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PROCEEDINGS OF A WORKSHOP ON

AGRICULTURE, FORESTRY, AND WILDLIFE: CONFLICT OR COEXISTENCE?

held at

THE UNIVERSITY OF NEW ENGLAND

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INTRODUCTION TO THE PROCEEDINGS

The workshop on Agriculture, Forestry and Wildlife: Conflict or Co-existence? was initiated by the North and North-west Regional Research Conference in June 1974. It occurred a year later, in August 1975; and these proceedings have taken a further year to prepare. I can only apologise for this lengthy preparation, and say that I think it has, nevertheless, been worthwhile. In these proceedings are presented all except four of the papers which were given at the workshop. I regret these missing papers, which were all stimulating. Those by Associate Professor B.N. Richards and Professor J.R. Burton respectively introduced the recurring theme of the inter-relatedness of wildlife and the land use practices we were to discuss, and reviewed the scope that existed for balancing conservation and production interests. Mr. R. Harden's paper on the ecology and control of the dingo in northeastern N.S.W. presented an important analysis of the process and economics of dingo "eradication" campaigns, and contrasted their probably slight effect with the inexorable spread of habitat change resulting from the pastoral industry.

Dr. H.F. Recher's paper could have been billed as a "keynote address"; it certainly acted as such in focussing the attention of all participants upon the need to foresee the consequences of, and to take long-term collective responsibility for, land use practices. Dr. Recher reviewed land use development in Australia over the past century of rapid agricultural expansion and the spread of exotic mammals such as cattle, sheep and rabbits. He noted the apparent disease epidemics which affected the native mammal fauna at the turn of the century, from which some marsupials, such as native cat and tiger cat, have never recovered. Despite all these changes, the forest fauna was in general less affected than the arid-zone fauna until ten to fifteen years ago. Since that time there has been an accelerating fragmentation of the remaining forests, through practices such as establishment of pine plantations, wide-scale clear-felling, and wide-scale burning. This fragmentation is leaving precarious "islands" of forest fauna. And yet, he claimed, Australia is the one continent which can afford to leave substantial areas of rainforest uncut, and which has foresters professional enough to manage the whole as an ecosystem.

Dr. Recher went on to exemplify the effects upon fauna of pine plantations, extensive fire, and extensive clear-felling, drawing upon results of long-term studies, carried out by himself and his colleagues at Nadgee nature reserve and at Eden, and by John Disney on birds in pine plantations. Since each of these studies will be fully reported when work on them is more complete, I refrain from quoting them in detail here. From the conservationist's viewpoint

the study of birds in pine plantations produced perhaps the most bleak results. Where wet sclerophyll forest is replaced by pines, a third of the common birds are eliminated as breeding species, the density of birds falls to near that in dry sclerophyll forest, and the bird species diversity falls even below that in dry sclerophyll. Pine plantations lack nesting holes, lack structural diversity, and provide feeding opportunities for few species except those pre-adapted by normally using casuarinas. In clear-felling operations where immediate regrowth is allowed, small terrestrial mammal populations may suffer very little, although the understorey bird population may decline. However, arboreal mammals, such as the greater, yellow-bellied, feather-tailed, and sugar gliders, will be indirectly killed unless opportunity is provided for them to survive and recolonize the regrowth as it matures.

Dr. Recher proposed a system of rotational felling which would allow continuity of colonizing opportunity for fauna displaced from felled mature forest; and he extended this concept to cover whole parks systems, warning his listeners of the danger of allowing all parks to become uniformly old and subject to catastrophic risk, like a bad fire year, which might suddenly leave a region with no old forest. Dr. Recher's studies of the effects of the January 1973 wildfire on small mammals at Nadgee showed that wildfire or control burn need be disastrous only when frequency, intensity, and season of burn are ignored. He felt that the greatest offenders were those organisations which, like the N.S.W. National Parks and Wildlife Service, used fire for socio-economic reasons; their offence being that, in their consistent and frequent use of fire, they produced monotony and depressed the diversity of the burned areas. Dr. Recher saw the three practices he reviewed, pine-planting, fire, and clear-felling, leading to simplification of the environment, even to the production of monocultures, and to fragmen tation into small "islands" of naturalness, with inevitable extinction of species and therefore simplification of the fauna and flora. Many of these consequences could be avoided by taking a broader, state- or nation-wide view of management goals, and through a broadening of the currently narrow, single-purpose, socio-economic base for planning.

This paper contained nearly all the main themes of the workshop: the historical spread and impact of man's land use, wildlife in our managed environments, and objectives for future developments in land use, with a plea for multiplicity of purpose. The missing theme was that of wildlife pests, animals harming man's land use practices. This theme is covered widely in these proceedings.

One paper which was not presented at the workshop has been added to these proceedings, and that is the one by Beverley Ellis on the diets of macropods.

So much is talked about kangaroos and wallabies as pasture- or crop-eating pests that we asked Ms Ellis to review what was known of their food habits for these proceedings. This she has done most readably.

Editing has been done with a light hand to allow authors to put their points in their own style. I hope as a result to have left something of the air of spontaneity that the workshop had. The opening address by Professor A. Lazenby has been given verbatim to remind participants of the stated aims with which we began. By no means all those aims were achieved, for a variety of reasons. But in the bringing together of professionals from so many different fields, in the discovery of common ground and the definition of divergences of opinion, the workshop worked. Its successor should work even better.

The urgency to resolve the problems that land use and wildlife pose for each other has not diminished. Yet, since the workshop was held, funds for research into these problems have become less available. Until government agencies are established and funded, with research responsibilities across the whole of the environment including land use and wildlife, we are going to watch the limited struggles of separate departments to tackle problems from their own narrow production points of view. Foresters must be partly excused from this generalisation, since we had at the workshop examples from Queensland, New South Wales and Victoria of forest authorities carrying out basic research into the effects of forest practices on wildlife and vice versa. Yet where is the research on the future contribution of forest commission lands to the planned conservation of faunal communities in a whole state or a continental region? This breadth of research view must be taken before breadth of management planning will follow.

To those who helped organise the workshop I am grateful, especially to Frank Hartridge for his gentle urging and Sophia Geddes and the Department of Continuing Education for taking on the whole burden of administration. For help in the preparation of these proceedings I am grateful to Lorraine Blight and Jan Browne for typing and re-typing, to Bruce Whan for re-drawing and standardising most of the figures, and to John Weir for sharing the editorial load and adding much-needed impetus.

July 1976.

Peter Jarman.

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VERBATIM REPORT OF THE OFFICIAL WELCOME

by

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AGRICULTURE, FORESTRY AND WILDLIFE: CONFLICT OR CO-EXISTENCE?

It is my pleasant task this morning to welcome you to this Workshop which the University of New England has the responsibility of organising and hosting on behalf of the North and Northwest Regional Research Conference. The title of the Workshop - 'Agriculture, Forestry and Wildlife: Conflict or Co-existence?' - might be described as pure McClymont, as those of you who know him can testify. Indeed, the role of opening the proceedings was to have been performed by Professor McClymont; however, as he is in Mexico for a few days, I am appearing as a stand-in.

When he asked me if I would open the Workshop, Peter Jarman gave me two bits of paper. The first was factual and contained background information on the aims of the Workshop, whilst the second was a brief outline of what Professor McClymont was thinking of saying had he been here. I have made use of both papers in preparing this introduction, although I take full personal responsibility for any views expressed.

As with many conferences, symposia and workshops with which the University of New England is involved, the expertise has been drawn from several organisations. Members of the N.S.W. Department of Agriculture, the Forestry Commission and the National Parks and Wildlife Service, in addition to University staff, have been involved both in the planning of the Workshop and in presenting the papers to be given and discussed during the next three days. Stated simply, the Workshop was designed to bring together some of the people engaged in agriculture, forestry and wildlife conservation and management, to look more precisely at where their interests overlap and examine what flows from this. Examples can be cited of benefits arising from an overlap of interest but yet there are other instances where disastrous consequences have followed.

Amongst the objectives of the Workshop is an attempt to see what can be done to maintain good working relations between the interests of

agriculture, forestry and wildlife where they overlap. It is a revealing commentary on the present situation that we have such little real information on the reciprocal impact between wildlife and other forms of land use on which to base logical decision-making.

Even if we had this information, clearcut guidelines seldom exist making clear who has the responsibility to do what in dealing with different problems - dingoes and rabbits excepted. Any plans which are made or action which occurs are essentially ad hoc and have generally been the responsibility of the field worker. It follows then that a second and important objective of the next three days is an attempt to define legislative responsibilities in order to provide a framework in which the interests of agriculture, forestry and wildlife can be protected and reconciled. I am hopeful that such responsibilities might be determined fairly soon on both a State and Australia-wide basis.

It is true, of course, that the CSIRO Division of Wildlife Research has Australia-wide responsibilities. But one division of one organisation can't hope to cover the whole spectrum of wildlife research and its research interests have tended to be concentrated in one or two areas and on fairly basic studies. In looking at the consequences even of such studies, co-operation is needed with other interests and with the States. To cite just one example - that of feral pigs; their ramifications into wildlife, agriculture and forestry serve as a fairly obvious example of the need for co-operation between the organisations involved in agriculture, forestry and wildlife in each State in collecting data to define acceptable methods of management of the pigs.

I have already spoken of the lack of hard data to enable meaningful decisions to be made in the co-existence which is necessary between agriculture, forestry and wildlife. This co-existence should be encouraged in Australia, a country with so many things in its favour - a vast land area, a broad spectrum of wildlife with several unique species, broad forest tracts and a low human population density. Yet even when we have taken the first logical step - namely, to prevent wholesale killing - the consequences of destruction of the habitat of wildlife have been little studied; reliable information just does not exist, therefore, to enable a proper basis for co-existence between wildlife and other forms of land use. This brings me to a third and major reason for the Workshop, to initiate steps to obtain funds for investigating some of the more important problems and implementing some of the conclusions.

Since settlement, Australian agriculture, though of increasing importance, has been mainly extensive, enabling a degree of co-existence between it and wildlife. Recently, however, there have been several important changes. Agriculture has become more and more the dominant form of land use with monoculture increasingly the rule. Techniques, which have become available for pest control, have been more and more powerful and have tended to have increasing side effects; even so, in the longer run pest problems have tended to increase. We have become more aware of the complex interrelationships between the various forms of life in our ecosystem whilst the importance of wildlife in our conception of quality of life, its aesthetic, ethical and recreational role, has only recently been articulated.

It is therefore a most opportune time to hold a Workshop such as this, not only to appreciate the general changes in our philosophy but to look at some specific problems. For instance -

- to what extent are the continual clearing and drainage required for agriculture, the trend towards intensive monoculture, and the increasing use of modern herbicides and pesticides, factors in the changed population of natural fauna and flora;

- how can we better monitor, predict and control the effects of agricultural management on wildlife and on pest problems and to what extent can we keep the populations of such pests below epidemic proportions by maintaining or increasing diversity in agriculture, including, for example, maintaining natural areas for wildlife on individual properties;

- to what extent can some forms of wildlife be managed as an exploitable resource which could provide revenue for land owners without creating a pest problem for others;

- how can we better utilise the expertise in the various organisations involved directly or indirectly in wildlife management in order to reduce conflict and better achieve co-existence between agriculture, forestry and wildlife.

I hope that the Workshop will be not only informative but will result in some concrete plans being formulated which might be put to Government agencies and research organisations.

Apart from identifying current problem areas I am hopeful that we can make some intelligent guesses about the future, by asking professionals - both the scientists and the managers - to say where agriculture and forestry are going in the next few years. I hope that we will thus be better able to predict what wildlife problems will be created and therefore start working on some such problems immediately.

