THE NORTHERN TERRITORY OF AUSTRALIA

Copy No. 1

CONFIDENTIAL

CABINET DECISION

NO. 2707

Submission No.: 2290

Title: N.T. BUFFALO POLICY

Cabinet endorsed the following principles for implementation of the Northern Territory Buffalo Policy -

- Adoption of approved T.B. Eradication Programmes by landholders;
- Simultaneous control programmes for feral cattle and buffaloes;
- Compensation to be paid for T.B. carcass condemnations and for buffalo destocking;
- A detailed geographical control planning for T.B. eradication for both cattle and buffaloes to be developed and publicised as soon as possible;
- Development of a more accurate T.B. test for buffaloes;
- Encouragement of private game management reserves to cater for tourists including safari type hunting operations;
- Continued operation by the Government of the buffalo marshalling facilities to process buffalo breeders from feral catching operations into T.B. free domesticated herds;
- Provision, through the Territory Development Corporation, of developmental finance, on favourable terms, especially directed towards the nucleus breeding population;
- Reservation of areas with a high conservation and/or recreation value;
- Re-examination of the suitability of land systems and their use with a view to improving future optimum land use patterns;
- Encouragement of multi-purpose activities to the maximum degree possible (e.g. pastoral with tourist activities; T.B. eradication with domestication).

Cabinet asked that the Government's policy of involving Aboriginal people in ventures of this type be encouraged to the utmost.

(M.R. FINGER),
Secretary to Cabinet.
1 December, 1982.

/2..

THE NORTHERN TERRITORY OF AUSTRALIA

Copy No. 1

CONFIDENTIAL

CABINET DECISION

NO. 2707

2.

Submission No.: 2290

Title: N.T. BUFFALO POLICY

Cabinet requested that the following proposed actions be the subject of separate Cabinet Submissions -

- Establishment of a 1,000 head intensively managed and research herd on the Coastal Plains Research Station as a buffalo national genetic conservation resource;
- Establishment of a nucleus domesticated buffalo breeding population with a minimum of 20,000 head by pastoralists to be assisted by an upgraded government extension effort;
- Establishment of 10 industry development projects each with 500 buffaloes which will be part of the nucleus breeding population. These projects will be joint industry-government (50:50) co-operative activities carefully planned and monitored to demonstrate a range of improved buffalo production techniques over a variety of land management systems;
- Establishment of a government game management reserve with 6,000 controlled buffaloes for controlled public hunting and sightseeing;
- Introduction of a programme for the restoration and conservation of wetlands;
- Introduction of a programme for the regeneration of areas degraded through overgrazing and erosion; and
- Reassessment of the system of allocating buffalo tenders.

(M.R. FINGER),
Secretary to Cabinet.
1 December, 1982.

CONFIDENTIAL

THE NORTHERN TERRITORY OF AUSTRALIA

CONFIDENTIAL

Copy No. 1

FOR CABINET

SUBMISSION No. 2290

Title:	N.T. BUFFALO POLICY
Cabinet Member	MINISTER FOR PRIMARY PRODUCTION
Purpose:	To determine a N.T. Buffalo Policy which will state . The long term objective for the role of buffaloes in the N.T. . The principal strategies for achieving this objective.
Relation to existing policy:	There is no single overall policy at present. It is consistent with previous Cabinet Submissions relating to tuberculosis eradication: No. 678 18 April 1979 No. 1775 16 June 1981 No. 2173 28 January 1982 No. 2395 16 June 1982 No. 2564 7 October 1982
Timing/ legislative priority:	No immediate legislation is required although some possible later changes may be required. Timing is reasonably urgent in order to integrate with decisions relating to T.B. eradication in cattle andbuffaloes.
Announcement of decision, tabling, etc.:	Preferably by end of December 1983. A statement will be prepared for release by the Minister for Primary Production. Statement can also be tabled in the Assembly.
Action required before announcement:	
Staffing implications, numbers and costs, etc.:	D.P.P. : + 6 staff + $175 000/year
Total cost:	Direct establishment and T.B. campaign Costs: $M8.994 Recurrent and development costs (1983-92): $M3.654.

CONFIDENTIAL

Department/Authority: DEPARTMENT OF THE TREASURY

COMMENT ON CABINET SUBMISSION No.

TITLE: NORTHERN TERRITORY BUFFALO POLICY

COMMENTS:

The proposals are understood to be an essential concomitant of the cattle Brucellosis and Tuberculosis eradition program considered by Cabinet on 1 December 1982. As with that program, the buffalo BTB eradication program is expected to be cost shared by the Commonwealth.

If the same cost sharing arrangements apply as it is hoped will apply for the cattle BTB eradication project, 70% of the campaign costs and 75% of the compensation costs would be expected to be met by the Commonwealth.

The implementation of the buffalo BTB eradication program in the Territory would, of course, need to be subject to the Commonwealth in fact accepting the proposals for cost sharing.

SIGNED: P.F. TEMPLE

DESIGNATION: Deputy Under-Treasurer

DATE: 8/12/82

CONFIDENTIAL

Department/Authority LAW

COMMENT ON CABINET SUBMISSION No.

TITLE: N.T. BUFFALO POLICY

COMMENTS:

There appear to be no immediate constitutional or legal barriers to the proposal. The submission foreshadows possible legislation in the future - but no details are available at this stage. Constitutional issues, if any, and legal issues may be tackled as and when they arise in implementing the policy.

SIGNED: S.R.BAILEY

DESIGNATION: Director, Executive & Policy Unit for Solicitor-General.

DATE: 23 November, 1982. *CONFIDENTIAL*

A. R. Cal/1611. Government Printer of the Northern Territory

Department/Authority PUBLIC SERVICE COMMISSIONER

COMMENT ON CABINET SUBMISSION No.

TITLE: N.T. BUFFALO POLICY

COMMENTS:

Insufficient time has been available to this Office to examine the projected additional staff resources for Department of Primary Production and the consequential impact on other Departments/Authorities of the proposed Buffalo Policy.

It is also not clear from the Submission as to the extent to which the estimated additional Department of Primary Production staff overlap those previously identified as being required for the B.T.B. eradication campaign.

These matters, and their impact on existing Maximum Staff Allocations, will be examined in detail upon submission of the staffing proposals to the Cabinet Committee on Establishment. In this regard it is noted that, as at 31 October 1982, the Department of Primary Production's staffing level was 384 against an M S A of 390.

SIGNED: P.O. BARTHOLOMEW

DESIGNATION: for Public Service Commissioner

DATE: 23 November 1982

A. R. CAUDELL, Government Printer of the Northern Territory

NOTE RE COMMENTS BY A.D.M.A.

The following paragraph numbers referred to by A.D.M.A. have been changed in the Cabinet Submission as follows:

Paragraph	20	Changed	to	21
"	23	"	"	24
"	27	"	"	28
"	28	"	"	29
"	29	"	"	30

Department/Authority: AGRICULTURAL DEVELOPMENT AND MARKETING AUTHORITY

COMMENT ON CABINET SUBMISSION No.

TITLE: N.T. BUFFALO POLICY

COMMENTS:

1. The Agricultural Development and Marketing Authority endorses the purpose of the submission, namely, to determine a policy relating to the role of buffalo within the Territory, considering economic, environmental and disease control issues.

2. It is opportune to develop such a policy at this time because of the commitment now given to disease eradication, and community and sectional interests in preserving the buffalo resource for both commercial exploitation and for tourism.

3. The Authority is of the opinion that consideration should be given to the market outlets for buffalo and buffalo products (hides, meats) as part of the policy, as the commercial development of the industry is dependent upon there being an outlet for such products at prices that are attractive to producers.

4. Consideration should be given to allocating funds for market development, working in close association with the private sector. Such a programme would include the further development of markets for live exports, but more significantly, to upgrade the market for buffalo meat.

5. I would suggest that the section of the submission titled: "Consideration of the Issues" be altered so that paragraph 20 within this section be introduced after the "Options" section. In fact, the submission argues that option 23 (c) is preferred, whereas paragraph 20 outlines the means by which this could be achieved.

6. It is suggested that paragraph 29 be expanded to indicate the proportion of funds associated with the TB campaign that will be met by the Commonwealth.

7. Support is given to the proposal whereby a basic 1000 head herd is established at CPRS to preserve a national genetic pool for buffalo, yet at the same time, other domesticated herds are encouraged. The submission is not clear in the relationship between the ten industry development projects referred to in paragraph 20 (3) and the establishment of a nucleus domesticated buffalo breeding population referred to in paragraph 20 (2).

   It is therefore suggested that the submission contain some cross referencing between the numbers referred to in paragraph 20 and the financial statements contained in paragraphs 27 and 28.

SIGNED: B. J. CAMERON

DESIGNATION: CHAIRMAN, A.D.M.A.

DATE: 24 NOVEMBER 1982 *CONFIDENTIAL*

.../2

Department/Authority: AGRICULTURAL DEVELOPMENT AND MARKETING AUTHORITY

COMMENT ON CABINET SUBMISSION No.

TITLE: N.T. BUFFALO POLICY

COMMENTS:

8. A direct follow-on from the above comments is some estimate of the benefits the Territory can anticipate seeing from the expenditure of over $13 million of both Commonwealth and N.T. Government funds. Admittedly, a proportion of these funds are Commonwealth sourced because of the TB eradiction campaign, but the N.T. Government's contribution is still substantial and therefore, monetary benefits should be more clearly defined.

9. It is also suggested that the question of land availability be considered, particularly as the Buffalo Industry Symposium of February 1981, drew attention to the fact that availability of suitable land was a restraint on the commercial development of the buffalo resource.

10. Before the Government can endorse the provision through the NTDC of development finance on favourable terms to establish the nucleus breeding herds, additional modelling and feasibility studies are required, particularly as the AACM study suggests that it was unlikely to be economic to borrow significantly to establish such herds. Care must be taken to avoid the Government being committed to the provision of funds as part of the adoption of the policy statement.

SIGNED: B. J. CAMERON

DESIGNATION: CHAIRMAN, A.D.M.A.

DATE: 24 NOVEMBER 1982 *CONFIDENTIAL*

NORTHERN TERRITORY OF AUSTRALIA

DEPARTMENT OF THE CHIEF MINISTER

P.O. BOX 4396
DARWIN, N.T. 5794

23 November, 1982

82/242

Dr. C.H. Gurd,
Secretary,
Department of Primary Production,
P.O. Box 5160,
DARWIN. N.T. 5794

Dear Dr. Gurd,

CABINET SUBMISSION - N.T. BUFFALO POLICY

We support the policy as outlined but have reservations concerning the implementation of it on Aboriginal land.

Implementation must be carried out through the Northern Land Council who must obtain the agreement of Traditional Owners.

Traditional Owners are not against the eradication of disease, the main problem exists in the allocation of funds. There are current disputes over Buffalo eradication contracts on the Waugait Reserve and at Bulman in the Arnhem Land Reserve.

The responsibility for resolving these disputes lies with the Northern Land Council and unfortunately are a time consuming exercise. Results may not be obtained as quickly as desired.

The policy would also call for increased activity by Department of Primary Production officers on Aboriginal land, and in this respect we would suggest that selected Aboriginals be trained in the treatment of T.B.

A communication programme will be required to ensure that as many Aboriginals as possible are aware of the campaign and that they support it. This will necessitate constant contact with the Northern Land Council and Aboriginal communities within the Buffalo Control areas.

The Communication Section of this office may be able to assist in preparing material for dissemination to Aboriginals.

for J.D. GALLACHER
Director
Office of Aboriginal Liaison

Northern Territory Tourist Commission

November 25, 1982.

Dr C. Gurd,
Secretary,
Department of Primary Production,
P.O. Box 4160,
DARWIN, N.T. 5794.

Dear Dr Gurd,

CABINET SUBMISSION: N.T. BUFFALO POLICY

The Northern Territory Tourist Commission has examined the Draft Cabinet Submission as requested and fully supports the proposals recommended for tourism and recreation purposes and the specific actions proposed for Cabinet's consideration:

- Establishment of a Government Game Management Reserve with 6,000 buffalo for controlled public hunting and sightseeing.

- Encouragement of private Game Management Reserves to cater for tourists including safari type hunting operations.

- Reservation of areas with a high conservation and/or recreational value.

Such action appears to meet the consumer expectations of our Territory image/wildlife product and allow existing tour operators an opportunity to capitalise on the sightseeing, safari and hunting potential of this market.

The Tourist Commission supports the opportunity for private Game Parks and is aware of private Game Management proposals/of for Stapleton Station; Nimrod; Annaburro Station; Wildman Station and Gimbat Station and also a proposal to hold a small buffalo herd in Kakadu National Park (if necessary). No doubt a tourism strategy needs to be developed in line with tourism potential/ viability and total policy.

.../2

Tourism is recognised as a major growth industry in the Northern Territory and the intended policy will assist the continuation of tour operators involved in the wildlife/safari market and enable a long term plan for investment in land for tourism/ recreation purposes and continued promotion of this important aspect of the Territory's tourist product.

In terms of planning the Northern Territory Tourist Commission is available in assisting with the feasibility of Government and private Game Parks with travel and marketing trends or statistics.

However its prime purpose will be to encourage increased visitation to the Northern Territory with major promotions of the Northern Territory product in the interstate and overseas market place and thereby assist the industry achieve viability.

In conclusion the Northern Territory Tourist Commission endorses your Cabinet Submission on the N.T. Buffalo Policy.

Forwarded for your information.

Yours sincerely,

ERIC H. POOLE,
CHAIRMAN.

CO-ORDINATOR GENERAL
DEPARTMENT OF THE CHIEF MINISTER
DARWIN

25 November, 1982

Dr. C.H. Gurd, C.M.G., C.B.E., K.ST.J.
Secretary,
Department of Primary Production,
P.O. Box 4160,
DARWIN N.T. 5794

Dear Charles,

Cabinet Submission - N.T. Buffalo Policy

No objection is raised to the thrust of the submission to put forward a single policy for buffalo in the Northern Territory. The matter has been discussed between Graeme Munro and your Graham Kirby. The submission could be critized on the basis of length and there is room for condensing certain areas without losing the thrust.

It may have been helpful to include the history of buffalo (i.e. background) as an attachment to the submission and also to include the recommendations in an attachment as a policy statement for endorsement by Cabinet.

It is accepted that there must be a significant conservation component in a buffalo policy, both in relation to buffalo and the conservation and restoration of wetlands areas. However it is questionable whether the conservation aspects should play such a large part in this submission as against a separate submission, bearing in mind that this submission is triggered by the impetus of the BTB Eradication Campaign.

I understand that there is a measure of ministerial support for the proposal to establish a Government Game Management Reserve (paragraph 20 (4)) but the proposal may need more thought before publication from the point of view of whether Government should be entering so overtly into competition with the private sector. Government may also need to question the establishment of a nucleus domesticated buffalo breeding population of 20,000 head (paragraph 20(2)) particularly in view of the fate of a similar proposal regarding banteng cattle and banteng crossbreds.

I understand that, in fact, the Conservation Commission was heavily involved in formulation of this policy, particularly from the point of view of wetlands conservation and similar matters and that paragraph 33 of the submission will be amended accordingly.

RAY MC HENRY

NORTHERN TERRITORY OF AUSTRALIA

SECRETARY

DEPARTMENT OF LANDS

P.O. BOX 1680
DARWIN N.T. 5794

Telephone 897722

Reference 82/528

The Secretary,
Department of Primary Production,
Darwin Plaza,
Smith Street Mall,
DARWIN. N.T. 5790.

Dear Dr. Gurd,

CABINET SUBMISSION - N.T. BUFFALO POLICY

I refer to your letter of 19 November 1982, requesting comments on your Cabinet Submission.

The Department of Lands supports the underlying objectives of the submission, that is, the effective management of the buffalo resource for effective disease eradication/control and to minimize degradation of the natural environment.

However, it is our view that the submission does not fully adress certain matters.

It is not made clear how buffalo in game reserves, as distinct from domesticated herds, are to be controlled or tested.

Similarly, paragraph 18 refers to testing of feral animals. It is not clear how this could be carried out in practice.

Paragraph 20(3) proposes the setting up of industry development projects on a joint Government-Industry basis. The need for Government participation seems questionable, if buffalo domestication is indeed viable, and taking into consideration the proposals to also establish a genetic conservation herd at Beatrice Hill (para. 20(1)) and for Government encouragement to pastoralists (para. 20(2)) to maintain a nucleus domesticated breeding population of at least 20,000 head.

Yours sincerely,

D.F. DARBEN

26.11.82

Mr G. Kirby M.L.A.

29/11

Northern Territory Development Corporation

NDC

From the Office of the Chairman

The Secretary
Department of Primary Production
PO Box 4160
DARWIN NT 5794

Dear Sir

CABINET SUBMISSION - N.T. BUFFALO POLICY

I refer to your letter of 19 November, 1982 seeking the Corporation's comments on the above Cabinet Submission.

The Corporation fully supports the thrust of the submission and believes that the recommendations will provide a much needed resolution to the various problems associated with buffaloes in the Territory.

As you are aware, the Corporation is currently preparing a submission to Cabinet on the provision of developmental finance, as mentioned on pages 11 and 18 of your submission. I anticipate that the Corporation will be ready to submit financing proposals to Cabinet next week and I suggest, therefore, that the two submissions be presented together to the Cabinet meeting on 14 December.

Kind regards

E.J. SIMPSON

26 November 1982

THE ISSUES

1. There is an urgent need to determine a single overall N.T. buffalo policy which will state
   - The long term objective for the role of buffaloes in the N.T.
   - The principal strategies for achieving this objective.

BACKGROUND

2. Buffaloes, present in the Top End since 1826, have remained largely as a feral animal resource exploited at various times for hides, meat consumption (pet, game, table, manufacturing), live export for slaughter, live export for breeding/working, tourism and as the N.T trade symbol.

3. Secure pastoral leases were first granted in the late 1960's in the Adelaide-Alligator Rivers area where the buffalo industry has been based.

4. Conflicts of opinion began to emerge from that time. These conflicts involved the resource potential of buffaloes; their ability when uncontrolled to degrade the environment; and their importance in the N.T. and national context of bovine and ruminant diseases

(especially tuberculosis and exotic diseases such as Foot and Mouth).

5. Recognition of the responsibility and opportunity of the N.T. to provide buffaloes to emerging S.E. Asian countries.

6. These concerns were examined by the Board of Inquiry into Feral Animals which reported its findings and recommendations to the N.T. Government in 1978.

7. Subsequently the Minister for Primary Production initiated a Buffalo Industry Symposium "to help to develop the policy necessary to ensure such programmes -- to promote a controlled buffalo industry, which will do minimal damage to the environment, and satisfy our common interest -- proceed".

8. The Symposium in February, 1981 documented its discussions, conclusions and resolutions (in "Proceedings of the Buffalo Industry Symposium") with a remarkably high degree of consensus across widely different community interest groups.

9. Subsequently the Feral Animals Committee, established by the N.T. Government in 1979, set up a Buffalo Working Party to bring many of the buffalo issues into a clear focus for decision and action.

10. These issues were considered against the background of the N.T. Government's overall rural policy "to encourage those industries, which are technically efficient, environmentally sound, conducive to closer settlement and which will result in a viable rural community". (Ministerial statement to the Assembly on 20 November 1980)

11. Relevant to certain asepcts of a N.T. buffalo policy are:

- Cabinet and Board of Conservation Commission have recommended the acquisition and creation of game management areas

- Eradication policy for bovine tuberculosis and brucellosis January 1982 and eradication campaign for 1982/83 (Cabinet Submission No. 1807/Decision No. 2137 - 28/1/82).

12. On 3 June 1982 the Chief Minister presented an interim report on buffalo industry policy to the Legislative Assembly.

CONSIDERATION OF THE ISSUES

13. Buffaloes already exist as a significant resource (population of 280 000head) in the Top End. They earn income from primary production ($6M) and tourism. They

represent a cost to the N.T. in tuberculosis eradication and in environmental degradation.

14. Given this current situation, individuals, organisations, producers, land managers, investors, community interest groups, government departments and others are looking to Government for a policy on buffaloes so that longer term co-ordinated management decisions and investment plans can be more confidently made. There is no single overall policy at present.

15. Important documents relevant to the consideration of a buffalo policy are included in the submission as the following Attachments:

B. Joint Conservation Commission/Department of Primary Production report on buffalo control in the Northern Territory with special reference to BTB eradication and environmental conservation. Prepared by a Working Party convened by B. Ford.

C. A preliminary survey of environmental damage associated with activity of feral buffalo. Prepared by P. Fogarty for Feral Animals Committee.

D. Eradication policy for BTB in the Northern Territory. Agnote Ref. No. 82/34 prepared by G. Calley.

E. Proceedings of the Buffalo Industry Symposium. Extracts of conclusions/recommendations and programme of the February 1981 public Symposium.

F. Productivity and management of the water buffalo in Australia. Prepared by B. Ford, September 1982.

16. After public debate at the Buffalo Industry Symposium the following consensus conclusions/recommendations were reached:

"That all presently involved with the buffalo industry together with positive action by the Government, as a matter of urgency, actively foster the development of a controlled, domesticated, viable, disease free and environmentally sound, long term N.T. buffalo industry, utilising to the maximum advantage, the existing feral buffalo herds."

"The prime responsibility for future development of the buffalo industry lies with the industry itself within the legislative framework to be laid down by the government. The industry should aim to establish production systems that will be ecologically stable in the long term."

17. The Buffalo Working Party of the Feral Animals Committee has identified the key components to be considered in a buffalo policy. These are:

(1) The over-riding priority to eradicate T.B. from N.T. buffalo by 1992 as an integral part of the National Brucellosis and Tuberculosis Eradication Campaign to which the N.T. is fully committed and for which considerable Commonwealth funds are provided.

(2) The pastoral production value of buffaloes which are potentially more productive than cattle in many Top End areas. They appear to have attractive long term market potential both as meat products and live animals, especially in Asia. Considerable improvement in production levels is possible through improving domestication, control and the use of management practices which increase carrying capacity, growth rate, reproduction and survival. These developments would positively support any T.B. eradication measures.

(3) The current and future value of the recreational industry which requires the continued presence of adequate numbers of accessible buffaloes (in a controlled management system). These recreation uses include:

- Sightseeing by individual or group tourists
- Public hunting (in a game managemet reserve)
- Safari hunting.

Part of the recreational needs could be well met by landholders involved in buffalo production enterprises.

(4) The protection and improvement of the environment in buffalo grazing lands. The uncontrolled buffalo spread and population increase has substantially changed the wetland ecology. In many areas the damage has been severe with major losses of wildlife habitat. Fundamental to environmental protection and regeneration is control over buffalo grazing (stocking rates, time of grazing and grazing patterns). Environmental improvement and protection includes:

- Wetland protection and rehabilitation
- Regeneration of degraded areas
- Reservation of areas with a high conservation and/or recreation value.

(5) Additional important factors include:

- The suitability of land systems, tenure,

size, use etc. for future buffalo production, environmental conservation/protection areas and recreation activities. These should be re-examined with a view to a future optimium land use pattern

. Developmental finance and infrastructural support to pastoral enterprises will be critical to pastoralists due to the urgent action required. Pastoralists will play a key role in determining the long-term value of buffaloes to the N.T. economy.

18. A buffalo policy should aim to achieve a reasonable balance and co-ordination between these components.

19. The T.B. compaign would require all currently domesticated buffalo to be T.B. tested and all feral buffalo to be tested or to be captured for slaughter or to be shot-out. Approved eradication programmes are required on pastoral properties and a geographical strategy required for feral buffaloes.

20. The proposed T.B. programme would lead to a quick and dramatic drop in the buffalo population. If this population drops to too low a level the future value and viability of buffaloes to the N.T. recreational and pastoral industries will be severely threatened.

Urgent measures are therefore needed in conjunction with the T.B. programme.

21. The urgent measures proposed are:

(1) The establishment of a 1000 head intensively managed and researched herd on the Coastal Plains Research Station as a buffalo national genetic conservation resource.

(2) The establishment of a nucleus domesticated buffalo breeding population with a minimum desirable size of 20 000 head by pastoralists actively assisted by an upgraded government extension effort. The larger this herd, the faster it can respond to any new and expanded market opportunities. At present this population numbers approximately 5000 head, many of which are destined for export.

(3) The establishment of 10 industry development projects each of 500 buffaloes which will be part of the nucleus buffalo breeding population. These projects will be joint industry-government (50:50) co-operative activities carefully planned and monitored to demonstrate a range of improved buffalo production techniques (nutrition, husbandry, fencing, breeding, selection, pastures etc.) over a variety of land management systems.

(4) The establishment of a government game management reserve (with 6 000 controlled buffaloes) and the encouragement of private game management reserves (6 000 buffaloes).

(5) Continued operation by the government of the buffalo marshalling facilities on Anaburroo to process buffalo breeders from feral catching activities into T.B. free domesticated herds.

(6) Provision through the Territory Development Corporation of developmental finance, on favourable terms, especially directed towards the nucleus breeding population.

22. With the reduction of the buffalo population there will be an increased opportunity to introduce a programme of environmental protection and rehabilitation, in particular, for wetlands and degraded areas.

23. The reservation of new areas with a high conservation and/or recreation value would follow from any re-examination of land use patterns.

OPTIONS

24. Three basic options were considered:

(a) Eliminate all buffalo from the N.T.

(b) Establish and maintain a small, closely managed T.B. free herd so as to preserve the genetic resource for possible future use.

(c) Promote efficient pastoral and tourist industries based on utilisation of larger T.B. free buffalo herds.

25. Of these three options, the first is seen as undesirable, the second is considered a minimal requirement, and the third is the most desirable objective.

THE PUBLIC IMPACT OF THE RECOMMENDATIONS

26. A policy statement per se will be widely welcomed.

27. If this policy generally expresses the consensus reached at the 1981 Symposium it should be generally accepted throughout the N.T. community.

FINANCIAL CONSIDERATIONS

28. DIRECT ESTABLISHMENT & T.B. CAMPAIGN COSTS:

		($M)
(1)	Feral Buffalo Eradication	3.000
(2)	T.B. Test Programme	0.458
(3)	Compensation T.B. Condemnations	0.315
(4)	Destocking Compensation	4.371
(5)	Establishment Buffalo Recreational Facility	0.794
(6)	Establishment of Government Conservation Herd	0.056
		$M8.994

29. RECURRENT AND DEVELOPMENT COSTS (1983-1992):

		($M)
(1)	Recreational Industry Operation Costs (1984/85 - 1991/92)	0.080
(2)	Operation of Marshalling Facility	0.100
(3)	Maintenance C.P.R.S. Conservation Herd (1984/85 - 1991/92)	0.451
(4)	Buffalo Research (1983/84 - 1991/92)	0.669
(5)	Industry Extension (1983/84 - 1991/92)	0.804
(6)	Industry Development	1.550
		$M3.654

30. A substantial proportion of costs associated with the T.B. campaign will be met by the Commonwealth Government.

EMPLOYMENT CONSIDERATIONS

31. The implementation of the buffalo policy will have employment effects across the private and government sectors in T.B. eradication, buffalo industry production research and extension (6 additional DPP staff), recreational industry and environmental conservation. In addition there will be employment multiplier effects throughpout the community.

COMMONWEALTH AND LOCAL GOVERNMENT RELATIONS

32. Commonwealth:

- Australian Bureau of Animal Health: National T.B. Campaign, Livestock exports
- Australian National Parks and Wildlife Service: Kakadu management
- Department of Primary Industries: Export meat inspection
- Department of Aboriginal Affairs: Aboriginal reserves
- Department of Trade and Resources: Overseas trade
- Australian Meat and Livestock Corporation: Meat and livestock processing and promotion
- C.S.I.R.O.: Buffalo ecology and production.

33. Local government: Northern Land Council/Aboriginal communities.

CO-ORDINATION AND CONSULTATION

34. . Conservation Commission of N.T.: Environmental conservation and rehabilitation; reservation and management of parks and reserves.
. N.T. Tourist commission: Tourism/recreation promotion
. N.T. Development Corporation: Developmental financing.
. Department of Chief Minister: Aboriginal liaison.
. Department of Lands & Housing: Land administration and buffalo management on Vacant Crown Lands.
. Agricultural Development and Marketing Authority.

LEGISLATION

35. No immediate changes are required. Some possible later changes may be required to legislation on land administraton, stock diseases, stock routes, environmental protection, product standards etc.

PUBLICITY

36. A statement to Legislative Assembly will be prepared for release by the Minister for Primary Production and Tourism.

TIMING

37. A policy should be determined as soon as possible given the time lapse since the Board of Inquiry into Feral Animals and the Buffalo Symposium, and given the urgency of the national TB campaign.

RECOMMENDATION

38. That Cabinet approve the following N.T. BUFFALO POLICY:

(1) OBJECTIVE

In the process of eliminating T.B. from buffaloes by 1992 the N.T. Government, in conjunction with private enterprise, will urgently and actively foster the development of domesticated buffalo herds to form a suitable resource base for the possible evolution of long term, viable and environmentally sound buffalo production and recreation industries.

(2) STRATEGIES

The key component strategies which are adopted to achieve this objective are tuberculosis eradication, improved pastoral productivity, improved recreational use and environmental conservation.

These strategies will be implemented in a balanced way.

(3) SPECIFIC ACTIONS

The following specific actions will be undertaken within these strategies in order to achieve the policy objective:

- Adoption of Approved T.B. Eradication Programmes by landholders.
- Simultaneous control programmes for feral cattle and buffaloes.
- Compensation will be paid for T.B. carcass condemnations and for buffalo destocking.
- A detailed geographical control planning for T.B. eradication for both cattle and buffaloes will be developed and publicised as soon as possible.
- Development of a more accurate T.B. test for buffaloes.
- Establishment of a 1 000 head intensively managed and researched herd on the Coastal Plains Research Station as a buffalo national genetic conservation resource.
- Establishment of a nucleus domesticated buffalo breeding population with a minimum of 20 000 head by pastoralists actively assisted by an upgraded government extension effort.
- Establishment of 10 industry development projects each with 500 buffaloes which will be part of the nucleus breeding population. These projects will be joint industry-government (50:50) co-operative

activities carefully planned and monitored to demonstrate a range of improved buffalo production techniques over a variety of land management systems.

- Establishment of a government game management reserve with 6 000 controlled buffaloes for controlled public hunting and sightseeing.
- Encouragement of private game management reserves to cater for tourists including safari type hunting operations.
- Continued operation by the government of the buffalo marshalling facilities to process buffalo breeders from feral catching operations into T.B. free domesticated herds.
- Provision, through the Territory Development Corporation, of developmental finance, on favourable terms, especially directed towards the nucleus breeding population.
- Introduction of a programme for the restoration and conservation of wetlands.
- Introduction of a programme for the regeneration of areas degraded through overgrazing and erosion.
- Reservation of areas with a high conservation and/or recreation value.
- Re-examination of the suitability of land systems and their use with a view to improving future optimum land use patterns.

. Encouragement of multi-purpose activities to the maximum degree possible (e.g. pastoral with tourist activities; T.B. eradication with domestication).

39. That Cabinet note:

Appropriate Departments/Authorities will submit to Cabinet more detailed proposals (including resources) on certain aspects of the N.T. Buffalo Policy.

ROGER STEELE
Minister for Primary
Production

25/11/82.

/ /1982

ATTACHMENT A

STATEMENT TO ASSEMBLY ON N.T BUFFALO POLICY

To be prepared.

ATTACHMENT B

JOINT CONSERVATION COMMISSION/DEPARTMENT OF PRIMARY PRODUCTION REPORT ON BUFFALO CONTROL IN THE NORTHERN TERRITORY WITH SPECIAL REFERENCE TO BTB ERADICATION AND ENVIRONMENTAL CONSERVATION

1 POLICY OBJECTIVES AND PRIORITIES

The basic policy objectives are to eliminate TB in Territory buffalo by 1992; to examine options for maintaining buffalo in the N.T. for various useful purposes; and to provide adequate environmental conservation.

Initially three basic options were considered:

(a) Eliminate all buffalo from the N.T.

(b) Establish and maintain a small TB free herd (possibly on a government farm) to preserve the genetic resource for possible future use.

(c) Promote efficient pastoral and tourist industries based on utilisation of larger managed TB free buffalo herds.

Of these three options, the first is seen as undesirable as it denies the opportunity to develop Northern Territory industries, the second is considered a minimal requirement, and the third is the most desirable policy. With this aim in view, the following recommendations are made:-

1. *The over-riding objective is to eradicate TB from Territory buffalo by 1992.*

2. *The second priority is to retain a TB free herd of some size; the actual size will depend upon a range of practical management and economic considerations.*

   These include achieving better buffalo management and ensuring proper environmental conservation.

II THE T.B. CONTROL PROGRAMME

1. Application of the programme to the buffalo population

The national Brucellosis and Tuberculosis Eradication Campaign provides the main stimulus for buffalo control. The Campaign aims to eradicate bovine tuberculosis from the Territory by 1992. Due to the relatively high incidence of tuberculosis in feral buffaloes, successful completion of the campaign requires them to be eliminated. The campaign policy therefore requires a framework for the buffalo control programme.

The working party recommends that, in areas with significant populations of both uncontrolled cattle and buffaloes, the control programme must address both species in order to be effective.

The T.B. eradication campaign in the N.T. is based on the adoption of "Approved Eradication Programmes" by landholders. Landholders who have not entered into an Approved Programme for T.B. control by 1st January 1984 should be subject to compulsory destocking. This is earlier than the date indicated by the present D.P.P. policy for the northern tuberculosis eradication zone (Appendix I). Due to the size of the overall control task and its time limitations, it is recommended that control be initiated as early as possible - even before 1984 in areas where it is clear that Approved Programmes are not intended. It is also recommended that landholders who have an Approved Programme but still have a T.B. incidence of over 0.1% on a part of their property on 1st January 1986 should be subject to compulsory de-stocking of that area.

The working party recommends that landholders subject to compulsory destocking should be encouraged wherever possible to carry out the destocking themselves. Where this is not possible or is unsatisfactory, the government should organise the operation.

