further considerations include soil type, severity of degradation, cultivation methods, planting and costs and benefits. Future research possibilities are identified.

SOIL TYPE & SEVERITY OF DEGRADATION

Mechanical rehabilitation has been notably unsuccessful on degraded black soils (grey/brown cracking clays). Natural regeneration, in the absence of stock, is often the best course of action (Sullivan and Andison 1991g). Studies have indicated that establishing pastures on black soils is difficult. This is due to the rapid drying of surface soil under the hot dry conditions which often follow rainfall (Younger and Gilmore 1978a). In some cases the soil has been depleted of viable native pasture seed and seed has to be re-introduced to achieve revegetation.

Revegetation of degraded red soils (non-cracking red clays, red sandy clay loams or similar soil types) will often require mechanical rehabilitation. These soils commonly have a strong surface crust and tend to seal on wetting. This can:

- impede the penetration of seed into the soil and the emergence of germinating seeds;
- limit infiltration of rainfall; and
- result in greater runoff.

Appropriate cultivation improves infiltration by slowing the flow of water and reducing the amount which runs off.

Some soils do not have the appearance of black soils, but respond poorly to mechanical rehabilitation. Rehabilitation of the non-cracking calcareous earths between the Camfield River channels on Wave Hill and Camfield was unsuccessful. The subsequent appearance of self-sown Mitchell grass, however, confirmed that these soils will regenerate naturally with wet season spelling. A non-cracking calcareous clay on VRD did respond to mechanical rehabilitation, however native pastures may have regenerated naturally with spelling. This soil had a self-mulching surface not unlike that of black soil.

Scalded soils which are sodic, have strong surface crusts and seal when wet require waterponding for rehabilitation.

Mechanical rehabilitation will not control gullies. Gully control requires earthworks, is costly, and is mainly undertaken to protect station infrastructure, such as roads, fences and watering points.

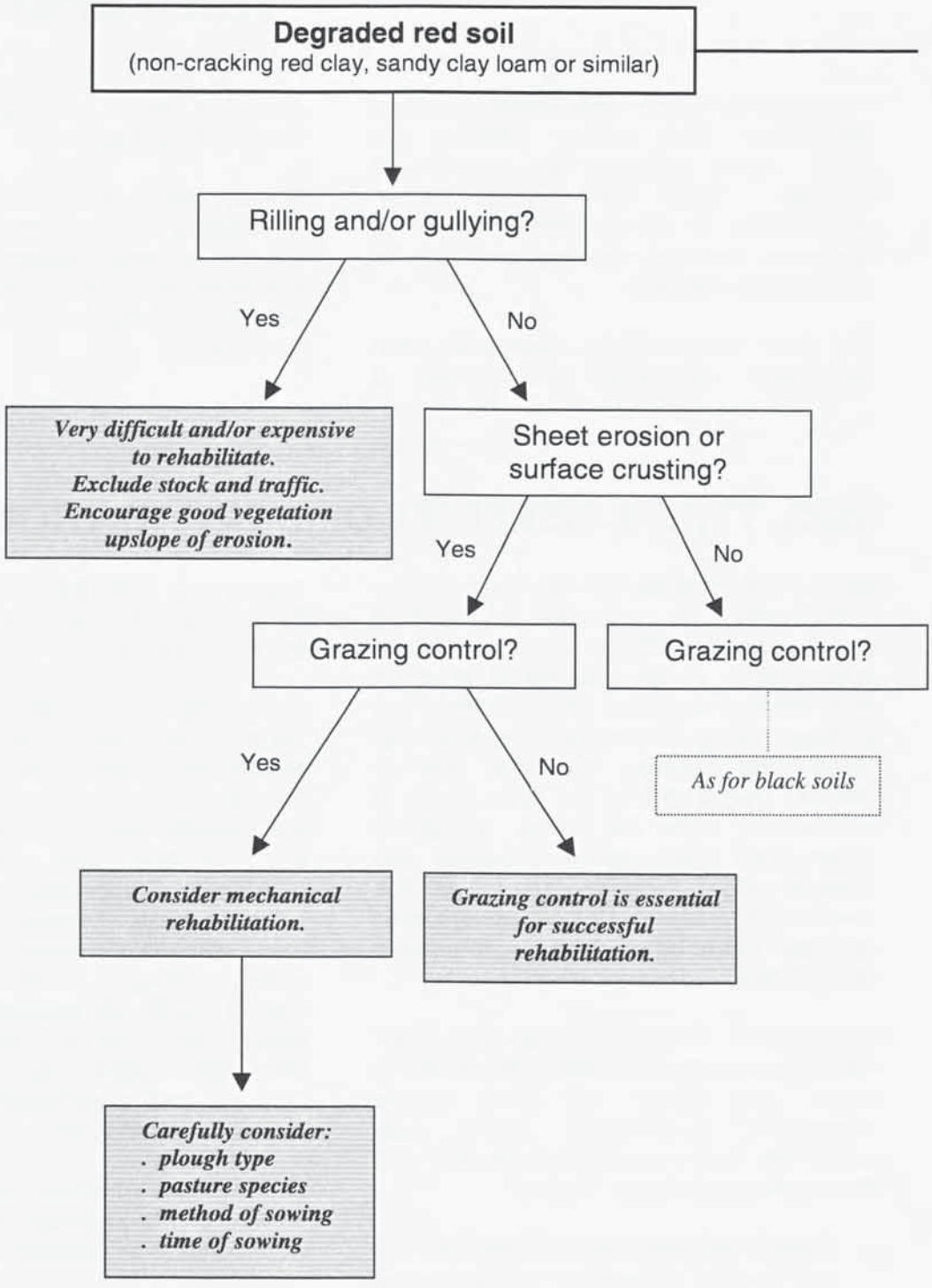


Figure 11 *Land rehabilitation decision tree for degraded red and black soils and scalds.*