The participants in the Workshop are diverse, knowledgeable and numerous. The 85 or so from outside the University who have registered, when joined by the staff and students participating, make up more than 100 people. They include foresters, timber millers, potential wood chippers, a pet food manufacturer, farmers, graziers, Agriculture Department officers, National Park rangers, people from universities, colleges of advanced education, agricultural colleges, the State Pollution Control Commission, CSIRO Land Use Division and some conservation bodies. They come not only from N.S.W. but also from Victoria, Queensland and the A.C.T.

In concluding my official welcome, may I say that with such participants if the Workshop isn't a trail-blazer, if it is not a memorable beginning in defining the need for co-existence between agriculture, forestry and wildlife, then I will be both surprised and disappointed.

WHAT IS WILDLIFE?

P.J. Jarman

You may wonder why we should begin this workshop by asking so simple a question as What is wildlife? Most people assume they know what wildlife is, and probably have some hazy notion of whether they are for or agin it. But the range of ideas conjured up in people's minds by the word 'wildlife' is so broad, and the term itself is so artificial, that we should try at the outset to establish a common ground in our thinking.

I said that the term is artificial. I mean that there is no natural, taxonomic definition of wildlife. Wildlife is just a fragment of the animal kingdom which happens to be of direct interest to mankind in certain ways. It is a human-created category and therefore reflects human attitudes towards it. It is discussed by us in this workshop only because our attitudes towards it are often conflicting. Its interests for us is usually in direct proportion to the impact it makes upon us through our senses, even the sense of financial security.

Interest arising from impact on the senses usually means that the animal in which you are interested is visible, noisy, touchable or smelly. If a large, trumpeting elephant knocks you over you are temporarily very interested in it, more so than in a single grasshopper under foot. That grasshopper must multiply to millions before making much impact and hence becoming of interest to any but a few entomologists. The out-of-sight, out-of-mind principle operates very freely between man and animals, and for a long time has operated to exclude all small, obscure, nocturnal and rare mammals, birds, reptiles and amphibians from what the public would regard as wildlife.

Australian wildlife has suffered badly from this. So many of even its mammals are small, obscure, nocturnal and rare that its mammal fauna has not received a fraction of the public and professional attention it deserves, and the cumulative impact has been so slight that it has taken a long time for a public consciousness of wildlife to develop. Moreover, the effect has been for the relatively few large, obvious species to be taken as exclusive representatives of wildlife. So the plentiful survival of the red or grey kangaroo, the emu or the dingo is too often taken to be synonymous with a healthy state of affairs for the whole wildlife community. As you will be hearing in these talks, this is not necessarily so.

Australian wildlife deserves, and is at last starting to get, great attention because of its unique island-continent background. Two ancient mammal stocks, the monotremes and the marsupials, survive here, the latter with abundant families, genera and species; some marsupial families exhibit classic cases of adaptive radiation. Besides the two monotreme and 119 marsupial species there are 108 indigenous terrestrial mammal species, half of which are bats. The rodents are represented by a group of ancient invaders, commonly called the old endemics, and several groups of more recent arrivals. The breeding birds of Australia, although relatively low in numbers when compared with other continents, show a degree of endemism, of restriction to their original continent, exceeded only by the birds of South America. Forty-one percent of Australia's land bird species belong to families found only in Australia and New Guinea. The continent is the home of some remarkable bird families, such as the megapodes, the bowerbirds, lyrebirds, and scrub birds. The reptiles and amphibia are just as interesting.

When the continent was first discovered the fauna, especially the mammals and birds, attracted great attention because of its strangeness to european eyes. Specimens of the wildlife reaching Europe were highly valued and aroused great interest. The same enthusiasm for the fauna within Australia seems barely to have survived the departure of the early collectors and explorers. To read Wood Jones, writing in the mid 1920's, is to read of whole populations of species of the commonest native mammals disappearing without even a museum specimen being kept. Early settlers throughout the continent regarded the wildlife, quite understandably, as either something to use or something to eradicate if it were thought to be a pest. The lucky species were those that were useless or unnoticed.

Tolerance towards wildlife came later with greater affluence and independence of the people from the forces of nature, when wildlife could neither decrease nor increase their annual wealth. Where wildlife had a monetary value placed on it, however, it was often briefly elevated to the rank of an exploitable resource and as quickly exterminated. The growth of urban Australia produced a majority of people insulated from the direct impact of wildlife, but educated to appreciate its scientific, aesthetic or cultural interest. From this educated interest in the aesthetics of wildlife has arisen the conservation movements which are now gathering such public strength. In some cases the movements outrun the scientific information upon which the conservation should rightly be based.

Education brings an awareness of wildlife to people quite insulated from any of its potentially harmful effects; hence the strident calls for kangaroo "preservation" come more often from urban than rural communities.

But the conservationist feelings came too late for many species. Even by 1863 John Gould was aware that the Thylacine.....the Tasmanian wolf.... faced extinction. The usual processes of direct slaughter, habitat alteration and possibly epidemic disease were involved in its disappearance. Many other species followed or even preceded it, until now Australia is considered by the I.U.C.N. to have 30 marsupials, 18 birds and 6 reptiles so rare as to cause international concern. Another 5 marsupials are almost certainly extinct, and some authorities would list 7 endemic rodents as extinct and half-a-dozen as endangered. At least 2 bird species are extinct, and perhaps a dozen are endangered.

The Europeans brought to Australia an educated aesthetic regard for european wildlife, and, while ignoring or slaughtering the indigenous wildlife, busily set about "acclimatizing" the inclement continent by introducing deer, rabbits, hares, foxes and bird species galore. These and the inevitable escaped or released domestic animals and imported domestic pests have added the most troublesome of all wildlife to Australia. We suspect, but can never prove, that these feral animals, which now include 17 spp. of mammals and over 25 species of birds, have hastened the disappearance of indigenous wildlife.

The legal inheritance brought with the europeans was really no help to wildlife either. The status of wildlife in British law had hardly changed since the Middle Ages and did little more than define categories of rights to kill wildlife or "game" species. Protection could be afforded only by withdrawing the right to kill a species. This was occasionally done, increasingly so in this century. Nevertheless, defence of property nearly always remained a justification for a landholder to kill wildlife on his land. Happily, in the past few years nearly all States have adopted legislation giving protection to nearly all mammals, birds and reptiles. Feral animals, and poisonous snakes, which are about to attack one, are usually not protected.

While direct and open slaughter is now and has at times in the past been forbidden, almost without exception there has been no legislative prevention of indirect slaughter. While it is legally possible to compel a landholder to retain his soil resources, or his tree resources in special cases, it is not comparably possible to compel him not to destroy his, or the government's, wildlife resources through land use and habitat destruction. Although the government retains ownership of, and responsibility for wildlife, it has yet to protect fully the survival of that wildlife. Other publicly-owned resources such as water catchment or minerals in the ground do not remain exposed to the whims of the landholder; wildlife, sometimes to its detriment, does. Hence the possible conflicts we are discussing in this workshop.

I have given the impression that wildlife is just a collection of species, some more notable than others. I would prefer us to think of wildlife as forming communities of interacting species. Only a few of the papers at this workshop are going to be about communities, because it is so much harder to grasp what all the species in a community are simultaneously doing. But remember while you listen to the papers that all the effects we talk about are not just the effects of land use on one species, or of one species upon land use; there are always ramifications of the effects to some, most, or all species in the system.

Species in a wildlife community vary in their sensitivity or vulnerability to change. Once again the "obviousness" factor comes into play. We react to and act upon what we notice most and first, what thrusts itself under our noses. But we must learn not to ignore the unobtrusive or late responses of the small and unobvious species in the community, which may still have a vital role to play in the system's stability. We should be concerned with conserving the interacting system as a whole, not with band-aid preservation of the obviously affected species.

The scientific interest in fully functioning systems is going to increase. Man is going to become more and more fascinated by the processes of balance achieved in these communities as his own community and environment become less stable. The feeling that some human land uses can still function without total destruction of their wildlife communities is becoming increasingly, emotionally important to people.

We rightly distrust people who profit at our unconsidered expense. Increasingly we will see those organisations that unnecessarily destroy wildlife in this distrusting light, as profiteers at our expense. So it is imperative that the major organisations affecting and dictating land use should mutually inform themselves of the reactions of their land use upon wildlife, and should try to predict what wildlife will do to their land use in the long run, before taking drastic steps against the wildlife. In time the public may require them to do this, and there is no political harm in forestalling a public request.

Professionals like those at the workshop are deciding now what happens to wildlife. This workshop presents example after example of human decisions bearing upon wildlife. Some decisions....mainly in the past, I hope.....have been taken on the flimsiest evidence. For instance, at the end of last century one land holder's uninvestigated complaint led to the destruction of 380 wombats in one year in the Armidale district. Most land use decisions have been taken without even thinking of wildlife, yet have been profoundly and long-lastingly influential. Whether to graze sheep or cattle, to burn or not to burn, to drain a marsh or channel a stream; decision like these are made yearly by so many people, and have been made over the past century by their predecessors. And usually there has been no obligation upon them even to think of the impact of their decision on the wildlife. Many of the people involved have thought deeply, and some have been active in their concern for wildlife. Pressure upon them to be concerned with wildlife in the future is mounting. Perhaps this workshop will produce some ideas on the ways in which this innate or compulsory concern for wildlife can be productively channelled through research into action; action aimed at making human land use compatible with the persistence of wildlife communities.

I said at the start that wildlife is a category of animals created by man out of his own interest. To this extent wildlife is man-made; and quite certainly from now on wildlife will be what the public in general, and professional land users in particular, make it.

A PERSONAL VIEW OF KANGAROOS

P.A. Wright

I cannot pretend to speak with any learned authority on this subject, my only claim to knowledge being that from childhood I have lived on the land, and thus had an opportunity of being involved in, and with, the business of making a living from the land, and observing some of the effects of man's so called conquest of nature for his own domestic purposes on the land itself, and the native fauna and flora it supported. I have not always been conservation conscious. In my early youth I had more sympathy with my father in his efforts to wrest my daily bread from the unwilling elements, than with the seeming hordes of kangaroos which he periodically organised small armies of well armed men to destroy. The land was well forested, and with him I rejoiced in the bounteous pasture which nature provided when the trees were ringbarked. With him later also, I gained much satisfaction from the application of more sophisticated means of encouraging nature to produce more and more of her bounties in the interests of family security and comfort, with little or no thought of the possible re-bounds that were to come. With hindsight however, I do admit to a weakness of the stomach at the sight of mass kangaroo slaughter and, as time went on, the harbouring of sneaking doubts as to the wisdom and necessity of turning nature inside out in order to accommodate our needs. But it was quite unfashionable then to even question. I suppose it was not until I took over the management of my present property, then in a deplorable state of want and neglect from previous ill-fated attempts at development, that I began to think about conservation.

Happily, it had not been over cleared; it was naturally well watered, and supported a happy medium of kangaroos, wallabies and other wildlife. But its pastures were unproductive and, by its geographical nature it was, and still is, ideal rabbit country. Apart from the boundary enclosure, it had virtually no fences. Thus, like my father, I met the problem of development head on, but unlike him, at a time when conservation was beginning to be talked about. There were three basic needs; better pastures, subdivision fencing and rabbit eradication. Happily, myxomatosis had just been released, and

its devastating effects were followed up with warren ripping to apparently total effect. But they gradually came back, and are still a problem. The aerial fertilizing and seeding technique, then in its infancy, was also put to work over the whole property, and fencing was still comparatively cheap. It all permitted a rapid transformation, which has been continued ever since, not only to the benefit of sheep and cattle, but also, it was soon noticed, to the kangaroos. The first pasture paddocks were used, as was the custom, as "hospital paddocks" for the poorer stock, but the 'roos soon moved in, and I found myself organising shooting drives, in which I found neither joy nor financial reward. At about this time my good friend Alan Strom was advocating the declaration of Nature Reserves under the Fauna Protection Panel, and here appeared a way of compromise, - let the 'roos enjoy the new fruits of nature, but contain the population explosion under controlled conditions. I became interested also in the idea of monitoring the effect of property development upon wildlife, and vice versa, and so the property was dedicated as a Nature Reserve, - later as a Wildlife Refuge. It was not however, until recent years that the latter became possible, and humane controlled shooting was introduced, through the joint efforts of Mr. Brian Vile of the N.P.W.S., and the University School of Natural Resources, who commenced controlled studies on the property.