Buffaloes voluntarily destocked under Approved Programmes should be eligible for destocking compensation under a similar scheme to that applying to cattle, as an incentive for early control and adoption of Approved Programmes. It is recommended that a buffalo destocking compensation scheme be finalised by 1 April 1983. No compensation should be payable for meatworks turnoff from properties without an Approved Programme, however.

In areas with an Approved Programme, compensation should be payable for animals which are shot on site by the landholder because they are unmusterable or cannot be economically utilised, provided adequate monitoring is possible. The level of this compensation should be sufficient to cover the actual cost of shooting, plus a cash incentive to encourage removal of such animals. Where shoot-outs have been organised by the government, no compensation should be payable to the landholder.

The overall B.T.B. programme and the strategies for its implementation should be explained clearly and in detail to individual landholders so that they can make their planning decisions as a matter of urgency. Any support measures government decides to provide the industry must be clearly stated at the time, to allow for informed decisions. A summary of Government costs for this programme are detailed in Appendices II - XI and summarised in Part VI.

2. Adoption of a geographical strategy for T.B. control

An overall geographical strategy must be developed for removal of uncontrolled buffaloes (and cattle) in the northern T.B. area, so that inefficient piecemeal efforts are avoided. This strategy would need to take account of a number of factors including the likely level of future economic utilisation, geographical situation, and T.B. incidence.

Such a strategy could commence in the Daly River Reserve /Wagait area, moving eastwards; and in Arnhem Land/Kakadu, moving westwards. Destocking of some of these areas where no managed

buffalo programme is intended must commence in the 1983 dry season.

The programme for control in Kakadu Stage 1 should be resolved with the Australian National Parks and Wildlife Service as soon as possible, with the aim of removal of uncontrolled buffaloes (and cattle) in the 1983 and 1984 dry seasons.

Negotiations on the programme should be commenced urgently through the Northern Land Council with landholders of Wagait, Daly River Reserve, Arnhem Land and Kakadu, and in areas where future commercial utilisation of buffaloes is unlikely.

Some strategic fencing may be necessary to achieve the control needed for disease programme requirements. The sites for any such fencing should be determined, as part of the overall geographical strategy, as a matter of urgency.

In view of the size of this task, and the time limitations on achieving the final result, it is recommended that a detailed geographical control strategy for both cattle and buffaloes be developed and publicised as soon as possible.

3. Requirements to achieve complete control

Conversion of feral buffaloes into controlled herds for export, breeding or recreational uses will probably utilise only a small proportion of the total number to be controlled by 1992. Most will need to be commercially slaughtered or destroyed on site. As many of these animals as possible should be utilised commercially. However, in some areas the numbers which can be used economically will be restricted for reasons such as inaccessibility or low population density.

At some stage of the T.B. eradication campaign, accessible buffalo numbers will decline to a stage where continued economic operation of buffalo meatworks is jeopardised. Before the conclusion of the 1983 killing season, D.P.P. should report on options keeping an export meatworks open in the face of declining throughputs.

The magnitude of the effort required to achieve final removal of those buffaloes which are not economically utilised is difficult to estimate. The resources needed for an effective final cleanout are still unknown. Trial cleanouts will be undertaken in several areas in 1982 and 1983 so that some experience is gained in the procedures.

Despite the obvious difficulties in prediction, the working Party has attempted some approximations (Appendix V) of the resources required to achieve elimination of feral animals (cattle as well as buffaloes) in the area of main buffalo concentration. On the basis of the buffalo survey figures, and allowing for natural increase, it is estimated that between 150 000 and 300 000 buffaloes and cattle may fit into this category. The equipment and manpower resources needed to achieve eradication of these animals could cost between $3-$4 million over a period of six years.

It is recommended that this estimate be taken into account by Government in forward budgeting planning.

III PROMOTION OF BUFFALO UTILISATION INDUSTRIES - RECREATIONAL

In relation to the future of buffalo in the Northern Territory, its use for recreational purposes will probably be a major factor in ensuring its survival. Recreational use of buffalo could include public hunting, sightseeing and safari hunting.

1. Public Hunting

An area is required, to be accessible at reasonable cost to the "average" shooter, and large enough to permit the annual harvest of a minimum of 200 adult buffaloes. Access would be restricted in terms of daily use and animals harvested. The Reserve would be effectively fenced and initially stocked with TB free buffaloes which would be run in a "wild" state. The TB status of the harvested animals would be monitored by post mortem of harvested buffalo.

A case study of a Game Management Reserve (including buffalo, waterfowl and pigs) was carried out for one particular area (Appendix VI). The study determined that establishment costs would be approximately $0.75 million, annual running costs $0.11 million, and annual returns to the administering authority $0.10 million. Indirect returns to the N.T. commercial community could be as high as $5 million annually.

This concept has already been approved in principle by Cabinet. This area would also help to cater for the needs of the tourist industry in respect to sightseeing.

It is recommended that the N.T. Government seek a suitable site, establish and operate at least one Game Management Reserve for public hunting and sightseeing.

2. Sightseeing

Sightseeing mainly concerns the viewing and photographing of buffalo by interstate or overseas visitors travelling in coaches. However, it also would include individual encounters with buffalo under natural conditions by locals or tourist in a daytrip or camping situation.

Representation has been made to the F.A.C by the Tourist Bureau on behalf of approximately 16 tour operators for whom buffalo, along with crocodiles, are the main species which meet the wildlife expectations of their clients.

Such requirements could be met by the Game Management Reserve described above.

3. Safari Hunting

The other type of hunting envisaged would be the safari type on game ranches, though this is seen as a lower priority. Safari Hunting would be aimed at the wealthier hunter and have restricted access due to the high costs involved (provision of luxurious accomodation, transportation, and guides; and the charging of high royalties on trophy animals) and the limited numbers of trophy animals. It is felt that this use could be catered for by a private landholder, provided TB freedom could be maintained.

It is recommended that the Northern Territory Government examine ways of encouraging landholders to develop enterprises involving buffalo hunting and sightseeing.

IV PROMOTION OF BUFFALO UTILISATION INDUSTRIES - PASTORAL

If the recommendations in Part I are accepted, options for government policy concerning the buffalo pastoral industry range from the maintenance of a government herd to conserve the genetic resource, to various degrees of assistance to promote the establishment of controlled buffalo pastoral enterprises. The future of the existing buffalo meat processing and live export industries is directly dependent on whether a transition to managed TB free herds can be achieved on a sufficiently large scale to support such enterprises.

The Working Party considers that, in the absence of some government initiatives, the number of buffaloes entering T.B. free breeding herds will continue to be relatively small. This is primarily due to management uncertainty regarding the long term viability of buffalo breeding enterprises. However, buffaloes are potentially more productive than cattle in many areas of the Top End, and appear to have attractive long term market potential both as live animals and meat products. Therefore, government initiatives to foster a buffalo pastoral industry should be seriously considered.

The Working Party recommends that a basic requirement is for D.P.P. to establish a herd of 250 to 300 breeding buffaloes at the Coastal Plains Research Station by 1984 (see Appendix VII). This would ensure that a viable national breeding herd of buffaloes continues to exist, primarily to preserve the genetic resource for future use.

Studies carried out by consultants (reference No 1) indicate that the development of intensive buffalo farms on areas of average quality land that have no current infrastructure is not likely to be economic. However, the consultants suggest that development of buffalo enterprises may be viable in certain circumstances where the investment or operating costs are lowered. These circumstances would include situations where, for example, the developer has access to inexpensive breeding stock, the property is currently partly developed or has areas of good quality natural pasture.

One way in which the government can reduce capital costs is to provide breeding buffaloes from Crown land at little or no initial cost to those establishing buffalo breeding schemes. This could be achieved by continuing a scheme similar to the present "Buffalo Marshalling Facility", where breeding buffalo are purchased at nominal cost (see Appendix IX). However, it is likely that the majority of these animals will continue to be exported to the detriment of the present breeding herd.

It is recommended that attention should be directed to a scheme under which suitable breeders are distributed, at no initial cost, to producers engaged in buffalo breeding. The main aim of the scheme would be conservation of buffalo breeding stock for future use. The buffaloes would remain government property until paid for by the producer, and could not be exported or sold without approval. Repayment to Government would be made in cash or in the form of buffalo progeny (rather than export) which would reduce capital costs considerably. Costs to government would be reduced royalty revenue, payment of catching costs (plus incentive) and administration costs. Such a scheme would greatly reduce the initial investment cost of buffalo breeding enterprises. It would significantly improve the developers assessed viability when finance was sought.

The Working Party is not in a position to recommend other buffalo pastoral industry support measures until more detailed analyses of the viability of controlled buffalo enterprises are undertaken. It is recommended that D.P.P. undertake more detailed analysis of buffalo industry viability as soon as possible.

The Working Party considers that, due to the current low level of development, D.P.P. research and extension will play a major role in fostering future development of controlled buffalo pastoral enterprises (see Appendices X and XI). Therefore, D.P.P. should expand its research and extension support for the buffalo industry, particularly in the areas of fencing, pastures, buffalo husbandry and weed control.

V ENVIRONMENTAL CONSERVATION ISSUES

There is abundant evidence that the spread and population increase of buffalo across the subcoastal plains of the Top End has resulted in substantial changes to the ecology of these wetlands (Appendix XII). In many areas environmental damage has been severe, with

major losses of wildlife habitat. Such factors must be taken into account when making any cost/benefit analysis for future buffalo production and management.

Wetland protection and rehabilitation must be an essential ingredient of any proposed land use of the coastal plains. Exclusion of uncontrolled stock over the coastal wetlands is as essential for wildlife conservation as it is for T.B. control.

In those areas where buffalo farming is to proceed, careful attention to stocking rates and pasture management will be needed. Revegetation of degraded areas and the use of native species should be evaluated, particularly the re-establishment of Hymenachne on extensively degraded plains.

Where wetland areas have not yet been substantially modified by buffalo or other agents, high priority should be given to their inclusion within National Parks, Conservation Reserves, or some other means to secure their conservation status. Some of the wetlands of the East and South Alligator Rivers will be protected within Kakadu National Park. However, much of the area has been badly damaged and long and careful management will be needed for rehabilitation.

Special conservation measures should be directed at those areas which have high conservation (and/or recreation) value, and which are under threat from buffalo. Such areas include Melacca Swamp on the Adelaide River plus much of the Finniss River and Reynolds River floodplains. Some areas of Aboriginal land should also receive similar consideration including areas such as Arafura Swamp and the Moyle River Wetlands. Further research is needed to identify other priority areas.

It is recommended that the restoration and conservation of wetlands should be an integral part of the overall buffalo management programme, with Government support for reservation and rehabilitation where appropriate.

VI FINANCIAL SUMMARY

A DIRECT ESTABLISHMENT AND CAMPAIGN COSTS

	$m
1. Feral Buffalo Eradication (1)	3.000
2. T.B. Testing Program: - Testing Costs (1)	0.221
- Reactor Compensation (2)	0.237
3. Compensation for Carcasses Condemned for TB at Abattoirs (2)	0.315
4. Destocking Compensation (2)	4.371
5. Establishment of Buffalo Recreational Facility (3)	0.794
6. Establishment of Government Conservation Herd (3)	0.056
	8.994

B. RECURRENT COSTS ONGOING (ANNUAL)

1. Buffalo Recreational Facility operating costs (1984/85 - 1991/92) (3).	0.080
2. Buffalo Research (3)	0.669
3. Information Extension (3)	0.804
4. Maintenance of Government Genetic Conservation Herd (1984/85 - 1991/92) (3)	0.451

C. RECURRENT COSTS - SHORT TERM (ANNUAL)

1. Operation of Marshalling Facility (3)	0.100
2. Industry Development (3)	1.550
	3.654

(1) Approximately 30% NT Government Cost.

(2) 25% NT Government Cost.

(3) 100% NT Government Cost.

APPENDIX II

COST OF BUFFALO TB TESTING PROGRAM

(a) TESTING COST

Year	No. of Tests	Cost Per Text	Total Cost
		$	$
1983/84	18,000	1.60	28,800
1984/85	30,000	1.60	48,000
1985/86	30,000	1.60	48,000
1986/87-1991/92	60,000	1.60	96,000
			$220,800

(b) REACTOR COMPENSATION COST

Year	No. of Tests	No. of TB Reactors (1)	Average Compensation ($)	Total Compensation ($)
1983/84	18,000	180	115	20,700
1984/85	30,000	300	115	54,000
1985/86	30,000	300	115	54,000
1986/87-1991/92	60,000	600	115	108,000
				236,700

(c) TOTAL COST BUFFALO TB TESTING PROGRAM

	$
Testing Cost (2)	220,800
Reactor Compensation (3)	236,700
	$457,500

(1) TB reactor rate assumed to average 1%.

(2) Approximately 30% N.T. Cost

(3) 25% N.T. Cost.

APPENDIX III

COST OF COMPENSATION FOR BUFFALO CARCASSES CONDEMNED AT ABATTOIRS

Year	No. Slaughtered	Condemn Rate	No. Condemned	Compensation per Carcass	Total Compensation
				$	$
1983/84	50,000	1.6%	800	90	72,000
1984/85	40,000	2.0%	800	90	81,000
1985/86	40,000	1.5%	600	90	54,000
1986/87-1991/92	30,000	4.0%	1,200	90	108,000
					315,000

APPENDIX IV

BUFFALO DESTOCKING COMPENSATION

YEAR: 1983/84

SLAUGHTER — 50,000 of which 7,500 (15%) are classed as normal turnoff and not eligible for compensation. Therefore, pay transport and levy costs for 42,500.

Transport - Average distance 200 km @ $1.10/"K"/loaded km 16 animals/"K" = $13.75.

Slaughter levy $6

Total compensation cost $19.75 x 42,500 = $829,500.

DESTROY — 12,000 young calves @ $25 = $300,000.
(12,000 calves = 40% of 30,000 destocked females)

DESTROY — Unmusterables; 5% of Slaughter Cows and Bulls 2,500 @ $40 = $100,000.

MARSHALL & TEST — 6,000 heifers
(= 20% of 30,000 destocked females)
600 young bulls
(= 10% of marshalled and tested heifers).

Resell at purchase price and handling cost. Nil Net Cost.

SLAUGHTER — 5,400 young bulls, surplus to requirements of marshall and test program.

Transport + levy compensation + price support compensation.

Transport 200 km @ $1.10/"K"/loaded Km and 24 animals/"K" = $9.20/animal.

+ $6 slaughter levy.

Price support. (To account for meat price differential between sale of light weight animals and price/kg that would have been obtained by growing to heavier weight) = $9.

Total compensation/young bull slaughtered = $24.

Total compensation = 5,400 x $24 = $129,600.

TOTAL COMPENSATION: 1983/84:

	$
Slaughter Cows and Bulls	829,500
Destroy Young Calves	300,000
Destroy Unmusterables	100,000
Slaughter Young Bulls	129,600
	1,359,100

YEAR: 1984/85

SLAUGHTER 40,000 of which 6,000 (15%) are classed as normal turnoff.

Transport and levy costs for 34,000 head = 34,000 x $19.75 = $671,500.

DESTROY 9,600 young calves @ $25 = $240,000. (9,600 calves = 40% of 24,000 destocked females).

DESTROY — Unmusterables: 5% of slaughter cows and bulls 2,000 @ $40 = $80,000.

MARSHALL AND TEST — 4,800 heifers (=20% of destocked females) and 480 young bulls at Nil Net Cost.

SLAUGHTER — 4,320 young bulls, surplus to requirements of marshall and test program.

Young bull compensation = 4,320 x $24 = $103,680.

TOTAL COMPENSATION 1984/85

	$
Slaughter Cows and Bulls	671,500
Destroy Young Calves	240,000
Destroy Unmusterables	80,000
Slaughter Young Bulls	103,680
	$1,095,180

YEAR: 1985/86 — Same rate as for 1984/85.
i.e. Destock 40,000 buffalo for slaughter
TOTAL COMPENSATION: $1,095,180

YEAR: 1986/87 — Halve the rate for 1984/85 and 1985/86.
i.e. Destock 20,000 buffalo for slaughter.

TOTAL COMPENSATION: 1986/87 $547,590

YEAR: 1987/88 — Halve the rate for 1986/87
i.e. Destock 10,000 buffalo for slaughter
TOTAL COMPENSATION: 1987/88: $273,795

TOTAL COMPENSATION 1983/84 - 1987/88

Year	Destocking Compensation
	$
1983/84	1,359,100
1984/85	1,095,180
1985/86	1,095,180
1986/87	547,590
1987/88	273,795
TOTAL	$4,370,845

APPENDIX V

T.B. Eradication Control Programme - Models for the Destruction of Non-commercial Buffalo and Cattle Compulsorily Destocked.
NOTE: This is a "worse possible situation" Scenario.

Model 1 (see Table 1)

Assume population size in each stratum corresponds to the 1981 survey level (commercial harvesting accounts for the net annual gain of 14.5%).

Assumptions

1. Two helicopters available, to be used for up to 150 shooting days during each dry season.

2. Each stratum shot over twice, aiming for a control level of 90% the first year, the remaining 10% plus natural increase (20%) the second year.

3. Each helicopter team averages 400 animals/day the first year, 200/day the second year. A time/area factor of one week/ helicopter/ 4,000 km^2 is added to the second year's control effort because of animal scarcity.

4. 9 hours/day/helicopter and 3 hours general shooting per helicopter team.

Model 2 (see Table 2).

Assume population size in each stratum is 20% below the 1981 survey level (commercial harvesting accounts for the net round increase + 20% of existing level).

Assumptions - Same as for Model 1.

Table 1 Refer to Assumption under Model 1. Two helicopters and five men used each year.

Year	Stratum	Established Population	Number Shot	Days Required	Hours Required
1	4	93,331	84,000	105	1,890
2	4	11,197	11,197	30	540
	3,5,8(b)	35,319	32,000	40	720
3	3,5,8(b)	3,983	3,983	35	630
	1,2(a)	67,172	60,800	76	1,368
4	1,2(a)	7,646	7,646	28	504
	2(b),7	69,003	62,400	78	1,404
5	2(b),7	7,924	7,924	38	684
	6,8(a)	59,317	53,600	67	1,206
6	6,8(a)	6,860	6,860	45	810
			330,410	542	9,756

Table 2 Refer to Assumptions under Model 2. Two helicopters and five men used each year.

Year	Stratum	Established Population	Number Shot	Days Required	Hours Required
1	4	80,665	72,800	91	1,638
2	4	9,438	9,438	25	450
	3,5,8(b)	28,255	25,600	32	576
3	3,5,8(b)	3,186	3,186	33	594
	1,2(a)	54,445	48,800	61	1,098
4	1,2(a)	6,764	6,764	25	450
	2(b),7	56,495	51,200	64	1,152
5	2(b),7	6,254	6,254	34	612
	6,8(a)	47,454	42,400	53	954
6	6,8(a)	6,065	6,065	41	738
			272,507	459	8,262

Figure 1. Strata used for Buffalo Survey and Models.

Stratum	No. of Buffalo	No. of Cattle	Area ('000 km^2)	Clean-up Time (days)
1	40,441	-	4.9	7
2	42,731	10,000	12.5	19
3	6,737	3,000	9.2	7
4	73,331	22,000	2.2	3
5	5,980	-	14.4	11
6	39,714	-	14.7	22
7	43,003	-	17.7	27
8	31,205	8,000	86.7	65

ESTIMATED COSTS (over 6 years)

Model 1

Helicopter Hire	-	9.756 x $200/hr	=	$1,951,200
Salaries	-	10.84 man years x $20,000	=	216,800
T.A.	-	2,710 man days x $34/day	=	92,140
Overtime	-	7,800 hours x $10 (T½)	=	78,000
Ammo	-	1,321,640 rds x $.39/rd	=	515,440
Equipment, vehicles, etc.			=	30,000
				$2,883,580

Model 2

Helicopter hire	-	8,262 x $200/hr	=	$1,652,400
Salaries	-	9.18 man years x $20,000	=	183,600
T.A.	-	2,295 man days x $34/day	=	78,030
Overtime	-	6,500 hours x $10 (T½)	=	65,000
Ammo	-	1,090,028 rds x $.39/rd	=	425,110
Equipment, vehicles, etc.			=	30,000
				$2,434,140

APPENDIX VI

CONSERVATION COMMISSION OF THE NORTHERN TERRITORY

FERAL ANIMALS COMMITTEE

GAME MANAGEMENT RESERVE PROPOSAL

CONTENTS

1. INTRODUCTION

1.1 Proposal

The proposal is to establish a game management reserve, for the use of local and visiting hunters based buffalo, pigs, ducks and geese as the game species. The buffalo is the priority species but the area would also be managed for feral pigs, and ducks and geese (in season). This would not significantly compete with the existing safari operators because where Banteng and Sambar deer are their priority species, there is no competition; and where buffalo are the target species, the operators provide a very different type of hunt in that guides, accommodation and transport are all provided.

Providing sightseers with visible buffalo, and a variety of birdlife is an important secondary goal.

1.2 Justification

The proposal is being brought forward for the following reasons:

1. Cabinet and the Board of the Conservation Commission have recommended the acquisition and creation of game management areas and now is a propitious time to implement these recommendations;

2. there is a strong, though unorganised, public demand for hunting opportunities (14,379 shooters hold Class A or B licences and in the last 22 months 1,705 visiting shooters obtained temporary A and B licences);

3. an area, such as the Case Study Area, would provide annual net returns to the C.C.N.T. that would almost cover running costs

and indirectly provide annual returns to the N.T. Commercial Community of over $5 million (see Addendum IV);

4. any area similar to the Case Study Area would have a high capitalised value for recreation (almost $5 million) and produce a high annual recreation value (over $530,000) (see Addendum V);

5. the N.T. has an opportunity to take the lead for Australia in this field (areas already exist overseas);

6. this would provide an exciting alternative method for returning the presence of an animal identified with the Northern Territory, the buffalo; and

7. setting aside part of each week for "buffalo visits" would provide tour guide operators with the ability to satisfy their client's demand for visible buffalo (see Addendum VI);

1.3 Economic Approach

Overseas wildlife agencies are currently attempting to determine the economic value of recreation in order to compete for land with other interests on equal terms. Basically the methodology assumes that wildlife is a public industry, turning out a product (animals harvested and/or viewed). This product has a value (to the users) which is calculated as the Annual Recreation Value (ARV). The next step is to determine the necessary capital investment (at the current interest rate) that would be needed in order to return the calculated ARV. This is the Capitalized Value (CV) of the production resource (the breeding stock).

Given that tourism is one of the N.T.'s major industries, an added economic consideration is the return to the N.T. commercial community in dollars spent by interstate visitors. This return is exclusive of returns to the Commission, which are also significant.

2. CASE STUDY - MARRAKAI GAME MANAGEMENT RESERVE PROPOSAL

2.1 For the purpose of demonstrating the concept, the South Marrakai Area was selected. It should be stressed that other areas could also meet the requirements of close proximity to Darwin, accessibility, and varied topography. In fact, an area with floodplain, but without a major river, could be more suitable because security would be greatly simplified.

2.2 Proposed Area

The Marrakai Game Management Reserve, consisting of the South Marrakai Block and adjoining blocks west of the river combine to make an appropriate area for the above proposal for the following reasons:

1. it is close to Darwin (N100 km);

2. it provides a site suitable for buffaloes and pigs, in terms of stocking rates and habitat; and

3. it has the potential for developing suitable waterfowl habitat and reasonable access.

The area covers about 480 km^2; approximately 50% of which is undulating terrain, 35% is floodplain and 15% is plain.

Cost/Benefit Analysis

It is envisaged there would be an entrance fee for all hunters and sightseers, and a further charge for buffalo ($50 for local hunters, $100 for out-of-state hunters. The economics of the proposal (approximately estimated) are as follows:

Establishment Costs (see Add.I)	Annual Running Costs (see Add.II)	Annual Returns (to C.C.N.T. only) (see Add.III)	Annual Returns to the Commercial Community (see Add.IV)
$794,000	$111,500	$103,300	$5,573,304

Therefore the net return per year to the C.C.N.T. would almost cover running costs. Of more importance is the magnitude of the tourist dollars (over 5 million) that would be circulated within the N.T. commercial community.

Area Use

The area could be opened for the dry season months of April to October, with different days of the week given over to alternative uses (see Addendum VI). A maximum of 70 hunters per day could be spread over the area with buffalo hunters taking preference, waterfowl hunters using the open water sites and pig hunters filling in remaining alternative areas.

Buffalo hunting could be allowed four days a week from July through October at a maximum of 10 hunters per day (chosen by a lottery system, 50% local, 50% out-of-state). The fifty-fifty split is a compromise between providing sport for local hunters and encouraging the tourist industry.

Duck and goose hunting could be allowed concurrently with an allowable maximum of up to 60 hunters per day.

Pig hunting could be allowed from April through October for four days per week and up to 20 hunters could be allowed at one time (if above allotments unfilled).

Tour guide operators could be allowed to use the area for sightseeing for two days per week, alternative to hunting days, with no stipulated maximum numbers.

Organisation Details

See Addendum VI for an outline of management concepts on safety, firearms, carcass retrieval, camping, etc.

3. ADDENDA

3.1 ADDENDUM 1 - Establishment Costs

Establishment Costs - Initial

		$
1.	Fencing, 125km @ $1,000/km.	125,000
2.	Three ranger residences @ $90,000 each.	270,000
3.	Roads, 125km @ $100/km.	125,000
4.	Water for residences (bore, tank, etc.)	10,000
5.	Check-in, check-out station.	20,000
6.	10 Campsites (fireplace, table, toilet).	25,000
7.	Four dams.	70,000
8.	Mimosa control* (initial spray)	50,000
9.	Miscellaneous (vehicles, sheds, radios, equipment, etc.	42,000
10.	Buffalo (acquire clean herd).	36,000
11.	Power to residences	20,000
		$794,000

Later Additions (paid out of revenue earned)

		$
1.	20 additional campsites.	50,000
2.	Sighting-in range.	5,000

* This might not be necessary, as biological control is to be tested soon (within 6 months).

3.2 Addendum II - Annual Running Costs

		$
1.	Salaries, 3 rangers @ $20,000 each.	60,000
2.	Vehicles maintenance @ $2,000 each.	6,000
3.	Residence maintenance @ $2,000 each.	6,000
4.	Road maintenance.	12,500
5.	Fence maintenance (includes firebreaks).	10,000
6.	Duck habitat management	6,000
7.	Campsite maintenance	5,000
8.	Mimosa control*	6,000
		111,500

* See comment in Addendum I

3.3 Addendum III - Return to the Conservation Commission

1. Projected total number of hunters = 70/day
   for 140 days = 9,800 hunters
   9,800 x $5 entrance fee = $49,000

2. Projected number of buffalo hunters -

Status	Number	Charge	Returns
Local	250	$ 50	$12,500
Out-of-state	250	$100	$25,000

4. Projected number of sightseers
   (guided tourists)
   = 150/day for 56 days
   = 16,800 tourists
   16,800 x $1 entrance fee = $16,800

	$
Hunting =	86,500
Tourism =	16,800
Total =	103,300

3.4 Addendum IV - Returns to the Northern Territory Community, Less Returns in Addendum III

Assume:
1. 90% of Tour Guide sightseers are visitors.*
2. 50% of buffalo hunters are visitors.
3. 30% of waterfowl/pig hunters are visitors.
4. Average visitor stay is 9.3 days. **
5. Average visitor expenditure is $33 per day. **

Number of Visitors:

Sightseers	.9	x 16,800 =	15,120
Buffalo Hunters	.5	x 500 =	250
Waterfowl/Pig Hunters	.3	x 9,300 =	2,790
Total Visitors:			18,160

Visitor Days

9.3 x 18,160 = 168,888

Returns to Community

168,888 x $33 = $5,573,304

---

* Out-of-state.

** Tourist Bureau Estimates.

3.5 Addendum V(i) - Bioeconomic Calculations

Consumption Value (Buffalo)

Area Buffalo Population		2,500	
Annual Harvest Rate		x 20%	
Number of Buffalo Harvested	=	500	
Man-days to Harvest 1 Buffalo		x3	
Man-days Produced	=	1,500	
Average Value per Man-day		x $160	(includes royalty)
Hunting Value		= $240,000	

Non-Consumption Value (Buffalo)

Non-consumption Man-days	8,400	
Value per Man-day (85% of $20 trip value)	x $17	
Non-hunting Value	= $142,800	

Annual Recreation Value	$382,800

Addendum V(ii)

Perennial Resource Value (Capitalised Value

Annual Recreation Value	$382,800
Appropriate Interest Rate	11%
Capitalised Value	$3,480,000[2]

[1]Value of each buffalo killed $\frac{382,800}{600} = \$638$

[2]Capitalised value per buffalo $\frac{3,480,000}{1,800} = \$1,933$

Consumption Value (Pigs)

Area Pig Population		1,000
Annual Harvest Rate		x 25%
Number of Pigs Harvested	=	250
Man-days to harvest 1 pig		x 2
Man-days Produced	=	500
Value per Man-day		$25
	=	$12,500

Non-consumption Value

Annual Recreation Value	$12,500[3]

Addendum V(iii)

Perennial Resource Value

Annual Recreation Value	$12,500
Appropriate Interest Rate	11%
Capitalised Value	$113,646[2]

[1]Value of each pig killed $\frac{\$12,500}{250} = \$\ 50$

[2]Capitalised value per pig $\frac{\$136,364}{1,000} = \$114$

Consumption Value (Waterfowl

Area Waterfowl Population		11,400
Annual Harvest Rate		x 35%
Number of Waterfowl Harvested	=	3,990
Man-days to Harvest, Duck or Goose		x .8
Man-days Produced	=	3,192
Value per Man-day		x$35
Hunting Value	=	$111,720

Non-consumption Value

Non-consumption Man-days		8,400
Value per Man-day (15% of $20 trip value)		x $3
Non-consumption Value	=	$25,200
Annual Recreation Value		136,920[1]

Addendum V(iv)

Perennial Recreation Value	$136,920
Appropriate Interest Rate	11%
Capitalised Value	$1,244,727[2]
[1]Value of each duck or goose killed	$\frac{136,920}{3,990}$ = $34
[2]Capitalised value per duck or goose	$\frac{1,244,727}{11,400}$ = $109
Total Annual Recreation Value	$532,220
Total Capitalised Value	$4,838,373

3.6 Addendum VI - Annual Calendar for Various Activities

	Sun	Mon	Tue	Wed	Thur	Fri	Sat
January	-	-	Closed	-	-	-	-
February	-	-	Closed	-	-	-	-
March	-	-	Closed	-	-	-	-
April	T	B,P	B,P	T	M	B,P	B,P
May	T	B,P	B,P	T	M	B,P	B,P
June	T	B,P	B,P	T	M	B,P	B,P
July	T	B,P,D	B,P,D	T	M	B,P	B,P,D
August	T	B,P,D,G	B,P,D,G	T	M	B,P,D,G	B,P,D,G
September	T	B,P,D,G	B,P,D,G	T	M	B,P,D,G	B,P,D,G
October	T	B,P,D,G	B,P,D,G	T	M	B,P,D,G	B,P,D,G
November			Closed				
December			Closed				

B = Buffalo Hunting, P = Pig Hunting, D = Duck Hunting,
G = Goose Hunting, T = Tourist Operators
M = Closed for maintenance.

WLFS F

3.7 Addendum VII(i) - Management Details

Safety

In order to provide as safe a sport as possible, the following will be required:

1. hunters must be in pairs to hunt buffalo and/or pigs;
2. limited numbers of hunters per day;
3. only one set of hunters per parking area (areas will be numbered and assigned); and
4. safety colours will be worn. (Safety will be stressed at all times)

Check-in/Check-out

All hunters or tourists will be checked in and out. During check-in parking/camping and hunting areas will be allocated, radios distributed (buffalo hunters only), rules and safety discussed, and sample bullets collected.

Check-out will include collecting game-take information, collection of scientific data (if required), and return of allocated radios.

The station will only be open from 0700 to 1800 and all day visitors must be out by 1800 as the gate will be closed at this time.

Firearms

Only stipulated calibres will be allowed and a fired bullet will be collected from each rifle for ballistic reference. The hunters will be informed that any unreported dead buffalo will be checked and this should greatly discourage unauthorised shooting.

Addendum VII(ii)

Carcass Retrieval

The Reserve staff will provide buffalo carcass retrieval as part of the service, using a balloon tyred vehicle with a hoist. A radio will be assigned to each buffalo party so that they can notify the rangers when they have shot their buffalo.

Vehicle Access

Vehicle use will be allowed on established roads only and any off-road use will be dealt with severely. Buffalo retrieval will be by the Reserve's special vehicle which will have a hoist and balloon tyres for minimising off-road damage.

Camping

About 10 of the parking areas (with provision for more if the demand is present) will include campsites for those hunters who want to spend time scouting the area and selecting a particular animal; want an early morning hunt; or, in the case of pigs or ducks, want a hunt longer than one day. Night hunting will not be allowed.

Scientific Data Collection

Hunters using the area must agree that scientific data, if required, can be collected from carcasses during check-out. This could be only measurements or could include organs, jaws, etc.

Reserve staff

A three man staff is envisaged plus the part-time use of the ranger located at Fogg Dam for patrolling the eastern boundary. Patrolling for poachers and hunter misconduct, check-in/check-out, extension, and carcass retrieval are seen as their main duties.

Addendum VII(iii)

Guides (optional)

Certain locals (who meet certain requirements) could be licenced to provide guide service to those buffalo hunters who desire this type of hunt.

Buffalo Hunting

It will be made clear to the buffalo hunters that they are entitled to one animal only (hopefully the ballistic check will discourgae multiple shooting).

Only the shooting of mature animals will be allowed and the shooting of females (except for trophies) will be discouraged.

Every effort must be extended to finish off wounded buffalo for humane and safety reasons. The hunters must be encouraged to call for ranger assistance if they feel unable to cope with a wounded animal. If this is found to be unworkable, the use of conscientious registered guides mught have to be a condition for hunting buffalo.

Pig Hunting

Pig hunters will not be confined to a specific number of animals but dogs will not be allowed.

Duck and Goose Hunting

Waterfowl hunters will only be allocated areas adjacent to billabongs or the lakes. Canoes and retriever type dogs will be allowed.