DECISION TREE

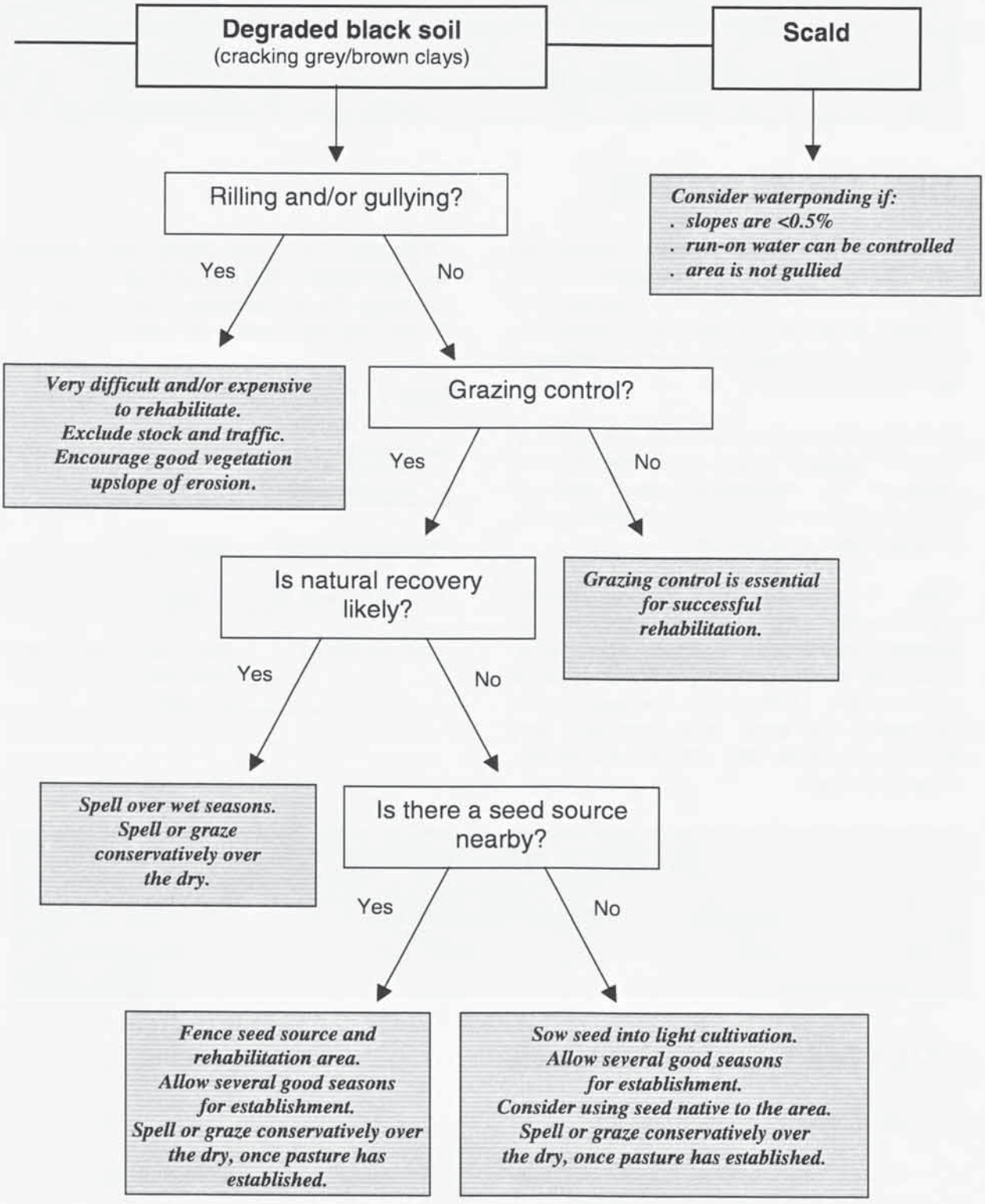


Figure 11 *Continued.*

Soil type and severity of degradation

- *Mechanical rehabilitation has been notably unsuccessful on degraded black soils.*
- *Revegetation of degraded red soils often requires mechanical rehabilitation.*
- *Degraded non-cracking calcareous earths and black soils are best managed for natural regeneration.*
- *Scalded sodic soils require waterponding for rehabilitation.*

TIME OF PLANTING

As with all agricultural pursuits, mechanical rehabilitation is subject to the vagaries of the weather. Time of planting is a balancing act between anticipated amount and distribution of rainfall, site accessibility and availability of staff and machinery.

If planting takes place prior to the onset of the wet season, there is a risk of seed predation by wallabies, rats, ants or termites. Some commercially available seed is treated with insecticides.

Table 4 outlines the general rainfall requirements for pasture growth. In northern-most areas of the semi-arid tropics, conditions enable planting to occur as early as November. To the south, the likelihood of dry spells after early rains increases and planting should be left until late December or early January.

Of course, the earlier plants can establish and consolidate, the better their chances of surviving the dry season: thus the gamble on how the wet season will break.

Table 4 *General rainfall requirements for pasture growth phases.*

General rainfall requirements	Pasture growth phases
Adequate early falls	Germination
Regular follow-up rain	Seedling survival
Long wet season	Plant establishment and consolidation prior to the dry season.

Time of planting

- *In northern-most areas of the semi-arid tropics, planting can occur as early as November.*
- *In more southerly locations, planting should be left until late December or early January.*

CULTIVATION METHODS

Effective rehabilitation cultivation will:

- intercept and reduce runoff, increase infiltration and improve soil moisture;
- reduce the potential for further erosion by preventing concentration of runoff;
- provide a deep, loose seedbed;
- trap or catch wind and water borne seed and organic matter;

- break up surface crusts;
- provide a more suitable environment for plant emergence and growth;
- offer a range of moisture conditions for pasture establishment; and
- maintain its profile for several seasons and not subside.

The opposed disc plough has consistently delivered the best results on degraded red soils. These ploughs are not always available, however, and may not be the most practical implement.

All cultivation implements have advantages and limitations (Appendix A). The advantages of 3-point linkage mounted and towed implements are summarised in Table 5.

Table 5 *Advantages of 3-point linkage and towed cultivation implements.*

3-point linkage implements	Towed implements
Manoeuvrable	Can be pulled by a tractor, grader or dozer.
Easy to raise and lower.	Require hydraulics for raising and lowering.
Easy to load and transport.	May be heavier and more effective on hard country.
Generally smaller and less expensive than towed implements.	

CULTIVATION PATTERNS

To intercept runoff and avoid concentration of water, cultivation should follow the contour.

When opposed discing, discontinuous furrows prevent the accumulation of water to the point where overtopping and breaching occur. Staggered furrows prevent the concentration of runoff spilling from the line of furrows above (Figure 12, Plates 47, 114). This cultivation pattern is inherent in pitter ploughing.

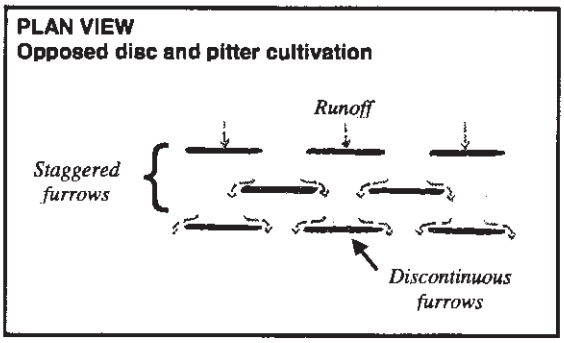


Figure 12 *Discontinuous and staggered furrows are recommended to prevent water accumulation, overtopping and breaching of cultivation.*

In the Ord catchment regeneration area, opposed disc hills were 20 m long with 6 m gaps, and runs were at least 5 to 7 m apart (Fitzgerald 1967). Ten metre long hills with 2 m gaps have been used more recently in Victoria River District work. The distance between runs will depend on the slope and severity of degradation. Closer spacing between runs will be required on higher slopes and more severely degraded soils to achieve good vegetative cover.