I can only guess at the original 'roo population, and would put it at 200, or less. I suppose it was only co-incidence that the population exploded when the Refuge signs went up, but explode it did. The first counts made by the study group revealed a population of some 800 in 1972. However, by this time the whole property was relatively improved pasture; the 'roos did not concentrate on small areas in the previously damaging proportions. Per acre this seemingly excessive population amounted to only 0.1. Controlled professional night shooting was introduced, and the population is now kept at around 200 - 300, a figure which has virtually no impact on domestic stock carrying capacity, or property development and management. Some 1,100 'roos were shot over the last three years, but we still have the optimal number.

Some observations in this regard are relevant. Number control by daylight driving is not only barbarous; it is time consuming, expensive, relatively ineffective, and creates a race of fear-ridden animals. This latter condition results in much damage to fences.

Professional night shooting is humane, efficient, relatively inexpensive, and above all in no way disturbing. Left this way, the 'roos develop regular traffic ways, passing quietly under fences and doing no damage. They do not disturb domestic stock, as they do in wild flight. Being quiet they become, as it were, part of the landscape. I have had bush 'roos take up residence in the garden, coming and going as they please. Other than when their numbers do become excessive, they in no way interfere with property management; a condition of mutually happy co-existence can be developed, and I find that visitors, as well as myself, derive much satisfaction from it.

Whilst this condition may not be applicable to all property situations, I believe the principle offers opportunity for very wide application in wildlife preservation generally. Though the "save-the-kangaroos" fraternity may throw up their hands in horror, the ultimate answer would be to commercialise the 'roo and harvest them in controlled conditions. Even as it is, their ability to survive is greatly enhanced through the provision of better nutrition, just as with domestic stock. Speaking generally however, the impact of development for agriculture on wildlife is in need of concentrated research attention. We must cease to regard wildlife as a competitor to be destroyed, either wilfully or as an unavoidable process of development. There is growing evidence to suggest that destruction of wildlife (in which I include trees, and all things that crawl, wriggle and fly) is going against good pastoral and agricultural practice, and that our effort to fill its place with man-made substitutes is backfiring. I believe our endeavours must increasingly be pointed towards working with, and not against nature; but we need to know so much more. I suggest that a diversion of available research funds to this may well be far more rewarding than towards higher yielding crops and pastures, or more productive animals. After 25 years here I begin to perceive that we have, in changing the environment, but substituted many problems with others, some of which may well be irretrievably damaging. Each human age, it seems leaves a legacy of problems for the next, but time, and our ability to manipulate and change the environment, moves ever faster.

The kangaroo is no longer my enemy here. One day, who knows? - he may become a means of sustenance. At least I know now how to preserve him, but my thirst for knowledge now extends to broader pastoral environmental fields, and I enter a plea for a rational, rather than emotional approach to gaining this.

CHANGES IN THE WILD LIFE COMMUNITY OF THE WATERLOO VALLEY BETWEEN 1866 AND 1975

A.W. Cameron

Introduction

This discussion deals with two properties, Kalanga, selected by my family in 1866, and Inkerman acquired in 1970. Both properties are in the same valley situated about 16 miles west of Glen Innes. Kalanga is approximately 3,200 feet above sea level and although only 4 miles distant, Inkerman is 1,000 ft to 1,500 ft higher.

I came to live at Kalanga in 1920. Prior to that my father had lived here from 1866 to 1886. My information comes from the personal experience of myself and my father, from Government Gazettes between 1857 and 1895, from files of the "Glen Innes Examiner" 1874-1895 and extracts from the itinerary of Commissioner G.J. Macdonald and Deepwater and Waterloo Station diaries.

From what one can learn from early reports, the only open country when the white man came to the area was on the floor of the valleys. The slopes and hills were heavily timbered. Owing to the limited feeding grounds marsupial populations were not great and numbers were probably kept in check by the aborigines and the dingoes. Hollow trees were plentiful and provided shelter for the possum family and birds which nest in hollow trees.

All unnecessary green timber on Kalanga had been ringbarked by 1920 but much of the dead timber remained standing and was finally all burnt off when pasture improvement was commenced in the 1950's. From the size of the trees on Inkerman, it would appear that practically all the trees had been killed prior to World War I. However, no timber treatment appears to have been done since and a regrowth of white gum has taken place since. As the country is very steep there is evidence of a number of land slides having occurred since the trees were first ringbarked, but none appear to have occurred since the regrowth of timber became established. As these trees are comparatively young very few of them are hollow.

My father often spoke of the wild life when he first knew the country. It consisted of kangaroos, wallaroos, swamp wallabies, kangaroo rats, dingoes, possums, koalas, gliders, tiger cats and native cats. He would recall how, on the 16 mile sulky ride to Glen Innes up to 100 koalas

could be counted. By 1920 kangaroo rats, koalas, tiger cats, dingoes and native cats had completely disappeared and possums and gliders were very rare.

Native Animals

Kangaroos

Apparently when ringbarking was first implemented on a large scale it triggered off a population explosion in the kangaroos by opening up new feeding grounds which coincided with the reduction in dingo numbers and as by this time the aborigine had adopted the white man's tucker, the kangaroos' original enemies had virtually ceased to exist. The Pastures & Stock Board at Glen Innes paid a bonus on 239,453 kangaroo scalps in the four year period of 1883-1886. The bonus rate fluctuated between 3 pence and 9 pence per head. Kangaroo skins became of commercial value and the bonus was dropped on kangaroos by 1889.

By 1920 the kangaroo population was small on Kalanga and I attribute this mainly to the fact that the country was opened up and they had to go back to the hills for shelter and also the rabbit had eaten out some of the grasses which they preferred. Eradication of the rabbit and the growing of improved pastures did not bring about any change in population during the clover-dominant era of the pastures. However, now that the grasses are dominating the pastures, their numbers are increasing. They are very partial to green oats and seem to travel long distances to crops.

When we took over Inkerman in 1970 much of the country was timbered and it all carried coarse grasses such as kangaroo grass and tussocky poa which were dormant in the winter months. The neighbouring property was well improved and the kangaroo population used the Inkerman country as cover and marauded the neighbouring pastures at night in the winter and spring. However they seemed to prefer the green shoots on the kangaroo grass in the late spring and summer. Aerial top dressing was implemented at Inkerman from 1970 and the pastures are gradually improving. During the first two years of our occupation it was common to come across the carcase of a kangaroo or wallaroo and I am sure that these animals were not shot. I think they probably succumbed to internal parasites on the poor quality pasture which existed. Since the pastures have improved the mortality rate has decreased until during the last two years I have not seen a carcase. Now the numbers are gradually increasing and if sheep are excluded from a paddock the kangaroos gradually congregate there.

Wallaroos

Like the kangaroo the wallaroo numbers apparently increased with the kangaroo but never reached the same proportions, probably because they did not have the same propensity to travel. It is rare to see one on Kalanga today as the country is too open for them. However, the country at Inkerman suits their habits as there are a number of stony outcrops for them to live in. With pasture improvement and stocking with sheep, succulent grasses are growing on the tops of the rises and hills. Sheep tend to camp at night on high ground thus building up the soil fertility on these camps which are in close proximity to the habitat of the wallaroo. At Inkerman the wallaroo population is rising at a greater rate than the kangaroo population.

Wallabies

Although the wallabies increased in numbers in the '80's and '90's they did not reach the plague proportions of the kangaroos. The bonus ranged from 2 pence to 6 pence and bonuses were paid on from 5,000 to 15,000 in a year. In the neighbouring district of Tenterfield a bonus was paid on 61,531 wallaby scalps in 1892. It is rare to see a wallaby on Kalanga today and while there are a few at Inkerman their numbers do not appear to be increasing.

Dingoes

The last dingo in this area was shot during the first world war. Running sheep and opening up the country has eradicated the dingo and forced him on to the eastern scarp of the district where he is confined by aerial baiting.

Kangaroo Rats

Although in plague proportions in the '80's and '90's these small marsupials have completely disappeared and I have never seen one here. In the early 1880's before the arrival of the hare they were used for coursing and by 1886 a bonus of 2 pence a scalp was offered. That year 157 scalps were paid for and this figure rose to 11,264 in 1889 and the bonus reached the peak of 6 pence per scalp. 16,429 scalps were paid for in the Tenterfield district in 1892.

Koalas

A disease wiped out the koalas and there has not been one in this area since 1920.

Native and Tiger Cats

These animals appear to be extinct here now.

Gliders

A few gliders are seen from time to time at Inkerman and probably their numbers are restricted through lack of hollow trees.

Possums

Like the gliders their numbers appear to be kept down owing to the lack of hollow trees, as they are quite numerous in the town of Glen Innes where they have 'cover' in the roofs of houses.

Imported Animals

Hares

Hares were the first of the imported animals to be declared noxious in this district. The first one was sighted about the year 1889 when the local paper recorded that the dog population of Glen Innes gave chase. By 1893 a bonus of 2/6d was offered and 73 scalps paid for. Numbers increased steadily and in 1895 the bonus had dropped to 6d a scalp and 257 were paid for. It is worthy of note that in 1892, 58,808 scalps were paid for in the Mudgee district. By the early 1900's hare drives were being held in this valley and up to 250 were being shot in an afternoon. By 1920 they had ceased to be a problem and their numbers are gradually decreasing in this valley. Only an odd one has been seen at Inkerman.

Rabbits

Apparently the rabbit did not reach the Glen Innes district until the early 1900's. So far I have not been able to pinpoint the date. However, they were here in plague proportions in 1920 and it was not until 1935 that we had them under control at Kalanga. Eradication of harbour and the introduction of myxomatosis has eliminated them on this basalt country in which they find it hard to 'dig in', but in view of past history it is necessary to see they do not gain a foothold. How much damage they did will never be fully assessed but it is clear they eradicated a number of the species of better natural grasses. Stock Returns of 1884 show Kalanga as comprising 2,700 acres and running 4,200 sheep. By 1920 the holding had been increased to 3,500 acres but would not run more than 3,000 sheep. In the 1880's Louis Pasteur was paid £20,000 for a cholera vaccine to eradicate rabbits in Australia. Apparently the public outcry against its use was such that it was never used.

Foxes

It appears that the fox followed the rabbit into this area. When the rabbit numbers were high they did not seem to have much effect on the rabbit population. Today, however, when rabbit numbers are low the fox is making an important contribution by keeping the rabbits and hares down. On the other side of the ledger he must be responsible for keeping down, if not eradicating, a number of ground nesting birds and has probably had a lot to do with the extermination of the kangaroo rat. Although they do kill lambs my personal experience has led me to believe that, if numbers are controlled, they are not a dangerous threat in this direction. As they eat blackberries they could be responsible for spreading this pest. When their numbers reach a certain level epidemics of mange among them tend to limit the population size. While there are considerably more in this area today than there were in 1920 their numbers have tended to vary over the last 20 years. When we consider their numbers appear to be increasing to dangerous proportions we have had good results from poisoning on a neighbourhood basis. Fowl heads are procured from abattoirs and all landholders distribute these, impregnated with poison, just prior to the lambing season.

Birds

When I came to Kalanga in 1920 there were very few small birds in the area. However as we decreased the rabbit population the small bird population increased. Whether this was coincidental I am not in a position to say.

Since 1920 there have been changes in the bird population here.