APPENDIX VIII

ESTABLISHMENT OF GOVERNMENT CONSERVATION HERD

Cost of establishing genetic resource conservation herd at Coastal Plains Research Station. Total herd 1,000 head.

Costs:		$
Staff; 2 x labourers @ $13,000 + 40% on-costs	Total: =	36,400
Operating expenses @ $20/animal	Total: =	20,000
	TOTAL	$56,400

RECURRENT COST OF GOVERNMENT CONSERVATION HERD

Cost of holding genetic resource conservation herd at Coastal Plains Research Station. Total herd 1,000 herd.

Costs:		$
Staff; 2 x labourers @ $13,000 + 40% on-costs	Total =	36,400 p.a.
Operating expenses @ $20/animal	Total =	20,000 p.a.
	TOTAL	$56,400 p.a.

APPENDIX IX

OPERATING COSTS GOVERNMENT MARSHALLING YARDS

The buffalo marshalling and testing yards are intended to operate as soon as possible to nil net cost. Buffalo processed through the facility will be resold at a price equal to purchase price plus operating costs. A contingency allowance of $100,000 has been included in the financial summary given in Part VI for non recovered operating costs.

APPENDIX X

INDUSTRY INFORMATION EXTENSION

Buffalo industry information extension, and supervision of joint industry government development and research projects on pastoral properties.

Costs: Staff; 1 x Scientists Class 2 @ $27,000 + 40% on costs
1 x Technical Officer @ $22,500 + 40% on costs

	$
Wages Total	69,300 p.a.
Operating costs, vehicle etc.	20,000
Total	$89,300 p.a.

APPENDIX XI

RESEARCH ON INDUSTRY DEVELOPMENT

Research on Conservation herd

Costs: Staff; 1 x Scientist Class 2 @ $27,000 + 40% on costs.
1 x Technical Officer @ $22,500 + 40% on costs.

	$
Wages Total:	69,300 p.a.
Operating expenses:	5,000 p.a.
TOTAL	$74,300 p.a.

Industry Development

Co-operative government-industry development projects on pastoral properties.

10 projects each of 500 head - established over 4 years.

Establishment Costs

Average $175/ha, Range ($50 - $300)
@ 2 ha/beast = $350/beast area

Establish average of 1,250 head p.a. in each of first 4 years.

Therefore, establishment cost = 1,250 x $350 = $437,500 in each of first 4 years.

50% Government Cost (50% Pastoralist) = $218,750 p.a. in each of first 4 years.

Operating Costs

Maintenance fences and waters 12.5% of initial cost = $44/beast area.

Fertilizer: Range $0 - $66
Average $33/beast area ($16.50/ha)

Total Maintenance $77/beast area.

50% Government Cost (50% Pastoralist) = $38.50/beast area.

YEAR	ESTABLISHMENT COST	MAINTENANCE COST
1983/84	$0.219 m	$0.048 m
1984/85	$0.219 m	$0.096 m
1985/86	$0.219 m	$0.144 m
1986/87	$0.219 m	$0.193 m
1987/88	Nil	$0.193 m
1988/89	Nil	To be reviewed
1989/90		in subsequent
1990/91		years.

REFERENCE NO. 1

SOUTH MARRAKAI BUFFALO STUDY REPORT
PREPARED BY CHRIS GILES/DAVID YOUNG
A.A.C.M., FOR THE BUFFALO WORKING PARTY.

ATTACHMENT C

Technical Report

A PRELIMINARY SURVEY OF ENVIRONMENTAL DAMAGE ASSOCIATED WITH ACTIVITY OF FERAL BUFFALO

Peter Fogarty

Feral Animals Committee
Conservation Commission of the Northern Territory
Darwin N.T.
May 1982

A PRELIMINARY SURVEY OF ENVIRONMENTAL DAMAGE ASSOCIATED WITH ACTIVITY OF FERAL BUFFALO

Peter Fogarty,
Consultant to:-
Conservation Commission of the Northern Territory.

1982

CONTENTS

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It is a pleasure to thank the following people for contributing knowledge, advice and critcism to this report: Messrs. Ray and Tommy Petherick, residents of the Finniss River area; Mr. Dave Lindner, resident of the South Alligator area; Mr. Gerry O'Neil, Mr. Dennis Mathews, Mr. Malcolm Forbes, Mr. Chris Haynes of Australian National Parks and Wildlife Service; Mr. Bob Richards, Mr. Bob Fox, Mr. John Waithman, Dr. Bob Begg, Mr. Rod Applegate, Mr. Paul Findlater of the Conservation Commission of the Northern Territory; Dr. Mike Ridpath, Dr. Don Tulloch, Dr. John Taylor of CSIRO Division of Wildlife Research; Dr. Bob Galloway, CSIRO Division of Land Use Research, Mr. Brian Ford, Department of Primary Production; Mr. Richard Hill, Department of Zoology, University of NSW; Mr. Trevor Menzies, Department of Lands.

1. *INTRODUCTION AND OBJECTIVES*

1.1 Background

It is generally accepted that grazing by large numbers of feral buffalo over a period of many years has caused extensive modification to the wetland-alluvial systems between the Daly River and Cobourg Peninsula. The nature of environmental modification is extremely complex, as shown by Figs. 1.1 and 1.2, and the absence of any completed empirical studies has meant that the problem is not well understood. This, in turn has led to speculation and contention on many aspects of the environmental effects of feral buffalo.

The Feral Animals Enquiry (Board of Enquiry, 1979) compiled evidence which showed that substantial changes have occurred on the northern wetlands since European settlement and these changes have been closely associated with the build-up in numbers, and spread of feral buffalo. While evidence presented to the enquiry was largely circumstantial, the severity of the problem and the need to make early decisions concerning control and rehabilitation justified the use of such evidence.

1.2 This Survey

The objectives of this survey were to describe the condition of each of the major northern wetlands from the Daly to the East Alligator in terms of the nature of damage which occurs there, and to provide direction for early rehabilitation works, more detailed studies, and land management on buffalo farming enterprises.

While it is recognized that buffalo affect the environment through a complex series of interactions which do not lend themselves to a rapid appraisal, there are sources of information which permit an assessment of the degree to which land has changed in association with buffalo grazing.

- There are a number of reports, published and unpublished, describing generally the nature of damage caused by feral buffalo (Board of Enquiry, 1979; Australian National Parks and Wildlife Service, 1980; Stocker 1971(a); Ellis, 1972). Field survey has allowed such information to be related to particular areas.

- Over much of the Top End, there is aerial photography for 1950, 1963 and 1978-81 at detailed scales. Combined with an idea of buffalo occupancy in an area, it is possible to gain a reasonably accurate picture of progressive changes over this period.

- There are a number of informants who have been associated with particular areas over a sufficient period to be able to confidently document changes associated with buffalo activity.

During this survey, rapid field inspection over the wetlands was carried out by helicopter and vehicle. Through lack of time it was not possible to locate and inspect all areas which have been subject to heavy buffalo activity, nor was it possible to account for forms of damage which are not readily observed (for instance, changes in vegetation species composition, pollution of water bodies, effects on native animal populations). In some instances, local informants were able to provide details on these aspects.

It was apparent that there was a reasonable correlation between the component landform elements of each wetland area and most forms of observable damage. This is logical when it is considered that buffalo behaviour involves concentrated activity on elements such as perennial waterholes, backplain swamps and lower fringing slopes, while activity is more dispersed on elements such as open plains and upland terrain. Further, the various component elements are subject to different natural processes (for example, sheetwash on fringing slopes, high velocity flood flows along channels), which interact with modifications caused by feral buffalo to produce forms of damage characteristic of particular elements. By describing damage as it pertains to the component elements of each wetland, a degree of order is gained which simplifies somewhat this highly complex problem.

Figure 1.1

A simple diagram to illustrate the agents which contribute to change in the wetland system, and hence the difficulty in clearly defining the environmental effects of buffalo.

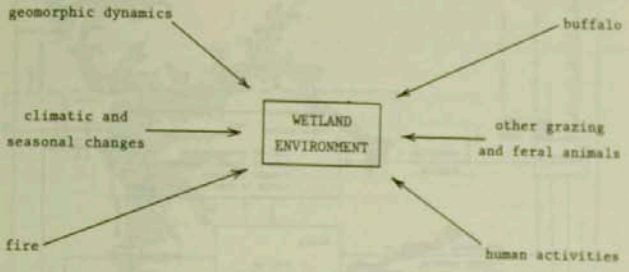


Figure 1.2

This diagram indicates the complexity of interactions which occur as a result of buffalo activity. It is apparent from the diagram that there are both direct effects from buffalo activity on the components of the wetland system, which in turn initiate interactive effects between the individual components.

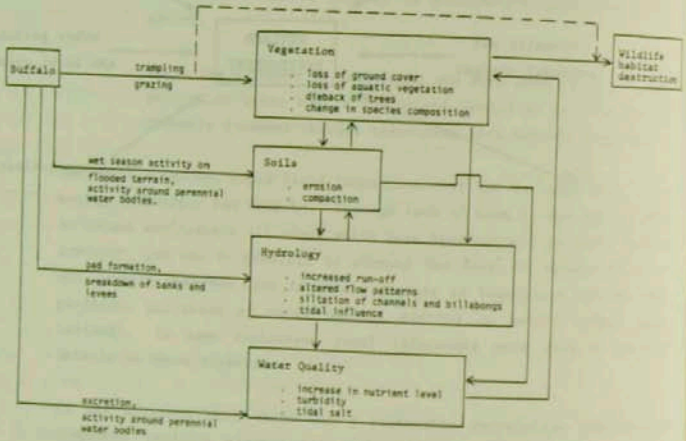
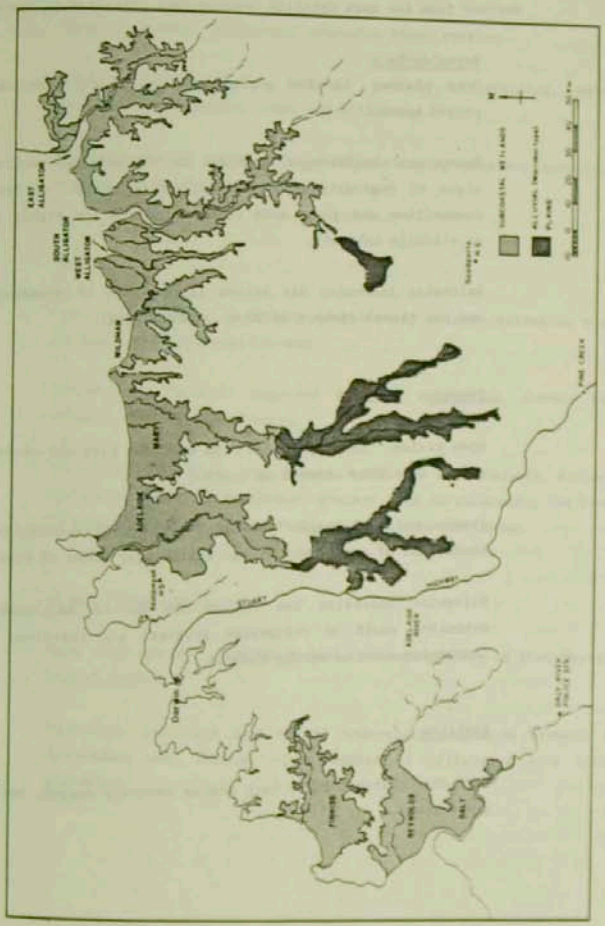


Figure 1.3

Wetland-alluvial systems covered by this survey.



1.3 Summary of Findings

The following is a summary description of damage on each wetland area, derived from the more detailed descriptions presented in Chapter 2:

- Reynolds-Daly

  Open plains: heavily grazed with scattered bare and severely pugged areas.

  Swamps and billabongs: subject to concentrated activity, early signs of degradation with reduction in extent of fringing reed communities and grass mats (these elements are highly significant as wildlife habitat).

  Saltwater intrusion has killed large areas of freshwater grasses and has caused dieback of 20 ha of *Melaleuca*.

- Finniss

  Open plains: heavily grazed with numerous bare and severely pugged areas; extensive network of tracks.

  Swamps and billabongs: severe reduction of vegetative cover on banks, and of grass mats within billabongs; areas of bank erosion.

  Saltwater intrusion has caused 300 ha of *Melaleuca* dieback, extensive death of freshwater grasses, and threatens the lower freshwater section of the Finniss.

- Adelaide

  Open clay plains: lower back plains severely pugged, heavy loss of grass cover.

Swamps, billabongs: subject to concentrated activity, banks are heavily degraded, extensive reduction of vegetative cover, highly turbid and polluted water, reduction in value as wildlife habitat.

Fringing slopes: moderately extensive sheet erosion.

Marrakai type plains: numerous pockets of scalding, severe degradation of channel banks and billabongs.

Generally heavy infestation of *Mimosa pigra*, possibly associated with heavy grazing by buffalo.

Mary

Open clay plains: generally very heavily grazed, extensive areas of bare, heavily pugged ground.

Billabongs: heavily degraded fringing vegetation, severe bank erosion, highly turbid water.

Saltwater intrusion has caused 4,200 ha of *Melaleuca* dieback, extensive death of freshwater grasses, and is theatening the lower freshwater section of the Mary, at Shady Camp billabong.

Wildman-West Alligator

Open clay plains: heavily grazed, extensive areas of bare heavily pugged ground.

Saltwater intrusion has caused moderately extensive dieback of *Melaleuca*, and filling of a number of billabongs with tidal sediments.

South Alligator - East Alligator

Open clay plains: generally heavily grazed with extensive tracts of bare ground particularly on lower Cairncurry and Cooper Creek plains; backplains are consistently degraded by wallowing, pugging and consequent loss of grass and sedge cover.

Swamps and billabongs: heavy degradation of fringing communities and swamp vegetation; severe erosion of banks and levees; highly turbid and polluted water.

Saltwater intrusion has caused major changes to South Alligator and East Alligator plains, involving growth of tidal channels, filling of numerous billabongs with tidal sediment, loss of freshwater grasses on plains, and dieback in *Melaleuca* swamps.

2. DESCRIPTION OF DAMAGE

This chapter aims to characterise the wetland areas between the Daly and East Alligator Rivers in terms of the buffalo associated damage which occurs on them. The chapter comprises descriptions of the component bio-physical elements of each wetland, derived from a number of land resource surveys which cover the study area at various levels of detail (Bennell, 1979; Forster, 1977; Story et al. 1969; Christian & Stewart, 1953). They allow the elements to be defined in terms of landform, drainage, soils and vegetation, and their general distribution within each wetland. Damage to each element has been described broadly in terms of form, occurrence within the element, and processes which have contributed to its development. This information has been presented in a tabular form, and has in some cases been elaborated upon in the text, in particular to draw attention to areas of greatest concern.

The terminology used in this chapter is defined in a glossary in Appendix I.

2.1 Finniss - Reynolds - Daly wetlands

The Finniss, Reynolds and Daly wetlands have been subject to heavy grazing pressure since the early 1960's (Petherick, pers. comm.) but retain a diverse and productive character. On the mid-Reynolds, buffalo numbers have been kept to a minimum by Stapleton Station management and changes in that area are attibutable to cattle. The other areas have been subject to high numbers of both cattle and buffalo. While these wetlands have not yet been extensivly degraded, there has been some modification of most component elements, particularly elements such as billabongs, swamps and rainforest pockets where there has been concentrated activity.

Information on the nature of changes to the wetlands has been obtained from long term local residents, Messrs. R. & T. Petherick, as well as field inspection and interpretation of air photograph sequences. The general occurrence of damage on each of the three wetlands is shown in Tables 2.1 and 2.2.

Table 2.1(a)

Reynolds - Daly Plains

TERRAIN UNIT	MAP UNIT (Bennell, 1979)	DISTRIBUTION	DRAINAGE	SOILS	VEGETATION
Open plains	8e, 8f	Extensive on mid reaches of Reynolds.	Wet season flooding with most areas remaining wet well into the dry season.	Humic gleys, dark cracking clays.	Grassland of *Para*, *Hymenachne*, *Oryza*.
Open plains	8d	Extensive on lower Reynolds and Daly plains.	Wet season flooding.	Dark cracking clays.	Tussock grassland: *Sacharum*, with single stem *Phragmites*, and areas of dense *Phragmites*.
Closed swamps	3d	Extensive on mid and lower Reynolds.	Flooded in wet, and for much of dry season.	Humic gleys.	Melaleuca forest, generally dense ground cover of *Hymenachne-Oryza*. In mid Reynolds, forests contain more open areas, and less uniform canopy cover.
Open swamps	8f, 8g, 3d	Limited extent; associated with mid reaches of Reynolds.	Flooded in wet season; a large proportion remains flooded through dry season; slightly elevated levees dry out early in dry season.	Humic gleys.	Complex unit comprising *Hymenachne-Oryza* swampy grasslands, *Phragmites* fringing channels, grass mats, lily beds on water surface; *Melaleuca* and Palm forests fringe swamps.
Old river channels and associated billabongs.	3d, 8f	Moderately extensive on lower and mid Reynolds.	Wet season flooding; large proportion remains waterlogged or inundated for whole of dry season.	Humic gleys, dark cracking clays.	Woodland to open forest of *Melaleuca* with associated *Hymenachne-Oryza* ground cover. Grass mats of *Isachne*, *Hymenachne* etc. on billabongs; mostly dense reed and grass cover on banks.
Rainforest	1a	Very limited occurrence, on seepage areas, perennial tributaries and old sand dunes.	Generally waterlogged year round. Dunes remain above flood level.	Humic gleys, organic sands.	Rainforest with species including *Nauclea*, *Acacia*, *Carpentaria* and *Livistona palms*, *Terminalia*, *Melrosideros*.

Table 2.1(b)

Reynolds - Daly Plains

TERRAIN UNIT	DAMAGE	OCCURRENCE	PROCESS
Open plains, lower.	Large bare areas, numerous pads, pugged surface.	Scattered, general occurrence.	Due predominantly to cattle activity.
Open plains, more elevated.	Bare areas with pugged, wallowed surface.	Extensive on Daly plains (i.e. Litchfield Station), minor on lower Reynolds.	
	Death of grasses adjacent to tidal channels.	Extensive on lower Reynolds.	Growth of tidal channels and associated east water flooding.
Closed swamps	Heavy pugging, numerous wallows.	Extensive on lower Reynolds.	
	Dieback of Melaleuca.	Head of tidal channels on lower Reynolds.	Headward extension of tidal channels into Melaleuca swamps.
Open swamps.	Loss of grass cover on more elevated areas; invasion by herbaceous species; reduction in extent of Phragmites along channels, associated reduction of grass mats. Heavy pugging of swampy grasslands.	General.	Areas of concentrated activity for cattle and buffalo.
Old river channels and billabongs.	Reduction of ground cover along banks; small areas of bank erosion; partial loss of grass mats.	General.	As above.
Rainforest.	Trampling and grazing of small trees, very pugged surface.	Severe in coastal rainforest patches; increasing degradation of rainforest pockets in mid reaches of catchment.	Subject to heavy pressure in wet and dry season; pigs probably more important in causing damage.

Table 2.2

Finniss River: Lower

TERRAIN UNIT	MAP UNIT (Forster,1977)	DISTRIBUTION	DRAINAGE	SOILS	VEGETATION
Broad open plains.	8a1	Extensive.	Wet season flooding.	Dark cracking clays.	Tussock grassland, *Ischaemum* dominant with areas of dense *Phragmites*.
Closed swamp.	7b	Extensive.	Flooded in wet and early dry season. Pockets remain wet year round.	Dark cracking clays.	*Melaleuca* forest with dense ground cover of *Hymenachne*, *Oryza*, *Leersia*.
Old stream channel infils.	8a2	Moderately extensive within open plains.	Flooded in wet and early dry season, tidal flooding at end of dry season, of areas adjacent to Finniss channel.	Organic dark cracking clays.	*Hymenachne-Oryza* grassland.

TERRAIN UNIT	DAMAGE	OCCURRENCE	PROCESS
Broad open plains.	Numerous patches of bare ground, extensive pads and wallows.	General.	
Closed swamps.	Very heavy pugging, wallows and patches of bare ground.	General.	
	Melaleuca dieback. Patches of bare ground.	See Plate 2.1; total of approx. 300 ha associated with Finniss and Little Finniss Rivers	Initiation of tidal channels and extension into *Melaleuca* forest; exacerbated by buffalo activity.
Old stream channels.	Very heavy pugging and grazing, extensive bare areas by end of dry season.	General.	Area of concentrated activity as remain flooded well into dry season; supports *Hymenachne-Oryza* while surrounding plains have *Ischaemum* dominant.
	Filling with saline sediment, death of freshwater grasses, colonization with *Sporobolus*.	See Plate 2.1, associated with channels adjacent to Finniss River.	Initiation and extension of tidal channels from main Finniss channel.

Table 2.3(a)

Pioneira River: mid reaches

TERRAIN UNIT	MAP UNIT (Forster,1977)	DISTRIBUTION	DRAINAGE	SOILS	VEGETATION
Open plains	7a1, 7a2, 7a3	Extensive	Flooded in wet and early dry seasons; pockets remain water-logged year round.	Dark cracking clays, humic gleys.	*Hymenachne-Oryza-Para* grassland.
Closed swamp	7b	Extensive.	Flooded in wet and well into dry season, large areas remain wet year round.	Humic gleys.	*Melaleuca* forest, with large patches of open ground; 100% ground cover of *Hymenachne-Oryza*.
Open swamp	7a1	Moderately extensive.	Most of area flooded or water-logged year round. Small areas of elevated ground dry out soon after wet season.	Humic gleys.	Complex, with fringe of dense *Phragmites*, and also occurring in pockets throughout. *Hymenachne* extensive, with some *Para*; areas of grass mats on water, formed of *Isachne*, *Hymenachne*, associated with beds of *Nelumbo* lilies. Pockets of *Typha*, *Scleria* reeds.
Billabongs and river channels	-	Limited extent	Perennial water; wet season flooding; tidal intrusion into Pioneira channel occasionally, at end of dry season.	Banks have dark cracking clays.	i) Levee: grassland with *Para*, *Pseudoraphis*, *Imperata*, single stem *Phragmites* etc; scattered *Maculea*, and dense pockets of *Phragmites*. (ii) Near continous fringe of *Phragmites* along bank. (iii) Frequent occurrence of grass mats on water surface; composed of *Isachne*, *Cyclosaurus*, *Hymenachne*, *Leersia*.

Table 2.3(b)

Finniss River: mid reaches

TERRAIN UNIT	DAMAGE	OCCURRENCE	PROCESS
Open plains	Patches of bare ground, with heavy pugging.	General	
Closed swamp	Heavy pugging, numerous wallows reduction of ground cover.	General	
Open swamp	Severe pugging, numerous wallows; partial destruction of grass mats, reduction in extent of *Phragmites* beds.	General	Subject to heavy grazing pressure.
Billabongs and channels	Heavy grazing and pugging of levee; bank erosion; severe reduction in extent of grass mats; associated increase in turbidity of billabong.	General	Subject to heavy grazing pressure.

The main areas of concern are those elements which have a high value for conservation and recreation due to their vegetative and habitat diversity, which is generally related to the presence of perennial or near-perennial water and hence tend to be subject to concentrated stock activity.

2.1.1 Billabongs

Deep freshwater billabongs are a significant feature of the mid reaches of the Finniss and the Reynolds wetlands and in both areas they have been substantially modified by stock activities. These elements are composed of a clay levee elevated above most wet season floods, and steeply sloping clay banks. In an undisturbed condition the levee supports a dense cover of *Hymenachne*, *Para* and other perennial grasses, together with pockets of dense *Phragmites* and scattered large *Nauclea*, *Melaleuca* and *Alstonia*. The banks down to the water are densely grassed, a large proportion of which is beds of *Phragmites*. Extending out over the billabong are mats formed of species which include *Isachne*, *Leersia*, *Cyclosaurus*, *Hymenachne* and anchored at the bank in a mass of roots at the base of the fringing *Phragmites* beds. The habitat significance of these mats, while not yet documented, is thought to be extremely important, for a diverse range of animals (R. Hill, pers. comm.) not the least of which is the saltwater crocodile (G. Webb, pers. comm.).

The changes associated with buffalo and/or cattle activitiy to billabongs are:

- on the levee, reduction or loss of grass cover, heavy pugging and wallowing, invasion by herbaceous species such as *Heliotropum*, *Phyla*, *Walteria*, and exotics such as *Hiptus*, *Sida* and in places *Mimosa*. Soil erosion has occurred in some areas to form small gullies, and expose the roots of trees.

- Reduction in extent of *Phragmites* beds which stabilise banks; more extensive on Finniss; consequent under-cutting and slumping of banks is occurring in places; breakdown of banks by cattle and buffalo.

- Loss of a large proportion of grass mats following breakdown of banks. Petherick (pers. comm.) reports that on some billabongs on the Reynolds which previously supported 80-90% coverage of grass mats, there is now less than 10% coverage. This has profound implications for wildlife dependent of these features.

- Increased turbidity of water in billabongs due to breakdown of banks by buffalo and wet season erosion.

2.1.2 Open swamps

Open freshwater swamps are also major elements of the mid-Finniss and mid-Reynolds wetlands.

They are perennially wet areas which are composed of:

- swampy *Hymenachne-Oryza* grasslands;
- reed beds of *Phragmites*, *Scleria*, *Scirpus*;
- small areas of elevated ground which dry out by the early dry season, and which support low perennial grasses;
- extensive beds of lilies and floating grass mats on water bodies;
- fringing forest communities, often rainforest or paperbark.

Heavy pressure by both cattle and buffalo on these elements on the Finniss and Reynolds has caused, and continues to cause significant modification. The areas of higher ground have severely reduced cover of grasses and are dissected by pads. Reed beds which fringe water bodies have been heavily trampled in places, and there has been some loss of grass mats.

2.1.3 Saltwater intrusion

The increasing influence of tidal saltwater has been determined by comparing 1950, 1963 and 1978 aerial photographs, on both the Reynolds and Finniss. The effects of saltwater intrusion are only apparent on 1978 aerial photographs, that is, since the wetlands have been subject to heavy pressure from feral buffalo. Observations by Petherick (pers. comm.) on the Finniss confirm this finding.

The Finniss River flows to the sea as a defined single channel. After wet season flows have ceased, the freshwater section forms a series of long billabongs, separated from the tidal reaches. Tidal saltwater originally flooded into the freshwater section once or twice a year on peak tides (Petherick, pers. comm.). It is now reported that the freshwater reaches are flooded more frequently by saltwater due to the deepening of the previously shallow channel connecting the tidal and freshwater reaches, as a direct consequence of buffalo activity in and along the channel (Petherick, pers. comm.). As a result there has been death of lilies and loss of condition of fringing vegetation along the lower freshwater reach. Petherick also reports a threat from extending tidal channels into the Bullcoin Billabong system which runs parallel to the main Finniss channel.

Other consequences of saltwater intrusion are 300 ha of *Melaleuca* dieback, adjacent to the tidal Finniss channel, and at the head of the Little Finniss to the south. Shallow billabongs associated with old river channels on the lower Finniss plains have also been intruded by extending tidal channels, killing off the aquatic grasses which colonise the banks.

The Reynolds River does not have a single channel draining from the headwaters to the sea; rather, it consists of a fragmented system of long billabongs and old channel fills. During the wet season the plains are subject to sheet flooding which eventually drains into the sea through a number of small channels. These channels

run from *Melaleuca* swamps across an open plains vegetatated by an *Ischaemum-Phragmites* association, into the littoral zone. During the dry season, as freshwater flows cease, the channels are subjected to an increasing tidal influence.

Aerial photograph interpretation indicates that the tidal influence has extended upstream by between 100 and 400 metres along the different channels. This has occurred since the 1963 aerial photographs were taken. *Melaleuca* dieback has occurred in four situations, and a total of approximately 80 ha has so far been affected. Also, lower areas of the open perennial grassland have been killed off by saltwater flooding adjacent to the channels, leaving bare salt flats which in places have been colonized by *Sporobolus*.

It has been estimated for one of the channels (Mr. G. White, Fisheries Officer, pers. comm.) that the rate of headward retreat has been 20-30 metres/year over the past 6 years at least. With continued rapid extension of tidal creeks, large *Melaleuca* forest communities and extensive open grasslands are threatened by saltwater intrusion.

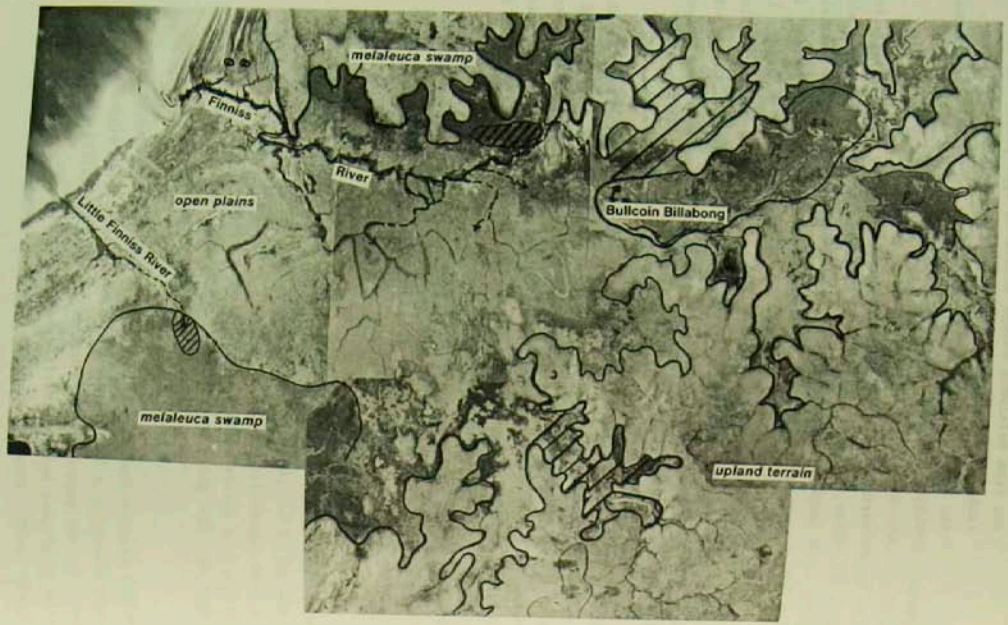

melaleuca swamp
Finniss
River
open plains
Little Finniss River
melaleuca swamp
Bullcoin Billabong
upland terrain

PLATE 2.1

Aerial photo compilation at 1:160000 of the Finniss wetlands showing degradation associated with heavy buffalo and cattle grazing.

(i) Close hatching indicates areas of *Melaleuca* dieback attributable to saltwater intrusion.

(ii) Tidal channels are indicated by dotted lines, and direction of intrusion by arrows. Note tidal channels have extended into old channel infills on the lower Finniss plains, and also threaten lower Finniss freshwater system, at point F.

(iii) Open hatching shows perennially wet, open swamps, which are subject to heavy grazing pressure in the dry season.

(iv) The mid-Finniss swamp is the encircled area upstream of point F. It is composed of numerous billabongs with associated fringing forest and grass mat communities, swampy *Melaleuca* forests, and numerous pockets of rainforest. It is being heavily degraded by buffalo activity.

(v) The plains of the lower Finniss support predominantly open perennial grassland. Heavy grazing has created numerous patches of bare pugged ground and an extensive network of pads.

Figure 2.1

The Reynolds-Daly wetlands showing elements where buffalo and cattle have caused significant degradation.

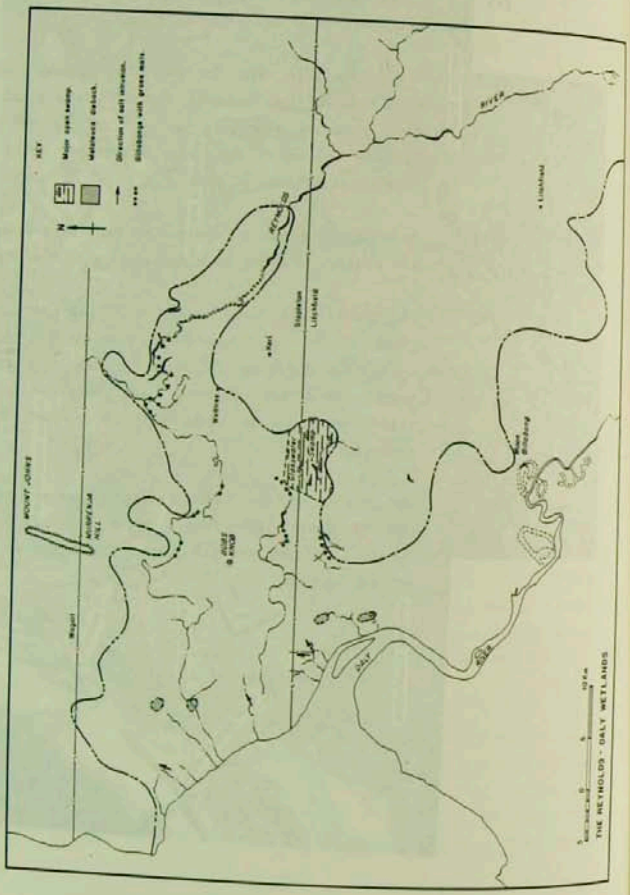
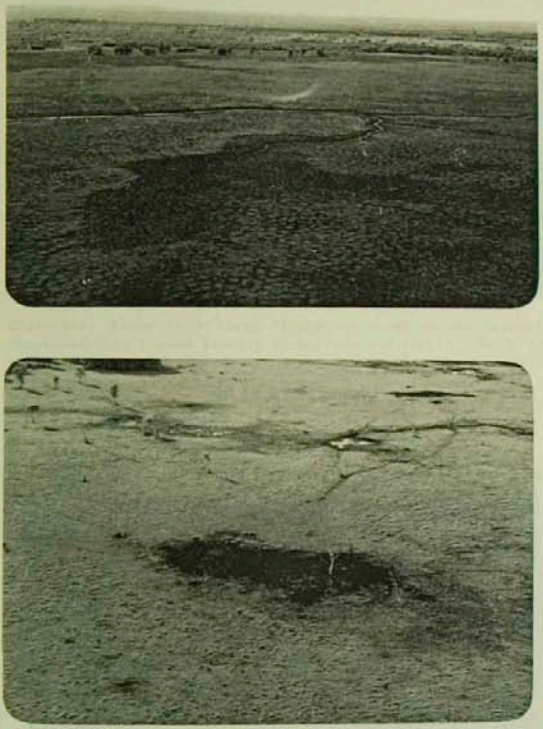
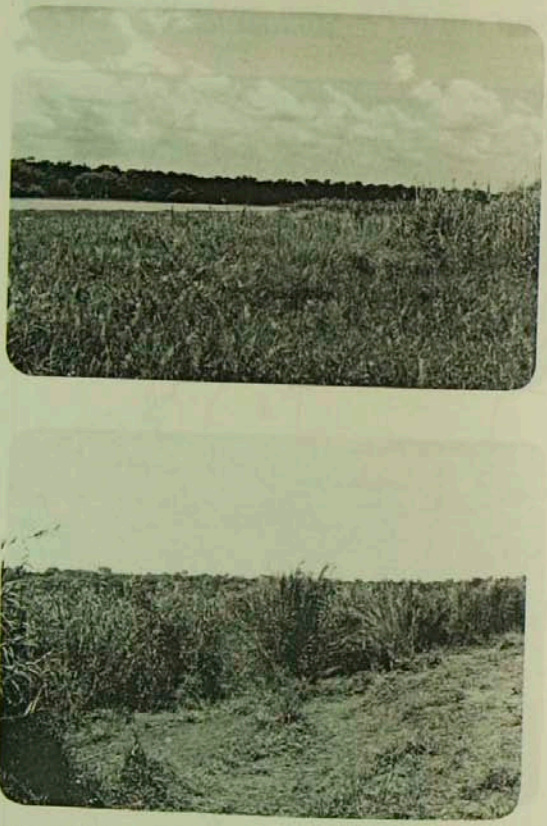


PLATE 2.2



The plains show signs of heavy grazing pressure. The upper photo is of the Lower Daly plains on Litchfield Station, where heavy cattle and buffalo pressure has extensively reduced ground cover. The lower photo is of a *Hymenachne-Oryza* pasture on the Reynolds to the south of Stapleton Station.