The use of a chisel plough immediately upslope of opposed disc runs was found to be the most successful cultivation technique on gently sloping areas in the Ord catchment (Fitzgerald 1982). The chisel plough improves infiltration of water ponded by opposed disc hills and provides a good seed bed. Follow-up cultivation in subsequent years between initial opposed disc runs will assist in the spread of plants. Chisel ploughs or pitters could be used.

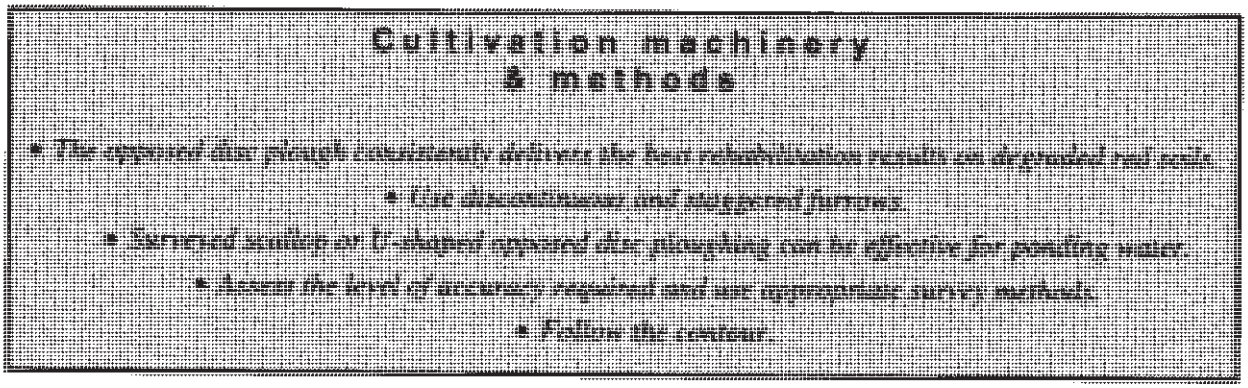
Small scallop or U-shaped opposed disc hills can be very effective for ponding water and improving rehabilitation results, as was illustrated on Argyle Station (page 22). Surveying for this cultivation pattern is advisable to ensure hill ends are at the same level. If the ends are too high, more water will be ponded than the hills can contain and breaches will result.

FOLLOWING THE CONTOUR

The contour can be determined in a number of ways depending on the nature of the slope and the level of accuracy required.

Water flows at right angles to the contour and the direction of flow can be indicated, for example, by soil surface wash, terracing, small rills and/or debris caught on the upslope side of obstacles. Finding the contour by eye in this way may be adequate if the slope is low and uniform, or a pitting implement is to be used across the whole area.

The use of a hose, dumpy, laser or other level is recommended on steeper or irregular country to reduce the risk of causing erosion. Detailed and accurate surveying is required for waterponding bank layout. Cultivation machinery should follow contours marked either on the soil surface or with pegs.



PLANTING

The final use of the rehabilitated area and the costs and benefits of rehabilitation need to be kept in mind when deciding how to achieve revegetation.

Considerations include:

- encouraging self-sown native species to establish;
- planting native or introduced species;
- choosing the pasture species to plant;
- seed treatments;
- planting methods; and
- fertilisers.

SELF-SOWN NATIVE SPECIES

Native pasture species will often colonise cultivation if:

- an area of non-degraded country is nearby;
- the degraded area still contains viable seed; or
- the area is protected from stock for a number of seasons.

The spreading of logs and branches on bare red soils can trap litter, moisture, and wind and water borne soil, and provide an environment for native pastures to establish.

Waterponded areas and opposed disc scallops have produced good establishments of native pastures on Argyle, Auvergne, Bunda and Kidman Springs.

PLANTING NATIVE OR INTRODUCED SPECIES

The expense of mechanical rehabilitation may warrant the planting of specific pastures with known germination rates to ensure revegetation and productivity.

Rehabilitation work has traditionally involved the use of introduced pasture species because restoring productivity for livestock has been, and often still is, a prime consideration. Introduced pasture species are also commercially available, relatively cheap and easily obtained.

GANT's Katherine Region Revegetation Centre is testing some 50 native grass species for revegetation potential on a variety of soil types. In the last 10 years, interest has grown in the use of native pastures, particularly on black soils where introduced species have never performed very well (for example on the Barkly Tablelands and at Mount Sanford). Little work has been done on the planting of native pasture seed on red soils.

In some areas, such as in or near national parks, the use of native species may be preferred. The use of less palatable native species, such as black speargrass, might even be considered to deter livestock from a rehabilitation area. Young speargrass plants are still very attractive to stock, however, and will require protection.

Native grass seed is becoming easier to obtain due to demand from the mining industry. Whether harvested locally or purchased, the use of native grasses for rehabilitation might be considered.

Purchased seed (both native and introduced) should only be bought with a recent **seed analysis certificate**. This should specify at least: % germination; % hard seed; purity; and other seed content. Analysis certificates should accompany all seed bought from reputable suppliers. This information is essential for calculating sowing rates and knowing what is being planted.

CHOOSING SPECIES

The main species used for rehabilitation in the semi-arid tropics of the NT include buffel, birdwood, kapok, Indian couch, sabi grass, Mitchell grass, native millet, Flinders grass and legumes such as verano and seca stylo.

Planting a mixture of species helps to ensure establishment of at least one species under different seasonal conditions. Ensuring species planted are appropriate to the soil type is important. For example, Mitchell grass is appropriate for black soils.

Buffel and birdwood

Buffel and birdwood are by far the most extensively used pasture species in rehabilitation because they are persistent, productive, and grazing, drought and fire tolerant. They are also readily available and relatively cheap.

Buffels and birdwoods are not ideal, however, as:

- runoff can concentrate between tussocks and cause erosion;
- maintaining a mixed species pasture is difficult, so if the buffel dies, little else is left;
- well-established buffel stands can deteriorate where tussock mortality occurs and plants are not replaced (as in places on Mistake Creek, for example);
- buffel will not spread from furrows on degraded red soils. Limited spread may occur along drainage lines and on sandy areas.

The spread of buffel in the semi-arid tropics has never rivalled that in Central Australia where it is considered by some to be environmental weed.

No particular variety of buffel has shone above another in rehabilitation work to date and no variety has successfully established on degraded black soil in the semi-arid

tropics of the NT. Nunbank, sold as "black soil buffel", has not been any more successful than other varieties. Locally harvested seed is probably the most suitable variety for a particular area, but if this is unavailable, commercial seed will suffice.

In the Ord, birdwood is considered to be more tolerant of grazing and drier conditions than buffel (Petty 1990).

The ideal rehabilitation species would have all the qualities of buffel except its tussocky habit and limited ability to spread. An ideal plant would have a creeping habit capable of creating vegetation cover which protects the soil surface from runoff and raindrop impact.

This ideal species is yet to be found!

Kapok
Kapok bush was extensively used in the Ord catchment regeneration work and early Victoria River District demonstrations. It produced large quantities of light, fluffy seed and showed an ability to spread and colonise degraded land. A motor driven machine was used to vacuum seed from the ground and separate it from leaf litter and soil (Plate 49). Kapok has not been used much in recent years.