Galahs

Galahs have come into this area since World War II. Probably this was brought about by the use of the header for stripping grain. Prior to the war most grain was harvested by cutting the crop with a reaper and binder, putting the sheaves into a stack and threshing it out of the stack, after which the trash was burnt. In stripping the grain with a header, a proportion is left in the paddock which is readily available to the galah. Being an early nester the galah utilises most of the nesting accommodation available so that the birds that nest later have to look elsewhere. In the short time they have been in residence the galahs have increased rapidly and may reach plague proportions in the near future.

Eastern Rosellas

Eastern rosellas were numerous in 1920 and it was common to see flocks of 100 birds in the late summer. Today their numbers have decreased and we seldom see a flock of more than 20. The same applies to the red-rump or grass parrot. I attribute this decline in numbers firstly to the clearing of the timber and secondly to the invasion of the galah.

Starlings

In the 1920's flocks of up to 500 starlings could be seen in the summer months feeding on insects among the flocks of sheep on the open country, and the droppings on the backs of the sheep bore ample testimony to their presence. Today it is rare to see more than about 40 in a flock. Like the rosellas I attribute this falling off in numbers to lack of nesting facilities.

Whistling Eagles

This bird has disappeared from the scene in the last 15 years. In the 1920's I can remember numbers of from 50 to 100 congregating on the flats when the scarab beetles were hatching out of the ground. Each year they nested in the big trees along the flat and their whistle was a familiar sound in the summer months. Their disappearance seems to co-incide with the use of organic phosphates in blowfly repellants.

Dusky Moorhens and Reed Warblers

These birds were not present on the creek in 1920, but have made their appearance since. Perhaps their coming heralds the doom of the creek as the clear running stream it used to be. Water run off has declined since the use of fertilisers and a spring at the back of Kalanga which was permanent for a hundred years has failed completely. Already the Reddestone and Furracabad Creeks are spoilt by bullrushes which have held the silt so that the channel can no longer carry the flow of extra water after rain.

Comparison between the Merino Sheep, the Kangaroo and the Aborigine

They all have the ability to travel over long distances for food and water, and have nomadic habits which have allowed them to thrive under Australian conditions where seasons tend to be uncertain. While the aborigine is fast disappearing from the scene his decline is probably due mainly to the change to the white man's way of life. There are signs that the merino sheep is being pushed out of the New England region by pasture improvement which suits the British breeds better. What of the kangaroo? Will he adapt himself to the new conditions? Although he doesn't like clover there are signs that he likes the imported grasses and his numbers will increase.

Conclusion

The coming of the white man has been responsible first for 'population explosions' in the native fauna. When the first ringbarking was done there were still patches of scrub for shelter and the virgin growth of grass on the newly ringbarked country probably increased the oestrogen in grass which in turn stimulated the breeding of the marsupials. As ringbarking increased and more of the country became exposed, the marsupial became easier prey to man and later foxes for the smaller ones.

Ringbarking and clearing also destroyed a number of the nesting sites for birds and as these became scarcer in many cases the stronger forced out the weaker.

It would appear that the two most important things in a wildlife population are cover and food and the ratio between the two play an important part in the increase and decrease in populations.

At Kalanga the yellow box trees have been defoliated by lerps over an area of about 60 acres. Some of these trees appear to be recovering but some are definitely dead. Is this disease eventually going to kill all the yellow box trees? Since the introduction of artificial fertilisers the amount of water run off has decreased. Will we reach a stage where our creeks cease to run?

With the present rural depression it is becoming more and more difficult to deal with noxious weeds and animals. Will we reach a stage where we have further 'population explosions' among animals? Are changes in bird populations going to change the vegetation? What is going to happen as a result of some of the chemicals we are using today?

We can go on asking questions but if we are going to answer some of them it is important to know what happened in the past. Also there is a need for keeping records of the changes which are taking place. The change is often so gradual that we do not realise that it is happening.

RECORDS OF WILDLIFE AS PESTS IN THE ARMIDALE DISTRICT, 1812-1975

K.A.Johnson and P.J.Jarman

The New England Tablelands were discovered by Oxley in 1812, and by 1832 the first settlers had arrived, at Walcha, with sheep. Thereafter the rate of settlement was very rapid. By 1840 there were 66 stations operating, and by 1848 all the best grazing land was occupied. In the following eight years only 10 stations were added in the rough country to the east. The Land Act of 1861 allowed free settlers to take up land of 40 to 640 acres (16 to 259 ha) before government survey, and so restriction of stock with fences began to take the place of shepherding.

Oxley and early settlers described the country as an open park-like tussock grassland, irregularly and fiercely burned by aborigines. By 1860 aborigines were no longer free to burn the grassland, and squatters indulged in regular burning in late winter as a pasture management practice. This, plus grazing and the use of introduced grasses and clovers, altered the tussocky nature of the grassland.

Reports of the 1830s mention aborigines and dingoes as predators of sheep, with kangaroos and possums scarce in numbers. By the 1870s possums had increased so greatly that they were important pests of maize crops, and rat-kangaroos were noted as pests on small fields of potatoes. Also in the 1870s, kangaroos and, it appears, wallaroos had increased to an extent where they competed strongly with sheep for pasture.

The first half-century then is characterised by three main types of wild-life pest: (i) the predator of stock; the dingo.

(ii) predators of crops; the possums and rat-kangaroos.

(iii) competitors with stock for feed; kangaroos and wallaroos.

Kangaroos and other large macropods were thought to be sufficiently damaging in the 1870s for squatters to offer a bounty of 6d for kangaroos and 3d for wallabies. In the 1880s kangaroo numbers were high indeed, and there are records of 10,000 being killed on one property in one year, and 20,000 on

TABLE 1

	Rock Wallaby	Hare	Rat K'roo	K'roo + W'roo	Dingo
1881				6D	10S
1883	3D			6D	10S
1887	3D		3D	3D	20S → 30S
1890	3D		6D	CROW	20S
1902	1D	3D	2D	6D	40S or 20S
1907	STOPPED	⋮	⋮	6D	⋮
1909	1D	2D		9D	
1911	FOX 10S			⋮	
1912	5S 2/6	2D	2D	9D	20S → 17/6
1913	5S 2/6	2D	STOPPED	1S	25S → 17/6
1914	2/6	2D		1S	ditto
	⋮	↓		⋮	15S → 7/6
		STOPPED			⋮

Bounties offered by the Armidale Pastures Protection Board, 1881 to 1914

another property in 4 years. Admittedly these properties were probably quite large. Pressure on government was such that in 1880 the "Pastures and Stock Protection Act" was passed which lead to bounties being offered on scalps of pest species.

On the 24th of January 1881 the first bounties were offered in the Armidale district, and the first scalps were to be received "on the 8th of March at 10am in the presence of a receiver and a member of the Board." These original bounties were offered at the rate of 10/- for dingoes and 6d for kangaroo and wallaroo. In 1883 rock wallaby was added at 3d. We are not certain what rock wallaby were, but they were probably not scrub wallaby, swamp wallaby, kangaroo, wallaroo or rat-kangaroo, as these were separately named in the records. It may in fact have been brush-tailed rock wallaby, (*Petrogale penicilata*), very few colonies of which now remain in the Armidale Pastures Protection Board District.

Other species were of course killed without the incentive of a bonus. From the time of their abundance in the 1870's, possums were taken for their skins which were collected by itinerant skin dealers at 3/- a dozen. The value of their skins increased considerably until they had to be protected. Exactly when they were made a protected species we do not know.

In 1880 the rat-kangaroo was put on the bounty list at 3d a scalp, and dingoes, which had risen in bounty value to £1 in 1886, were further raised to 30/- in August of 1887. In that year the bonus on kangaroos and wallaroos was stopped on the 1st November, and at some time between then and 1913 they were proclaimed protected species. In 1890 the bonuses were dingo £1, rock wallaby 3d, and rat-kangaroos had doubled to 6d.

More complete P.P.B. records are available from 1900. In 1902 bounties were offered at the rate of dingoes £1 to £2, depending on where caught, scrub wallaby had been added at 2d, the rock wallaby was down to 1d, rat-kangaroos were down to 2d, crows were now on the list at 6d, and the hare had been added at 3d. This list shows that supposed predators of stock, dingoes and crows, were considered very important relative to the herbivores. Local associations had been formed for the destruction of dingoes. The first introduced species, the hare, is now on the list. In December 1904 the P.P.B was asked by the "Sparrow Pest Association" to place the introduced sparrow on the noxious animals list. The board acknowledged its pest status but advised that it could not act on the suggestion.

That most renowned of the introduced species, the rabbit, featured only briefly in the bounty records in 1905. The Tamworth Board had taken the rabbit more seriously much earlier, offering a bonus of 1/- on it in 1882, when their annual bounty estimates were 100,000 kangaroos and wallaroos, and only 1000