PLATE 2.3



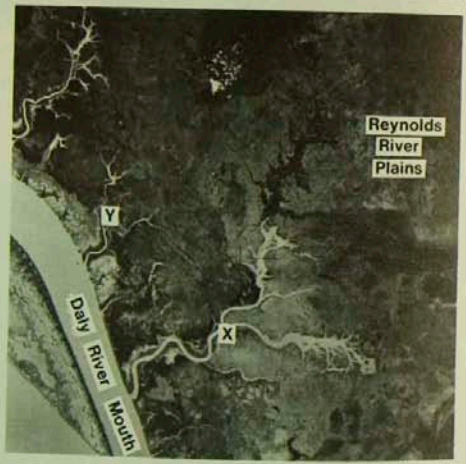
Bullcoin billabong on the Finniss, where previously extensive grass mats have been severely reduced in area according to local inhabitants. The upper photograph shows a section of grass mat which still is in good condition. The lower photograph shows damage to the bank of the billabong, including loss of grass cover and trampling of *Phragmites* on the water's edge, which contribute to eventual loss of the grass mats.

PLATE 2.4

Glasswater Swamp is a large freshwater swamp on the Reynolds wetlands which has been grazed heavily by buffalo and cattle. While the swamp is not yet severely degraded, it has been significantly modified.

Shown here is the result of heavy grazing on levee areas in Glasswater Swamp; loss of perennial grass cover and replacement by herbs and forbs, and damage to *Phragmites* reed beds which fringe the perennially wet areas. This pre-disposes the grass mats which grow on the latter areas to destruction by floodwaters. Buffalo moving through the swamp also break up the grass mats.

PLATE 2.5

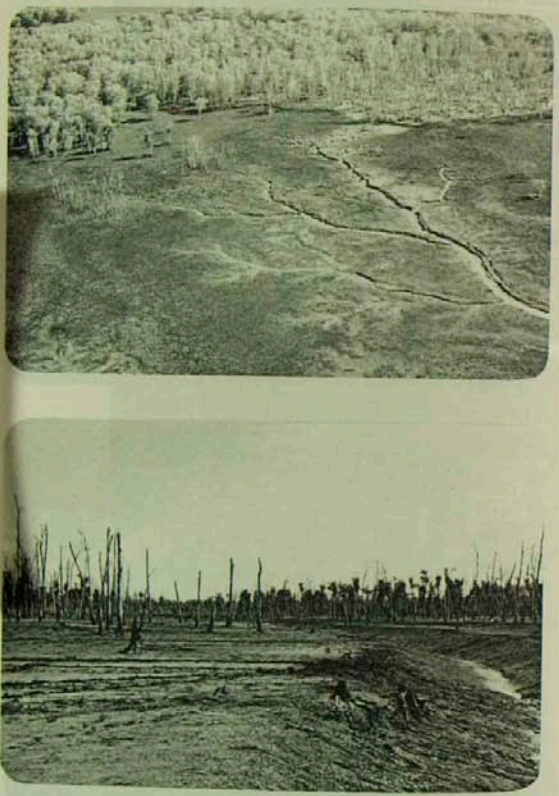


The effects of saltwater intrusion on the Reynolds. The upper aerial photograph was taken in 1950, and the lower in 1978. In 1950, the channels draining from the wetlands to the sea were stable, while in 1978 the channels have widened considerably, and the tidal influence extends much further in land. It has caused death of grasses on the plains adjacent to the channels, and Melaleuca dieback in the swamps at the channel heads. Points X and Y are the same points respectively on each photo.

PLATE 2.6

The extension of tidal channels on the lower Reynolds has lead to the death of grasses adjacent to channels (upper photograph), and paperback dieback in swamps at the head of channels (lower photograph).

PLATE 2.7



Saltwater intrusion adjacent to the Finniss River (upper photograph) and at the head of the Little Finniss (lower photograph) has caused widespread paperbark dieback, and further large areas are threatened. In both situations, previously stable freshwater channels have become incised to permit tidal saltwater into these areas at some stage following the build up in buffalo numbers in the area. Petherick (pers. comm.) reports that buffalo graze and wallow in large numbers in and along the channels, and would thus contribute to channel erosion.

2.2 Adelaide River

The Adelaide River wetlands are formed of both sub-coastal plains in the lower catchment, and Marrakai type terrain in the mid and upper catchment (see Fig. 3.1). The sub-coastal plains, are characterised by a high proportion of relatively elevated, better drained plains, and a small proportion of lower, poorly drained plains. As such there is only minor occurrence of the *Hymenachne-Oryza* association, and of perennial open swamps and billabongs. Tables 2.4 and 2.5 indicate that the impact of buffalo activity is most profound on the poorly drained backplain elements, the fringing slopes of the sub-coastal plains, and the flood channel and billabong systems of the Marrakai type plains. Melacca swamp is currently undergoing heavy grazing pressure by buffalo and cattle, and is also an area of concern. Saltwater intrusion has not caused the extensive and obvious changes which are apparent on the wetlands to the east.

2.2.1 Freshwater swamps

Melacca swamp is situated on the lower Adelaide plains and is the only large freshwater swamp in the catchment. The swamp is composed of a diverse range of plant communities and is highly significant as a wildlife habitat area. It has formed where a spring fed perennial stream flows from the upland terrain onto the coastal plains. The stream and swamp are fringed by *Melaleuca* and palm forest. Within the swamp are large beds of reeds, predominantly saw edged reed *Thoracostachym sumatrosum* and also *Typha, Phragmites, Scirpus*, lilies and *Eleocharis* (G. Webb, pers. comm.).

The significance of the area lies in the following points (Webb, pers. comm.):

- it is the only such swamp on the Adelaide system;

PLATE 2.7

Saltwater intrusion adjacent to the Finniss River (upper photograph) and at the head of the Little Finniss (lower photograph) has caused widespread paperbark dieback, and further large areas are threatened. In both situations, previously stable freshwater channels have become incised to permit tidal saltwater into these areas at some stage following the build up in buffalo numbers in the area. Petherick (pers. comm.) reports that buffalo graze and wallow in large numbers in and along the channels, and would thus contribute to channel erosion.

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The significance of the area lies in the following points (Webb, pers. comm.):

- it is the only such swamp on the Adelaide system;

Table 2.4(a)

Adelaide River: lower

TERRAIN UNIT	MAP UNIT (Story et al. 1969)	DISTRIBUTION	DRAINAGE	SOILS	VEGETATION
Plains, slightly elevated.	Cp1, Cm3	Extensive in whole area.	Wet season flooding, drain early in dry season.	Uniform dark cracking clays.	Predominantly perennial grassland, with sedges.
Lower plains.	Cp2, Cm1	Moderately extensive in whole area.	Deep wet season flooding, remaining wet well into dry season.	Uniform dark cracking clays.	Predominantly sedgeland with areas of grassland.
Shallow billabongs and depressions.	Cm4	Limited extent, associated with lower plains unit.	Flooded for wet and much of dry season.	Uniform dark cracking clays.	Sedgeland.
Open freshwater swamps.	-	Very limited extent, Melacca swamp is only example.	Year round inundation.	-	Complex of *Melaleuca* forest, beds of reeds, aquatic grasses and sedges, fringe community of palm and *Melaleuca* forest.
Closed swamp.	Pw1	Limited extent, situated in embayments along edge of plains.	Flooded in wet season and well into dry season.	Uniform dark cracking clays.	*Melaleuca* forest; ground cover of sedges.
Fringing slopes.	Rh4, Pw4	Forms continous margin between plains and upland terrain.	Wet season waterlogging on lower slopes.	Lower slopes have organic loams over gravelly clay; headland areas and upper slopes have sandy, shallow earths with extensive surface gravels.	Lower slopes have *Melaleuca-Tristania-E. papuana-Pandanus* woodland to open grassland with scattered *Nauclea* and *Banpana*. Upper slopes and headlands have eucalypt woodland to open woodland.
Monsoon forest.	-	Restricted extent within fringing terrain.	Waterlogged for much of year.	Humic gleys: organic loam over mottled light clay.	Evergreen closed forest, with open understory.
Low dunes and shoreline banks.	-	Restricted extent on plains adjacent to coast.	Remain above flood level, except for swale areas which are inundated in wet season.	Uniform sands on ridges. Uniform clays in swales.	Grassland with scattered patches of monsoon forest, and individual monsoon forest elements.

Table 2.4(b)

Adelaide River: lower

TERRAIN UNIT	DAMAGE	OCCURRENCE	PROCESS
Plains, slightly elevated.	Bare patches, wallows; pugged surface.	Scattered pockets.	
Lower plains.	Heavy pugging, extensive loss of grass cover.	General.	
Shallow billabongs and depressions.	Very heavy pugging on banks, loss of grass and sedge cover by end of dry season, very high level of suspended sediment in water.	General.	Area of concentrated activity due to presence of water well into dry season.
Open freshwater swamps - (Melacca Creek).	Destruction of reed beds and aquatic grasses; loss of grass cover and heavy pugging on slightly elevated areas; heavy pugging and wallowing along fringes; heavy increase in turbidity of water.	General.	Area of concentrated activity due to perennial freshwater.
Closed swamps.	Very heavy pugging, loss of ground cover.	General.	
Fringing terrain.	Heavy pugging and wallowing.	General occurrence on lower slopes which abut plains.	
	Sheet erosion.	Extensive loss of topsoil from fringing slopes on Marrakai south area; and headland areas on Marrakai north.	Heavy grazing removes grass cover, wet season run-off displaces soil material.
Monsoon forest.	Heavy pugging, wallowing; trampling and browsing of small trees and seedlings.	General.	Area of concentrated activity due to location adjacent to plains, presence of shade and in some cases perennial water.
Low dunes and shoreline banks.	Heavy grazing and trampling of grasses; heavy pugging, wallowing in swale areas.	General.	

Table 2.5

Adelaide River: mid and upper reaches

TERRAIN UNIT	MAP UNIT (Story et al. 1969)	DISTRIBUTION	DRAINAGE	SOILS	VEGETATION
Broad open plains.	Fw1, Fb1.	Extensive over whole area.	Shallow flooding or waterlogging in wet season.	Soloth/solodic association.	Mostly perennial grassland with areas of Melaleuca low woodland.
Lower, active flood plains.	Fw2, Fd2.	Moderately extensive.	Deep wet season flooding.	Soloth/solodic association.	As above.
Major channels and levees.	-	Limited extent.	Occasional wet season flooding.	Yellow massive earths.	Eucalypt woodland - open woodland.
Non-perennial channels, flood channels and billabongs.	Fb4, Fw4.	Moderately extensive.	Flooded in wet and early dry season.	Banks formed of yellow massive earths.	Mostly Melaleuca woodland or open woodland; areas of grassland.
Drainage lines of upland terrain.	-	Limited extent.	Wet season flooding	Sandy massive earths.	Grassland with pockets of Eucalypt woodland.

TERRAIN UNIT	DAMAGE	OCCURRENCE	PROCESS
Broad plains.	Pockets of scalding	General; large pockets on upper Margaret flood plain.	- concentration of grazing; - loss of grass cover; - erosion of surface soil; - exposure of dense, hard subsoil.
Major channel and levees.	Gully erosion.	Small pockets along Adelaide River.	Scouring of tracks by flood waters, and run-off from plains.
Non-perennial channels and billabongs.	Gully erosion of banks, scalding on levees.	Extensive in all areas; particularly severe on Howley Creek, Margaret River.	- while plains dry out rapidly after wet season these units hold water well into dry season; - buffalo and cattle cut tracks into bank; - annual flooding scours out tracks to form gullies; soil is erodible, and gullies develop rapidly; - associated scalding on banks where heavy grazing leads to loss of surface soil and exposure of dense clay subsoil.
Upland drainage lines.	Gully erosion.	General.	Buffalo pads often follow drainage lines; runoff water concentrates along pads, initiating gully development.

- the swamp is immediately adjacent to saltwater and is likely to be closely involved in the movement and breeding patterns of many aquatic species which require both fresh and saltwater;

- it is a major breeding ground for saltwater crocodiles;

- it appears to be a major refuge for water birds particularly as there are no other similar extensive perennial freshwater bodies on the Adelaide; and

- the area is within one hour's drive of Darwin and is thus easily accessible to tourists and study groups.

Buffalo are continuing to substantially modify the swamp and hence its viability as habitat. Pigs and cattle have also contributed to the damage, particularly along the edges of the swamp. The modifications have included heavy trampling and grazing of reed beds and aquatic vegetation, formation of swim channels which probably alter water movement within the swamp, and an increase in the turbidity of water within the swamp. Slightly elevated areas within and surrounding the swamp have also been subject to heavy trampling and wallowing.

2.2.2. Fringing slopes

The fringing slopes are the elements of upland terrain which abut the plains. Relative to the adjacent plains they have considerably greater canopy cover (and hence shade), and are not flooded in the wet season. They are therefore subject to heavy buffalo activity in both wet and dry seasons.

The erosion potential of these slopes is high due to their physiographic situation, whereby they are subject to large amounts of runoff from upslope. Soils are generally sandy and low in aggregate stability, and readily broken down by rainsplash if exposed.

Sheet erosion has occurred extensively on fringing slopes in the Marrakai south area, where large areas have lost between 10 and 20 cm of topsoil to expose a hard gravelly surface on which natural regeneration is very slow. Invasion by exotic species, for instance, *Hiptus*, *Cassia* and *Mimosa* is widespread. While less extensive in the Marrakai north area, sheet erosion has consistently degraded headland areas.

2.2.3. Marrakai type plains

This terrain is characterised by broad expanses of alluvial plains, incised channels with narrow levees, and flood channels and associated non-perennial billabongs. The soils on this terrain are predominantly a soloth/solodic association, for which the important features are a strong texture contrast between an A horizon which has a high content of fine sand and silt, and a dense, clay B horizon. Both horizons are unstable when wet and are potentially highly erodible if the vegetation cover is removed.

During the wet season, the plains are extensively flooded and flood channel networks become active. The plains drain rapidly after the wet season, with flood channels contracting to form a discontinuous chain of billabongs. Buffalo and cattle concentrate on these areas during the dry season. Buffalo and cattle have been responsible for severe degradation of the latter features, in all parts of the catchment. Due to the concentrated activity, grass cover on the banks is reduced, and tracks are cut into the banks as stock gain access to water holes. Wet season floods scour out tracks, and due to the unstable nature of the soil, gully erosion develops rapidly once initiated. There are also pockets of scalding across the plains, where it would appear that heavy grazing has removed the grass cover, and the hardsetting nature of the soil surface has prevented regeneration. In some cases the topsoil has been lost, to expose the hard, dense subsoil, and regeneration is similarly retarded.

Figure 3.1

Adelaide River wetlands, showing some of the areas of concern.

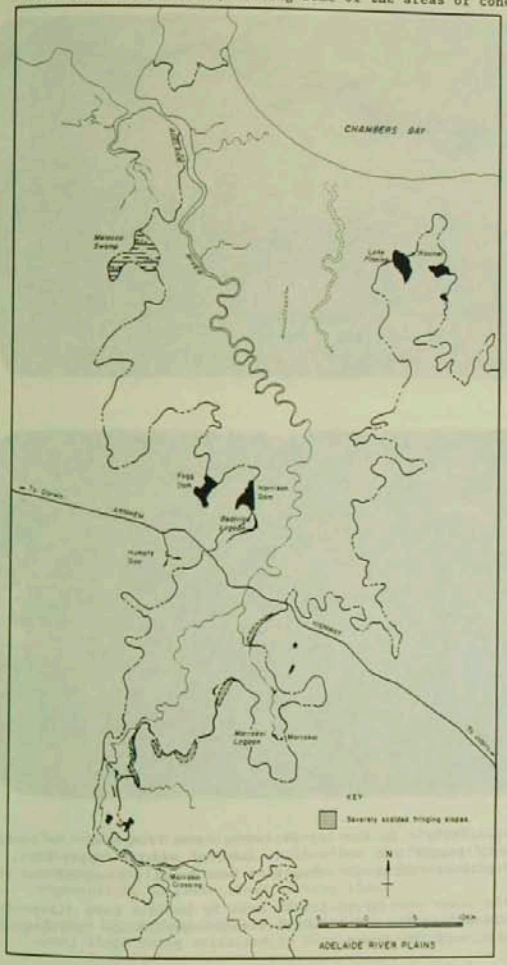


PLATE 2.9

Melacca Swamp: In the top photograph the fringe of the swamp has been heavily pugged and wallowed to destroy aquatic vegetation, while the reed grasses within the swamp have been heavily trampled and grazed.

In the lower photograph tracks made by buffalo have dissected *T. sumatrosum* beds. The channels so created may change hydrological characteristics of the swamp.

PLATE 2.10

The upper photograph shows sheet erosion of fringing country which is extensive in the Marrakai south area. Surface soil has been completely removed from the lower slope, to expose hard weathered rock. Natural regeneration on these areas is very slow.

In the lower photograph, a headland has suffered sheet erosion with the lower slope being colonised by *Mimosa* and the upper slope by *Hiptus*.

PLATE 2.11

Severe gully erosion and scalding of channel banks on Marrakai plains of the Adelaide River. The upper photograph is at Marrakai billabong where continued heavy pressure from buffalo and cattle has lead to extensive degradation. The lower photograph shows the effects of severe gully erosion on solodic soils on plains adjacent to Burrells Creek.

2.3 Mary River

As on the Adelaide, the Mary wetlands are composed of sub-coastal elements in the lower reaches, and Marrakai elements in the mid and upper reaches. The sub-coastal plains are characterised by the large extent of lower, poorly drained plains which support, or have supported a *Hymenachne-Oryza* association (Calder, 1981). *Melaleuca* swamps are likewise an extensive element. The Mary River itself is formed of a series of long billabongs which in the wet season are linked to form a continous channel. There are also numerous other perennial billabongs associated with previous river channels.

The Mary wetlands have been subject to heavy grazing for well over 50 years and there appears to have been substantial modification to most elements. As shown in Tables 2.6 and 2.7 there are large tracts of plains which have been bared of grass cover, billabongs have lost their diverse fringing communities with consequent bank erosion, fringing slopes have been extensively scalded, and saltwater intrusion has caused major changes to Melaleuca swamps and freshwater billabongs. The following section elaborates on the main areas for concern on the Mary.

2.3.1 Saltwater Intrusion

The intrusion of saltwater into previously freshwater environments has caused extensive changes on the lower Mary plains. The elements which have been affected are the *Melaleuca* swamps, associated areas of swamp grasslands, and channels and billabongs which drain from the plains into the sea. It is apparent from 1950 aerial photography that saltwater intrusion was already occurring at that stage, although not extensively. The intrusion of saltwater into the above elements has been the result of extension of tidal influence along existing channels, the headward extension of existing small tidal channels, and the formation of new tidal channels.

Table 2.6(a)

Mary River: lower

TERRAIN UNIT	MAP UNIT (Story et al. 1969)	DISTRIBUTION	DRAINAGE	SOILS	VEGETATION
Plain-slightly elevated.	Cm3, Cp1.	Extensive.	Wet season flooding, drain early in dry season.	Uniform dark cracking clays.	Grassland with areas of sedges and herbs.
Lower plains.	Cm1, Cp2.	Extensive; usually form backplains to elevated areas adjacent to channels.	Deep wet season flooding, remain wet well into dry season.	Uniform dark cracking clays.	Grassland with *Hymenachne-Oryza*; areas of sedgeland.
Major billabongs, flood channels and associated banks and levees.	Cp2.	Limited occurrence.	Perennial water in most billabongs; wet season flooding of banks and levees.	Banks and levees formed of uniform clays.	Billabong fringe community of *Pandanus, Barringtonia, Melaleuca, Mauclea* and areas of grassland.
Closed swamps	Pw1	Extensive on lower plains, small areas over remainder of area.	Flooded in wet season and much of dry season.	Dark uniform clays.	*Melaleuca* woodland to open forest; sparse ground cover of grasses and sedges.
Fringing slopes.	Rh4, Pw4	Forms continous margin between plains and upland.	Lower slopes waterlogged in wet season.	Lower slopes have organic loam over gravelly clay, upper slopes gravelly and sandy earths.	Lower slopes vary from grassland, Eucalypt woodland, and patches of monsoon forest, upper slopes have Eucalypt woodland - open woodland.
Old sand dunes and shoreline barriers.	-	Limited extent on lower plain.	Elevated above wet season flooding.	Uniform sands.	Grassland with scattered trees and shrubs including *Ficus, Pandanus, E. papuana*.

Table 2.6(b)

Mary River: lower

TERRAIN UNIT	DAMAGE	OCCURRENCE	PROCESS
Plains-elevated.	Areas of bare ground, pugging, wallowing, numerous pads.	Plains on Pt. Stuart Station extensively degraded; frequent occurrence elsewhere.	
Lower plains and associated shallow billabongs.	Extensive bare areas, heavily pugged surface, numerous swim channels.	General.	
Major billabongs, flood channels and associated banks and levees.	. extensive bare areas on banks, heavy pugging, bank erosion extensive on billabongs.	General	Areas of concentrated activity.
	. Saltwater intrusion of billabongs on lower plains	See map.	Extension of tidal salt water along major channels, promoted by buffalo activity and useage by small boats within channels in wet season.
Closed swamps.	. Extensive dieback of *Melaleuca*.	On lower portion of plains, approximately 4,200 ha affected. See map.	Initiation and extension of tidal channels into *Melaleuca* swamp. Buffalo activities implicated in development of tidal channels.
	. Heavy pugging; loss of ground cover.	General.	
Fringing country.	. Heavy pugging, wallowing.	Extensive on lower slopes which abut plains.	Concentrated activity on lower slopes; loss of grass cover; soil loss in sheet-wash.
	. Sheet erosion.	Extensive occurrence on lower slopes, and on headland areas.	
	. Secondary salting; associated dieback of *Melaleuca*, death of grasses, areas of sheetwash.	Lower slope area, mostly between Alligator Head and Wild Boar on west side of Mary.	Process is unclear; associated with heavy grazing and loss of ground cover.
Old sand dunes.	Extensively bared of grass cover, dissected by pads.	General.	Subject to heavy pressure during wet season as ridges are within plains but elevated above flood level.

Table 2.7

Mary River: mid and upper reaches

TERRAIN UNIT	MAP UNIT (Story et al. 1969)	DISTRIBUTION	DRAINAGE	SOILS	VEGETATION
Broad, open plains.	Fb1, Fb2, Fw1, Fw2.	Extensive	Wet season inundation; dry out early in wet season.	Solodic-solodic association.	Predominantly perennial grassland with areas of *Melaleuca* woodland.
Major channels and levees.		Minor extent.	Occasional wet season flooding, flow through much of dry season.	Deep yellow massive earths.	Eucalypt woodland to open woodland.
Non-perennial channels, billabongs and associated banks and levees.	Fb4, Fw4	Moderately extensive.	Wet season flooding; channels dry up into series of billabongs early in dry season.	-	Variable; *Melaleuca* woodland, eucalypt woodland and grassland.

TERRAIN UNIT	DAMAGE	OCCURRENCE	PROCESS
Broad open plains.	Scalding.	Large areas on McKinlay plains, and on Hardies Creek plain.	Loss of grass cover, erosion of surface soil, exposure of dense, hard subsoil.
Major channels and levees.	Gully erosion of banks and levee, scalding on bank.	Small areas along Mary River, large areas on McKinlay.	Dissection of banks by pads; erosion of pads initiates gully development. Soils are susceptible to erosion and gullies develop rapidly.
Non-perennial channels and billabongs.	Gully erosion, and scalding of banks; heavy pugging around billabongs.	Severe along flood channels of McKinlay River.	Plains dry out soon after wet season; channels and billabongs hold water well into dry season so are subject to concentrated activity, causing reduction of grass cover on banks. Erosion of bare areas and pads by wet season floods.

The activity of buffaloes has likely hastened, and in some cases initiated channel development, and hence saltwater intrusion. There is however a component of natural instability due to the minimal relief differences between salt and freshwater environments, the close proximity of the two types of environments, and the constant movement of water and sediment during wet season floods and dry season tidal flows. In essence, it is not posible to establish the relative roles of buffalo, and natural changes in causing saltwater intrusion, but it is generally felt that the changes are generally undesirable owing to the high value for wildlife habitat and recreation of the elements so affected.

The changes associated with saltwater intrusion have been determined by comparison of 1950, 1963 and 1981 large scale aerial photographs, combined with field inspection and observations by other workers familiar with the problem. The changes include:

- extensive growth of small tidal channels, particularly leading from Tommycut Creek into the large Melaleuca swamp to the west of the creek. These channels variously follow a sinuous course indicative of a natural path, and also straighter courses indicative of an influence such as a buffalo pad or swim channel;

- channels draining northwards directly into the sea have extended through breaks in low shoreline banks into *Melaleuca* swamps;

- there has been approximately 4,200 ha of *Melaleuca* dieback between 1950 and 1981. Saltwater channels had intruded parts of the *Melaleuca* swamp by 1950, but there had been little actual dieback;

- between 1950 and 1980 the tidal saltwater extended its influence up Tommycut and Sampan Creeks some 8-10 km; and

- the width of the above channels at their mouths, and for 5-6 kilometres upstream, increased from approximately 30 metres to between 50 and 60 metres, between 1950 and 1981, permitting a greater volume of saltwater to move inland.

While the relative role of buffalo in causing saltwater intrusion is not known, they contribute to the problem in the following ways:

- the widening and extension of channels is promoted by grazing and trampling along channel banks and at channel heads;

- channel development may be initiated along the course of a buffalo pad or swim channel;

- Stocker (1971b) describes the breakdown of low shoreline banks and levees as a direct result of trampling, and also heavy grazing by buffalo. This permitted tidal saltwater to break through low points on the banks, into freshwater environments;

- it is possible that heavy reduction of grass cover on the plains promotes increased volumes and velocities of run-off from the plains, with consequent incision of channels.

The influence of saltwater at Shady Camp Billabong has been noted by M. Genner, C.C.N.T. (pers. comm.) Shady Camp Billabong represents the lower freshwater reaches of the Mary River. Saltwater has been extending up Sampan Creek for some years, as observed on aerial photograph sequences since 1950. Sampan Creek was originally connected to Shady Camp billabong by a shallow, discontinous channel which stopped flowing after the wet season. When carrying water in the wet season however, the channel has been subject to buffalo activities, and also power boat usage, which formed a deepened and continous channel. In the 1976 dry season, saltwater penetrated into Shady Camp Billabong along this latter channel. Consequent death of lilies on the billabong, and loss of condition of *Pandanus* and *Barringtonia* which fringe the billabong

was reported. In 1978 a causeway was constructed to halt intrusion into the billabong. It was subject to use as a crossing point by stock and vehicles, and in the 1980 wet season was eroded by floods sufficiently to permit salt intrusion again in the ensuing dry season. The lower Mary billabong system thus continues to be threatened by saltwater intrusion.

2.3.2 Billabongs

There appears to have been substantial change to vegetation communities which fringe the billabong systems on the sub-coastal plains, and this has had consequences for bank stability and water quality. The changes are apparent by contrasting 1950 and 1981 aerial photography. On the earlier photographs there is a relatively dense fringing community along many billabongs, and the water in the billabong had a low reflectance which indicated to low levels of suspended sediment. The present picture is one of a highly degraded fringing community consisting of scattered clumps of *Pandanus*, *Barringtonia*, *Nauclea*, *Melaleuca* with root systems bared by erosion. Bank erosion has been extensive, and is responsible in part for the highly turbid water in the billabongs. Petherick (pers. comm.) has reported on the general similarity in appearance of the Mary wetlands pre 1950 and the Finniss today, and specifically, on the presence, pre 1950 of grass mats on Island Billabong and Alligator Head Billabong.

2.3.3 Fringing slopes

The slopes which fringe the wetlands have suffered extensive sheet erosion. The most heavily degraded slopes are the headlands which have often been used as bases for catching operations, and also have served as natural buffalo camps. They have been extensively bared of top-soil by sheet erosion to expose the very gravelly and hard sub-soil. Sheet erosion has also affected a significant

proportion of the lower fringing slopes away from headland areas. Consequent weed infestation, particularly by *Sida* and *Hiptus*, has been heavy.

Secondary salting has occurred on the lower fringing slopes to the south of Alligator Head, and has caused general death of grasses and associated Melaleuca. It is likely that heavy grazing has initiated this process.

Regeneration of vegetation is apparent on previously heavily degraded lower fringing slopes within the Mary River Reserve, where heavy culling of feral buffalo over the past three years has taken place. A dense grass cover has become established over the uneven sheet eroded terrain, and filling of wallowed and pugged areas is occurring. On the upper slopes, where a hard, gravelly surface has been exposed by erosion, a dense cover of *Calytrix* has become established in places. Weed infestation is also extensive.

2.3.4 Marrakai type plains

As for the Adelaide catchment, the mid and upper reaches of the Mary are composed of Marrakai type terrain. The general description presented in Section 4.2.3 for the Adeliade also pertains to the Mary. The extent of damage is however considerably greater on the Mary. Scalding of the solodic soils of the plains is extensive along Hardies Creek, where approximately 2,500 ha has been affected, and on the McKinlay plains where approximately 800 ha have been affected. Widespread gullying of scald areas has also occurred. Natural regeneration on these areas is very slow owing to the extremely hard and impermeable surface of scalds.

The banks, channels and billabongs of the Mary and McKinlay are also severely degraded by gully erosion and scalding.

Figure 2.3

The Mary River wetlands.

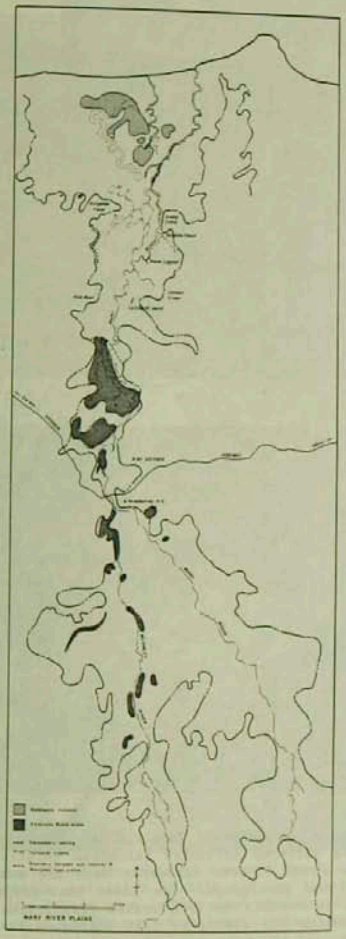
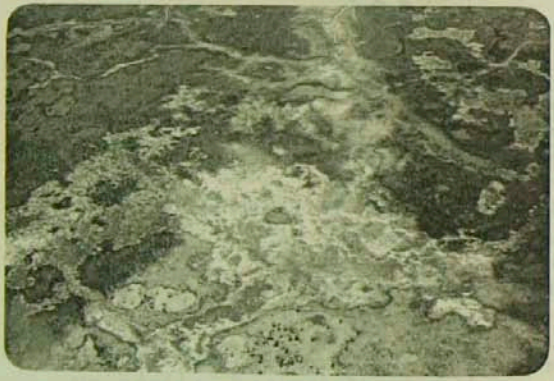
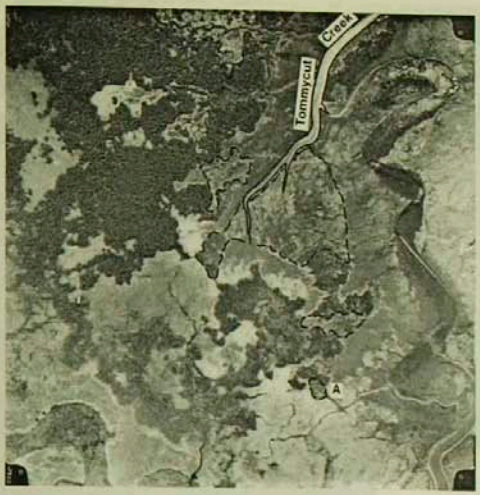


PLATE 2.12



Melaleuca dieback on the lower Mary Plains. The upper photograph is an area which has suffered saltwater intrusion relatively recently. The tidal channel which directs saltwater into the swamp is seen in the upper left of the photograph. The lower photograph shows an area of dieback which is visible on 1963 aerial photographs. It has not been possible to define the source of salt intrusion as there are numerous channels which link the area with major tidal streams.