Indian couch and sabi grass
Indian couch has many of the desirable qualities of a rehabilitation species. It has, however, proven difficult to establish in sizeable stands, with isolated patches being the most common outcome. New varieties may prove more successful.

Sabi grass has shown potential in more northerly rehabilitation areas on Auvergne, Bullo River, Bunda and Kidman Springs.

Mitchell grass, native millet and Flinders grass
While the results may be variable, Mitchell grass and native millet are recommended for planting on black soils. The use of locally harvested seed is preferable. Seed is available from GANT and commercial suppliers.

Legumes
The inclusion of a legume will assist grass establishment and persistence, and make a more productive pasture stand. Careful grazing management is required to maintain a good grass/legume mix.

Stylos are the most hardy and promising introduced legume in extensive grazing systems of the semi-arid tropics at present, though in higher rainfall areas many other legume species might be considered. In the late 1980's verano and seca stylo were the most suitable, with seca being the more drought tolerant. New varieties have since been released, but seca and verano remain the most popular varieties in the semi-arid tropics of the NT.

SEED TREATMENT

Seed treatments are used to improve germination rates and the ease of seed handling and sowing. They include:

- coating the seed with fertiliser, insecticide and/or fungicide, which have been added to a clay or lime based product; or

- physically altering the seed coat to break dormancy by freezing, rubbing, hammering, immersing in acid, heating or scarifying.

Legume seed should be inoculated with the appropriate rhizobium culture prior to sowing. The need for seed treatment depends on the type and age of seed, time and method of planting and past experiences. Treating seed has some disadvantages and advice should be sought from DPIF. The cost/kg of bare seed and loose fertiliser should be weighed up against the cost/kg of coated seed.

Buffel
Fluffy seed like buffel or very small seed is much easier to handle and sow when coated. Again, several experiences in this review indicate that **establishment problems have been encountered with coated buffel and birdwood seed**.

Kapok
Kapok germination is greatly enhanced by freezing the seed. Removing the fluffy seed covering (de-linting) by rubbing it between two rubber plates or using acid treatment, also improves germination but leaves a very small and fragile seed.

Black speargrass
Black speargrass seed with its awns attached is matted and very difficult to sow. Removal of the awns improves ease of handling and germination rates. At Kidman Springs a hammer mill was used to break up speargrass seed which successfully established on a waterponding area. While some seed was destroyed, the resulting mixture of broken awns and awnless seed was much easier to sow.

Seca stylo
A high proportion of fresh seca stylo seed is often "hard" and will not germinate readily after planting. Such seed can be softened by dipping in 80°C water for 5 minutes. Dry heat or scarification will also soften hard seed and increase early germination rates. In practice, heat treating seca is difficult.

Sowing untreated seca early may provide several opportunities for germination over a season or seasons, whereas treated seca may all germinate at once, making the whole stand vulnerable.

Storage
The germination rates of fresh seed will often improve with time. The point at which rates deteriorate with age will depend upon storage conditions and the type of seed. Cool, dry storage facilities maximise seed longevity.

PLANTING METHOD

Seed may be sown on rehabilitation areas with seedboxes or drum seeders attached to cultivation machinery, or by drum seeders towed along cultivation in a separate pass. Seedboxes can be fitted to most rehabilitation machinery allowing seed to be sown directly into a specific position. Presswheels can be used when direct seeding in this manner. Drum seeders drop seed across the cultivation from a height. The advantages and limitations of using seedboxes and drum seeders are listed in Table 6.

While the use of presswheels in rehabilitation has not been fully explored, there is some evidence of their effectiveness on black soils (Younger and Gilmore 1978b). This could be a result of improved seed/soil contact. Presswheels should be used with caution on red soils as some types cause a crust to form above the seed reducing emergence.

A light chain or piece of steel is sometimes dragged across the cultivation to lightly cover the seed. The use of harrows is not recommended as they further break up the soil and flatten the cultivation profile, rendering it less effective. Aerial seeding is not recommended.

Table 6 Advantages and limitations of using seedboxes and drum seeders in revegetation.

	Seedboxes	Drum seeders
Advantages	• Accurate seed placement. • Good control of seeding rates. • Unaffected by wind.	• Drops seed across a range of positions increasing the chance of seed being placed in best position.* • Can be simple machines with few mechanical problems. • Can distribute light fluffy seed.
Limitations	• Best position is not always known and will depend on moisture conditions. • Mainly suited to small, smooth seed.	• Some seed will be wasted by poor placement.* • Wind may be a problem.

* *Some drum seeders catch seed leaving the drum and direct it to the desired position.*

SOWING RATE

The recommended sowing rate for uncoated seed such as buffel is 2 - 4 kg/ha of cultivation. Less seed is required to meet this rate if the germination rate is higher. The germination rate is specified on the seed analysis certificate.

Seed mixes should also be sown at 2 - 4 kg/ha. Early Ord River work was seeded with a 1:1:1 mix of buffel, birdwood and kapok at about 0.6 kg/km of opposed disc furrow or 1.1 kg/ha (Fitzgerald 1968b).

Higher sowing rates can be used, however the loss will be greater should the season be unfavourable. Budget constraints will influence sowing rates.

FERTILISER

Application of fertiliser is recommended when planting introduced pasture species to assist establishment and growth.

Fertiliser rates will vary considerably depending upon the size of the operation, budget constraints, soil types, the product used and the species to be grown.

A large range of fertilisers is available and special mixes can be supplied for specific situations. Fertilisers containing nitrogen, phosphorus and sulphur (that is, sulphur fortified mono-ammonium phosphate) are ideal for grass plantings. High analysis fertilisers containing phosphorus and sulphur are recommended for legume plantings. These fertilisers are usually the most cost effective as they require lower application rates and are therefore cheaper.

One strategy for rehabilitation sites is to apply a low rate (50 kg/ha) of fertiliser containing most essential nutrients at planting. This will help the plants get a good start. Once pastures are successfully established, the application of higher rates or additional fertiliser, can be justified.

Some soils may be deficient in specific nutrients and this needs to be addressed. For example, very light sandy soils may require potassium and some trace elements to achieve good plant vigour.

A spreader or spinner is usually used to spread fertiliser, but it can be mixed and sown with heavier seed through a seedbox or drum seeder.

Advice on availability and the most appropriate and cost-effective product to use should be sought from DPIF Pastures Officers or fertiliser companies and distributors.

Where stock cannot be excluded from the area, fertiliser is sometimes omitted to reduce the attractiveness of the pasture. Fertiliser is not required when sowing native pasture grasses, as they are adapted to low nutrient soils.

Planting

- Buffel or birdwood and a style have proven most successful for rehabilitation of red soils.
- Mitchell and Flinders grasses and native millet have proven most successful for rehabilitation of black soils.
- Be prepared to experiment.
- Sowing rates should be in the order of 2 - 4 kg/ha.
- Fertiliser will assist introduced pasture establishment and growth.
- Native pastures will not require fertiliser.
- Seek advice and information on new grass and legume varieties.
- Be sure to obtain a seed analysis certificate for all purchased seed.