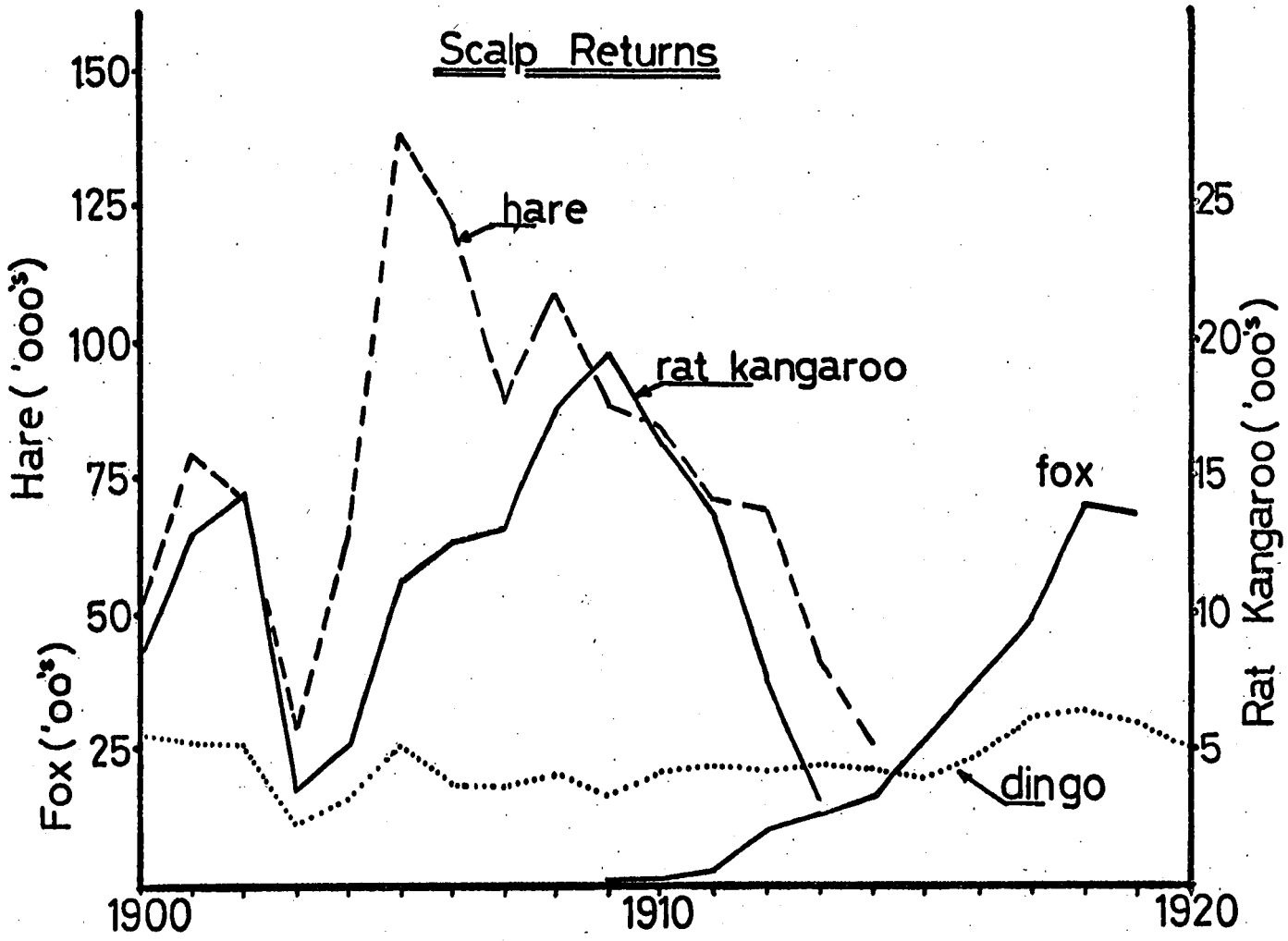


Figure 1: Scalp returns: Armidale Pastures Protection Board

rabbits. The Armidale Board at first treated the rabbit with complacency as they considered it to be in small numbers. However they did state in 1902 that "natural enemies of the rabbit must be "RELIGIOUSLY PROTECTED", but still continued to offer a bounty on the dingo. In 1903 the stock inspector was called on to act as rabbit inspector. The low numbers of the pest did not warrant the employment of a fulltime Inspector. In October 1904 several Board members referred to the steady increase of rabbits. By 1905 poison carts were operating in the area and by 1906 the Board considered compelling land owners to destroy rabbits i.e. the rabbit was not yet a proclaimed noxious animal in the district. In 1907 it was considered that rabbits were not as plentiful as in 1902. To a suggestion in May 1909 that electrified wires be placed at the base of netting fences to control rabbits, the Board replied that there were not enough rabbits in the district to warrant such a method being tested. The rabbit now seems to have caught them by surprise. In October of 1909, 6 months later, they considered the appointment of a Special Rabbit Inspector as "absolutely necessary as the rabbit pest was assuming serious proportions". The first report of the inspector was heard by the Board in May 1910, and subsequent reports dealt mainly with the rapid increase and spread of the rabbit.

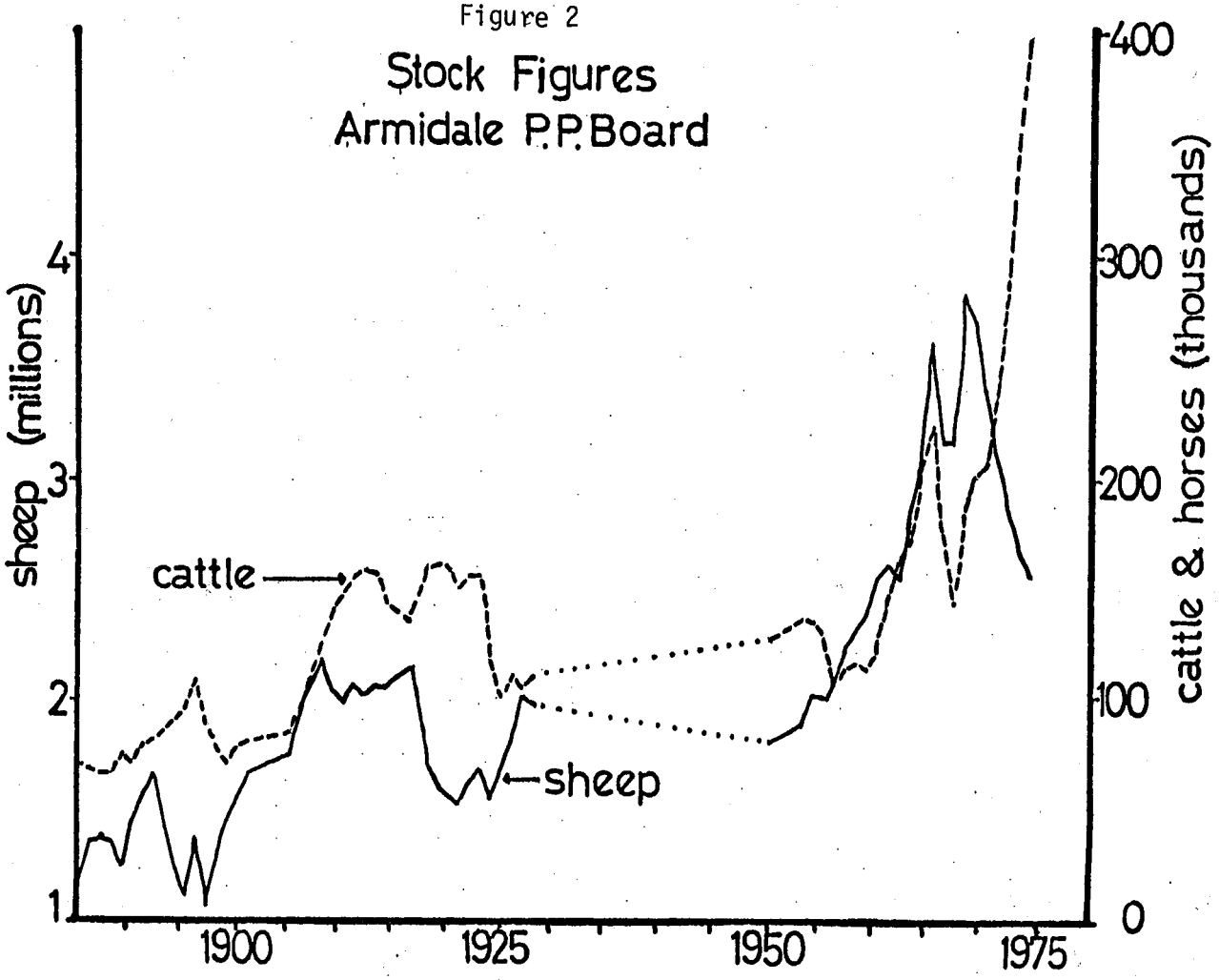
The last introduced species to be added to the bounty list was the fox, which came into the bounty records in 1909, and was bountied at 10/- a scalp in 1911. It was first mentioned in 1903 when a bounty of £1 was considered.

Over the period 1900-1919 there were profound changes in the numbers of scalps of the various species being returned. There is a correlation between the decline in hares and rat-kangaroos, and the increase in abundance of rabbits, and the subsequent increase in fox returns. Dingo returns remained surprisingly constant over this period. At the time observers felt that the increase in foxes was responsible for the decline in hares and rat-kangaroos. At this distance in time we can not refute this, but it is clear that sheep and cattle numbers were also increasing fast over this period, and the final disappearance of tussock grasslands under grazing pressure or pasture improvement was probably important. In June 1913 the bonus on rat-kangaroos was discontinued because the Board considered it to have declined and to be falling prey to the fox. On November 10th 1914 the bonus on hares was dropped due to the stringency of the Boards budget caused by the European war.

So in 1914, the board was left offering bounties only on the three predators: dingoes, crows and foxes.

What is the current status of the rat kangaroo and hare? The hare is now infrequently seen around Armidale although still maintains its numbers. We

Figure 2


Stock Figures
Armidale P.P.Board
sheep (millions)
cattle & horses (thousands)
cattle
sheep
1
2
3
4
0
100
200
300
400
1900
1925
1950
1975

do not know where we could find rat kangaroos on the Tablelands now. Rock wallabies are still to be found, but only in a few isolated colonies. By contrast, kangaroos, wallaroos, swamp wallabies and red necked wallaby (which we assume to be the 'scrub wallaby' of the records) are fairly numerous, and in some places are shot in large numbers, with or without licences issued by the National Parks and Wildlife Service. Many landholders think that kangaroos, wallaroos and other macropods have been, or are, increasing again.

This leaves us with a picture of the dynamic nature of pest populations in the district. From the earliest records we detect possums being at first scarce, then increasing to pest proportions, then declining to rarity, and protection. They are now common and, at least around towns and orchards, at times are treated as pests. Kangaroos and wallaroos have followed the same pattern, but rat kangaroos, hares and possibly rock wallaby have never recovered from the decline after the pest-status peak in their numbers (Figure 1). Foxes seem not to have declined, even though there is an effective price tag on them of about $10 to $15 a skin. Dingoes, discussed by Bob Harden, make their presence felt only along the boundary between forested and pastoral land. They have been pushed back to the edge of the escarpment.

Possibly other pests will rise and decline. Perhaps pigs and galahs are rising now. The past 20 years has seen an increase in the use of fertilisers, an increase in croplands, and an enormous increase in stock numbers (Figure 2). We do not know what effects these changes in land use are having.

One could look at the bounty records and conclude that bounties had in many cases been effective. We think however, that the changes in pest populations are a result of the way changing land use practices have affected habitat, and that pest control may best come via the manipulation of the pest's habitat.

Could it be that attempted control of noxious animals through shooting, poisoning, the payment of bounties and aerial baiting is, in fact, an exercise in futility? Perhaps this is too simple a view, and the individual farmer can still benefit himself by applying control or extermination methods on his own property. But the picture we get from these pest destruction records is one of widespread phenomena in population ecology, calling for equally widespread corrective measures to be applied through regional land use policies.

Acknowledgements

We would like to thank officers of the Armidale Pasture Protection Board for allowing us access to their records, and Ms. M.J. Currey for her help in data analysis.

AGRICULTURE, FORESTRY AND WILDLIFE IN THE UPPER CLARENCE REGION OF N.S.W. WITH PARTICULAR REFERENCE TO MACROPODS AND THE EDGE EFFECT

J.C. McCann

A survey by CSIRO Division of Wildlife (Calaby, 1966) revealed this area to have the richest mammal fauna so far reported from any area of comparable size in Australia. The report stated "It is of considerable significance to mammal conservation in Australia that such a rich and varied fauna can still be found in an area with a long history of European economic exploitation, and there is no doubt that this situation is largely accounted for by the combination of State Forests and the local form of management of private and leasehold land for beef production."

However, the basic reason for abundance and diversity of wildlife in the area is the habitat diversity which itself results from topographical, geological and climatic factors. Thus in the northern half of the area there are the McPherson and Great Dividing Ranges and the upper section of the Koreelah, Tooloom and Richmond Ranges. These have large areas of basaltic or basalt-influenced soils and high rainfall which support sub-tropical rainforest and high site quality wet sclerophyll eucalypt forest.

Further south towards the Clarence River, soils derive from Jurassic sandstones and shales and are often rocky. Altitude and rainfall are lower so that rainforest is usually restricted to gullies while the predominant vegetation is low site quality wet sclerophyll and dry sclerophyll forest. Within both of these zones there are smaller scale variations based on localised soil and topographic changes which produce a mosaic of forest types.

Another factor influencing the diversity of species in the area is the geographical location of the region approximately mid way along the eastern coast of Australia, immediately east of the Darling Downs. This allows an overlap of northern and southern species, e.g. red-legged and red-necked pademelons.

The main factor in maintaining this wildlife diversity since European man arrived has been the pattern of land usage, the reservation of much of the native vegetation on the ranges as State Forests around 1916 and the utilisation of the lower slopes and valley floors for cattle grazing.

Macropods

This paper is limited to macropods. There are eleven species of macropod in the area ranging from the grey kangaroo down to the potoroo. These will be discussed in detail.

Effect of European land usage

The overall effect of the land use pattern has been to provide large areas of suitable daytime habitat adjacent to a greatly improved feed resource, suitable to nocturnal grazing animals, over an extremely long interface. This is known as the edge effect.

1. Forest land

Past selective logging has changed the previously overmature forests with a rather open ground layer, to forests with a mixture of age classes (regeneration, advance growth and overmature trees) and a much denser understorey. This has probably led to an increase in species utilising dense habitats such as the black-striped wallaby, and to a decrease of species favouring more open habitats, such as the grey kangaroo.