PLATE 2.13



Melaleuca dieback at the head of Tommycut Creek on the lower Mary. The upper photograph was taken in 1980 and the lower in 1950. The areas defined by the dotted line in the upper photograph have suffered dieback since 1950, with the source of saltwater being Tommycut Creek.

PLATE 2.14

A 1980 aerial photograph composite to illustrate the problem at Shady Camp. A recent channel has been formed to join the tidal Sampan Creek with the previously freshwater Shady Camp billabong. It is likely that the channel has been created by activities of both buffalo, and power boats gaining access into Sampan Creek from Shady Camp billabong. A causeway was constructed in 1978 to prevent saltwater intruding into the Mary River, but was broken down in the ensuing wet season floods. Salt water probably now intrudes into Shady Camp billabong during late dry season spring tides.

PLATE 2.15

Melaleuca dieback on the lower Mary, as shown on these aerial photographs has resulted from breakdown of low shoreline banks and extension of small tidal channels into the swamp, as described by Stocker (1971b). In the upper photograph, taken in 1950, dieback is not apparent but there are a number of tidal channels which have breached the shoreline banks, for instance at point A. In the lower photographs, taken in 1980, most of the area of *Melaleuca* swamp in the upper photograph has suffered dieback as a consequence of saltwater intrusion. Point B is the same on each photograph and illustrates the degree to which the area has changed.

PLATE 2.16

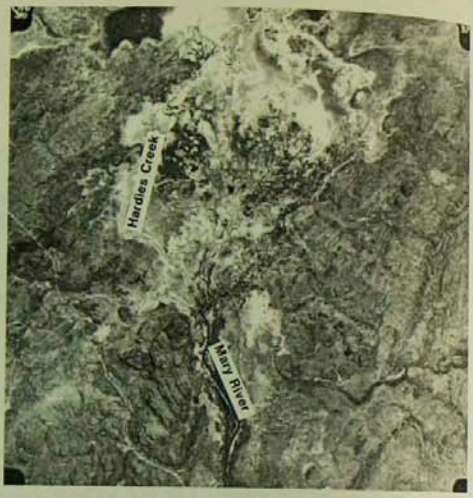
A 160 000 scale aerial photograph showing the extent of sheet erosion on the fringing slopes along the Mary. It shows up as a light tone due to the lack of vegetative ground cover. Also conspicuous on the photograph is the extensive network of swim channels on the Mary, radiating from upland terrian, across lower back plain elements onto better drained plains. The black line on the photograph delineates upland from wetland terrain.

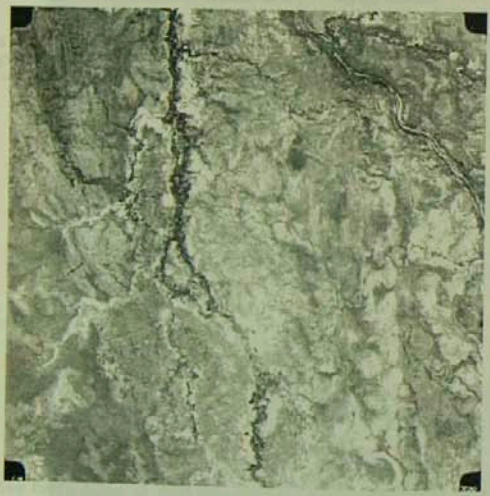
PLATE 2.17

Weed colonization of sheet eroded upper fringing slopes at Alligator Head. A large proportion of fringing slopes along the Mary have suffered sheet erosion to some degree, with subsequent weed invasion.

Secondary salting has killed grasses and trees (*Melaleuca*) on lower fringing slopes in the area to the south of Alligator Head.

PLATE 2.18





Aerial photographs at 1:160 000 scale showing degraded Marrakai terrain on the Mary Plains. A bare soil surface shows as an almost white surface on the photographs. The upper photograph is of the large scald area at Hardies Creek; the lower photograph is of the McKinlay plains where channel banks and levee areas have been severely gullied and scalded.

2.4 South Alligator - East Alligator

Changes to most of the elements which comprise the South and East Alligator wetlands appear to have been substantial, in association with over 60 years of heavy buffalo activity (refer to table 2.9). Ongoing studies by CSIRO and ANPWS on the South Alligator will eventually provide a more accurate picture of the nature of changes which have occurred (Section 3.3 refers). It is apparent from four year old exclosure plates at CSIRO's Kapalga Research Station that there has been substantial change in species composition and cover on the plains and fringing slopes, and field inspection reveals extensive bare, heavily pugged surfaces. Air photo interpretation combined with field inspection also points to severe degradation of billabongs and swamps, and widespread changes due to saltwater intrusion. Current investigations by ANPWS aim to establish an understanding of the latter process.

2.4.1 Saltwater Intrusion

The South and East Alligator wetlands have been significantly changed over the past 20 or 30 years by the extending influence of tidal saltwater. A network of small channels leading from major channels has developed on the plains, directing saltwater into a number of freshwater environments. It is apparent from aerial photograph interpretation that growth and senescence of such channels has been a natural feature of floodplain development; however, the rate of growth, and extent of saltwater flooding has probably been considerably increased by heavy feral buffalo activity (as discussed in 2.3.1 previously).

In brief, the changes caused by saltwater intrusion which have occurred extensively are: (see fig. 2.4)

- death of aquatic and fringing communities of billabongs and swamps;

- subsequent filling of billabongs with tidal sediment, and colonisation by sporobolus and mangrove species;

- tidal flooding and accretion of sediment on plains adjacent to, and at the head of tidal channels, establishment of *Sporobolus* ground cover; and

- dieback in *Melaleuca* swamps.

2.4.2 Billabongs and swamps

As on the Mary wetland, billabongs and swamps have suffered heavy damage directly from buffalo activity as well as from saltwater intrusion. The degree of change can best be determined by contrasting 1950 and 1980 and aerial photographs. For the Leichhardt billabong system, Giina billabong and Goose Camp billabong, there has been a large reduction, and in the case of Goose Camp billabong, almost complete loss of the fringing community. In 1950, it is apparent that there was a dense canopy along much of the length of their banks. At present, the banks of Goose Camp Billabong support only a few trees and clumps of *Pandanus*, and the banks have been severely eroded. There are a number of erosion channels which have formed along buffalo pads, dissecting the leveee. It is felt by Lindner (pers. comm.) that these gullies have an influence on flow patterns and drainage on the adjacent plains, whereby the plains are able to drain earlier in the dry season with consequences for habitat availability for Magpie Geese.

The fringing community of the billabongs in the Leichhardt system have likewise been severely reduced in density and extent, and erosion of the levee and banks is severe. The water in the billabong is highly turbid and polluted.

Table 2.8 (a)

South Alligator - East Alligator

TERRAIN UNIT	MAP UNIT (Story et al. 1969)	DISTRIBUTION	DRAINAGE	SOILS	VEGETATION
Plains: slightly elevated.	Cp1, Cm3.	Extensive.	Wet season flooding, drain early in dry season.	Uniform dark cracking clays.	Grassland with sedges.
Lower plains.	Cp2, Cm1, Pw3.	Extensive.	Deep wet season flooding, remain wet well into dry season.	Uniform dark cracking clays.	Predominantly sedgeland with areas of grassland.
Open freshwater swamps.		Limited extent; situated in back plain embayments; more extensive on lower Magela Creek wetlands.	Hold water for most of year.	Uniform clays, humic gleys.	Sedges, aquatic grasses, lilies, reeds, scattered pockets of *Melaleuca*.
Closed swamp.	Pw1	Extensive on Magela wetlands; minor unit on East and South Alligator, forms small areas within backplain embayments.	Flooded during wet, and well into dry season.	Uniform dark cracking clays.	*Melaleuca* woodland to forest; sedgeland on small open areas.
Freshwater billabongs.	-	Limited extent only.	Perennial or near-perennial water, wet season flooding.	Banks formed of dark uniform clays.	Variable composition, usually in highly degraded condition: *Pandanus, Barringtonia, Melaleuca, Nauclea, Cathormion* as pockets of shrubland, or as continuous fringe.
Fringing slopes.	Eh4, Pw4.	Continuous unit forms margin between upland and alluvial terrain.	Lower slopes waterlogged during wet season.	Lower slopes generally have medium textured loam over gravelly clay (humic gley); upper slopes have gravelly, sandy massive earths.	Lower slopes variable; open grassland, Eucalypt woodland, pockets of *Tristania* and *Melaleuca* woodland, to monsoon forest. Upper slopes generally eucalypt woodland.

Table 2.8 (b)

South Alligator - East Alligator

TERRAIN UNIT	DAMAGE	OCCURRENCE	PROCESS
Plains-slightly elevated.	Bare surface, heavily pugged.	Extensive on lower South Alligator, Cairncurry and Coopers Plains.	
Lower plains.	Heavy pugging, extensive loss of sedge and grass cover.	General occurrence.	
Open freshwater swamps.	. Heavy pugging and wallowing around edges.	General occurrence.	
	. Death of aquatic grasses and associated *Melaleuca*.	See Fig. 2.4.	Extension of tidal channels into freshwater elements.
Closed swamp.	. Dieback of *Melaleuca*.	Large proportion of these elements has been affected by salt intrusion; on both East and South Alligator.	Initiation and extension of tidal channels.
	. Heavily pugged, bare surface.	General occurrence.	
Freshwater billabongs.	. Degradation of bank vegetation, bank erosion.	Most billabongs on South Alligator, East Alligator and Coopers Creek.	
	. Saltwater intrusion.	See Fig. 2.4	Iniation and extension of tidal channels.
Fringing slopes.	. Heavy pugging, wallowing.	General occurrence on lower slopes.	Subject to concentrated activity due to situation adjacent to plains, and in comparison with plains, better drainage and presence of shade.
	. Sheet erosion.	Severe on headland areas, and in pockets on lower fringing slopes.	

Figure 2.4

Changes to the South Alligator wetlands as a result of saltwater intrusion, determined by contrasting 1950 and 1981 aerial photographs.

Recent tidal channels are shown as dashed lines. These channels have directed saltwater and tidal sediments into previously freshwater environments. Billabongs which have been subsequently infilled, and colonised by salt tolerant species are shown by dark shading. A number of small dams have been constructed by ANPWS and local residents over the past 2 years in an attempt to halt intrusion into the billabong-swamp systems in the vicinity of the tidal head of the South Alligator.

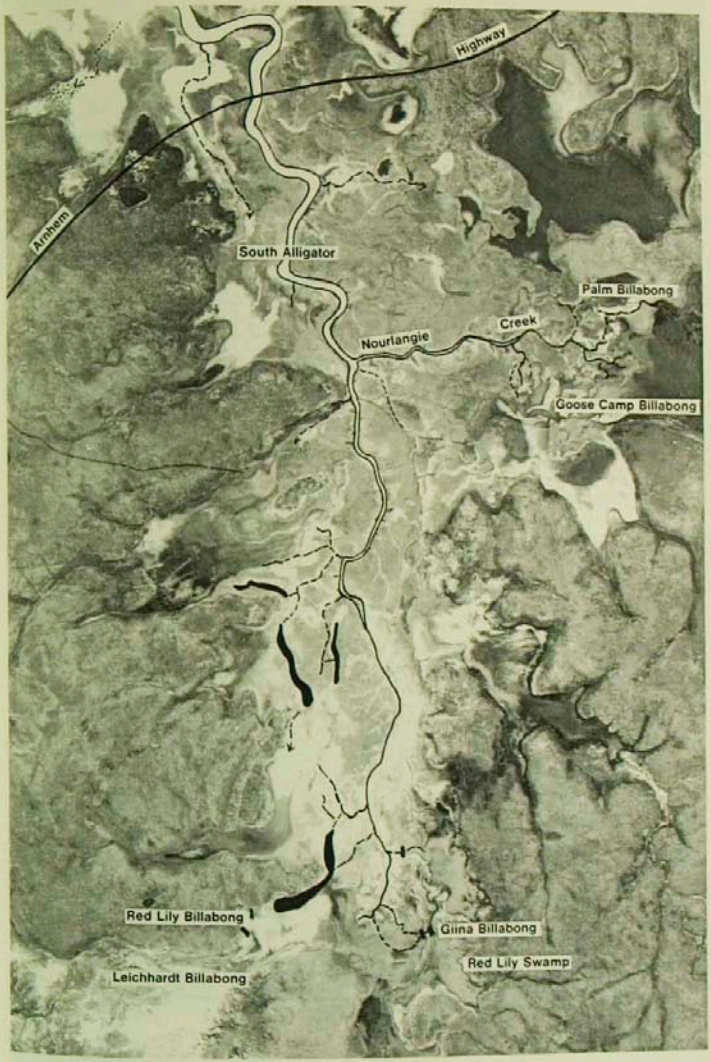
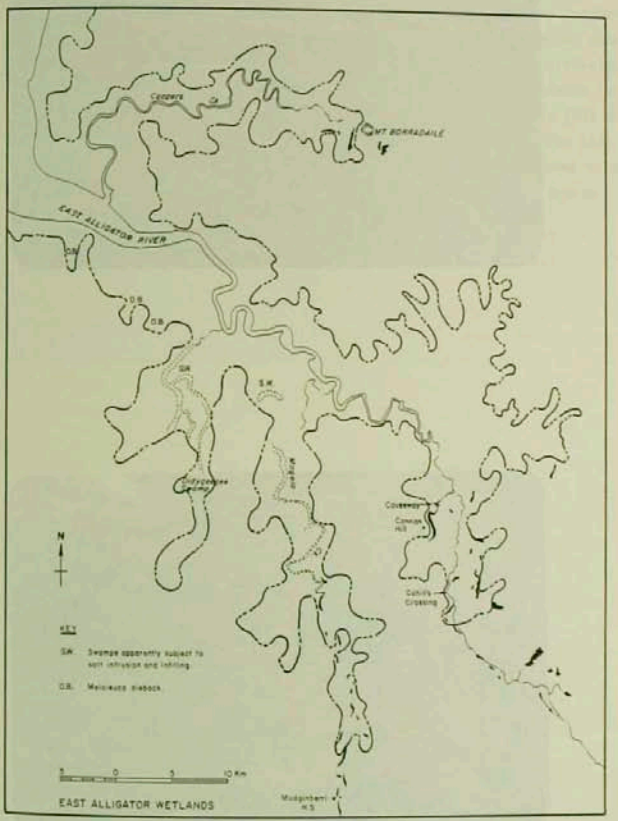

Highway
Arnhem
South Alligator
Palm Billabong
Creek
Nourlangie
Goose Camp Billabong
Red Lily Billabong
Giina Billabong
Red Lily Swamp
Leichhardt Billabong

Figure 2.5

The East Alligator wetlands, and location of particular areas of concern.



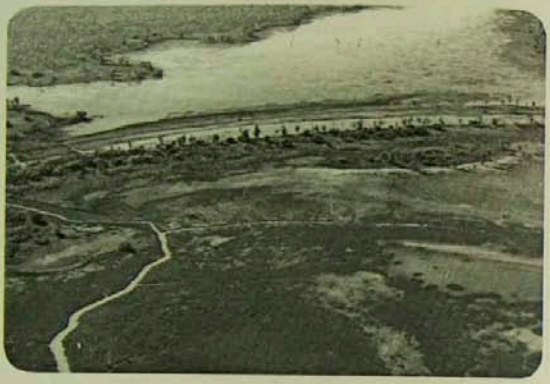


PLATE 2.19

The growth of tidal saltwater channels has caused widespread change on the South Alligator plains. In the upper photograph, the channel in the foreground has extended from the tidal head of the South Alligator into Giina billabong and Red Lily swamp. The channel has also been responsible for saltwater flooding and the deposition of tidal sediments onto the plain, and subsequent colonization by *Sporobolus*. The intrusion into Red Lily swamp caused death of aquatic grasses and *Melaleuca*, as shown in the lower photograph. A small dam was constructed in 1979 at the point where the tidal channel entered Giina billabong. The tidal channel has become choked with tidal sediments and stabilised with *Sporobolus*, and saltwater no longer influences this freshwater system.

PLATE 2.20

Billabongs on the South Alligator have been heavily degraded. The upper photograph shows Goose Camp billabong and the lower photograph, Leichhardt billabong. Banks have been heavily eroded as a result of concentration of buffalo activity in these areas. Erosion of soils from around roots of trees, and bank subsidence has caused serious decline in the quality of the fringing community. Water in the billabongs is turbid and polluted.

3. *REHABILITATION*

3.1 General Considerations

In planning rehabilitation measures, there are a number of considerations which will have an important influence on the type of measures adopted, and the priority with which they are implemented. Importantly, the type of land use, either current or proposed, and the degreee to which degradation has advanced will have a major bearing.

3.1.1 Land use

Conservation. Currently, conservation reserves cover a significant portion of the South and East Alligator wetlands (Kakadu National Park), and small areas on the lower Mary and Adelaide plains. The land within these reserves has been significantly degraded by buffalo activity. It is the policy of both ANPWS and the CCNT that buffalo are considered incompatible with the objectives of the reserves, and park management involves, or will involve removal of buffalo from most of the above land.

Land eminently suited to conservation is situated on the mid-Finniss wetland, and over much of the Reynolds wetland. These latter areas are significant because of their floral and faunal diversity, their relatively good condition compared with the northern wetlands, and the current lack of representation of such ecosystems in reserves. Forster, (1977); and Bennell (1979), give details on the bio-physical composition of those areas.

In essence, rehabilitation in conservation areas would be based on exclusion, and natural regeneration due to the relatively long timescale over which management objectives can be implemented. Rehabilitation of severely degraded areas which would not be expected to naturally regenerate would probably be undertaken using native species in an attempt to approximate pre-buffalo conditions.

Production: With disease control restrictions, it is likely that buffalo will have to be managed relatively intensively, by fencing and possibly pasture improvement. This will also favour environmental management. While it is not yet clear where such enterprises might be undertaken, it does appear that the sub-coastal wetlands and adjacent upland terrain are most suited. Owing to the general extent of degraded terrain, particularly on the northern wetlands, it is likely that degraded elements would be encompassed in land used for buffalo farms. The need arises therefore to undertake early rehabilitation measures on degraded elements which have productive capacity, such as open plains and fringing slopes. Further, it would be desirable to initially plan property boundaries to avoid the larger elements which are susceptible to degradation, although it is likely that some billabong-swamp systems would be incorporated into farm units. It is suggested that joint management with the Conservation Commission would permit such areas to be protected, and where necessary, rehabilitated.

Game management reserves for hunting and tourist usage: Game reserves would be an extensive operation with buffalo controlled only by boundary fencing. Areas which have been mooted for this type of operation are Marrarkai South and/or Marrakai North, on the Adelaide plains.

It is reasonable to expect that degraded areas would be excluded from such an operation to permit natural regeneration, in conjunction with rehabilitation measures on severely degraded elements. In the Marrakai area, numerous billabongs, and a major proportion of the fringing terrain can be considered degraded. The area also has widespread infestation of *Mimosa pigra* on alluvial elements.

3.1.2 . Stage of degradation

It is self evident that elements which have not been significantly modified by feral buffalo will regenerate more rapidly and with less input than elements which are severely degraded. Elements not

severely degraded will only require exclusion of buffalo to promote regeneration to a pre-buffalo or to a productive condition. Elements which have been heavily degraded are likely to require active measures or at least a considerably greater length of time for vegetative rehabilitation and stabilisation of the soil surface.

3.1.3 Current rehabilitation

The only current rehabilitation projects are on the South and East Alligator and are being carried out by ANPWS, and also by local resident, Mr D. Lindner. Effort is being directed at the control of saltwater intrusion on the South Alligator, in conjunction with an investigation programme which aims to establish an understanding of the processes which comprise saltwater intrustion. The program for rehabilitation and investigation is yet to be formalised by ANPWS, but they have adopted the policy that changes which have resulted from saltwater intrusion are undesirable, and therefore the necessity exists to implement control measures to protect threatened freshwater environments.

3.2 Rehabilitation measures

Table 3.1 summarises the main aspects of the various forms of rehabilitation, in terms of the situations where they are applicable, what is entailed in their implementation, costs (where available) and how they fit in with different land use objectives. The following section elaborates on some of these points.

3.2.1 Exclusion

Exclusion is essentially the removal of buffalo from an area to promote natural regeneration, or to protect other rehabilitation

measures. The precise effects of exclusion are not easily predicted due to the absence of scientific documentation, but casual observations give a picture of what might be expected.

- On the Mary River Reserve and the Magela Plains, heavy buffalo catching over recent years has promoted marked regeneration of perennial grass cover on plains and lower fringing slopes. Grasses have extensively stabilised the pugged and wallowed soil surfaces on the plains, and the irregular eroded surface of the lower slopes. Areas which have been subject to severe sheet erosion on upper slopes remain bare or support a cover of weeds and annual herbs and forbs.

- It is reported (T. Petherick, pers comm.) that on the Finniss in 1976, very high buffalo numbers combined with a long dry season caused heavy reduction of grass cover on the plains. With subsequent natural mortality and heavy culling, natural regeneration has been good. However, swamps and billabongs still exhibit the effects of heavy buffalo activity.

- A set of five exclosures were constructed by CSIRO in 1977 at Kapalga, on plains and fringing slopes. The exclosures indicate a marked regeneration of perennial ground cover at all sites, and development of a more friable soil surface.

It appears then that exclusion is likley to have a significant effect in promoting regeneration over large areas. Of concern however is the timescale of regeneration for theoretically all areas would eventually recover, but the period involved may well be unacceptable with respect to land use, or degradation may continue until a new point of stability is reached. In general, those areas which would not be expected to regenerate are those where there has been a substantial loss of vegetative stock from which regeneration could procede, where there has been significant loss of top soil, and where nutrient status has been altered (for instance, in areas of salt intrusion).

Exclusion should be considered a high priority in those areas which are currently subject to heavy buffalo (and in most cases, cattle), activity and due to their diversity of flora and fauna, have a high value for conservation and to a lesser extent, recreation. A number of these areas have been found during the course of this survey:

- Melacca Creek Swamp - approximately 600 ha on the lower Adelaide plains;
- Glasswater Swamp - 400 ha, and other associated billabong systems on the Reynolds system; and
- Central Finniss wetlands - 8,000 ha including extensive swamp-billabong system and numerous pockets of rainforest.

It is possible that areas of similarly high value exist on the Mary system, and it is recommended that they be identified by more detailed survey.

3.2.2 Controlled stocking

Controlled stocking involves the partial removal of stock from areas which are not yet in a degraded condition, but where continued heavy stocking will lead to pasture degradation.

It is applicable only where production or game management are considered as possible forms of land use.

From the survey of environmental damage, it appears that controlled stocking could be a consideration on the Finniss - Reynolds - Daly plains, and also areas on the lower Adelaide and Mary which have not been substantially degraded. Insufficient details are available from this survey to delineate specific areas on the latter wetlands, and a more detailed survey should be carried out to this

PLATE 3.1

The irregular surface created by pugging, wallows, and sheet erosion on lower fringing slopes at Alligator Head has been stabilised by grasses following heavy culling of buffalo from Mary River Reserve over the past three years.

This exclosure on CSIRO Kapalga shows marked natural regeneration of grass cover, and mellowing of the soil surface following its construction 4 years ago.

end. A survey by Calder, Ford and Lemcke (1981) gives an assessment of the distribution of Hymenachne pastures on the Mary as a benchmark for continued monitoring, and is of relevance in plannning controlled stocking in that area.

3.2.3 Revegetation

Revegetation involves the establishment of a ground cover in degraded situations where natural regeneration is not likely to occur within a desired period, the latter being a function of the proposed land use. Techniques are available for the establishment of vegetation on almost any form of soil surface, but cost and accessibility will be major limiting factors. A variety of techniques have been applied previously in the Territory by the Land Conservation Unit of the CCNT. They vary from range reseeding over large scalded areas in the Centre, and sheet and gully erosion in the Ord catchment, to intensive establishment of grass cover on borrow pits and mine waste dumps. In the case of rehabilitation of buffalo associated damage, revegetation would be applicable to:

- fringing slopes with severe sheet erosion such as occurs on the Marrakai south area, extensively on the Mary, and on the South Alligator;
- extensively bared areas of coastal plains as occur on the lower Mary, Carmor, Cairncurry and Coopers Creek;
- degraded billabongs which occur commonly on the Mary and South Alligator wetlands; and
- extensive scald areas and degraded banks and levees associated with Marrakai type plains in the Adelaide and Mary catchments.

It is important to keep in mind the need for exclusion of stock from areas which are undergoing revegetation, until full stabilisation has been achieved. This would probably involve a period of between three and five years.

3.2.4 Structural Measures

Structural measures are of concern primarily as a means of controlling saltwater intrusion. They may also be a consideration where it is necessary to control run-off, in conjunction with revegetation of eroded fringing slopes.

Previous attempts at bank construction are detailed in Table 3.2, and it is apparent that they have met with very limited success. This can be attributed to:-

- lack of stabilization of banks with grasses;
- lack of control of buffalo on banks, and to a lesser extent, vehicle access; and
- a lack of understanding of wet season flow characteristics.

In 1981, ANPWS in conjunction with CCNT constructed a number of banks on tidal channels which were responsible for salt intrusion into billabongs on the South Alligator and on the East Alligator, taking into account the above points. If these structures are successful, then further bank construction should be considered as a means of controlling salt intrusion.

The areas affected by salt intrusion have been described in Chapter 2. Those which should be considered for early action are:

- on the lower Mary, where the tidal channel of Sampan Creek has broken into Shady Camp billabong along a channel created by both buffalo activity and wet season usage by motor boats. The billabong represents the lower freshwater reaches of the Mary, and is significant for both recreation and conservation.

- The lower freshwater section of the Finniss and the adjacent billabong system is threatened by increasing frequency of tidal flooding in the dry season. Local residents have

attributed this directly to buffalo activities, which have deepened the channel that links the tidal and freshwater sections of the river. This section of river has high conservation and recreation values; and

- changes attributable to salt intrusion are also occurring on the East Alligator, and the lower Reynolds, and present a threat to the diverse ecological character of these areas. This rate of change needs to be established by monitoring, and future action taken if necessary.

3.3 Further investigations

As previously stated, the environmental effects of heavy buffalo activity are a complex set of interactions for which no empirical investigations have been completed. There are however a number of ongoing studies which should clarify some of the environmental effects, and also the effects of destocking (see Table 3.3). Unfortunately the results of these studies will not be available for a number of years.

The survey on which this chapter is based was broad and the proposals for control and rehabilitation are necessarily general. In order to provide more specific data with respect to implementing rehabilitation measures, the direction of further investigation should be towards:

- closer definition of the distribution of environmental damage, particularly in areas which will be considered for buffalo farming, and in areas which have a high conservation significance but are being degraded; and

- evaluation of techniques for rehabilitation, including exclusion as a means of promoting natural regeneration; use of native species, in particular, *Hymenachne*, to regenerate extensively degraded plains; use of native species in areas of conservation significance such as billabong and swamp elements; use of structural measures to control saltwater intrusion.

TABLE 3.1

REHABILITATION MEASURE	APPLICABILITY	COMPONENTS	COST	LAND USE CONSIDERATIONS
Total exclusion.	. areas where natural regeneration will return land to desired condition. . areas not yet seriously degraded and where immediate action is desirable to halt further degradation. . in conjunction with any other rehabilitation measure.	. removal of buffalo. . fencing. . maintenance of fencing and continued removal of buffalo. . monitoring of regeneration.	. fence costs are covered by Wesley-Smith (1981).	. where production is intended, areas can be subject to controlled stocking after regeneration. . on conservation reserves exclusion would be a continuing policy.
Controlled stocking.	. areas where degradation has not been severe as to warrant exclusion.	. fencing. . selective removal. . stocking rates. . protection of susceptible areas. . monitoring.	. as above.	. of relevance where production or game management is considered.
Revegetation i.e. establishment of a protective cover to stabilise erodible material and reduce run-off.	. where natural regeneration is likely to be very slow or non existant, such as where there has been significant soil loss and/or extensive loss of vegetative stock from which natural regeneration could occur.			
(i) Using native species.	. in conservation areas where desirable to approximate pre-buffalo conditions. . where native species establishment more practical and cheaper than introduced species, e.g. extensively bared areas of coastal plains which could be replanted to *Hyparrhenia*.	. decision on desirable species. . collection of cuttings &/or root stock. . distribution and establishment. . exclusion of stock.	. labour. . plant hire. . fencing.	. see "applicability".

continued/...

TABLE 3.1 continued/...

REHABILITATION MEASURE	APPLICABILITY	COMPONENTS	COST	LAND USE CONSIDERATIONS
(ii) Introduced species.	. where severity of damage necessitates preparation of seed bed, e.g. scalded plains, sheet eroded fringe slopes, degraded banks.	. on generally even surfaces such as scalds and fringing slopes. -ripping of surface. -discing. -spreading of seed and fertiliser	. to achieve total ground cover of eroded area: seed approx. $50/ha; fertiliser, including follow-up dressing $150/ha; plant hire, including D6 for ripping and tractor for discing, $120/hr covering 2 ha/hr. Approx. cost per ha $260.	. important on areas which are to be brought back into production.
		on uneven degraded surfaces such as banks and levees on Marrakai country -hydromulching, incorporating seed, hay mulch and bitumen emulsion.	Approx. $5,000 / ha for materails and equipment hire.	. Probably only a consideration on high value areas such as recreation reserves.
Structural controls.	. where requirement to control hillslope run-off to protect regeneration on lower slopes; would be in conjunction with rehabilitation program for fringe areas.	. preliminary data - levelling. . contour bank - construction with D6 or grader. . stabilization with grass. . exclusion of stock.	. plant hire $50-70/hr; 100 m of bank/hr; in most situations only one bank required.	
	. to block channels responsible for saltwater intrusion.	. preliminary data - levelling. - flow characteristics. . banks will vary in size according to width of channel. . need for stabilisation with grasses. . exclusion of stock and vehicles.	. cost estimates based on previous attempts. e.g. Canon Hill causeway, 750 cu metres of fill over existing base coat $9,700 in 1980, not including grass establishment and exclusion. . Smaller banks e.g. at Glina on South South Alligator built using ANPWS & local labour, & ANPWS plant, approximately $800 per bank.	. of relevance for areas which have conservation and recreation significance (not necessarily only existing reserves).

TABLE 3.2 An Evaluation of previous control measures

LOCATION	ACTION	PURPOSE	RESULT AND EVALUATION
Canon Hill, East Alligator.	Re-construction of causeway in 1980 and 1981, involving 750 cu. metres of lime stabilized clay fill, establishment of grass cover, by ANPWS and CCNT.	Halt salt intrusion into freshwater billabong, increase dry season cease to flow level and promote regeneration of billabong vegetation.	Original bank constructed in early 1970's failed due to wet season erosion of bank, possibly as a result of heavy use of causeway by buffalo. 1980 attempt partially broken down by wet season floods due to uneven level across causeway, creating point of weakness. 1981 causeway to be evaluated after 1981-82 floods.
Goose Camp Billabong, South Alligator.	Bank construction, eleven attempts between 1970 and 1979, on a number of erosion gullies which had formed along buffalo pads, by CCNT.	Probably to prevent early draining of adjacent plains which are important Magpie Geese feeding grounds.	Two major gullies remain active, one small gully successfully blocked. Failure of banks attributable to lack of appreciation of flood characteristics, lack of stabilisation of banks with grass and protection from continued buffalo activity.
	Establishment of Phragmites on bank, protected by fencing, in 1975, CCNT Rangers.	Stabilise eroding bank, promote re-establishment of original billabong habitat.	Successful establishmnt and spread while protected by fencing; following breakdown of fencing, Phragmites heavily damaged by trampling and grazing; small area only remain.
Giina Billabong, South Alligator.	Small dam construction on tidal channel by D. Lindner in 1979.	Halt intrusion of tidal saltwater into Giina Billabong.	Successful, has promoted infilling and stabilisation within tidal channel, and halted intrusion; effects of earlier salt intrusion apparent in Red Lilly; bank has since been vegetated and fenced by ANPWS.
Red Lily Swamp.	Small dam construction on tidal channel by ANPWS in 1981, fenced and vegetated.	Halt intrusion into Red Lilly Billabong.	Yet to be evaluated.
Leichhardt Billabong System, South Alligator.	Construction of two small dams on tidal channel in 1981 dry season using lateritic fill material; not vegetated or fenced.	Halt intrusion into lower Leichhardt System.	Yet to be evaluated.
Shady Camp Billabong, Mary River.	Construction of causeway by CCNT in 1978, not fenced or vegetated.	To halt saltwater intrusion into billabong.	Successful in 1979 wet season but eroded by 1980 floods - attributable to heavy useage of causeway by buffalo and also vehicular access.

Table 3.3

Ongoing investigations which pertain to environmental effects of buffalo.

OBJECTIVES	LOCATION	ORGANISATION	COMPONENTS
Establish understanding of processes of salt water intrusion and evaluate relative roles of buffalo and natural dynamics as causative agents.	South Alligator flood plain.	A.N.P.W.S.	. Interpretation of changes associated with salt intrusion, (and also general buffalo activity) on historical sequences of aerial photographs. . Level survey to determine flow patterns and to monitor erosion and deposition at selected sites. . Water quality sampling. . Sediment core sampling to interpret sedimentary history of plains. Action has already been taken to control intrusion into some billabongs, with further action planned in conjunction with research program.
Establish understanding of ecological interactions on sub coastal plains with particular respect to impact of buffalo.	Kapalga Research Station, South Alligator plains.	CSIRO	Phase 1: classify and measure vegetation distribution, succession, productivity; measure distribution, abundance, movements, and ecological requirements of major fauna species (water birds, dingoes, sea eagles, goannas, small animals on plains). Commenced 1976, no results published as yet. Phase 2: fence construction; one area to be excluded of buffalo, other to have "safe" stocking levels. Ecological effects of exclusion and controlled stocking will be measured. Commencing 1982.