COSTS AND BENEFITS

Sufficient technical knowledge exists to attempt and possibly achieve successful land rehabilitation. The issue of costs and benefits remains, however:

Is land rehabilitation worth doing?

How much are you willing to pay?

MacLeod and Johnston (1990) propose some private cost and benefit categories for rangeland rehabilitation (Table 7).

Table 7 *Private cost and benefit categories for rangeland rehabilitation (MacLeod and Johnston 1990).*

Costs	Benefits
Treatment cost: • initial • follow up • maintenance	Increased livestock production: • per animal • stocking rate
Grazing income foregone	Increased value of land
Additional capital: • livestock • fencing • other	Increased value of livestock
Financing costs: • interest • principal	Decreased taxation liability
Increased taxation liability	

A rational economic evaluation of mechanical land rehabilitation will usually conclude that the costs of reseeding or waterponding cannot be justified by future returns (Wang and Lindner 1990, MacLeod and Johnston 1990). As a result, there may be a case for public contribution.

Costs for rehabilitation or gully control may be more easily justified when protecting infrastructure.

Less tangible costs and benefits than those in Table 7 can be taken into account including:

- disappointing results;
- foregoing holidays at planting time;
- aesthetic improvement;
- dust suppression;
- a feeling of personal satisfaction or stewardship;
- improved public perception of the pastoral industry;
- visitor and tourist appreciation; and/or
- enhanced habitat for wildlife.

People's perception of the costs of rehabilitation can vary significantly. One landholder in the Victoria River District, for example, was not overly concerned with recouping costs for reclaiming a scalded area because he considered it an eyesore. Another landholder in the Alice Springs region doesn't pay himself wages and considers only the cost of fuel when constructing ponding banks. Other landholders may have to hire plant and equipment and would examine the costs and expected returns more closely.

Costs and benefits are to some extent in the eyes of the beholder and can be more fully defined by the individual concerned, rather than solely by the use of prescriptive economic categories.

FUTURE RESEARCH

Analysis of factors influencing the success or failure of rehabilitation reveals several shortcomings in our knowledge. Future research might focus on, for example:

- continuing the search for a pasture species (native or introduced) ideal for soil conservation;
- the use of native species for rehabilitation of different soil types;
- seed placement on rehabilitation cultivation;
- gaining a better understanding of the conditions required for germination on degraded black soils;
- methods of planting species on degraded black soils, including the use of presswheels, mulches and cultivation. A review of relevant work in western NSW, the West Kimberleys and QLD should first be undertaken; and
- testing vegetatively planted pasture species such as pangola, Bermuda grass, jarrah and perennial peanut on black soil and other soil types in the higher rainfall areas of the semi-arid tropics of the NT.

CONCLUSION

This review summarises the results of the land rehabilitation projects in the semi-arid tropics of the NT over a period of 50 years. The authors intend this review to be a practical and useful tool for landholders considering land rehabilitation. It should also provide direction for future research relating to mechanical rehabilitation.

In conclusion, the judicious management of land, control of livestock and feral animals and considered placement of infrastructure are far preferable to the expense and difficulty of land rehabilitation.

A tiresome cliché cannot be understated when referring to land degradation:

"Prevention is the best cure"

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(6) "The opposed disc plough for rehabilitation of degraded pastoral land"
(7) "Terms used in land conservation on pastoral land"
(8) "Land degradation explained"
(9) "Rehabilitation of degraded pastoral land using the pitter planter"
(10) "Waterponding for scald reclamation (Katherine region)"
(11) "Construction of waterponding banks with a grader (Katherine region)"
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Plough types

Check furrow plough

The check furrow plough has 1 to 3 tines with broad sweeps, which leave wide, deep furrows (Plates A1, A2). A forward facing disc trails in the furrow and is lifted up at intervals by a spiked, ovoid wheel. This results in regular "stops" or banks in the furrows, which prevent water running along the furrows for any distance.

Advantages	Limitations
• Interception of runoff is very good, preventing sheet erosion and ensuring good moisture retention for pasture establishment and growth. • The depth and width of the furrow ensures the cultivation has a long life span. • Good penetration of hard soils can be achieved if tractor is of sufficient horsepower. • The furrow and windrows create a range of moisture conditions, increasing the likelihood of successful rehabilitation under different seasonal conditions. • As for the opposed disc plough, can be used in conjunction with pitting and chisel ploughing.	• Accurate following of the contour is necessary for the best results. • Coverage of large areas is not practical. • A reasonable horsepower tractor is required to pull a check furrow machine. • Unsuitable for black soils. • Creates a cultivation type that is not trafficable to vehicles.
Recommended cultivation patterns	**Seeding**
• Start at the top of the area to be rehabilitated. • Follow the contour. • Spacing between runs will vary with slope and with the use of other implements. Runs should be closer together on higher slopes. Some experimentation may be required.	• A seedbox can place seed towards the top of the furrow, or a drum seeder can be towed over the furrow.

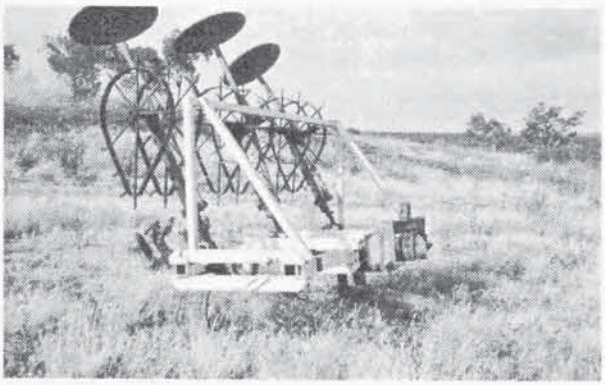

Plate A1
A 3-tine check furrow plough. Two tines have been removed to enable this plough to be pulled.

Plate A2
Allan Andrews of Auvergne Station and a single-tine check furrow plough.

Opposed disc plough *(Agrow plough, double disc plough, disc dammer)*

Two inward facing discs throw soil into a central continuous ridge leaving furrows on either side. These ploughs may have 1 to 3 tines preceding the discs to assist disc penetration and keying in of the ridge and soil surface (Plates A3 – A5). Seed may be direct seeded from a seedbox or spread by a drum seeder. Discontinuous ridges are created by lifting the discs in and out of the ground with hydraulics on larger ploughs, or 3-point linkage controls on smaller ploughs. The "Agrow" plough used in the Kimberleys is a towed opposed disc plough with 3 rippers, one central and one in front of each disc. Opposed disc cultivation is known as opposed discing, staggered furrows, furrows, ridges, banks or hills.