2. Agricultural land

The clearing of agricultural land for grazing has had the reverse effect. This has favoured species inhabiting more open country, particularly where clearing has been selective, and has adversely affected species favouring denser habitats. The most important change however, has been the dramatic increase in food available to macropods and the increased quality of that food (i.e. improved pastures) which has led to increased populations of macropods along the forest/pasture boundary.

The increased edge has not affected all macropod species equally. The effect has been very variable depending on the abundance of the species originally, how much of its habitat is located on forest boundaries and the ability of the species to adapt to edge conditions.

I have grouped the eleven species into three groups: those significantly affected by edge conditions, those only locally affected and those which are least affected.

Individual Macropod Species

Group 1 Significantly affected

(i) Red-necked wallaby (Macropus rufogriseus)

The most abundant large mammal in the area. It is found throughout all forest types except rainforest, and has adapted extremely well to the edge situation as well as the partially cleared country in the rough grazing areas. It has a decided preference for improved pasture and crops such as lucerne, and animals are known to travel 500 m from the forest edge to lucerne paddocks. This species is the one most adapted to edge conditions and populations have increased markedly along the forest edge.

(ii) Eastern grey kangaroo (Macropus giganteus)

This species is common in the area and its natural habitat consists of the more open forest types with grassy floors. Much of this habitat is adjacent to agricultural land, and, like the red-necked wallaby, the grey kangaroo has adapted well to edge conditions and populations have increased. Partial clearing of the denser forest areas on agricultural land has created an ideal habitat for this species and populations have built up here also. Greys are generally seen feeding on areas of short green grass, but they do feed on crops such as lucerne at times. Because of their size and their gregarious nature they can cause considerable damage.

(iii) Whiptail wallaby (Macropus parryi)

This species is common in the southern half of the area although it is classified as rare in N.S.W. being restricted to the N.E. corner. It inhabits the steep slopes and knolls in open eucalypt forests with a ground layer of short, thin stemmed grass, particularly kangaroo grass. Much of its habitat is adjacent to the forest edge or has been left uncleared or partially cleared in private property because of its steepness, and this species has increased in numbers in these areas. The whiptail does not move a great distance from its daytime habitat to feed and so does not feed a great deal on crops, as these are generally located on the creek flats.

(iv) Wallaroo (Macropus robustus)

This species is found mainly in the southern half of the area where more of its habitat, grassed rocky slopes and hilltops, occur. Because of the rocky nature of its habitat it will remain largely uncleared as pastoral improvement increases in this area and populations could build up to considerable proportions: although they are only moderate at present.

Group 2 Localised edge effect

(i) and (ii) Red-necked pademelon (Thylogale thetis) and Red-legged pademelon (Thylogale stigmatica)

Both these species inhabit rainforest and are very common in it. The two species do not seem to overlap but occupy different parts of the rainforest.

Approximately 25 percent of the State Forests in the area consist of rainforest, but this mainly occurs on shelves and plateaus away from the forest edge so that pademelon population have not increased much. One exception to this is Acacia Plateau where the amount of rainforest left is sufficient to allow the build-up of large populations. (This is in contrast to the situation on the Dorrigo Plateau).

(iii) Black-striped wallaby (Macropus dorsalis)

This gregarious species is found scattered throughout the area in moderate numbers and inhabits some small patches of rainforest and scrubby gullies with a rainforest understorey. Where these areas adjoin the forest edge populations can build up and feed out onto improved pastures and crops. However, populations are usually localised and the overall impact not great (e.g. Koreelah S.F.).

(iv) Swamp wallaby (Wallabia bicolor)

This species occurs in low numbers in areas of dense bracken and other ground cover mainly on the upper slopes of the ranges. These areas are usually away from the forest edge and improved pastures and so populations have not built up. On Yabbra S.F., where an area of suitable habitat adjoined a broad ridge cleared and planted to oats, grazing in moderate numbers occurred. Overall, impact is small due to low numbers.

Group 3 Those least affected by edge conditions

(i) Brush-tailed rock wallaby (Petrogale penicillata)

This species occurs on nearly all areas of suitable habitat such as the sandstone cliffs in the southern half and the volcanic outcrops in the northern half of the area. It is a gregarious species and individuals have definite, very restricted, territories. Its habitat is generally located away from the forest edge and improved pastures, and total numbers would be low in relation to other species. Impact on agriculture would be negligible.

(ii) Rufous rat-kangaroo (Aepyprymnus rufescens)

This species is found scattered throughout its habitat of open woodland and partially cleared woodland in low numbers. It does feed out into the open and is occasionally seen on lucerne crops, but because of its small size and low numbers the impact is insignificant.

(iii) Potoroo (Potorous tridactylus)

This species, the smallest macropod in the area, is relatively uncommon and found in woodland with a dense grass layer of native sorghum and blady grass. It does not appear to feed out from the forest edge and has no impact on agriculture.

Conflict or Co-existence

Present Situation

Although there are eleven macropod species in the area and an extremely long length of forest edge the situation so far has been mainly one of co-existence between forestry, macropods, and agriculture. There are a number of reasons for this:

1. Forest boundaries are usually located adjacent to the farmers "back paddock" where little pasture improvement has been carried out. These areas are visited less frequently by the farmer and, although he is generally aware of the high populations of macropods there, he is generally not concerned about their impact on rough grazing country.
2. Crops such as lucerne and maize are cultivated on the fertile alluvial creekflats, which are usually a long way from the forest edge and out of range of the edge effect, so that little damage is done to these crops by macropods. The main exception to this is Wallaby Creek and this area will eventually become a Nature Reserve.

The Future

As pasture improvement and crop growing increase, and areas closer to the forest edge are involved, conflict will arise. This will probably be caused by the first two species, the red-necked wallaby and grey kangaroo, and some control measures may be required. Hopefully this will involve commercial use of the animals rather than wastage and if the grazier can obtain some financial return it will foster an interest in the long term conservation of populations rather than extermination.

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ASPECTS OF MACROPOD PROBLEMS ON THE DORRIGO PLATEAU

K.A. Johnson

My field study area was located about 80 km east of Armidale on the Dorrigo plateau. Although european settlement of this area began around 1850, intensive development of agricultural and timber resources did not begin until 1900 - 1920 when selections were thrown open to farmers. Road and rail services were vastly improved during this period allowing greatly increased utilisation of forest resources. Dairying, beef cattle production and potato production are now major agricultural enterprises, and the sub tropical and warm temperate rainforests, along with the sclerophyll forests, have been well utilised by local saw mills.

Macropods became significant pests on the plateau towards the end of the 1960's, and here it is interesting to note the changing nature of pest problems. Marks, writing in 1910, reported weeds as the only pests of agriculture. No mention was made of either dingoes, rabbits or macropods in this publication. In a soils and land use survey on the plateau, McArthur (1964) stated that the area indeed had a pest problem which was limiting agricultural production. However, the pest species he recorded, apart from weeds, were Oncopera (a caterpillar which nocturnally grazes pasture), dingoes and rabbits. In the space of some 6 years, the entire nature of the pest problem altered. During this period, dingoes were aerially baited, rabbits were brought under control, and macropods became the dominant pest group.

My research centred on a beef cattle and potato producing property north of Dorrigo, situated in a belt of coachwood - crab apple warm temperate rain forest. The landholder was concerned about the fairly severe pressure pademelon (Thylogale thetis) and swamp wallaby (Wallabia bicolor) were putting on his pastures and potato crops, and was rather anxious to do something about it. Pademelons were the

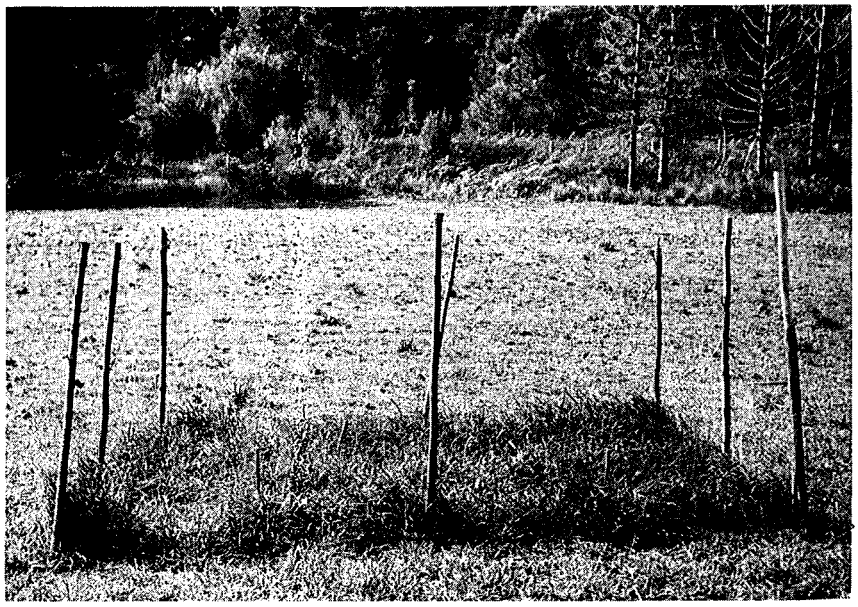

Plate 1: Two exclosures on a crop of oats after 92 days of grazing by pademelons outside the exclosures.

most abundant macropods in the area (cf. McCann's study at Wallaby Creek reproted in these proceedings), but swamp wallabies, parma wallabies (Macropus parma) and potoroos (Potorous tridactylus) were also present.

I was not convinced that pademelons were doing much harm until an exclosure trial on a 2ha crop of oats was completed (Plate 1). After 92 days the standing growth inside the exclosure was cut and dried. This showed that in the field 2,700 kg of dry matter/ha was being removed by pademelons and wallabies. This is equivalent to 123 bales of hay (at 23 kg or 50 lbs per bale), which would maintain a 454 kg steer for about 417 days.

Potato crops are also utilised by macropods. Swamp wallaby grasp the potato plant at the base in their mouth, hoist it from the ground, and eat the tubers. The tops are not often eaten. Sometimes they use their forepaws to dig the tubers from the ground. I made no attempt to quantify the loss of potatoes.

Most of the grazing pressure by macropods occurs near the forest edge, and the closer to the forest, the more intensive the grazing becomes. This trend was borne out by returns of a questionnaire survey. White clover pasture and oat crops were reported to be most notably used by macropods, but, of the areas sown, only one quarter was reported as suffering from pest damage. Again it seems that it was only the edges which were under pressure. Obviously the animals use the pasture edge as a food resource and the forest as a shelter. This is the "edge effect" I shall be referring to.

Since pademelons were the most abundant macropod in the area, most of my work refers to this species. I wanted to determine how regularly, over what duration, and over what area pademelons used the pasture, and similarly what use was made of the forest habitat. To determine this, I radio-tracked 10 pademelons. In addition I tracked three parma wallabies and two swamp wallabies which were trapped coincidentally in the pademelon study.

Figure 1 shows the pattern of use of forest and pasture for one pademelon which I radio-tracked. The pattern is typical for the other radio-tracked pademelons. The nocturnal radio-locations are taken from when the animal arrived to pasture in the evening until the last time it was on pasture the following morning. Diurnal radio-locations include all other points.

The animals use two reasonably discrete home ranges. The forest is used during day time for shelter and some sun-basking and foraging for food, while the pasture is utilised at night for grazing.

The nocturnal range is much smaller than the diurnal range. It covers 20% of the total home range compared with 80% covered by the diurnal home range (i.e. 1.4 ha compared with 5.4 ha). The nocturnal range is small even though the animal was spending about 10 hours out of a 24 hour day in this area. Note that the animal did not move more than 70 metres from the forest edge.

Movement to and from each range was remarkably regular. Each of the 10 pademelons I radio-tracked moved to pasture virtually every night, and the parmas did likewise. The time of movement was closely related to sunrise and sunset. At about dusk, pademelons quickly moved to pasture, their nocturnal home range, where they stayed all night. Then, shortly before sunrise, they quickly returned to the shelter of the forest.