4. MANAGEMENT

4.1 Introduction

It has been previously shown that there has been extensive modification of the wetland environments associated with heavy activity of uncontrolled feral buffalo. It must be an objective of any buffalo farming enterprise to ensure that the land is maintained in a non degraded condition.

There are two essential components to achieving this objective; stocking rates which do not exceed the carrying capacity of the land, and the protection of areas susceptible to degradation. Management is complicated by the fact that there are likely to be requirements for rehabilitation on some of the land which is considered for production, and this will need to be considered as a part of establishment costs. This is particularly true for any development on the Mary Plains, and for parts of the Adelaide Plains.

4.2 Considerations

Adoption of stocking levels which do not cause decline in pasture condition is a fundamental requirement for maintenance of pasture condition. There is a lack of documentation on this subject, but it should be possible for research workers in the field of buffalo production to generally define rates for different levels of improvement on a variety of land types. There will be a strong need to monitor pasture condition owing to the tentative nature of stocking levels determined in this way.

Flexibility in the application of stocking rates will needed to be observed. There is significant year to year variation in climate and hydrologic regimes which will strongly influence pasture condition and composition and hence carrying capacity, particularly on wetlands.

Also, buffalo tend to concentrate on certain elements within the landscape, even though overall density in an area might be relatively low. Assessment of stocking rates is based on the more extensive elements at the expense of these smaller yet often highly significant elements.

Definition and protection of those areas susceptible to degradation will be necessary. In essence it is those areas which are subject to concentrated activity which will be most susceptible to degradation, and in general it is such elements which are also significant for conservation and/or recreation (for instance, billabongs, river channels and levees, springlines, rainforest pockets). It is important that such areas are identified prior to development, and decisions made as to whether protection from buffalo is warranted. The possibility of joint management of such areas with the Conservation Commission should be investigated.

While damage may be caused, or at least be initiated by heavy grazing at any time of the year, the susceptibility to damage varies on most elements depending on the season, and associated hydrological conditions. Most importantly, in the case of wetland elements, susceptibility to damage is far greater during periods of flooding and waterlogging. In such conditions, the soil is more readily compacted and ground cover destroyed by trampling. Soil material is also thrown into suspension from where it is likely to be lost in floodwaters. Grasses are easily removed, roots and all, by grazing. Certain species, *Hymenachne* in particular, may stop growing if grazed off below water level (Calder, 1981). Controlled grazing should therefore aim to move stock from areas over the periods they are susceptible to degradation. Calder (1981) has proposed a system of rotational grazing based on utilisation of native and improved pastures to achieve the latter objective.

With pasture improvement on upland terrain likely to be a significant component in development of buffalo farms, there will be a need to adopt simple measures to ensure conservation of the soil resources. In essence, clearing should not be done on large areas but rather in wide

strips (say 150-200 m, depending on slope gradient) along the contour, with uncleared strips serving to control any accelerated runoff from cleared areas. Assuming that pasture establishment on areas cleared in year one is successful, remaining areas could be cleared in the following year. Specific advice pertaining to each clearing operation should be obtained from Soil Conservation Officers of the CCNT.

The foregoing points to the need for a knowledge of land resources upon which to base farm site selection and planning. This could be achieved by a land unit survey along the lines of those carried out by Land Conservation Unit of CCNT. Land unit surveys map describe the soils, landforms and vegetation in an area, determined from aerial photograph interpretation combined with field sampling. It would be possible to also map land degradation associated with previous buffalo grazing, and areas which have conservation and recreation significance. A survey of this nature covering the Adelaide plains or the Mary plains could be completed at a semi-detailed scale within a year. Following selection of development areas a further detailed survey would then provide a sound base for farm planning. It would enable:

- an accurate assessment of carrying capacity;
- planning of any necessary rehabilitation measures;
- selection of areas for pasture improvement;
- planning of stock movements when plains are flooded;
- location and protection of terrain elements susceptible to degradation; and
- rational design of paddocks.

5. *RECOMMENDATIONS*

(i) Immediate measures should be directed at those landscape elements which have high value for conservation and/or recreation, which are currently being modified by feral buffalo but which are not yet severely degraded. A number of such areas were identified by this survey and for which eradication of stock and continued control by fencing and/or shooting is recommended. They are:

- Melacca Creek swamp on the lower Adelaide plains;
- the mid Finniss wetlands; and
- swamp-billabong systems on the Reynolds, of which Glasswater swamp is the most significant.

A further detailed survey should be carried out to locate areas of similar significance on the Mary system for which sufficiently detailed information was not available. This could be incorporated in the survey work suggested in (vi) in this section.

(ii) Saltwater intrusion presents a major threat to all wetlands in the survey area. Extensive changes have already occurred on the Alligator Rivers and Mary River Plains, and smaller changes are apparent on all other wetlands. While the relative roles of buffalo and natural dynamics of the wetlands as causative agents, are not known, action is necessary to monitor the changes on all wetlands, and particularly wetlands as yet not extensively modified (i.e. Finniss and Reynolds). Control measures could be implemented if changes were considered undesirable. Satellite imagery would probably be suitable for this purpose.

Structural measures to exclude saltwater from billabong systems are currently needed:-

- at Shady Camp on the lower Mary River; and
- on the lower freshwater section of the Finniss River.

Detailed site investigations will be necessary to plan structures. Other areas not defined by this survey may also be considered for action.

(iii) Exclusion of uncontrolled stock, as appears likely over large areas with implementation of BTB control program, can be expected to promote natural regeneration over a large proportion of the wetlands previously modified by uncontrolled grazing by buffalo. The rate of regeneration, and the likely land use in an area (say, production vs conservation) will determine the need for further rehabilitation work. Due to the absence of relevant information it is not possible to predict the likely vegetative response to buffalo eradication. It is recommended that in areas where eradication is undertaken, the vegetative response be monitored, and the need for further rehabilitation works so assessed.

(iv) In those areas where buffalo farming is to procede, there will be a need to return degraded elements to productive capacity at an early stage. This is particularly relevant on the Mary and Adelaide wetlands where extensive tracts of plain and fringing slopes, which will be essential elements in a farming enterprise, are currently degraded and not likely to naturally regenerate in the short term. It is important to identify such degraded areas and initiate rehabilitation measures as soon as possible.

(v) The use of native species for regeneration should be evaluated. Attention should be directed to:

- the re-establishment of *Hymenachne* on extensively degraded plains. This has relevance to land used for conservation or production; and

- re-establishment of diverse billabong and levee communities which have been severely degraded on the northern wetlands.

(vi) Land resouce surveys should be carried out over areas where buffalo farming is a possibility. Such surveys would serve as a physical data base on which to evaluate suitability of different areas for farming, and on which to plan individual property development.

Such surveys would map and describe:

- land characteristics including slope, drainage, vegetation types and soil types for each terrain element;

- existing degradation;

- elements susceptible to degradation; and

- areas suited to conservation or recreation.

They would also facilitate planning of fence layout, stocking levels, pasture improvement, and rehabilitation.

6. *REFERENCES*

Australian National Parks and Wildlife Service (1980). Kakadu National Park, Plan of Management.

Bennell, M. (1979) Reynolds River Study; internal report, CCNT.

Board of Enquiry (1979). Feral animals in the Northern Territory; Department of Primary Production, Northern Territory.

Calder, G.J. (1981). *Hymenachne acutigluma* in the Northern Territory; Technical Bulletin 46, Department of Primary Production, Northern Territory.

Calder, G.J., Ford, B and Lemcke B., (1981). Report on Aerial Survey of Hymenachne on Mary River Plain; internal report, Department of Primary Production, Northern Territory.

Christian, C.S., and Stewart, G.A., (1953). Survey of Katherine Darwin Region; CSIRO Div. Land Use Research.

Ellis, P. (1972). Buffaloes and the N.T. Environment; Internal Report, Dept. N.T.

Forster, B.A. (1977). Report on the Land Units of Wagait Aboriginal Reserve, Technical Bulletin 22, A.I. & A.B., Northern Territory.

Stocker, G.C. (1971a). Water Buffaloes and Conservation in the Northern Territory; Wildlife in Australia, (8) 10-12.

Stocker, G.C. (1971b). The Effects of Water Buffaloes on Paperbark Forests in the Northern Territory; Australian Forest Research 5, 29-34.

Story, R., Williams, M., Hooper, A., O'Ferrall, R. and McAlpine, J. (1969) Lands of the Adelaide-Alligator AREa, N.T.; CSIRO Land Research Series No. 25.

Wesley-Smith, R. (1981). Fencing for Buffalo Control; Technical Bulletin 47, Dept. Primary Production, Northern Territory.

APPENDIX I

GLOSSARY

ANPWS : Australian National Parks and Wildlife Service.

CCNT : Conservation Commission of the Northern Territory.

Buffalo damage: -

- Pad : buffalo tracks which are formed by consistent use of the same route to and from points of activity. They are incised into the ground surface and may therefore concentrate runoff or floodwaters, promoting gully development.
- Swim channel : pads which have been enlarged by wet season usage, when the ground is covered by deep floodwaters. They are characteristic mainly of backplain elements which have lower elevation than both adjacent plains and upland terrain, and generally connect these latter elements.
- Pugging : very uneven and compacted soil surface created by wet season activity on clay soils.
- Wallows : depressions in the ground formed by buffalo, which when wet are used for cooling off.

Soil types: -

- Uniform cracking clays : soils characterised by a high content of clay throughout the profile. They crack upon drying out after wet season flooding, and are strongly coherent.
- Humic gleys : soils which have a dark organic surface horizon of sandy or loamy texture, grading into a lighter coloured subsoil of similar texture. This sharply overlies a mottled, often gravelly clay material at depths of between 30 and 100 cm.
- Solodic and Soloth Soils : soils in which there is a sharp contrast between the texture, and often the colour of the surface soil and subsoil. The surface is a sandy or loamy texture, light in colour and low in organic matter. It has low stability when wet. The subsoil is a dense clay which has slightly stronger colouring than the surface soil and is usually mottled.

A. S. CAUDELL, Government Printer of the Northern Territory

DIVISION OF AGRICULTURE AND STOCK

Department of Primary Production

Agnote

ATTACHMENT D

Ref. No. 82/34
MAY 1982

ERADICATION POLICY FOR BTB IN THE NORTHERN TERRITORY

by G. Calley, Senior Veterinary Officer, Darwin

AIM

The Department of Primary Production has as its objective the eradication of both tuberculosis and brucellosis from the Northern Territory by 1992.

This Agnote outlines the D.P.P. policies for achieving this objective.

BRUCELLOSIS

The following plan will apply to the whole of the Northern Territory.

(A) On 1st January 1984 all properties should have reached a brucellosis prevalence of 0.1% or lower. Any property, or part property, that has a brucellosis incidence in its herd above 0.1%, or has no Approved Program at this date, will be compulsorily destocked over the following two years. This destocking will be carried out until the brucellosis prevalence on that property is 0.1% or lower.

(B) By 1st January 1987 all properties in the Northern Territory should have totally eradicated brucellosis. Any property, or part property, from which the disease has not been totally eradicated by then will be compulsorily destocked over the following three years.

(C) Crown lands and parks will be destocked as necessary, so that they follow the timetable outlined in (A) and (B) above.

TUBERCULOSIS

As illustrated on the map, the Northern Territory is divided into two zones. Each of these zones has its own plan.

(A) The Tuberculosis Zones

The Southern Tuberculosis Zone is that part of the Northern Territory that lies south of a line running below the following stations:—

Auvergne, Bullita, Fitzroy, Delamere, Birrimba, Sunday Creek, Kalala, Hodgson Downs, St Vidgeon, Bing Bong, Booroloola Common, Spring Creek, Robinson River, Pungalina and Seven Emu.

The Northern Tuberculosis Zone is that part of the Northern Territory that lies north of the line described above.

(B) Southern Tuberculosis Zone Plan

By 1st January 1984 all properties in the Southern Tuberculosis Zone should have reached a tuberculosis incidence of 0.1% or lower. Any property, or part property, with an incidence of more than 0.1% or no Approved Program by then, will be compulsorily destocked over the following two years. This destocking will be carried out until the tuberculosis incidence on that property is 0.1% or lower.

By 1st January 1987 all properties in the Southern Tuberculosis Zone should have totally eradicated tuberculosis. Any property, or part property, that has not totally eradicated tuberculosis by then will be compulsorily destocked over the following three years.

(C) Northern Tuberculosis Zone Plan

By 1st January 1986 all properties in the Northern Tuberculosis Zone should have reached a tuberculosis incidence of 0.1% or lower. Any property, or part property, with an incidence above 0.1%, or with no Approved Program by then, will be compulsorily destocked over the following two years. This destocking will continue until the tuberculosis incidence on that property is 0.1% or lower.

By 1st January 1989 all properties in the Northern Tuberculosis Zone should have totally eradicated tuberculosis. Any property, or part property, that has not totally eradicated tuberculosis by then will be compulsorily destocked over the following three years.

(D) Crown Lands

Crown lands and parks will be destocked as necessary, so that they follow the timetable for both Tuberculosis Zones.

DESTOCKING

If a property fails to meet these deadlines on disease control, then compulsory destocking will be enforced.

Destocking will be carried out by a combination of the following:

(a) Owner or government initiated sale to abattoirs.

(b) Pet meat operation.

(c) Finally by an organised shoot out.

For any enquiries that you have concerning BTB contact your District Veterinary Officer, or Graham Calley in Darwin (phone 089-897321).

Agdex 401/653

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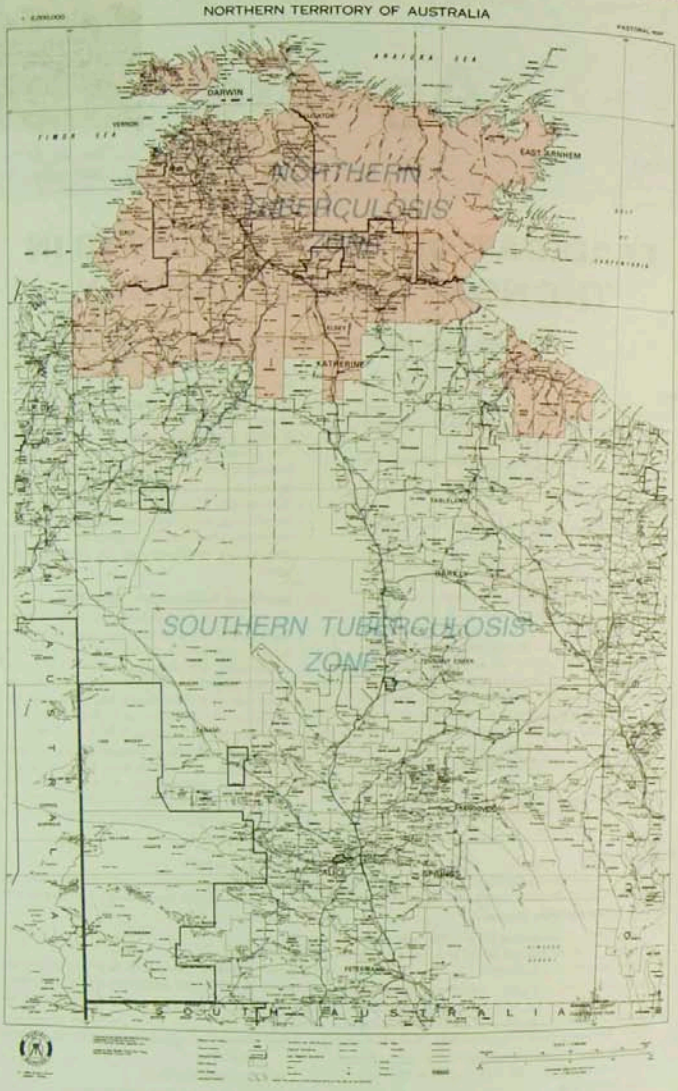
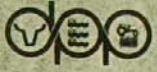


TUBERCULOSIS ZONES



ATTACHMENT E

THE DEPARTMENT OF PRIMARY PRODUCTION

and

THE N.T. BUFFALO INDUSTRY COUNCIL

present the

PROCEEDINGS OF THE BUFFALO INDUSTRY SYMPOSIUM

BUFFALO INDUSTRY SYMPOSIUM, DARWIN, N.T. 1981.

TABLE OF CONTENTS.

Editor's Note; Relevant discussions have been included after the speakers, but the bulk of discussion leading to formation of the conclusions and resolutions has been omitted.

BUFFALO INDUSTRY SYMPOSIUM - FEBRUARY 17-18 1981

CONCLUSIONS AND RESOLUTIONS

A. General

1. A buffalo industry of substantial economic value has existed in the Northern Territory for many years.

2. That all presently involved with the buffalo industry together with positive action by the Government, as a matter of urgency, actively foster the development of a controlled, domesticated, viable, disease free and environmentally sound, long term N.T. buffalo industry, utilising to the maximum advantage, the existing feral buffalo herds.

3. The prime responsibility for future development of the buffalo industry lies with the industry itself within the legislative framework to be laid down by the government. The industry should aim to establish production systems that will be ecologically stable in the long term.

B. Location.

1. That the Feral Animals Report on location of the industry be not implemented, and a controlled disease free buffalo industry be allowed to develop anywhere in the Northern Territory.

C. Land.

1. That the present land use systems, tenure, and size, be examined as a matter of urgency with a view to optimum land use, making land available to more producers in suitable property size and locality for a viable long term buffalo industry.

2. Introduce legislation to give pastoral leaseholders greater control over trespassers, and to ensure the success of disease control programmes and to prevent wilful environmental damage.

3. That this symposium draws the urgent attention of the Federal and Northern Territory Governments to the fact that the proposed Stage 2 of Kakadu National Park includes some of the best animal production land in the Top End.

4. That the government takes immediate action to compulsorily but equitably aquire adequate pastoral land suitable for development as intensive buffalo domestication projects, and distributes this land to experienced and eligible applicants.

5. That the Kakadu National Park be adequately fenced as a matter of extreme urgency to prevent migration of buffalo from adjacent pastoral properties into the Park.

6. That the Kakadu National Park managers and owners liase with buffalo owners and contractors for a thorough utilisation of buffalo in an equitable way with adjacent pastoral leases.

E. Diseases.

1. That the Federal and Northern Territory governments continue to promote the eradication of B/TB as a part of the National BTB Eradication Campaign, by the implementation of relevant legislation, the provision of testing services, expansion of the BTB Compensation schemes to include compensation at slaughter, provision of infrastructural support(finance availability), production research and extension, market promotion, taxation, etc, which directly promotes property development and controlled, domesticated, disease free buffalo production.

2. Where feral buffalo have to be removed from areas, and also in areas where prescribed diseases occur, eradication be done by buffalo contractors, and these areas to be contracted for an extended period of time to obtain complete eradication.

F. Buffalo Research and Extension Programme and Future Development.

1. That adequate resources be made available from the Northern Territory Government and other sources, to ensure a continuing buffalo development programme which includes;

.regular buffalo surveys,
.the provision of experienced buffalo husbandry extension officers who are available for on-property expert advice.
.financial support and encouragement of a private enterprise commercial on-property development using a 1,000 breeder herd with an improved production system.
.financial support and encouragement of the development of small buffalo private enterprise development projects using a 200 head breeder herd over a variety of land management systems.
.improved buffalo production techniques including fencing, breeding, nutrition, selection,pasture development.
.a planned programme of importing buffalo or semen, with a view to the establishment of a buffalo breeding centre.
.controlling, with the ultimate aim of eliminating, diseases in buffalo

G.Finance.

1. That the Northern Territory Government make specific loans and/or grants for the development of a controlled buffalo herd for the following;

a) a programme for long term loans (25 years) at concessional interest rates and/or with a moratorium on capital payments for seven (7) years for approved type fencing, yards, and pasture development.

b) a second programme for short/medium term loans to assist management for herd build up.

H. Other.

1. That some of the farms proposed for the Adelaide River and the Douglas River areas include farming buffalo. Buffalo have been very viable economically for many years-nothing has done so well in the area.

2. That Australia contributes internationally to the study of the water buffalo, (not in the feral state) by establishing a small research institute

I. Feral Animals Committee.

That the industry supports the following proposals;

- Accepts an invitation to the buffalo industry to be represented on the Committee.
- Put forward programmes to government on buffalo industry development and research, including domestication.
- Sponsor a Landsat imagery and mapping project to help assess and monitor environmental changes.
- Continue to press for compensation for BTB carcases condemned at abattoirs.
- Continue buffalo population survey work.
- Step up rehabilitation work in degraded areas.

End.

BUFFALO INDUSTRY SYMPOSIUM.

PROGRAMME.

TUESDAY 17th FEBRUARY, 1981.

8.30 a.m. OFFICIAL OPENING. The Minister for Primary Production, the Hon. R.M.Steele, M.L.A.

9.00 a.m. PREVIOUS ATTEMPTS AT THE DEVELOPMENT OF A BUFFALO INDUSTRY. Mr. Don Tulloch, C.S.I.R.O. Division of Wildlife Research, Darwin.

9.30 a.m. BUFFALO IN THE YEAR 2000 A.D. Dr. G.A.Letts, Chairman, Conservation Commission, Darwin.

10.00 a.m. Morning Tea.

10.30 a.m. BRUCELLOSIS AND TUBERCULOSIS- A TERRITORY VIEW. Dr.M. Carpenter, Senior Veterinary Officer, Department of Primary Production, Alice Springs.

11.00 a.m. ASSESSING THE CARRYING CAPACITY FOR BUFFALO ON THE COASTAL PLAINS AND ENVIRONS, FROM THE ADELAIDE RIVER TO THE EAST ALLIGATOR RIVER. Mr. M.Bound, and Mr.G. Hockey, Department of Lands, Darwin.

11.25 a.m. ABORIGINAL LANDS. Mr. Wes Llanhupuy,Chairman, Northern Land Council, Darwin.

11.50 a.m. MARKET OPTIONS AND THE FUTURE. Mr. Ted Simpson, Chairman, Territory Development Corporation, Darwin.

12.15 a.m. Open Discussion.

12.30-1.30 p.m. Lunch.

1.30 p.m. THE ROLE OF BUFFALO IN TOURISM. Mr. George Dunne, and Mr. Darryl Tutty, Tourist Commission.

1.55 p.m. BUFFALO IN THE NATIONAL DISEASE ERADICATION CAMPAIGN. Dr. John Digby, Australian Bureau of Animal Health, Canberra.

2.20 p.m. BUFFALO INDUSTRY COUNCIL REPRESENTATIVE FOR PRODUCERS. Mr. Jay Pandarvis, Manager, Mudginberri Station.

2.45 p.m. BUFFALO INDUSTRY COUNCIL REPRESENTATIVE FOR PROCESSORS. Mr. Des Pearson, Manager, Point Stuart Abattoirs.

3.10 p.m. Afternoon Tea.

3.30 p.m. THE C.S.I.R.O. WETLANDS RESEARCH PROGRAMME AT KAPALGA, AND IT'S BEARING ON THE BUFFALO INDUSTRY AND ISSUES CONCERNED WITH FERAL BUFFALO. Dr. M.G.Ridpath, C.S.I.R.O. Division of Wildlife Research, Darwin.

4.05 p.m. BUFFALO AND MANAGEMENT IN KAKADU NATIONAL PARK. Mr. C.D. Haynes, and Mr.M.Forbes, Australian National Parks and Wildlife Service, Darwin.

4.30 p.m. BUFFALO INDUSTRY COUNCIL REPRESENTATIVE FOR PET MEAT PRODUCERS. Mr. Alan Keeling, Bulman.

5.00 p.m. DISCUSSION, CHAIRMAN's SUMMING UP, CLOSE.

WEDNESDAY, 18TH FEBRUARY, 1981.

8.00 a.m. DEPARTMENT OF PRIMARY PRODUCTION BUFFALO INDUSTRY SURVEY RESULTS. Mr. Barry Lemcke, District Animal Production Officer, Darwin.

8.25 a.m. REPRODUCTION IN BUFFALO. Mr. Don Tulloch, C.S.I.R.O. Division of Wildlife Research, Darwin.

8.50 a.m. BUFFALO- ANIMAL PRODUCTION ASPECTS. Mr. Brian Ford, Senior Animal Production Officer, Department of Primary Production, Darwin.

9.15 a.m. BUFFALO INDUSTRY COUNCIL REPRESENTATIVE FOR THE LIVE EXPORTERS. Mr. David George, Darwin.

9.40 a.m. Open Discussion.

10.00 a.m. Morning Tea.

10.30 a.m. BUFFALO INDUSTRY COUNCIL REPRESENTATIVE FOR THE BUFFALO CATCHERS AND SAFARI OPERATORS. Mr. Robert Bright, Meneling Station, Batchelor.

10.55 a.m. BUFFALO INDUSTRY COUNCIL REPRESENTATIVE ADDRESS ON THE FUTURE OF THE BUFFALO INDUSTRY. Dr. D. Thomson, Darwin.

11.30 a.m. Open Discussion.

1.30 p.m. Open Forum Discussion.

5.00 p.m. Close.

ADDITIONAL SUBMISSIONS RECEIVED:

BUFFALO MANAGEMENT ON THE WAGAIT LAND TRUST. Mr.Tom Calma,President, Wagait Association.

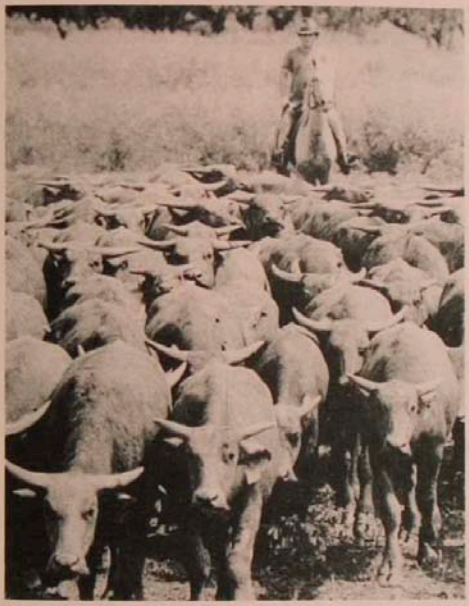
FACTS-ABORIGINES AND BUFFALO-OENPELLI. Mr. Alan Quinn,Gunbalanya Meat Supply, Oenpelli.

SUBMISSIONS BY: T.and S.Baldwin, Annaburroo Station
T.R. Halse, Howard Springs Pet Meat Supply.
K.Bowring.

ATTACHMENT F

NORTHERN TERRITORY
DEPARTMENT OF PRIMARY PRODUCTION
Division of Agriculture and Stock

PRODUCTIVITY AND MANAGEMENT OF THE WATER BUFFALO IN AUSTRALIA



by B. D. Ford, Animal Production Officer, Darwin.

Agdex 487/10

TECHNICAL BULLETIN No. 61
September 1982

ISSN 0158-2763

DEPARTMENT OF PRIMARY PRODUCTION
Division of Agriculture and Stock

PRODUCTIVITY AND MANAGEMENT OF THE WATER BUFFALO IN AUSTRALIA

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PREFACE

Since its introduction to Australia about 150 years ago, the Asian water buffalo has become so much a part of the Northern Territory's "Top End" that it is often used as a symbol of the area. As well as being a tourist drawcard, the buffalo has for a 100 years been a substantial generator of income in the form of meat, hides and breeding stock for export. In 1980/81 the value of animals exported and meat processed for human consumption was approximately $7m; future market prospects for meat and live animals are good.

Although efforts have been made to re-domesticate feral buffaloes from time to time, it was in the early 1960s that serious attempts were begun to farm them on a commercial scale. Since that time there has been a considerable build-up of knowledge on the domestication, productivity and management of the buffalo in Australia, both from commercial experience and research projects. Included in these projects has been a 10-year assessment of buffalo production levels, carried out by the author at Coastal Plains Research Station (C.P.R.S.) near Darwin.

In this Technical Bulletin the C.P.R.S. work is summarised and other available Australian information relevant to buffalo productivity and management is reviewed. In doing this, it has often been necessary to make comparisons with cattle and to refer to research carried out on buffaloes in other countries.

CONTENTS

PLATES

FIGURES

TABLES

INTRODUCTION

1.1 HISTORY OF INTRODUCTION AND UTILISATION

The Australian buffalo (*Bubalus bubalis*), which is of the swamp type, was introduced to the Northern Territory between 1826 and 1843 from eastern islands in the Indonesian archipelago (Letts 1962). These animals were intended as rations for the early settlements along the northern coast. However some escaped, or were released, and formed the basis of the present feral herds.

Feral buffaloes are now distributed over a wide area of the Northern Territory, but their main area of concentration lies between the Daly and East Alligator Rivers (Figure 1). Their preferred habitats are the seasonally flooded plains and adjacent higher wooded land along the northerly-flowing rivers (Tulloch 1977*a*). The climate in this area is under monsoonal influence. Approximately 90% of the annual average rainfall of 1 000 - 1 600 mm falls in the months October to March. Mean monthly temperatures range from a low in July of 25.1°C and 21.8°C in Darwin and Katherine respectively to a high in December of 29.6°C and 30.5°C respectively. The lands of the area have been described in detail by Story et al. (1969).

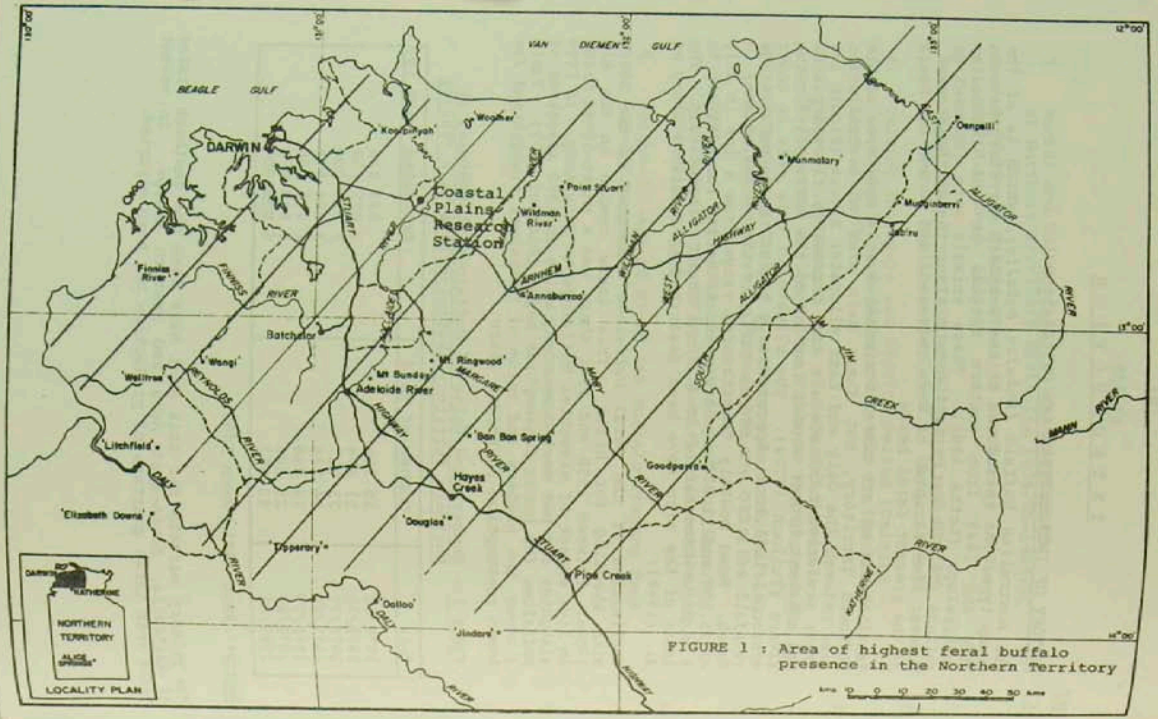
Utilisation of the feral buffaloes commenced in the 1880s with shooting for hides. This trade ceased in the mid 1950s. Between 1958 and 1962 there was a short-lived trade in live export of slaughter buffaloes to Hong Kong. In 1959 slaughter for pet meat commenced, while in 1960 slaughter of buffaloes for human consumption began (Rideout 1977). Table 1 shows the numbers and value of buffaloes slaughtered for human consumption in recent years.

TABLE 1:- Numbers and Value of Buffaloes Slaughtered at Northern Territory Abattoirs 1974/75 - 1980/81

Year	Number of Head	Estimated Value ($)
1974/75	15 392	593 216
1975/76	11 874	1 025 000
1976/77	22 037	1 377 300
1977/78	26 339	3 824 674
1978/79	16 446	2 895 748
1979/80	25 508	5 613 676
1980/81	43 953	6 852 000

Source: Anon 1981; Anon 1982

The primary markets for this meat have been the southern states of Australia, South-East Asia and Western Europe. In recent years over three quarters of production has been exported.


BEAGLE GULF
VAN DIEMEN GULF
DARWIN
Coastal Plains Research Station
Point Stuart
Wildman River
Annaburroo
Batchelor
Finniss River
Wangi
Mt Bundey
Mt Ringwood
Adelaide River
Litchfield
Ban Ban Springs
Hayes Creek
Douglas
Elizabeth Downs
Pine Creek
Goodparla
Munmalary
Oenpelli
Mudginberri
Jabiru
Jindare
Dalloo
STUART HIGHWAY
ARNHEM HIGHWAY
ALLIGATOR RIVERS
LOCALITY PLAN
NORTHERN TERRITORY
ALICE SPRINGS
KATHERINE
FIGURE 1 : Area of highest feral buffalo presence in the Northern Territory

The trade in live export of buffaloes for slaughter, breeding, or draft is growing. In the three years to 1980/81 an annual average of approximately 1 000 head were exported live (Anon. 1981). Since 1974, 1 500 buffalo breeders have been exported to countries in Asia, South America and West Africa (George 1981).

1.2 PRESENT INDUSTRY SITUATION

Recent surveys have estimated that the total population in the main buffalo area is about 250 000 (Graham et al. 1982). Virtually all these animals are feral. Utilisation of them for slaughter or domestication follows mustering with vehicles or helicopters.