Advantages	Limitations
• Soil is thoroughly disturbed, assisting water infiltration and providing a good seed bed. A ripper assists soil disturbance by the discs, further improves water infiltration and keys the hill into the soil surface. • Water is intercepted and held in furrows, providing more moisture for pasture establishment and growth. • The hill and furrow create a range of moisture conditions, increasing the likelihood of successful rehabilitation under different seasonal conditions. In very wet years, plants will established on the hills, whereas in drier years, plants may establish in the furrows. • The higher profile cultivation of the opposed disc plough has a longer effective life than other cultivation types. • Cutivation can be beneficial in deterring vehicular traffic on the rehabilitation area.	• Limited to flat or gentle slopes. • Unsuitable for black soils, where it can have a deleterious effect on native pasture regeneration. • Unsuitable on very hard scalded soils, which discs cannot penetrate. • Subsiding hills can expose established pastures' roots and may contribute to plant mortality in time (Plate 118). • Ineffective on sodic soils because hills will collapse and become ineffective very quickly on wetting. There may be some establishment in the short term, however in time the soil surface will seal over, restricting germination and infiltration. Establishment will then deteriorate. Waterponding is a preferable treatment for these soils. • On stony or rocky soils, opposed discing has proved successful, however the discs tend to ride up on stones and the full advantage of a high hill is not realised. Rippers would help in this instance. • Creates a cultivation pattern that is untrafficable. • May be considered slightly inefficient due to the proportionately small area of cultivation created by a pass.
Recommended cultivation patterns	**Seeding**
• Start at the top of the area to be rehabilitated. • Follow the contour. Leave several metres between runs. • Break up runs regularly, making approximately 5 m long hills and 2 m gaps. • Stagger runs so that hills cover the gaps in the run above. (That is, create a brickwork pattern as shown in Figure 12). • Making U-shaped ridges or scallops can enhance the water retention effect of hills. While very effective, this can be hard on machines and operators. Care must be taken to ensure that the ends of the ridges are not so high as to cause breaching. Accurate surveying and appreciation of the slope by the operator are important. • Pitting or chisel ploughing between opposed disc runs in subsequent years can improve the vegetative cover on rehabilitation areas and increase the efficiency of covering the area with cultivation. The effectiveness of pitting or chisel ploughing is enhanced in this situation because the opposed disc hills control the runoff.	• When direct seeding, seed is usually placed on each side of the hills, and sometimes along the outside edge of each furrow. • A drum seeder will drop seed across the width of the hills. This may improve the likelihood of success because the seed is placed across a range of moisture conditions.

Plate A3

An opposed disc plough showing the disc configuration.

Plate A4

An opposed disc plough used by WADA has 3 tines preceding the discs to assist disc penetration and to key the ridge into the soil surface. A seedbox directs seeds onto the sides of the ridge and furrows.

Plate A5

The opposed discs throw up a single ridge. In this case, a drum seeder drops seeds across the hill and furrows.

Pitter plough *(Paech pitter, pitter planter, tine pitter)*

A 3-tine plough on an eccentric axle which lifts the tines in and out of the ground at regular intervals, creating 3 rows of discontinuous and staggered pits (Plates A6 – A8). A plough with scalloped discs can also create a pitting effect (Plates 54 – 56).

Advantages	Limitations

• Soil is thoroughly disturbed, assisting water infiltration and providing a good seed bed.
• Water is intercepted and held in pits, providing more moisture for pasture establishment and growth.
• The discontinuous pits prevent the concentration of runoff.
• Accurate tracing of the contour is important, but not as critical as for opposed discing.
• The pit and windrow create a range of soil moisture conditions, increasing the likelihood of successful rehabilitation under different seasonal conditions. In very wet years, plants will establish on the windrows, whereas in drier years, establishment may occur in the pits.
• Good coverage of the rehabilitation area is achieved, in terms of the proportion of the area cultivated.
	• Limited to flat to gentle slopes up to 2 %.
	• Not recommended for use on black soils.
	• Unsuitable on very hard, scalded soils which are difficult to penetrate.
	• Ineffective on sodic soils because the cultivation will collapse and become ineffective very quickly on wetting. Waterponding is preferable on these soils.
	• Windrows on the upslope side of pits contribute to:
	  • the silting of pits and surface sealing in pit bottoms;
	  • the seed becoming buried too deep; and
	  • less than maximum interception and storage of runoff by the pits.
	• Pits are short lived and become ineffective on greater slopes because of silt deposition.
	• Pitting cultivation will not be as long lived as the higher profile opposed disc cultivation.

Recommended cultivation patterns	**Seeding**
• Start at the top of the area to be rehabilitated. • Avoid steeper slopes, rills and gullies. • Follow the contour and cover entire area with pits. • Can be used between opposed disc runs.	• Seed should be placed on the upper sides of pits, rather than the pit bottom, otherwise the emergence of seedlings may be obstructed by surface sealing, or the seedlings may drown. • A drum seeder drops seed across all of the pits and windrows. This may improve the likelihood of success by locating seed across a range of soil moisture conditions.

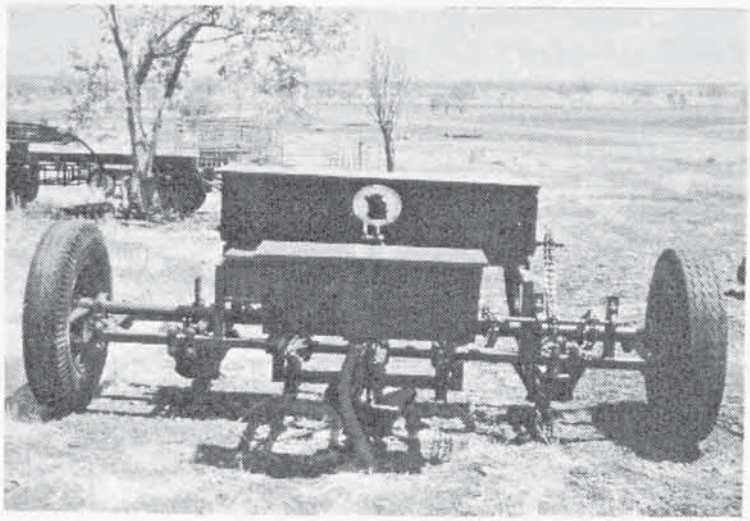

Plate A6
A Paech pitter plough.

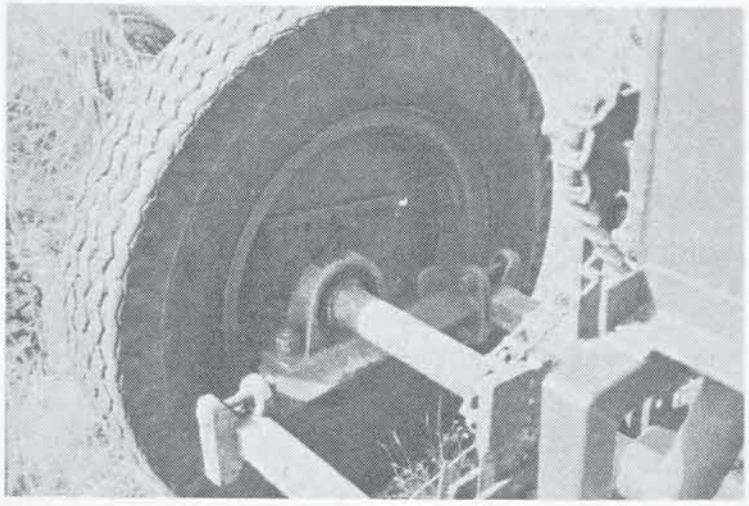

Plate A7
An eccentric (off-centre) axle lifts the pitter plough tines in and out of the ground as the wheel rotates.