These data indicate that pademelons and parma wallaby, utilising pasture, do so at night, and in a concentrated area relative to the diurnal home range located in adjacent forest.

How is this related to the increase in macropod numbers on the Dorrigo? The radio data indicate that these animals do not require a large area of forest habitat providing there is a reasonable quantity and quality of pasture available close by. Considering the large area of forest habitat present on the plateau, and that pademelons concentrate at its edge, one would expect access to food to be a major resource limiting population size. Hence an extensive forest/pasture edge has the potential to support a large macropod population. In the Megan/Leigh area of the plateau, farm land has been cleared in a way that has left a mosaic of interdigitating forest and pasture land, with a very extended forest/ pasture edge.

I think, then, that the most important factor contributing to the increase in pademelon populations on the Dorrigo has been pasture development and improvement, and the accessibility of pasture to the forest macropods. This has developed in three ways.

Firstly, from 1955 the potato industry began to expand. The crop requires intensive cultivation and heavy fertilising, and so the practise often is to plant one or two consecutive potato crops, sometimes with an oat crop between the two plantings, followed by the land being sown down to a clover and rye pasture. These species are usually nutritious and of high digestibility. According to local information, land available

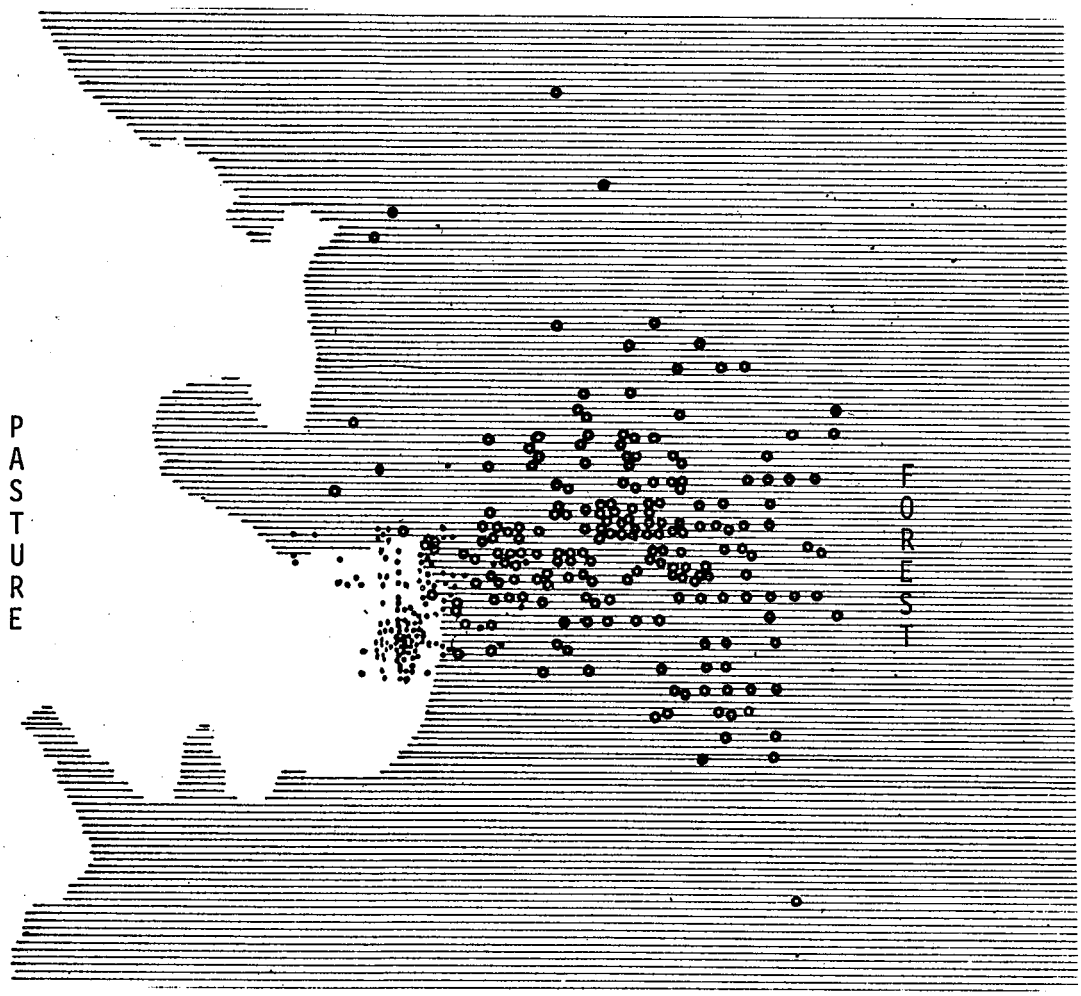

Figure 1: Diurnal locations (open circles) and nocturnal locations (dots), for pademelon No. 35, showing the apportionment of its time between pasture (unshaded area) and forest (hatched area).

for potato production has become scarce (crops may go in a cycle of 2 years potato and 5 to 7 years pasture i.e. a long rotation) and there is now a tendency to place crops closer to the forest. Hence the improved pasture which follows is increasingly accessible to the forest macropods.

Secondly, superphosphate use on the North Coast trebled between 1960 and 1970. In addition, molybdenated super and Q5 (nitrogen/phosphorus/potassium) fertilisers came into use, so I suspect that the nutritional quality of pasture, hence the nutritional status of pademelons, has improved accordingly.

Thirdly, I think that the decline in the dingo population (whether this was due to the aerial baiting programme of about 1967-1968 I do not know) has had an effect, but not solely through the removal of what was certainly a predator of macropods. Rather I think that dingoes may have been a constant harassment to pademelons, particularly to the more timid females and juveniles, and had the effect of reducing their free access to pasture, i.e. they chased them off. With fewer dingoes, the reproductive success of females and the survival rate of juveniles probably increased due to improved access to food.

Forest Management

I am not certain what effect forest management has had on pademelon populations. It could be that the forests have reached a seral stage, where the vegetation near the forest floor is providing near optimal conditions for pademelons.

Various control measures are used to limit the size of these macropod populations. Obviously if the whole area were cleared of forest there would be no diurnal habitat for the species, hence no pademelons. Shooting is a popular control method because it gives satisfaction to the landholder. Against these particular macropod species, however, I do not think that it is an effective means of control because it is expensive and time consuming, and mainly male macropods would tend to be shot as they tend to travel further onto the pasture, and to stay longer when the area is disturbed by a shooter. Since female pademelons appear to be promiscuous, the effect of shooting would be simply to harvest the males, and to reduce possible intra-specific social and competitive pressures on the population, thus allowing an increase in the rate of survival of young animals.

I oppose poisoning as a means of macropod control on principle. It is a non-specific control measure. There are many other wildlife species in the area which are not pests, but which would be susceptible to poisoning, e.g. possums, rats, and potoroos. An ecologically sound approach would seem to be to limit the availability of the pasture or crop being used by the macropods as a food resource. A netting fence along the pasture/forest interface would be most effective, but the expense is exhorbitant (at current prices the cost would be nearly 80 cents per metre). I have tried an electric fence and found that it effectively reduced the number of macropods using a potato crop which I observed. It is this method which would probably be of most use to the Forestry Commission where eucalypt seedlings in pl tations are to be protected.

Many farmers on the Dorrigo use hunting dogs of the hound group, like foxhounds or beagles, since these have less tendency to attack the neighbour's stock than might some other breeds. These hounds apparently do not kill many macropods, but the general racket and disturbance they create seems to keep animals off pastures and crops. Again the effect of this control measure upon the macropods would be to reduce the population to a level approaching that supported by the forest food resource alone.

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PRELIMINARY RESULTS ON THE DISTRIBUTION AND ABUNDANCE OF RED AND GREY KANGAROOS IN WESTERN N.S.W.

R.G. Sinclair

Aerial surveys of large mammals invariably return gross underestimates of true population size (see Table 1 in Caughley, 1974). The factors involved are numerous and are centred around the problems of seeing, recognizing and counting all of the animals present. These problems give rise to what is known as visibility bias. Workers recognizing this have attempted to overcome it either by (1) ignoring it, (2) reverting to use of their estimates as density indices under standardized conditions or (3) comparing their estimates with those obtained by some other technique. These solutions still retain their own inherent problems.

During 1974, we experimented with an aerial technique that estimates the extent of the visibility bias and allows calculation of a correction factor that is specific for a particular vegetation visibility class. Briefly, through experiments amenable to analysis of variance, we obtained significant effects of speed of flight, height above the ground and transect strip width. A number of other factors such as time of day, fatigue of observers, etc. were tested but were not significant. On the basis that sightability (i.e. the probability of an animal being seen) declines with increasing speed, height above ground and strip width, we examined the hypothesis that a regression of observed density on speed, height and strip width could be extrapolated backward to estimate true density at the zero value of these survey variables. That is, the "a" value of the regression equation being the intercept of the "y" axis, is an estimate of the true density. The results we obtained were generally consistent with this hypothesis.

Using this technique, we have been conducting an aerial survey of the area of N.S.W. west of the 500 mm annual rainfall isohyet counting both red and grey kangaroos. The work is part of a programme on the estimation of long term sustained yield offtake levels of red kangaroos in N.S.W. Dr. G.J. Caughley and myself are observers, Mr. D. Scott-Kemmis is habitat scorer and Mr. G. Wilson the pilot. Financial support is from both A.R.G.C. and the Department of Environment grants.