Conservation areas form a significant proportion of the land in the main area of buffalo concentration. Most of the remainder of the area is held under leasehold or freehold tenure, in about 20 parcels of land, 500 - 3 500 km^2 in size. Development is minimal for any type of controlled livestock production on the majority of these properties.

Earlier attempts at domestication (Letts 1977; Tulloch 1981) have not been followed through for mainly economic reasons. There has been little incentive for control programs when similar returns could be gained from buffaloes caught from the wild (Ford 1977).

More recently, pressure for control of the buffalo population has been increasing due to the need for tuberculosis control and environmental conservation. The Australian national program of tuberculosis eradication, which has already made significant progress in southern states, is jeopardised by the widespread prevalence of this disease in feral buffaloes in the north. The alternatives facing the feral herds are therefore domestication with appropriate testing, or elimination.

The favourable market prospects for buffaloes and their products should also provide an added incentive for improved buffalo husbandry. Good export markets for meat exist. There is also significant overseas demand for Australian buffaloes as breeding or draft animals, due to absence of the important diseases affecting buffaloes in other countries.

The current state of the buffalo industry in the Northern Territory has come under close scrutiny recently in an enquiry into feral animals in the Northern Territory (Letts et al. 1979), in a symposium on the Northern Territory buffalo industry (Best 1981) and in a survey of landholder's attitudes to the buffalo industry (Lemcke 1981).

1.3 BUFFALO RESEARCH IN AUSTRALIA

Early work included surveys and monitoring of disease status and susceptibility investigations (Letts 1964; Thomson 1977), and efforts at domestication (Letts 1977). The behaviour and population dynamics of feral buffaloes were studied in some depth between 1958 and 1974 (Tulloch 1979); this work is currently being extended by C.S.I.R.O. Division of Wildlife Research (Ridpath 1981).

Since the early 1970s the productivity of buffaloes run under controlled conditions has been studied in more detail. Areas studied have included nutritional and climatic physiology, behaviour, mortality, longevity, reproductive ability, weight and condition change under various conditions, carcass and meat characteristics, and husbandry methods. Pioneering work in these areas was carried out by officers of what was then known as the Animal Industry and Agriculture Branch of the Australian Government Department of the Northern Territory. Since the Territory achieved self-government in 1978 the studies have been taken up by the Animal Production Section and other sections of the N.T. Department of Primary Production. Other major inputs have been from the Universities of Sydney, Queensland and New England, and C.S.I.R.O. Division of Food Research.

This Technical Bulletin deals mainly with work carried out by the author on a herd of domesticated buffaloes at Coastal Plains Research Station (C.P.R.S.), near Darwin. For this reason the background to the herd is described in some detail.

1.4 THE C.P.R.S. BUFFALO HERD

Background

During the late 1960s and early 1970s there was a renewal of interest in controlled buffalo raising. At that time a decision was made to gather some baseline data on the productivity of domesticated buffaloes in their adopted habitat. Consequently a herd was assembled at the research station.

The animals were run on native pastures to simulate the nutritional conditions to which the feral herds appeared to be well adapted and under which many domesticated herds would probably be run in the future. A cattle herd was run with the buffaloes as a yardstick against which buffalo productivity could be measured. Brahman x Shorthorn crossbred cattle were used since they are adapted to the area and are utilised there commercially.

The Station

C.P.R.S. is situated at 12°33'S, 131°25'E, on the Adelaide River, approximately 50 km inland from Darwin (Fig. 1).

Over 90% of the average annual rainfall of 1 400 mm at the station falls in the months October to March, giving a period of useful pasture growth of some 26 weeks. Mean maximum temperatures range from 31°C in July to 35.5°C in October - November, while mean minimums range from 15°C in July to 24°C in November - February. The station is representative of the subcoastal plains and adjacent land systems, which are the favoured habitat of the feral buffalo.

The Animals

Measurements were taken from 1970 to 1978 on a group originally consisting of 33 buffalo cows, with 30 cattle cows (approximately 3/4 Brahman 1/4 Shorthorn) as controls. In order to obtain a cross section of the feral population, the buffaloes were taken from feral herds in five locations in the coastal Northern Territory. The cattle were two years old and the buffaloes were estimated to be three years old on entry to the herd. Palpation of the reproductive tract indicated that all the cattle and most of the buffaloes had not previously calved.

Two buffalo bulls and two 3/4 Brahman 1/4 Shorthorn bulls were run with the herd continuously so that calving was possible year round. Bulls were replaced after 12 - 24 months. Except for weaning age, both species were managed similarly; the buffaloes had access to the same areas as the cattle at all times. Supplementary feed was offered in dry seasons when survival of the animals was considered at risk. The only disease or parasite control required was routine testing to maintain freedom from bovine tuberculosis.

Pastures

During the dry seasons the group grazed the riverine plains which support mainly native grasses, with sedges and reeds, and a small amount of para grass (*Brachiaria mutica*), at a stocking rate of approximately 6 ha/adult equivalent. The floodplain species are of generally poor quality with crude protein levels declining to 2-3% at the end of the dry season.

During the wet season flooding of the plains, the herd was moved to higher land where the main pasture species are annual native grasses and legumes, with some naturalised Townsville stylo (*Stylosanthes humilis*). There the stocking rate was approximately 2 ha/adult equivalent. Wallows were available during the wet season, but were not always available during the dry. Adequate shade was available.

Measurements

The animals were weighed at approximately 6 week intervals and subjectively scored for body condition, on the basis of the amount of fleshing over the ribs and backline, using a scale from 2 to 9.

Pregnancy diagnosis and ageing of the foetus by rectal palpation was carried out at 12 week intervals, allowing determination of the time of later foetal losses. Dates of calving were noted, but the extensive nature of herd management precluded the recording of birth weights. Cattle calves were weaned at an average age of 192 days and buffalo calves at 276 days. This later weaning age of buffalo calves was due to some problems that were initially experienced with earlier weaning. It became apparent that later weaning had little adverse effect on fertility of the buffalo cows. Records were kept of cow and calf mortality.

In this way assessment could be made of adult weight and condition changes, pre-weaning and post-weaning growth rates of calves, cow and calf mortality, seasonality of conception and calving, frequency of calving, age and weight at first calving, and of management requirements.

PRODUCTIVITY

2.1 ENVIRONMENTAL ADAPTATION

Nutrition

Various differences in nutritional physiology have been suggested as reasons for the apparent ability of the water buffalo to utilise poor quality roughages better than cattle for survival, maintenance of condition, or production. These include differences in rumen function, numbers and proportions of rumen micro-organisms, volatile fatty acid concentrations and proportions, and digestibilities of various fractions. However more often than not definite conclusions cannot be made from the experiments carried out (Chalmers 1974; Ford 1978).

Some definitive work on nutritional physiology has been carried out in Australia. Siebert and MacFarlane (1969) recorded higher water turn over rates in buffaloes than in *Bos indicus* and *Bos taurus* cattle breeds. Similarly Moran (1978) concluded that buffaloes were less efficient utilisers of water than Shorthorn, Brahman, or Bali (banteng) cattle due to higher intakes of water per unit dry matter intake, higher urine outputs and lower percentage kidney reabsorption of filtered water.

Moran et al. (1979) found that, after correction for differences in live weight and feed intake, there were no significant differences between buffaloes and Brahman x Shorthorn cattle in voluntary feed intake, faecal excretion of organic matter and cellulose, urinary or faecal excretion of nitrogen, phosphorus and energy, or apparent digestibility of organic matter, cellulose, energy, nitrogen and phosphorus. The concentrations of ammonia and volatile fatty acids in the rumens of the two species were similar, but the Brahmans had a higher proportion of butyric and a lower proportion of propionic acid than the buffaloes.

In a comparison of the nitrogen metabolism of buffaloes with Brahman Cross, Bali and Shorthorn steers, Norton et al. (1979) found that the buffaloes had higher plasma urea levels and a greater irreversible urea loss than the other species, perhaps due to heat stress. However similar diet digestibilities and nitrogen balances indicate that these differences in urea synthesis and degradation did not constitute a significant nitrogen conservation mechanism in any one particular species. Likewise, Moran et al. (1979) concluded that there are few differences between cattle species, and between cattle and buffaloes, in their ability to digest and utilise a low quality roughage when comparisons are made between animals of similar live weight and feed intake. Differences under field conditions are thought to be more likely related to other factors such as diet selectivity, length of grazing period, or tolerance to parasites.

Feeding trials with a limited number (2) of buffaloes suggested that their fasting metabolism and feed intake may be less than both temperate and tropically adapted cattle breeds such as the Brahman (Vercoe and Frisch 1977).

If this is so, then the potential growth of buffaloes would be less than cattle when intake is not limited by stress. However when nutritional, climatic, or disease stressors restrict intake, buffaloes would require a smaller proportion of that intake for maintenance than cattle, thus making their use of pasture more efficient and their survival easier under these conditions.

Grazing behaviour

There are significant differences in grazing behaviour between buffaloes and cattle which may be at least partly responsible for some of the observed differences in performance of the two genera. Buffaloes are able to graze in much wetter conditions than cattle. They may become completely submerged while grazing on underwater plants. In this way they can utilise the flooded plains and swamps, while cattle tend to remain on higher ground. Buffaloes also have different grazing preferences and will eat fibrous material normally rejected by cattle, such as the prickly leaves of *Pandanus* sp. Buffaloes in central Queensland ate brigalow, mulga and sandalwood when little grass was available (Fridley 1972).

Climate

There is good evidence from other countries to indicate that water buffaloes are more easily heat stressed than some breeds of cattle, especially when they are exposed to direct solar radiation (Mason 1974). In Australian work, Moran (1978) concluded that buffaloes were less heat tolerant in both stationary and exercise trials than Shorthorn, Brahman x Shorthorn, or Bali cattle. The buffaloes appeared to be least capable of increasing their cutaneous evaporation when under heat stress. These characteristics could be related to their dark pigmented skin, their sparse reflective hair cover and the fact that in buffaloes the secretory surface of sweat glands per unit area of skin is only about one third that in cattle (Hafez, Badreldin and Shafei 1955).

In the Northern Territory, severe hyperthermia has frequently occurred during the catching process when buffaloes have been run for long distances (particularly with helicopter mustering), or when they have been handled during the hottest times of the day.

When water is available, buffaloes will form a wallow if one does not already exist. Feral buffaloes have developed patterns of behaviour whereby they wallow in the hottest parts of the day and graze during the cooler mornings and evenings (Tulloch 1967). Domesticated buffaloes exhibit similar behaviour. Although buffaloes prefer a wallow to shade as a means of thermal regulation, they seek shade if water for wallowing is not available and adopt daily patterns of grazing behaviour similar to cattle, spending less time grazing than animals able to wallow (Tulloch 1974).

Shade and wallows were found to have similar effects on thermal regulation, as measured by rectal temperatures (Tulloch and Litchfield 1981). Differences in productivity due to shade *versus* wallows have not been investigated.

Wallowing, and the coating of mud thus afforded, appears to have a secondary effect in reducing numbers of ectoparasites.

Diseases and parasites

The water buffalo in the Northern Territory is free of many of the important diseases that affect buffaloes in other countries, e.g. foot and mouth disease, rinderpest, rabies, haemorrhagic septicaemia, brucellosis, vibriosis, anthrax, Johne's disease, theileriosis and Jembrana disease (Thomson 1977).

Although no clinical disease has been seen, serological surveys have shown that many buffaloes have positive titres to various serotypes of leptospirosis and bluetongue, and to ephemeral fever and infectious bovine rhinotracheitis. The disease of most economic significance at present, due to national eradication programs, is bovine tuberculosis. The incidence in feral herds averages about 3% (Carpenter 1981).

Northern Territory buffaloes are also free from some of the parasitic diseases of economic importance in other buffalo raising areas, e.g. Surra, fascioliasis, and *Toxocara vitulorum*. Several other species of roundworms and tapeworms are present, but buffaloes grazing under extensive conditions do not suffer any noticeable effects (Bainbridge 1977). The localised dunging habits of buffaloes (Tulloch 1978) may make transmission of helminths more difficult. *Anaplasma* and *Babesia* are also present in N.T. buffaloes, but clinical disease is not evident.

The buffalo fly (*Haematobia exigua*) is often present in large numbers and, whilst appearing to be a source of annoyance to buffaloes, probably does not significantly affect production. Lice (*Haematopinus tuberculatus*) are

sometimes present in large numbers on animals in poor condition. The cattle tick (*Boophilus microplus*) occurs in only very small numbers on buffaloes in the field, but animals artificially exposed in the confines of a shed carry significant tick numbers (Bainbridge 1977).

With the exception of tuberculosis, diseases and parasites do not appear to be a serious cause of productive or economic loss in the feral buffaloes of the Northern Territory. However, with the intensification of management resulting from domestication, parasitic problems may increase.

2.2 ADULT WEIGHT AND BODY CONDITION

Weight

Mature or adult weight bears an important relationship with potential growth rate and breeding cow feed maintenance requirements. However mature weight data on Australian buffaloes is scarce, since few animals of known age have been weighed through to maturity.

Estimates of live weight from abattoir yields of bone-out meat (currently averaging approximately 100 kg/head from feral buffaloes) do not give a good estimate of mature weight since slaughterings have comprised animals of all ages and sexes. However boneless meat yields of up to 350 kg have been obtained from individual buffaloes, indicating that live weights of over 1 000 kg are sometimes reached. Two buffalo castrates held at Berrimah Research Farm until 10 - 12 years of age reached weights of over 1 000 kg (D.G. Tulloch, pers. comm., 1981).

Abattoir yields and other observations indicate that feral buffaloes vary considerably in weight-for-age from area to area. Although some of these differences have been attributed to a long history of harvesting the largest animals in certain areas, the relative contribution of genetics and nutrition to this effect has not been measured.

In the C.P.R.S. breeding herd the body weights of the Brahman x Shorthorn and buffalo cows stabilised at about 7 years and 8 - 9 years of age at weights of 356 kg and 459 kg respectively. These weights are means of 6-weekly weighings over a four year period, so they include effects of seasons and various stages of lactation and pregnancy. The cattle on average lost a greater proportion of their weight in the dry season than did the buffaloes.

It should be remembered that these cows had access to mainly native pastures, of relatively poor quality, all their lives. Weights on better pasture would be greater.

The 100 kg weight difference in adult breeder weights implies a greater feed maintenance requirement by the buffaloes. However there is some evidence that buffaloes may have a lower fasting metabolism and thus a lower maintenance energy requirement per unit live weight than Brahman x Shorthorn crossbred cattle (Vercoe and Frisch 1977). The greater weight of the buffalo breeding cow may therefore not necessarily mean a proportionally larger feed requirement for maintenance.

Body Condition

The ability of the buffalo to hold condition better than cattle on poor quality roughage diets has frequently been remarked upon, both in Australia (Tulloch 1968) and other countries (Cockrill 1974*b*). In the C.P.R.S. breeding herd, the average body condition score at all recordings between 1971 and 1976 was 7.4 for buffaloes (996 recordings) and 6.3 for cattle (888 recordings). The condition of both species showed a similar response to season of year as did live weight, i.e. depressed in the dry season months. However the cattle suffered a greater average seasonal reduction in condition than the buffaloes.

2.3 ADULT MORTALITY AND LONGEVITY

Mortality

Mortality rates in the C.P.R.S. breeding herd reflected the proportionally greater seasonal variations in live weight, and particularly in body condition, of the cattle compared with the buffaloes. Poor dry season pasture quality, exacerbated by occasional dry season calving and lactation, was responsible for the deaths of almost one half of the cattle herd in the 1970-78 period (Table 2). None of the buffalo breeder deaths were due to poor nutrition during the dry season, despite the fact that most buffalo lactations occurred then.

Buffalo deaths which do occur in the feral herds are mainly due to lack of available pasture caused by uncontrolled stocking rates, prolonged dry seasons or fires (Tulloch 1974). However the relatively large numbers of buffaloes and the few cattle in the poor quality native pasture areas of the coastal Northern Territory are largely a reflection of the better survival ability of the buffalo under these conditions. With an improvement in pasture species and management practices, a corresponding improvement can be obtained in the survival and productivity of cattle in these areas (Wesley-Smith 1972). The potential performance of breeding buffaloes under these improved conditions has received little attention, but data on growing stock is reported later.

TABLE 2:- Buffalo and Cattle Breeding Cow Losses in the C.P.R.S Herd 1970-78

Year	Buffaloes		Cattle	
	No. of losses	Reason	No. of losses	Reason
1970	0		0	
1971	1	Accident	0	
1972	1	Prolapsed uterus	2	Dry season emaciation during lactation
1973	1	Culled (temperamental)	1	Dry season emaciation during lactation
1974	0		7	Dry season emaciation during lactation (4) or following lactation (3)
1975	0		0	
1976	1	Escaped	3	Dry season emaciation during lactation
1977	0		1	Culled (bottle teats)
1978	0		0	
TOTAL	4		14	

(Original numbers were 33 buffaloes and 30 cattle)

Longevity

The water buffalo has a much longer productive life than cattle and it is common overseas for buffaloes in excess of 20 years of age to be still in use for draft (Cockrill 1968). In the Northern Territory feral buffalo cows up to at least 20 years of age have been seen with calves (Tulloch and Grassia 1981). Domesticated buffalo bulls have been still working effectively at 20 years of age (Tulloch 1979a) and cows at 22 years of age have still calved regularly (D.G. Tulloch, pers. comm., 1981). The buffalo cows in the C.P.R.S. herd are still calving regularly at approximately 15 years of age.

One of the implications of a long productive life for female buffaloes is that the turn-off rate of female progeny could be increased due to the need for fewer replacement breeders; as a result selection pressure on replacement heifers could be increased.

2.4 SEASON OF CALVING

Bulls were left with the cows in the C.P.R.S. herd throughout the year, so that the time of conception and calving was not restricted. The numbers of buffalo calves born by month, over a nine year period, showed a much more distinct seasonal trend than the cattle did (Table 3). Buffalo calving peaked in March, with over 90% of buffalo calves being born in the December - June period. A strongly seasonal calving pattern has previously been reported in both feral and domesticated buffaloes in the Northern Territory (Tulloch 1968, Tulloch & Grassia 1981) with most calves being born during the mid to late wet season, as in the C.P.R.S. herd.

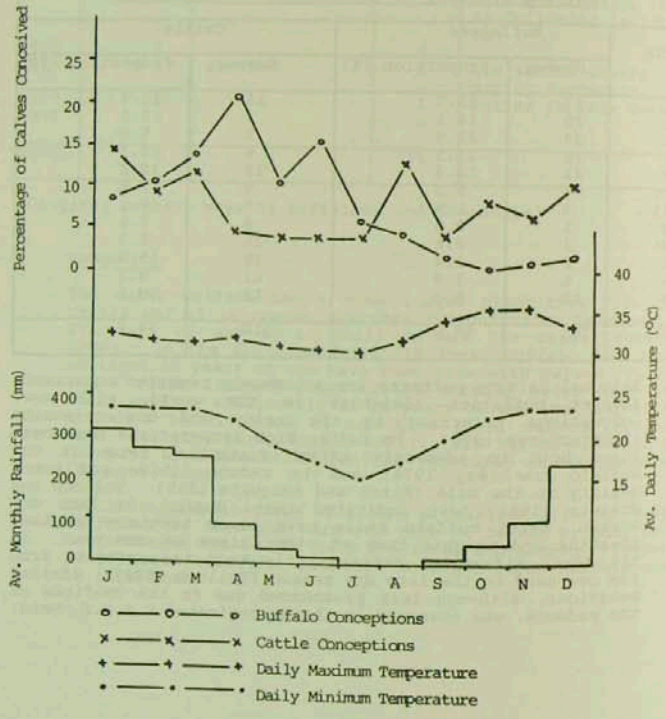
TABLE 3:- Number and Proportion of Buffaloes and Cattle Calving by Month in the C.P.R.S. Herd, 1970-78.

Month	Buffaloes		Cattle	
	Number	Proportion (%)	Number	Proportion (%)
Jan	17	11.0	14	11.9
Feb	25	16.1	3	2.5
Mar	34	21.9	7	5.9
Apr	18	11.5	4	3.3
May	21	13.5	12	10.2
June	14	9.0	9	7.6
July	3	1.9	9	7.6
Aug	1	0.6	9	7.6
Sept	1	0.6	10	8.5
Oct	2	1.3	18	15.3
Nov	6	3.9	11	9.3
Dec	13	8.4	12	10.2
TOTAL	155	99.8	118	99.9

Seasonal calving patterns are a commonly reported occurrence amongst buffaloes elsewhere in the world, with most conceptions occurring in the rainy and cooler months (Bhattacharya 1974). In India, high temperatures have been shown both to adversely affect conception rates in the buffalo cow (Roy 1974) and to reduce libido and semen quality in the male (Misra and Sengupta 1965). Tulloch and Grassia (1981) have indicated that, during the late dry season, feral buffalo bulls have lower testicle lengths, breadths and weights than at other times of the year. In the feral situation, buffalo bulls tend to segregate from the cow herd in the late dry season (Tulloch 1978). Similar behaviour, although less pronounced due to the confines of the paddock, was observed in the domesticated C.P.R.S. herd.

Assuming a gestation period of 323 days, the main buffalo calving period at C.P.R.S. followed conceptions in January - July, with a peak in April. The low level of conceptions during the late dry-early wet season (August - December) may be associated with the poor nutrition and lowered body weights at that time, perhaps exacerbated by the effects on both males and females of high temperatures (Figure 2).

FIGURE 2:- Percentage of Calves Conceived, Average Daily Temperature and Rainfall, by Month - C.P.R.S.



2.5 FREQUENCY OF CALVING

Over a seven year period there was no significant difference ($p<0.01$) between total numbers of male and female calves of either genus born in the C.P.R.S. herd.

Calving intervals were calculated excluding instances where calf losses occurred between birth and weaning. Table 4 shows that the buffaloes had significantly shorter calving intervals than the cattle ($p<0.01$) despite a gestation period longer by up to 40 days. These intervals, of 467 and 571 days, represent calculated average annual calving rates of 78% for the buffaloes and 64% for the cattle.

TABLE 4:- Calving Intervals and Service Period (Calving - Conception) For Buffalo and Cattle in the C.P.R.S. Herd, 1970-78.

Measurement	Buffaloes	Cattle
Number of Records	120	86
Mean Calving Interval (days ± S.E.)	467 ± 14	571 ± 14
Mean Estimated Service Period (days ± S.E.)	144 ± 12	288 ± 13

The shorter calving intervals of the buffaloes reflect a better ability than the cattle to reconceive while still lactating. Only 10% of the cattle conceptions occurred before their calves were weaned (at an average age of 192 days), so calving was generally limited to two calves in three years. Occasionally Brahman x Shorthorn cows raised calves in three consecutive years, but none did so in four or more years.

By contrast, 77% of buffalo conceptions occurred in the first 192 days of lactation, and calving in four or five consecutive years was common. Twelve of the original 33 buffalo cows raised a calf in six years out of seven, and four of these did so in six consecutive years.

There is some evidence that feral buffaloes in the Northern Territory also have relatively high reproductive rates. Of 1 141 feral buffalo cows examined at slaughter, 80% were found to be pregnant, and of those over three years of age, 88% were pregnant (Tulloch and Grassia 1981).

In Papua New Guinea, swamp buffaloes and Brahman x British breed cattle grazing poor quality pasture had calving intervals of 415 - 466 and 540 days respectively (Schottler, Boromana and Williams 1977). The buffaloes often conceived while still lactating, but the cattle rarely did so. The reproductive rate of buffaloes under extensive range conditions in Brazil is said to be remarkably high, with calving intervals of 14 - 15 months being reported from one herd, compared with 18 - 19 months in Zebu cattle (Cockrill 1974*a*).

It seems that the reproductive potential of the swamp buffalo is relatively high, and that the long inter-calving intervals often reported for buffaloes in other countries are due primarily to management limitations such as inadequate nutrition, poor oestrus detection in artificial breeding situations, or thermal and disease stress.

2.6 AGE AT FIRST CALVING

In order to measure time of first calving in buffaloes, 29 heifer progeny of the C.P.R.S. herd were first exposed to bulls at ages varying from 12 to 24 months, by introducing them to the main breeding herd. Regular pregnancy diagnosis was carried out and their calving dates were noted.

The calculated ages and weights at first conception of the 29 buffalo heifers were 848 ± 22 days and 304 ± 7 kg respectively. The first calf was produced at an average age of 1 168 days (approximately 39 months).

Tulloch (1979*b*) reports that feral buffalo heifers first show signs of sexual activity between 2 and 3 years of age. In a sample of slaughtered feral buffalo cows, pregnancy percentage increased from 5% at an estimated age of 3 years, to 82% at 3.5 years of age. The estimated age of 12 of these animals at first conception was 28.5 months (Tulloch and Grassia 1981). This is very similar to the age at first conception (approximately 28 months) of the domesticated C.P.R.S. heifers. Tulloch (1974) had previously reported the age of first conception of four domesticated buffalo heifers as 31 months.

Reports from other countries of ages of buffalo heifers at first successful conception range from 20 to 50 months, depending on environmental conditions and management (Bhattacharya 1974).

2.7 FOETUS AND CALF MORTALITY

Regular pregnancy diagnosis and observations of the C.P.R.S. herd allowed foetus and calf mortality to be monitored over

a period of seven years. Losses between the second positive pregnancy diagnosis (approximately 4 - 6 months gestation) and weaning comprised 8% and 7% respectively of buffalo and cattle pregnancies. These levels fall within the range commonly found in beef cattle (Preston and Willis 1974) and are similar to those reported for beef cattle in North Queensland by Holroyd (1981). A calf mortality rate of 8.8% was recorded from buffaloes in Papua New Guinea (Schottler et al. 1977), while Cockrill (1974a) reported 4% from a herd in Brazil.

Of the 13 buffalo foetus or calf losses, 4 occurred between 4 and 8 months of gestation, 5 occurred around term but calves were never observed, and 4 calves died within 24 - 48 hours after birth. There were then no mortalities until weaning. Cattle losses followed a similar pattern.

The reasons for these losses are not known. The herd was free of brucellosis, vibriosis and trichomoniasis. *Toxocara vitulorum*, a common cause of buffalo calf deaths in some countries, is not present in Australian buffaloes (Bainbridge 1977). However two of the buffalo calves were found dead in wallows, suggesting that the tendency of buffaloes to wallow might prejudice survival of the new-born calf. Bogging and drowning of buffalo calves has been reported in Papua New Guinea (Schottler et al. 1977).

2.8 PRE-WEANING GROWTH RATES

Live weight changes prior to weaning were measured on 133 buffalo calves and 114 Brahman x Shorthorn calves in the C.P.R.S. herd. These calves were born to the original breeding cows and to some of their heifer progeny which were included in the herd.

Up to approximately six months of age, there was no significant difference in pre-weaning live weight gain, either between sexes of calf, or between buffaloes and cattle (Table 5).

TABLE 5:- Rate of Live Weight Gain of Male and Female Buffalo and Cattle Calves Prior to Weaning - C.P.R.S.

Rate of Live weight Gain (g/day ± S.E.)		
	Buffaloes	Cattle
Male calves	474 ± 19	490 ± 23
Female calves	494 ± 18	519 ± 16
Both sexes	485 ± 13	504 ± 14

Similar growth rates (0.46 kg/day) were measured by Tulloch (1968) at Coastal Plains Research Station on three buffalo calves up to six months of age.

TABLE 6:- Pre-weaning Rate of Live weight Gain of Buffalo and Cattle Calves by Month of Birth - C.P.R.S.

Month of Birth	Pre-weaning rate of LWG (g/day)	
	Buffaloes	Cattle
January	584 a	621 a
February	505 ab	447 ab
March	459 ab	524 ab
April	391 b	358 b
May	384 b	353 b
June	510 ab	372 bc
July	487 ab	475 ab
August	*	615 a
September	*	508 ab
October	**	590 a
November	574 a	486 ab
December	572 a	553 ac

abc values in the same column followed by a common letter do not differ significantly (P = 0.05)

* No births recorded
** One record for October not included.

The C.P.R.S. calves of both genera which were born in the late dry to mid wet season period had significantly better growth rates than those born in the late wet to early dry season (Table 6). This effect is presumably related to the better pasture quantity and quality available during the pre-weaning period for the early wet season calf. The mid to late wet season peak in calving incidence which occurs in Northern Territory buffaloes is therefore not optimum for calf growth rates.

2.9 POST-WEANING GROWTH

Six post-weaning growth rate comparisons between buffaloes and Brahman x Shorthorn cattle grazing medium quality pastures have been reported by Ford (1978) and one by Robertson, Ford and Morris (1982). Each of these comparisons involved 5 - 10 animals of each genus run together until 2 - 3 years of age, with two groups being continued until 4½ years of age. Comparisons of 15 out of 26 periods of weight gain (i.e. wet season), or weight loss (dry season) indicated no differences in weight changes between buffaloes and cattle (Table 7).

TABLE 7:- Number of Wet or Dry Season Comparisons Showing Statistically Significant Species Differences in Live Weight Change

Species	Wet Season	Dry Season	Total
Buffaloes significantly greater	5	1	6
Cattle significantly greater	4	1	5
No significant difference	5	10	15

Sources: Ford (1978); Robertson et al. (1982)

The relatively few occasions when one genus performed better than the other were usually during the wet season. Up to about three years of age (or 300-320 kg live weight) better wet season gains were recorded in the buffaloes and, after that age, in the cattle. The fact that superior performance by the buffaloes, when it occurred, was usually in the wet season, is interesting. Considering the usual reputation of the buffalo for efficient utilisation of poor quality roughage, bigger dry season differences might have been expected.

Weight for age data from buffalo progeny of the C.P.R.S. herd (Table 8) run on various Research Stations gives an indication of the levels which can be expected on medium quality (semi improved) pastures.

TABLE 8:- Weight-for-age of Mixed Sex Buffalo Progency from the C.P.R.S. Herd

Age	Approximate Weight (kg)
3 weeks	50
6 months	130
12 "	190
18 "	240
24 "	290
30 "	330
36 "	360
42 "	390
48 "	410
54 "	430
60 "	450

These figures should be taken only as an estimate of growth rates to be expected. There will be variation in individual growth potential, and better gains than this would be expected on better quality pastures. Live weight gains of 0.57 kg/day over 8 months were recorded in yearling buffalo steers grazing good quality pasture at Tortilla Flats Research Farm and this compared favourably with the best gains reported from buffaloes grazing pasture in other countries (Ford 1978).

The potential weight gains of Australian buffaloes when intensively fed also appear to be good. For example, Charles and Johnson (1975) obtained daily gains averaging 0.56 - 0.74 kg/head over 86 - 287 days, by feeding various proportions of lucerne hay and commercial feedlot pellets to buffalo steers 11 - 20 months old. Mean live weight gains of 1.14 kg/day were measured in five 2½ year old buffalo steers fed on a feedlot ration (83% grain) for 69 days at Berrimah Research Farm (Ford unpublished). In this experiment, feed intake and live weight gain were less than for Brahman x Shorthorn steers given the same ration, but feed conversion for the buffaloes (6.6 kg D.M./kg gain) was similar to that for the cattle.

In three experiments at C.P.R.S. in which comparisons were made, there was no significant difference in live weight gain between grazing buffalo steers and heifers up to two years of age (Ford 1978). In addition, no difference in live weight gain was found between buffalo bulls and steers grazing pasture until 450 kg live weight at 4½ years of age (Robertson and Ford unpublished). In none of the work reviewed from other countries, did sexual state affect weight changes of buffaloes, either on pasture, or when intensively fed (Ford 1978).

2.10 CARCASS AND MEAT CHARACTERISTICS

Bruising

Meat losses from carcass condemnations due to bruising are very limited in buffaloes, despite often adverse ante-mortem treatment which would cause extensive condemnation in cattle (Pearson 1981). This effect is generally attributed to the protection afforded by the relatively thick hide of the buffalo.

Dressing percentage

Dressing percentage (carcass weight as a proportion of live weight) and carcass composition depend to a large degree on the stage of maturity at which an animal is slaughtered, so interpretation of these measurements warrants caution. From a review of experiments from Australia and other countries (Ford 1978), it can be concluded that buffaloes have a dressing percentage 3-5% lower than cattle of similar live weight due to their heavier head, hide and feet.

The dressing percentages of 10 buffalo steers and 8 Brahman x Shorthorn steers raised together and slaughtered at similar empty live weights (447 kg and 437 kg resp.) were 50.9% and 53.9% resp. (Robertson et al. 1982).

The dressing percentage of buffalo steers increased from 50.8% to 53.3% during 131 days in feedlot, during which time empty live weight increased from 214 kg to 301 kg (Johnson and Charles 1975). Six buffalo bulls slaughtered by Charles and Johnson (1972) had dressing percentages averaging 55.2% at an average empty live weight of 327 kg.

Dressing percentages of 8 buffalo bulls and 8 buffalo steers raised together and slaughtered at empty live weights of 430 kg and 419 kg respectively were 53.8% and 54.0% respectively (Robertson and Ford unpublished). Little difference in dressing percentage between buffalo steers and bulls has also been found in other countries (Ragab et al. 1966; Zicarelli et al. 1975).

Fat content

A characteristic of the buffalo appears to be a lesser tendency to lay down carcass fat than cattle. For instance Charles and Johnson (1972) remarked upon the relatively low proportion (10.6%) of dissectible fat in sides of 6 buffalo bulls, despite the fact that the animals appeared in forward store to fat condition at slaughter.

Johnson and Charles (1975) compared the carcass composition of buffaloes with three breeds of cattle by serially slaughtering animals over a period of 215 days of intensive feeding. The most outstanding difference between genera was in the ability to deposit fat in the carcass. Only 20% of the buffalo carcass weight gain was fat, compared with 81%, 30% and 63% respectively for Angus, Friesian and Hereford cattle. However, despite being older, the buffaloes were lighter (374 kg) than the cattle (442 - 513 kg) at slaughter, which might account for some of the difference.