Plate A8
A pitted area in Trap Paddock, Camfield Station.

Chisel plough *(scarifier)*

A chisel plough has any number of narrow tines (Plates A9, A10). Chisel ploughs alone are not usually recommended for rehabilitation work, however, they can be useful in combination with other rehabilitation plough types to help increase the area treated.

Advantages	Limitations
• A cheap or easily obtained or constructed machine. • Good coverage of an area is achieved. Provides a very basic seed bed. • Cultivation is easy, rapid and therefore relatively cheap. • Suitable for seed introduction into black soils. Suitable for many other soil types too, although effectiveness is questionable. • Can be used effectively between runs of other plough types such as opposed disc, check furrow or pitters to improve coverage. • Suitable chisel ploughs can be towed by a vehicle. • May be useful for follow up cultivation in regenerating areas or behind ponding banks when soils are damp.	• Poor penetration on hard soils. • Only suitable for very low slopes. • Will not control and will barely reduce runoff. Poor water interception and moisture storage. • Cultivation has a very short life span. Sealing of furrows may occur after only a few rainfall events. • When used in isolation, will only meet with success in good seasons. That is, when rains are not too heavy or erosive, moisture is not limiting, and the growing season is long enough to allow good establishment of vegetation.
Recommended cultivation patterns	**Seeding**
• Start at the top of the area to be rehabilitated. • Follow the contour. • Cover the entire area with cultivation. • Can be used to plough spaces between other rehabilitation plough runs.	• A seedbox can be used to directly sow into furrows. A drum seeder can be either mounted on the plough or towed separately across the cultivation • Broadcasting seed across the cultivation is another option. • The effect of harrowing is not known. Some covering of seed is probably desirable, but where cultivation is shallow, harrowing may cover furrows back in.

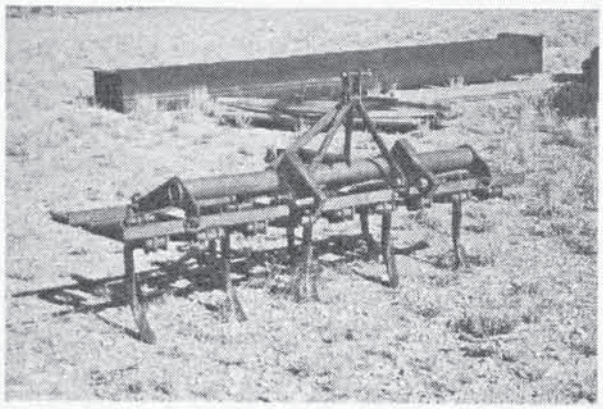

Plate A9
A chisel plough on Wave Hill Station.

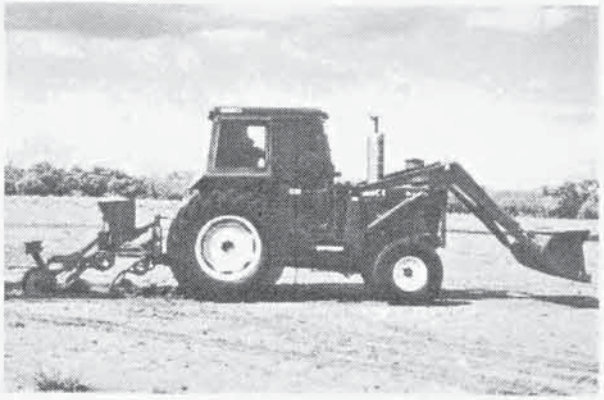

Plate A10
Chisel plough and seedbox with a drive wheel on the ground.

Pitting roller *(crocodile roller)*

Consists of a steel roller or cylinder with steel plates welded around the surface that leave pits in the ground when the implement is pulled (Plate A11).

Advantages	Limitations
• Similar advantages to the chisel plough. • Good coverage of large areas relatively cheaply. • Easy to pull. Small models can be pulled by a vehicle and are easy to transport. • Can be pulled through shrubby country or woody weed areas.	• Similar limitations to the pitter and chisel ploughs. • Poor penetration on hard soils. • Not suitable for rocky soils. • Pits have a relatively short life due to silting and sealing. • Effectiveness on black soils is not known.
Recommended cultivation patterns	**Seeding**
• Start at the top of the area to be pitted. • Pitting pattern does not require accurate following of the contour. • Cover the whole area to be rehabilitated.	• Seed can be placed in the roller to fall out of holes behind the plates and into the pits.

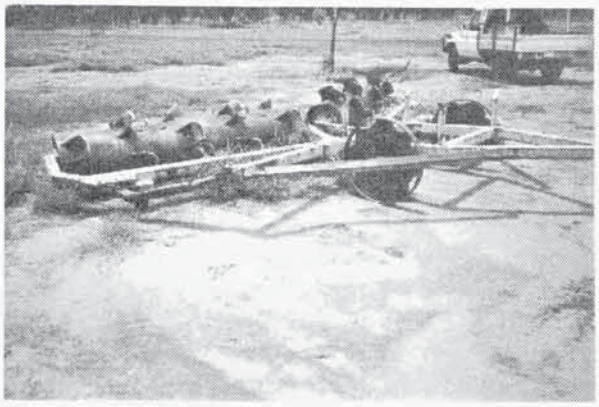

Plate A11
Pitting roller.

One-way disc plough

All the discs face the same way and create a fine, slightly sloping seedbed (Plate A12). This plough is NOT recommended for rehabilitation of degraded soils.

Offset disc plough *(disc harrows)*

Two rows of discs throw soil first one way, then the other, to create a fine, flat, shallow seedbed (Plate A13). Soil aggregates are broken down and surface sealing and crusting occur after rainfall. This has a deleterious effect on plant emergence and water infiltration. This plough is therefore NOT recommended for rehabilitation of degraded soils.

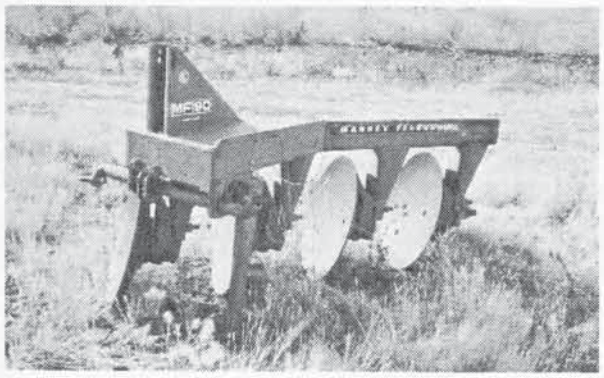

Plate A12
One-way disc plough.