In another experiment, buffaloes fed four rations differing in nutritive value were serially slaughtered over a period of 287 days (Charles and Johnson 1975). Significant differences among the groups in daily gain were recorded, but these differences were not associated with changes in carcass composition. Even animals lot-fed for 287 days had carcass fat levels of only 25.5% at live weights of 467 kg. Cattle of the late-maturing Friesian breed had similar carcass fat levels (23.3%) at an average live weight of 421 kg (Johnson and Charles 1975). A carcass fat proportion in excess of 25% seems normal for cattle at live weights above about 400 kg (Preston and Willis 1974).

Three buffalo steers and 3 Brahman x Shorthorn steers raised together and slaughtered at similar live weights (429 kg and 439 kg respectively) had carcass fat levels of 19.0% and 25.9% respectively (J. Robertson and D. Charles, pers. comm., 1981).

These experiments suggest that swamp buffaloes deposit a lower proportion of carcass fat than even the late maturing breeds of cattle at similar live weights. There are also indications that the buffalo has a lower ratio of subcutaneous to intermuscular fat and a higher proportion of kidney and pelvic channel fat than cattle (Charles and Johnson 1972). In addition, the fat is firm in texture and white in colour.

Castration appears to increase carcass fat percentage in buffaloes, but not to the same extent as in cattle. In a comparison of 20 buffalo steers with carcass data from 6 buffalo bulls, the steers had 16% carcass fat and the bulls 10.6% at similar carcass weights (Charles and Johnson 1975). Subcutaneous fat depth at the 12/13th rib was 7.6 mm for buffalo bulls and 11.8 mm for 8 buffalo steers raised together and of similar (230 kg) carcass weights (Robertson and Ford unpublished). Overseas work also indicates that carcass fat levels are higher by 2-3% in buffalo steers than buffalo bulls at similar carcass weights (Ragab et al. 1966; Zicarelli et al. 1975).

Muscle content

The proportion of lean tissue in the buffalo carcass is inversely related to the proportion of fat, in a similar way to cattle. For example, over an empty live weight range from 270 kg to 450 kg, the regression coefficient for the proportion of carcass muscle in buffalo steers was -0.050%/kg empty live weight, and that for carcass fat was +0.072%/kg empty live weight (Charles and Johnson 1975). The usually lower proportion of fat in buffalo compared to cattle carcasses is therefore reflected in a greater proportion of muscle. For example buffaloes had a greater proportion of lean in their carcasses both before (68.2%) and after (68.1%) a period of intensive feeding than Angus (59.8 and 48.0%), Friesians (59.6 and 57.7%) and Herefords (59.5 and 49.9%) (Johnson and Charles 1975). The proportion of muscle was 71.3% in 3 buffalo bull carcasses dissected by Charles, Johnson and Butterfield (1970), 68.6% in 6 buffalo bulls (Charles and Johnson 1972) and 60.4% in 3 buffalo steers (Robertson, pers. comm., 1981).

There also appear to be some differences in muscle weight distribution between buffaloes and cattle, the one of most economic significance probably being a smaller proportion of muscle surrounding the spinal column in buffaloes (Charles and Johnson 1972; Berg and Butterfield 1976).

In cattle the proportion of live weight comprised of muscle is relatively constant at about 32% with little variation among breeds (Callow 1962). In buffaloes, values recorded in Australia have included 37.5% for 2 buffalo bulls (Charles, Johnson and Butterfield 1970), 36.3% for 10 buffalo steers (Johnson and Charles 1975) and 37.1% in 6 buffalo bulls (Charles and Johnson 1972). It appears that lean as a proportion of live weight is therefore at least as high in buffaloes as in cattle, despite the tendency for a lower dressing percentage in buffaloes.

The high proportion of muscle and the low proportion of fat in the buffalo carcass makes it well suited to markets requiring a high yield of lean meat.

Meat Characteristics

Most buffalo meat produced in Australia is currently utilised for the manufacture of smallgoods, to which it is apparently very well suited. There is only a very small established trade in buffalo meat for use as table cuts. This is partly because most buffaloes have been, and still are, slaughtered following handling which is far from ideal for promoting tenderness. The buffaloes are generally taken from feral herds, are of variable age and are usually stressed during catching, transport and holding prior to

slaughter. However meat from young buffaloes slaughtered with minimal stress, and cooked properly (Robertson 1980), is usually quite acceptable and preferred by some.

There has been little objective work done on the quality of buffalo meat in Australia. However Robertson et al. (1982) compared various characteristics of cuts from 10 buffalo and 8 Brahman x Shorthorn steers grown together and slaughtered at similar ages (51 months) and weights (481 kg). The buffalo muscles were darker than those from the cattle, although the pH was similar. A relatively dark colour is characteristic of buffalo meat and may be associated with a higher total pigment and myoglobin content (Arganosa et al. 1973). It could make buffalo meat less attractive to some consumers.

Robertson et al. (1982) also found that mechanical properties of cooked samples of muscles of both species with relatively high connective tissue content indicated that buffalo was tougher than beef, due to the greater contribution of the connective tissue component of toughness in buffalo meat. Taste panel assessments of two muscles indicated little difference in tenderness between genera, but the longissimus dorsi was less juicy, and the psoas major was also less juicy, and had less flavour and overall acceptability in the buffalo. Cooking losses were greater in the buffalo. Tenderness and juiceness were improved in both species by tenderstretching, i.e. hanging carcases from the pelvic bone rather than the Achilles tendon.

Taste panel assessments on meat from younger (2½ year old) animals produced results similar to those of Robertson et al. (1982), (J. Robertson, pers. comm. 1982). Overall, buffalo meat was less acceptable than that from Brahman x Shorthorn cattle of similar age and history.

MANAGEMENT

3.1 DOMESTICATION

Feral buffaloes are relatively easily domesticated to a stage where all required husbandry practices can be carried out. Young animals (less than three years old) are generally considered more amenable to domestication however. Intractable individuals are sometimes found and should be culled as early as possible in the domestication process.

The procedures for catching and quietening feral buffaloes have been explained in some detail by Cuff (1970) and Grover (1977). The initial capture is usually by catching individual animals using vehicles, by self-trapping onto feed or water, or by herding into yards with vehicles and/or helicopters. Suitable animals for domestication are selected, transported to a strong yard and held there for a few days during which time they begin to eat hay. Occasional spraying with water aids quietening.

The domestication process involves continued exposure to man, vehicles, horses, electric fences etc, until a stage is reached where the animals can be handled through yards and allowed first into small, then larger, paddocks. Exposure to human activity and regular handling should be continued after release into paddocks.

Some of the stress problems associated with catching feral buffaloes have been explained by McCool (1981). Major losses during the domestication process in the past have been due to hyperthermia and stress associated with capture, and to inadequate shade, feed, water and follow-up handling. Commercial experience with domestication is now such that these problems should not occur.

3.2 HANDLING

Domesticated buffaloes can be herded in ways similar to cattle, using horses, vehicles, motorcycles or, if sufficiently quiet and in small areas, on foot. Horses are the preferred method in most situations in the Territory. Buffaloes usually respond well to a horseman in the lead when being mustered.

Occasionally problems have been experienced, as with cattle, with recently calved cows being difficult to handle and attacking musterers. This problem is most common in boggy conditions where the buffalo can move more easily than the horse. An accurately aimed whip can be helpful, but the situation should be avoided if possible by removing the animals from low lying areas before they become too boggy.

Mustering by aircraft, particularly helicopters, is becoming increasingly common in the cattle industry (Hill 1981) and is widely used for catching feral buffaloes. However, its use for domesticated herds at present is restricted due to the relatively intensive way in which these herds are managed.

Buffaloes can be worked through yards in a fashion broadly similar to that for cattle. However they should not be rushed but should be handled quietly and calmly and given time to think and move of their own accord. More particular care is needed to avoid heat stress than with cattle. Plently of shade should be provided and a water spray is useful for cooling and quietening purposes. Handling buffaloes in the hottest parts of the day should be avoided.

A slightly wider race is needed for buffaloes than that normally required to accommodate cattle. Dehorning also facilitates movement of buffaloes through crushes and raceways. A walk-through type head bail is most suitable in view of the wide horn span of the buffalo and the fact that buffaloes are often more reluctant to enter a conventional head bail than cattle. Buffaloes rarely kick with one leg like cattle, but sometimes kick with both hind legs. They are particularly sensitive to the hypodermic syringe.

3.3 FENCING

Feral buffaloes have earned a reputation for breaking down conventional fences. The tendency is to go through or under, rather than over, the fence. However, buffaloes trained to respect fences, either as calves, or during domestication, are as likely to be contained by adequately designed and maintained fencing as cattle.

While feral buffaloes remain adjacent to domesticated herds, a security problem will continue to exist. Additional problems for buffalo control are caused by the nature of the country where the buffalo is most numerous. The seasonally inundated plains (often with cracking clay soils) are responsible for fences washing away, accumulation of debris, corrosion of wires and instability of posts.

Details of fence designs suitable for buffalo control are given by Wesley-Smith et al. (1981). A four-wire suspension fence, including two barbed or two electrified wires, should be suitable. Electric fencing, although still in the early stages of development in the N.T., has proven very effective for buffalo control (including feral buffaloes). It offers advantages in terms of cost and flexibility, in addition to effectiveness. It is now common practice to train buffaloes to electric fences in yards during the domestication process.

3.4 GRAZING MANAGEMENT

Buffaloes differ somewhat from cattle in their grazing behaviour and this may be reflected in the systems of grazing management which are most appropriate for the buffalo herd. For instance, the fact that they tend to have different dietary preferences to cattle can be used to some advantage in pasture management.

During the 1970/71 wet season at Mount Bundey Station, 130 km south east of Darwin, a buffalo herd was used to control grass and woody regrowth in a newly planted Townsville stylo (*Stylosanthes humilis*) pasture. Comparison with cattle in an adjoining paddock revealed that the buffaloes did a more effective and even job since they were less selective and grazed the flatter, boggy country, whereas the cattle remained on the higher ground. A buffalo herd might therefore be employed for complementary grazing or pasture management on a cattle property.

It appears that buffaloes either do not eat, or are not effected by, the palm-like plant *Cycas media*, which is toxic when eaten by cattle and difficult to eradicate. It may therefore be easier to utilise the extensive areas where this plant grows in the Darwin - Adelaide River region with buffaloes rather than cattle.

Experience has also shown that buffaloes will generally not accept supplementary feed until later in the dry season than cattle.

The fact that buffaloes make wallows and graze in wetter conditions than cattle may also necessitate the adoption of different management practices for the domesticated buffalo herd. To avoid grazing and trampling damage to pasture, and to facilitate handling, buffaloes should be kept off low lying areas until they dry out. For example, exclusion of buffaloes from *Hymenachne acutigluma* until mid dry season (July) is suggested as part of an annual grazing system to protect this valuable native floodplain grass (Calder 1981). It may also be necessary to exclude them from susceptible areas where pad formation can lead to erosion, or from natural water supplies which can be fouled and eroded by wallowing and trampling.

Certain areas of the coastal plains have been severely degraded by a history of excessive numbers of feral buffaloes (Letts et al. 1979; Fogarty 1982). A substantial reduction in stocking pressure will be necessary in these areas to allow rehabilitation and an increase in their productivity back to previous levels.

Despite the fact that buffaloes prefer to wallow if they can, adequate shade appears to be just as effective in

maintaining thermal balance (Tulloch and Litchfield 1981). However, there have been no measurements on productivity of replacing the wallow with shade.

3.5 DEHORNING

One of the main reasons for dehorning cattle is the reduction in carcass bruising which results. However, bruising is not a significant problem in buffaloes and dehorning is carried out primarily to make movement through yards easier. It also reduces the risk of injury to those handling buffaloes and to other animals, particularly bulls, by fighting. Some export markets may require the horns intact however. In addition, the relatively thick necks of buffaloes mean that they are more difficult to hold in a head bail when completely dehorned.

It is best to dehorn calves at ages of up to 6 months since they are easier to handle than older animals. However, it is often necessary to carry out the operation at an older age, particularly during domestication of feral buffaloes. Fully grown buffaloes have on occasion had their horns completely removed and few losses have been experienced. However profuse bleeding results, the setback to the animal may be considerable, and complete dehorning of adults could not be recommended from a humane point of view. Ingrown horns can also be a problem with adult horns cut off towards the base. Horn tipping is more suitable.

Guillotine-type dehorners are useful in removing only the very ends of the horns of adult buffaloes. Both horn saws and embryotome wire are successful, but arduous and time consuming methods. Small, electrically driven, carpenter's circular saws with carborundum disc blades have been used successfully where large numbers of adult buffaloes have to be dehorned.

In the C.P.R.S. herd, buffalo calves are routinely dehorned between one and four months of age. Conventional scoop or cup dehorners are used. No regrowth occurs, provided the operation is carried out carefully and a ring of skin around the base of the horn is removed.

3.6 IDENTIFICATION

Fire-branding

Results of using different methods of fire-branding have been reported by Tulloch (1977). Brands of two different types were applied to various positions on the body and for different times. All brands were readable at 12 months, but by 24 months were an unsatisfactory means of identification.

In that experiment there appeared to be little difference due to position or time of application. However symbols were more easily recognisable than letters.

Grover (1977) states that the fire-brand applied to buffaloes "should be very simple, with a minimum number of joining lines, sharp and free from scale; it should also be applied very hot".

Fire-brands on some individuals in the C.P.R.S. herd are still visible after 10 years, although generally illegible. On the majority of animals they have disappeared. In general it can be concluded that fire-branding is an unsatisfactory means of permanently identifying buffaloes. This is no doubt due to the fact that the hide of buffaloes is vastly different to that of cattle on which fire-branding is routinely used for permanent identification. Individual identification by fire-branding, as with most other techniques of buffalo identification, is made additionally difficult by the coating of mud obtained if a wallow is available.

Freeze-branding

There has been only limited use of freeze-branding on buffaloes in Australia. However, Tulloch (1977*b*) reported that freeze-branding carried out using dry ice and ethyl alcohol was satisfactory for about one year, after which time the decrease in the number of white hairs reduced its value.

Results from freeze-branding of buffaloes in other countries have been not entirely satisfactory (Cockrill 1974*b*), probably due to the relatively sparse hair cover of the buffalo.

Horn branding

Fire-branding at the base of the horn appears to be a satisfactory long term means of identification, provided a dehorning policy is not adopted. Tulloch (1977*b*) found that horn brands remained legible until the branded animals were disposed of, three years later.

Ear tagging

Both plastic and metal eartags have been used extensively in the C.P.R.S. herd. Metal tags are of little value as they are almost inevitably lost and are usually extremely difficult to read as the animal usually has to be restrained while a hardened coating of mud is cleaned off the tag.

Plastic eartags are generally more resilient, although their efficiency varies with type. Some losses occur, numbers wear off and mud often makes legibility difficult. A system is used at C.P.R.S. whereby numbers are burnt or branded onto the plastic tag and then painted. The eartag number is thus made more legible and permanent.

Ear tattooing

Ear tattooing is the most satisfactory method available at present for permanent identification of buffaloes. Tulloch (1977*b*) indicates that ear tattoos were completely legible after eight years. Ear tattooing has also been successfully used on the C.P.R.S. herd and the system now used comprises ear tattooing for permanent identification, combined with a plastic ear tag numbered as described earlier, which can be replaced when the original number is lost.

3.7 CASTRATION

Before a decision is made to go to the trouble of castration, the need for the operation should be examined. Individual market requirements, e.g. for live export, may be for bulls rather than steers.

There appears to be little advantage in castration of animals destined for the meat trade. An experiment was done near Darwin to examine the effects of castration on growth, behaviour and carcass characteristics of buffaloes (Robertson and Ford unpublished). Of a group consisting of 16 male buffalo calves, half were left entire and half were castrated at 3-6 months of age. There was little difference in growth rates until slaughter at 4½ years of age. Dressing percentage was similar, but fat depth at the 13th rib was greater in the steer carcasses (11.8 mm) than in the bulls (7.6 mm). Although differences in conformation were noticeable at that age (the steers had finer forequarters and neck) there were no significant behavioural problems with the bulls until they were put into a paddock adjacent to cows at 3½-4 years of age. Since buffaloes raised commercially for meat would probably be sold off earlier than this age, it is unlikely that behavioural problems (fighting, obtaining access to cow groups, etc.) would warrant castration.

If a decision is made to castrate, then some anatomical differences between buffaloes and cattle should be taken into account. The buffalo scrotum is smaller and held more tightly to the body than it is in cattle. Whilst conventional castration by knife is possible, it is sometimes made difficult by the relatively tight skin around the scrotum and withdrawal of the testes, especially in

young animals or when the buffalo is prone, for example in a calf cradle.

The method adopted at C.P.R.S. is to use rubber ("Elastrator") rings designed for marking lambs. The ring is applied over the scrotum above the testes while the animal is standing. The operation appears to be painless. The scrotum below the ring drops off after 9 - 10 days; no cases of infection have been recorded. The rings are best applied between 2 and 6 months of age. With younger animals the testes sometimes have not descended sufficiently for the operation to be carried out effectively. Animals older than 6 months can also be done, but restraint becomes more difficult and the testes eventually become too large to fit through the ring.

3.8 WEANING

Weaning is carried out in cattle primarily to avoid a reduction in cow body condition, and perhaps eventually death, which could result from continued lactation, particularly throughout the dry season. Weaning also serves to increase fertility through its effect on condition and ability to conceive.

As mentioned earlier, the condition of buffalo cows at C.P.R.S. was not as severely reduced by lactation as it was in cattle. Similarly dry season lactation was not responsible for any buffalo cow deaths, although the situation may be different for old cows. In addition, the buffalo cow is more readily able to conceive early in lactation. For these reasons, weaning at 6 months of age or less, which would normally be recommended for cattle in this area, does not appear to be as critical for buffaloes.

It is interesting to note that in the feral situation female calves may remain with their mothers for many years. Although older calves may still suck the cow, the most recent calf appears to get preference (Tulloch 1979).

In a domesticated buffalo breeding herd, the best arrangement may be to wean the previous season's calf drop onto green feed early the following wet season. Thus calves born January to May would be weaned in about December, at ages of 7 to 11 months.

Some difficulties have been experienced in raising early weaned buffalo calves and many of these undoubtably have arisen from the physical trauma and stress associated with poor treatment during capture from the feral state.

Very young calves present a particular problem. They can be reared on milk replacers, but require considerable time and

patience. There is often a reluctance to drink from a teat; feeding from a bucket is usually easier. It should be remembered that buffalo milk is considerably higher in fat than cow's milk so it may be an advantage to boost the fat content if a milk substitute is being used. Green feed and concentrate should be introduced as early as possible.

Buffalo cows will readily foster orphaned calves and this presents an alternative means of rearing the early weaned calf. Buffalo calves of all ages seem to fret more than cattle calves when removed from their mothers. It is probably an advantage therefore to run a buffalo cow with a group of early weaned calves to alleviate the effects of this stress on the animals.

Calves older than 2-3 months of age can usually be reared satisfactorily by providing good quality feed, either grazed or fed as hay, together with a concentrate supplement. Problems have been experienced in the past when such calves have been expected to survive on poor quality or unpalatable hay alone.

3.9 MATING

Tulloch (1979) has reported on the mating habits of bulls in feral herds. During the mating season, bull groups graze adjacent to cow groups. Dominance is established by continual fighting for oestrus cows. It appears however that dominance changes and that several bulls may have an opportunity to mate with any one cow group during the main breeding season.

There is insufficient experience with domesticated breeding buffalo herds in the N.T. to draw conclusions on the implications of this behaviour for bull management policy. It is likely that the optimum number of bulls for any herd will depend on factors such as paddock size, cow number and distribution (according to topography, feed and water distribution), and bull age.

In the herd of 50-60 breeding cows at C.P.R.S., 2 or 3 bulls have been used to ensure coverage of all cows. This appears to have been adequate in paddocks up to 200 ha in area. When 3 bulls were used, one was almost invariably completely isolated from the main group and did not appear to take any part in mating activities. On this basis 4-5% bulls appeared satisfactory under these circumstances.

Arguments for restricting the mating/calving period could not be as strong for a domesticated buffalo herd as they are for cattle, where restriction is sometimes advocated mainly to prevent "out-of-season" calving and subsequent cow deaths. Buffaloes tend to be much more naturally restricted

in their conception/calving periods. Consequently cow deaths due to dry season calving and lactation do not appear to be a problem.

3.10 DISEASE AND PARASITE CONTROL

The disease status of the C.P.R.S. herd was described in an earlier section. Although buffalo fly (*Haematobia exigua*) was sometimes present in large numbers, its effect on production is probably minimal and no routine control measures were considered necessary. The only disease situation requiring attention in that herd was continued monitoring of freedom from bovine tuberculosis.

Lice infestations can build up in animals in poor condition, or in early weaned calves. In these circumstances continual measures may be necessary. It may also be desirable to treat young buffaloes for helminths when they are closely confined for a considerable time, e.g. in domestication programs, or after weaning.

REFERENCES

Anon (1981), Northern Territory Rural Production Statistics 1979/80, Technical Bulletin 43, N.T. Department of Primary Production.

Anon (1982), Northern Territory Primary Production Statistics 1980/81, Technical Bulletin 59, N.T. Department of Primary Production.

Arganosa, F.C., Sanchez, P.C., Ibarra, P.I., Gerpacio, A.L., Castillo, L.S. and Arganosa, V.G. (1973), 'Evaluation of carabeef as a potential substitute for beef', *Philippines Journal of Nutrition*, 26, 128-143.

Bainbridge, M.H. (1977), 'Parasites of buffaloes in the Northern Territory of Australia', In The Australian Buffalo - A Collection of Papers, Technical Bulletin 18, Animal Industry and Agriculture Branch, Department of Northern Territory.

Berg, R.T. and Butterfield, R.M. (1976), New concepts of cattle growth, Sydney University Press.

Best, F.G. (1981), Proceedings of the Buffalo Industry Symposium, Darwin, February 1981, Department of Primary Production and N.T. Buffalo Industry Council.

Bhattacharya, P. (1974), 'Reproduction', In The Husbandry and Health of the Domestic Buffalo, pp 105-158, F.A.O., Rome.

Calder, G.J. (1981), *Hymenachne acutigluma* in the Northern Territory, Technical Bulletin 46, Department of Primary Production, Darwin.

Callow, E.H. (1962), 'The relationship between the weight of a tissue in a single joint and the total weight of the tissue in a side of beef', *Animal Production*, 4, 37-46.

Carpenter, M. (1981), 'T.B. in buffalo - a Territory view', In Proceedings of the Buffalo Industry Symposium, Darwin, February, 1981, Department of Primary Production and N.T. Buffalo Industry Council.

Chalmers, M.I. (1974), 'Nutrition', In The Husbandry and Health of the Domestic Buffalo, pp 167-194, F.A.O., Rome.

Charles, D.D. and Johnson, E.R. (1972), 'Carcass composition of the water buffalo (*Bubalus bubalis*)', *Australian Journal of Agricultural Research*, 23, 905-911.

Charles, D.D. and Johnson, E.R. (1975), 'Live weight gains and carcass composition of buffalo (*Bubalus bubalis*) steers on four feeding regimes', *Australian Journal of Agricultural Research*, 26, 407-413.

Charles, D.D., Johnson, E.R. and Butterfield, R.M. (1970), 'Some anatomical characteristics of importance in assessing the potential of the water bufffalo for beef production in Australia', *Proceedings of the Australian Society of Animal Production*, 8, 95-99.

Cockrill, W.R. (1968), 'Observations on skin colour markings of the water buffalo', *Veterinarian, Oxford*, 5, 29-31.

Cockrill, W.R. (1974*a*), 'The buffaloes of Brazil', In The Husbandry and Health of the Domestic Buffalo, pp 677-691, F.A.O., Rome.

Cockrill, W.R. (1974*b*), 'Management, Conservation and Use', In The Husbandry and Health of the Domestic Buffalo, pp 276-312, F.A.O., Rome.

Cuff, H.C. (1970), 'Buffaloes - a need for domestication', *Turnoff*, 2 (1), 2-7. Animal Industry and Agriculture Branch, N.T. Administration.

Ford, B.D. (1977), 'The progress of buffalo domestication in the N.T.', In The Australian Buffalo - A Collection of Papers. Technical Bulletin 18, Animal Industry and Agriculture Branch, Department of N.T.

Ford, B.D. (1978), Live weight changes of swamp buffaloes and cattle in Northern Australia, M. Sc. Dissertation, Centre for Tropical Veterinary Medicine, University of Edinburgh.

Fridley, A. (1972), 'Buffalo drought trial in the grazing regions of Central Queensland', In A Collection of Papers related to the Northern Territory Buffalo Industry, Ninth Biennial Conference, Australian Society of Animal Production, Canberra.

George, D. (1981), 'Buffalo Industry Council Representative for Live Exporters', In Proceedings of the Buffalo Industry Symposium, Darwin, February 1981, Department of Primary Production and N.T. Buffalo Industry Council.

Graham, A., Begg, R., Graham, P. and Raskin, S. (1982), 'An aerial survey of buffalo in the Northern Territory', Technical Report Conservation Commission of the N.T.

Grover, L. (1977), 'Domesticating the feral buffalo', In The Australian Buffalo - A Collection of Papers, Technical Bulletin 18, Animal Industry and Agriculture Branch, Department of N.T., Darwin.

Fogarty, P. (1982), 'A preliminary survey of environmental damage associated with activity of feral buffalo', Technical Report, Conservation Commission of the N.T.

Hafez, E.S.E., Badreldin, A.L. and Shafei, M.M. (1955), 'Skin structure of Egyptian buffaloes and cattle with particular reference to sweat glands', *Journal of Agricultural Science (Cambridge)*, 46, 19-30.

Hill, B.A. (1981), 'Aerial mustering and cattle control', Technical Bulletin 40, Department of Primary Production, Darwin.

Holroyd, R.G. (1981), 'Foetal and calf wastage studies in *Bos indicus* cross breeds in a Northern Queensland beef herd', Australian Veterinary Association Yearbook 1981, p 176.

Johnson, E.R. and Charles, D.D. (1975), 'Comparisons of live weight gain and changes in carcass composition between buffalo (*Bubalus bubalis*) and *Bos taurus* steers', *Australian Journal of Agricultural Research*, 26, 415-422.

Lemcke, B.G. (1981), 'Buffalo Industry Survey 1980/81', Technical Bulletin 56, Department of Primary Production, Darwin.

Letts, G.A. (1962), 'Early livestock introductions to the Top End of the Northern Territory', *Australian Veterinary Journal*, 38, 282-287.

Letts, G.A. (1964), 'Feral animals in the Northern Territory', *Australian Veterinary Journal*, 40, 84-88.

Letts, G.A. (1977), 'History of water buffalo in Australia', In The Australian Buffalo - A Collection of Papers, Technical Bulletin 18, Animal Industry and Agriculture Branch, Department of N.T., Darwin.

Letts, G.A., Bassingthwaite, A. and de Vos, W.E.L. (1979), Report of the Board of Inquiry into Feral Animals in the Northern Territory, Darwin.

Mason, I.L. (1974), 'Environmental physiology', In The Husbandry and Health of the Domestic Buffalo, pp 88-104, F.A.O., Rome.

Misra, M.S. and Sengupta, B.P. (1965), 'Climatic enviroment and reproductive behaviour of buffaloes. III. Observations on semen quality of buffalo bulls maintained under two different housing conditions', *Indian Journal of Dairy Science*, 18, 130-133.

Moran, J.B. (1978), 'Digestibility and water metabolism in Brahman cross, Buffalo, Banteng and Shorthorn steers fed roughage diets', *Journal of the Australian Institute of Agricultural Science*, 44, 57-59.

Moran, J.B., Norton, B.W. and Nolan, J.V. (1979), 'The intake, digestibility and utilisation of a low quality roughage by Brahman cross, Buffalo, Banteng and Shorthorn steers', *Australian Journal of Agricultural Research*, 30, 333-340.

McCool, C.J. (1981), 'Catching wild livestock and feral animals - some of the problems', Technical Bulletin 36, Department of Primary Production, Darwin.

Norton, R.W., Moran, J.B. and Nolan, J.V. (1979), 'Nitrogen metabolism in Brahman cross, Buffalo, Banteng and Shorthorn steers fed on low quality roughage', *Australian Journal of Agricultural Research*, 30, 341-351.

Pearson, D. (1981), 'Buffalo Industry Council Representative for Processors', In Proceedings of the Buffalo Industry Symposium, February 1981, Department of Primary Production and N.T. Buffalo Industry Council.

Preston, T.K. and Willis, M.B. (1974), Intensive beef production, Pergamon, Oxford.

Ragab, M.T., Darwish, M.Y.H. and Malek, A.G.A. (1966), 'Meat production from Egyptian buffaloes. 1. Developmental changes and dressing percentage in a group of buffalo males', *Journal of Animal Production of the United Arab Republic*, 6, 9-30.

Rideout, B.L. (1977), 'The Buffalo Meat Industry', In The Australian Buffalo - A Collection of Papers, Technical Bulletin 18, Animal Industry and Agriculture Branch, Department of N.T., Darwin.

Ridpath, M.G. (1981), 'The C.S.I.R.O. Wetlands Research Programme at Kapalga, and its bearing on the buffalo industry and issues concerned with feral buffalo', In Proceedings of the Buffalo Industry Symposium, February 1981, Department of Primary Production and N.T. Buffalo Industry Council.

Robertson, J. (1980), 'Buffalo meat and how to cook it successfully, Agnote 80/40, Department of Primary Production, Darwin.

Robertson, J.A., Ford, B.D. and Morris, C.A. (1982), 'Live weight changes and carcass measurements in buffalo (*Bubalis bubalis*) and Brahman Shorthorn Cross (*Bos indicus* x *B. taurus*) steers grazing improved pastures up to four years of age', *Australian Journal of Agricultural Research*, 33 (4), in press.

Robertson, J.A., Bouton, P.E., Harris, P.V., Shorthose, W.R. and Ratcliff, D. (1982), 'A comparison of the mechanical properties of beef and buffalo meat' (in publication).

Roy, A. (1974), 'Observations on the physiology of reproduction', In The Husbandry and Health of the Domestic Buffalo, pp 159-166, F.A.O., Rome.

Schottler, J.H., Boromana, A. and Williams, W.T. (1977), 'Comparative performance of cattle and buffalo on the Sepik plains, Papua New Guinea', *Australian Journal of Experimental Agriculture and Animal Husbandry*, 17, 550-554.

Story, R., Williams, M.A.J., Hooper, A.D.L., O'Ferrall, R.E. and McAlpine, J.R. (1969), 'Lands of the Adelaide - Alligator Area, Northern Territory', Land Research Series No. 25, C.S.I.R.O., Melbourne.

Thomson, D. (1977), 'Diseases of water buffalo in the Northern Territory', In The Australian Buffalo - A Collection of Papers, Technical Bulletin 18, Animal Industry and Agriculture Branch, Department of N.T.

Tulloch, D.G. (1967), The distribution, density and social behaviour of the water buffalo in the Northern Territory, M. Sc. Thesis, University of Queensland.

Tulloch, D.G. (1968), 'Incidence of calving and birth weights of domesticated buffalo in the Northern Territory', *Proceedings of the Australian Society of Animal Production*, 7, 144-147.

Tulloch, D.G. (1974), 'The feral swamp buffaloes of Australia's Northern Territory', In The Husbandry and Health of the Domestic Buffalo, pp 493-505, F.A.O., Rome.

Tulloch, D.G. (1977*a*), 'The principal habitat of the water buffalo in the Northern Territory', In The Australian Buffalo - A Collection of Papers, Technical Bulletin 18, Animal Industry and Agriculture Branch, Department of N.T.

Tulloch, D.G. (1977*b*), 'Some aspects of management of domesticated buffalo', In The Australian Buffalo - A Collection of Papers, Technical Bulletin 18, Animal Industry and Agriculture Branch, Department of N.T.

Tulloch, D.G. (1978), 'The water buffalo, *Bubalus bubalis*, in Australia : grouping and home range, *Australian Wildlife Research*, 5, 327-354.

Tulloch, D.G. (1979*a*), 'Redomestication of water buffaloes in the Northern Territory of Australia', *Animal Regulation Studies*, 2, 5-20.

Tulloch, D.G. (1979*b*), 'The water buffalo, *Bubalus bubalis*, in Australia : reproductive and parent-offspring behaviour', *Australian Wildlife Research*, 6, 265-287.

Tulloch, D.G. and Grassia, A. (1981), 'A study of reproduction in water buffalo in the Northern Territory of Australia', *Australian Wildlife Research*, 8, 335-348.

Tulloch, D.G. and Litchfield, R.T. (1981), 'Wallows for buffalo', *Australian Wildlife Research*, 8, 555-565.

Vercoe, J.E. and Frisch, J.E. (1977), 'The importance of voluntary food intake and metabolic rate to production in different genotypes of cattle in different environments', Proceedings of the Third International Congress of the Society for the Advancement of Breeding Researches in Asia and Oceania (SABRAO), Canberra, February 1977, pp 1(c)42-1(c)45.

Wesley-Smith, R.N. (1972), 'Live weight gains of Shorthorn steers on native and improved pastures at Adelaide River, N.T.', *Australian Journal of Experimental Agriculture and Animal Husbandry*, 12, 566-572.

Wesley-Smith, R.N., Piesse, R., Hill, B., Lemcke, B. and Ford, B. (1981), 'Fencing for buffalo control', Technical Bulletin 47, Department of Primary Production, Darwin.

Zicarelli, L., Piceolo, V., Imparato, R. and Richetti, F. (1975), 'Fattening and carcass characteristics of entire and castrated buffaloes aged 30 and 42 months', *Acta Medica Veterinaria (Napoli)*, 21, 41-63.

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PLATE 1: *Part of the buffalo cattle herd at C.P.R.S.*

PLATE 2: *Mustering buffaloes by a conventional method*

PLATE 3: *Suitable electric fencing for buffalo control on flood plains*

PLATE 4: *Domesticated buffaloes wallowing*

PLATE 5: *Dehorning a young calf*

PLATE 6: *Horns can cause handling problems*

PLATE 7: *Firebranding is seldom legible after 12 months*

PLATE 8: *Identification burnt onto eartag*