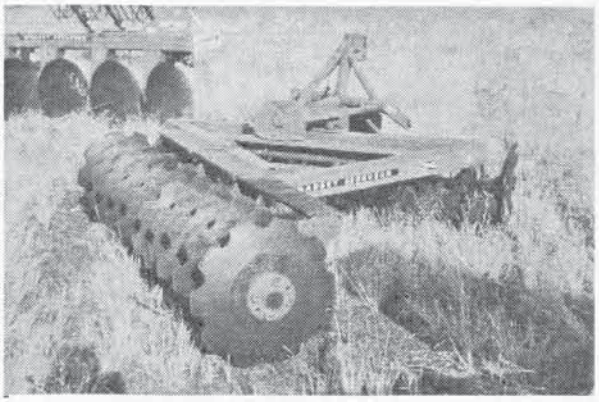

Plate A13
Offset disc plough.

Scientific and common names

Introduced species

Athel pine (noxious weed)
Tamarix aphylla

Birdwood
Cenchrus setiger

Blue pea
Clitoria species

Buffalo clover
Alysicarpus vaginalis

Buffel grass
Cenchrus ciliaris
Varieties - Gayndah, Biloela, Nunbank, USA, WA, colopo

Buffel, Cloncurry
Cenchrus pennisetiformis

Bulrush millet
Pennisetum glaucum

Calopo
Calopogonium mucunoides

Centro
Centrosema pascuorum
Varieties - bundey, cavalcade

Creeping couch
Bothriochloa insculpta
Varieties - Hatch, Bissett

Gamba grass
Andropogon gayanus

Giant panic, blue panic
Panicum antidotale

Green panic
Panicum maximum
Variety - trichoglume

Guar
Cyamopsis tetragonoloba

Guinea grass, panic
Panicum maximum
Varieties – hamil, coloniao

Indian couch, Bowen bluegrass
Bothriochloa pertusa
Varieties – Bowen, medway

Jarra (finger grass)
Digitaria milanjiana
Variety - jarra

Jointvetch
Aeschynomene americana
Varieties - Glenn, Lee

Kapok
Aerva javanica

Kazungula setaria
Setaria sphacelata
Variety - kazungula

Lablab
Lablab purpureus

Leucaena
Leucaena leucocephala

Makarikari panic
Panicum coloratum

Molasses grass
Melinis minutiflora

Pangola
Digitaria eriantha

Para grass
Brachiaria mutica

Peanut (perennial)
Arachis glabrata

Phasey bean
Macroptilium lathyroides

Poona pea
Vigna unguiculata

Purple pigeon grass
Setaria porphyranthes

Rhodes grass
Chloris gayanus

Rubber bush (noxious weed)
Calotropis procera

Sabi grass or Katherine liverseed
Urochloa mosambicensis

Sida (noxious weed)
Sida acuta, cordifolia, retusa

Siratro
Macroptilium atropurpureum

Sorghum
Sorghum x sorghum varieties Silk, Jumbo

Sorghum alum (Columbus grass)
Sorghum alum

Stylo, amiga, caribbean
Stylosanthes hamata
Varieties – amiga, caribbean

Stylo, verano, caribbean
Stylosanthes hamata
Varieties – verano, caribbean

Stylo, seca, Fitzroy
Stylosanthes scabra
Varieties - seca, fitzroy

Sudan grass
Sorghum sudanense

Sudax
Sorghum x Sorghum

Tickweed
Cleome viscosa

Townsville lucerne or stylo
Stylosanthes humulis

Wynn or roundleaf cassia
Cassia rotundifolia

Native species

Armgrass
Brachiaria species

Bauhinia
Lysiphyllum cunninghamii

Black wattle
Acacia holosericea

Bloodwood
Eucalyptus terminalis

Bluegrass
Dichanthium species

Bunched kerosene grass
Aristida contorta

Button grass
Dactyloctenium radulans

Comet grass
Perotis rara

Conkerberry
Carissa lanceolata

Coolibah
Eucalyptus microtheca

Couch, common native
Brachyachne convergens

Fairy grass
Sporobolus australiensis

Flinders grass
Iseliema species

Golden beard grass (ribbongrass)
Chrysopogon fallax

Kangaroo grass
Themeda triandra

Limestone grass
Enneapogon species

Lovegrass
Eragrostis tenellula

Millet, native
Panicum decompositum

Mitchell grass, barley, bull, weeping
Astrebla pectinata, squarrosa, elymoides

Nutwood
Terminalia arostrata

Pigweed
Portulaca species

Prickly acacia
Acacia farnesiana

Rattlepod
Crotolaria species

Rice grass
Xerochloa species

Roly poly
Salsola kali

Saltbush, old man
Atriplex nummularia
Variety - de Koch

Silky browntop
Eulalia fulva

Silver leaf box
Eucalyptus pruinosa

Speargrass, black
*Heteropogon contortus*Tickweed
Cleome viscosa

Verbine, annual
Psoralea cineria

Verbine, native
Psoralea patens

Wandarrie grass
Eriachne species

Whitewood
Atalaya hemiglauca

Wiregrass
Aristida latifolia or *inequiglumis*

Soil conservation in the public service

Host Agency	Year
Northern Territory Administration (NTA) Agriculture Section, Lands and Survey Branch	1952
NTA Agriculture Branch	1957/58
NTA Animal Industry and Agriculture Branch, Resource Development Division	1962/63
NTA Soil Conservation Service Primary Industries Branch	1968
DONT Land Conservation Section Animal Industry and Agriculture Branch	1969
DONT Soil Conservation Section, Animal Industries and Agriculture Branch	1975/77
DONT Forestry, Fisheries and Land Conservation Branch, Lands and Rural Development Division	1977
Territory Parks and Wildlife Commission (TPWC) Land Conservation Branch	1978/79
Conservation Commission of the Northern Territory (CCNT) Land Conservation Branch Regional Parks North Land Conservation Branch	 1980 1988 1989
Department of Lands, Planning and Environment (DLPE) Land Resources Division Natural Resources Division	 1995 1998

ADVICE AND ASSISTANCE

Advice and assistance regarding various aspects of land rehabilitation are available from following organisations:

General
Natural Resources Division, DLPE

Katherine	*Darwin*	*Alice Springs*
Randazzo Building	3rd floor, Goyder Centre	Natural Resources Bldg
16 Katherine Terrace	Palmerston	North Stuart Highway
Ph: 8973 8100	Ph: 8999 4455	Ph: 8951 8602

Pastures
Pastoral Division, DPIF

Katherine	*Darwin*	*Alice Springs*
Katherine Research Station	CS Robinson Building	Arid Zone Research Institute
Stuart Highway	Berrimah Farm	Stuart Highway
Ph: 8973 9739	Ph: 8999 2133	Ph: 8951 8111

Native pastures
Greening Australia NT

Katherine	*Darwin*	*Alice Springs*
G Block, Katherine Training Centre	Darwin Botanic Gardens	Ground Flr, Belvedere Hse
Second Street	Geranium Street	Cnr Bath & Parsons Street
Ph: 8972 2349	Ph: 8981 1344	Ph: 8953 2882