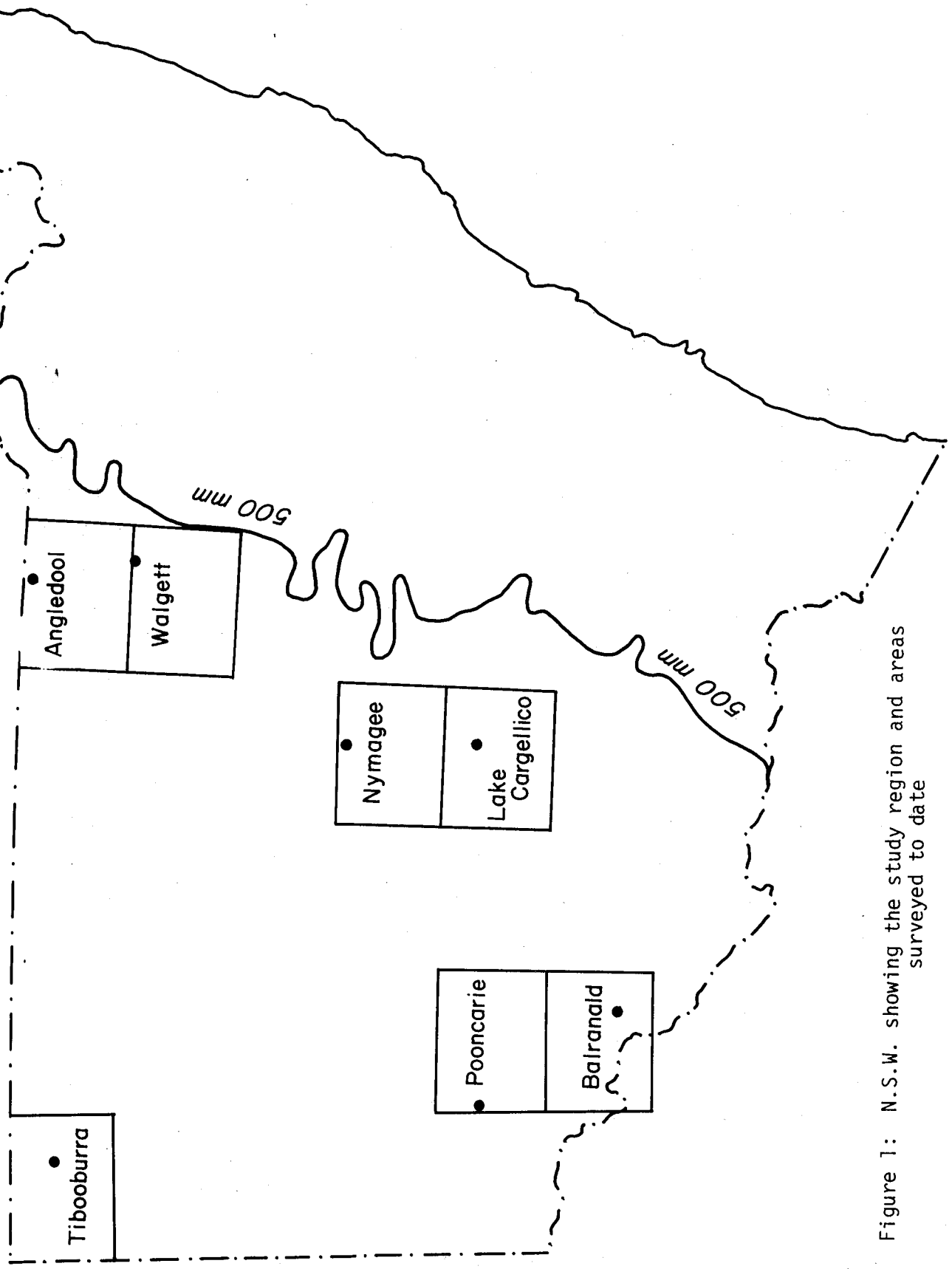


Figure 1: N.S.W. showing the study region and areas surveyed to date

Figure 1 shows the study area, i.e. some 400,000 km^2 that encompasses the whole of the range of the red kangaroo in N.S.W. and the areas censused to date, i.e. approx. 100,000 km^2. The surveys are based on 1:250,000 map sheet areas and are sampled at an intensity of approx. 2%. The levels of the survey variables being used are height 76 m, speed 160 kph and strip width 200 m.

In the 100,000 km^2 surveyed, the estimate (Table 1) of the total number of red kangaroos is 273,800 and for grey kangaroos is 496,600. At this stage of the project, no attempt is made to estimate the total population of the whole study area as the sampled areas are not sufficiently representative of the ranges of both species of kangaroo.

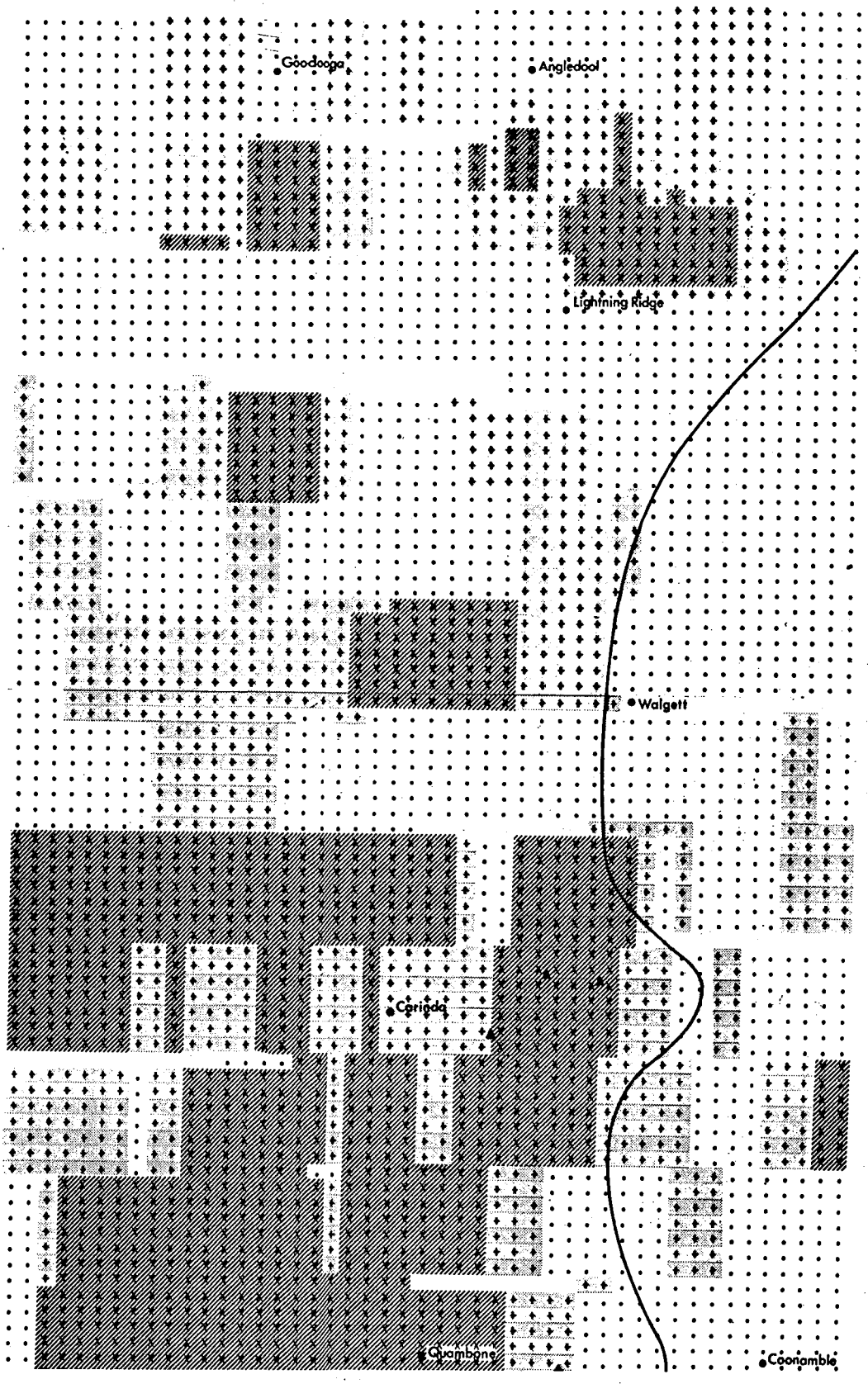
As an illustration of the range of densities likely to be encountered in western N.S.W. under recent climatic conditions, Table 1 shows the individual map sheet densities and numbers in the areas so far surveyed. The Tibooburra census was conducted in January, Balranald/Pooncarie in March, Angledool/Walgett in May and Nymagee/Lake Cargelligo in June of this year.

Habitat data are recorded concomitantly with kangaroo counts and this includes records of land-use practices. These data have not been analysed yet and we cannot draw firm conclusions on the interaction of kangaroo densities and different land-use practices. We can show that at the time of our surveys there was a boundary between areas of high and low kangaroo density that coincided reasonably well with a change in land-use.

The following figures represent the smoothed out distribution of kangaroos in the two 1:250,000 map sheet areas of Angledool and Walgett for red and grey kangaroos (Figures 2 and 3) and Nymagee and Lake Cargelligo for grey kangaroos (Figure 4). Each point represents the mean of the 6 points around it and has been put into one of 3 density classes, i.e. up to 4 kangaroos per km^2, from 5 to 10 per km^2 and over 10 per km^2. Actual observed densities ranged from zero to 80 per km^2.

The line on the right of the figures connects the most westerly points at which cultivated land was seen by the habitat scorer. It represents the extreme western boundary of the wheat belt but there remain to the east of this line large areas of uncultivated land. Because of this it is unlikely that food is a limiting factor to the density of kangaroos.

FIG 2 DISTRIBUTION OF GREY KANGAROOS ANGLEDOOL/WALGETT MAP SHEETS



▲ STATE FOREST
LESS THAN 4 PER SQUARE KM
5-10 PER SQUARE KM
GREATER THAN 10 PER SQUARE KM
BLANK = INSUFFICIENT DATA

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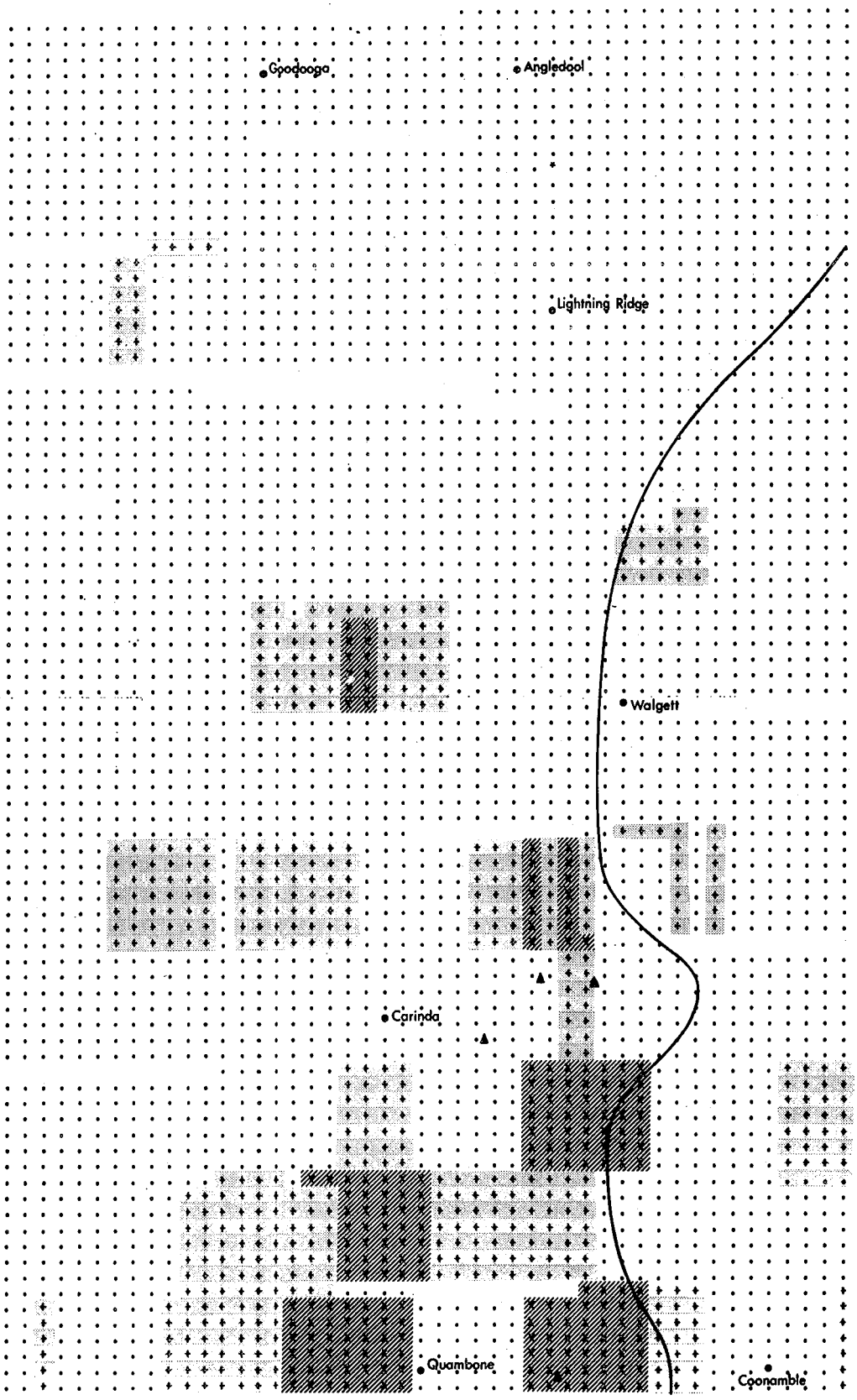
FIG 3 DISTRIBUTION OF RED KANGAROOS ANGLEDOOL/WALGETT MAP SHEETS



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5-10 PER SQUARE KM
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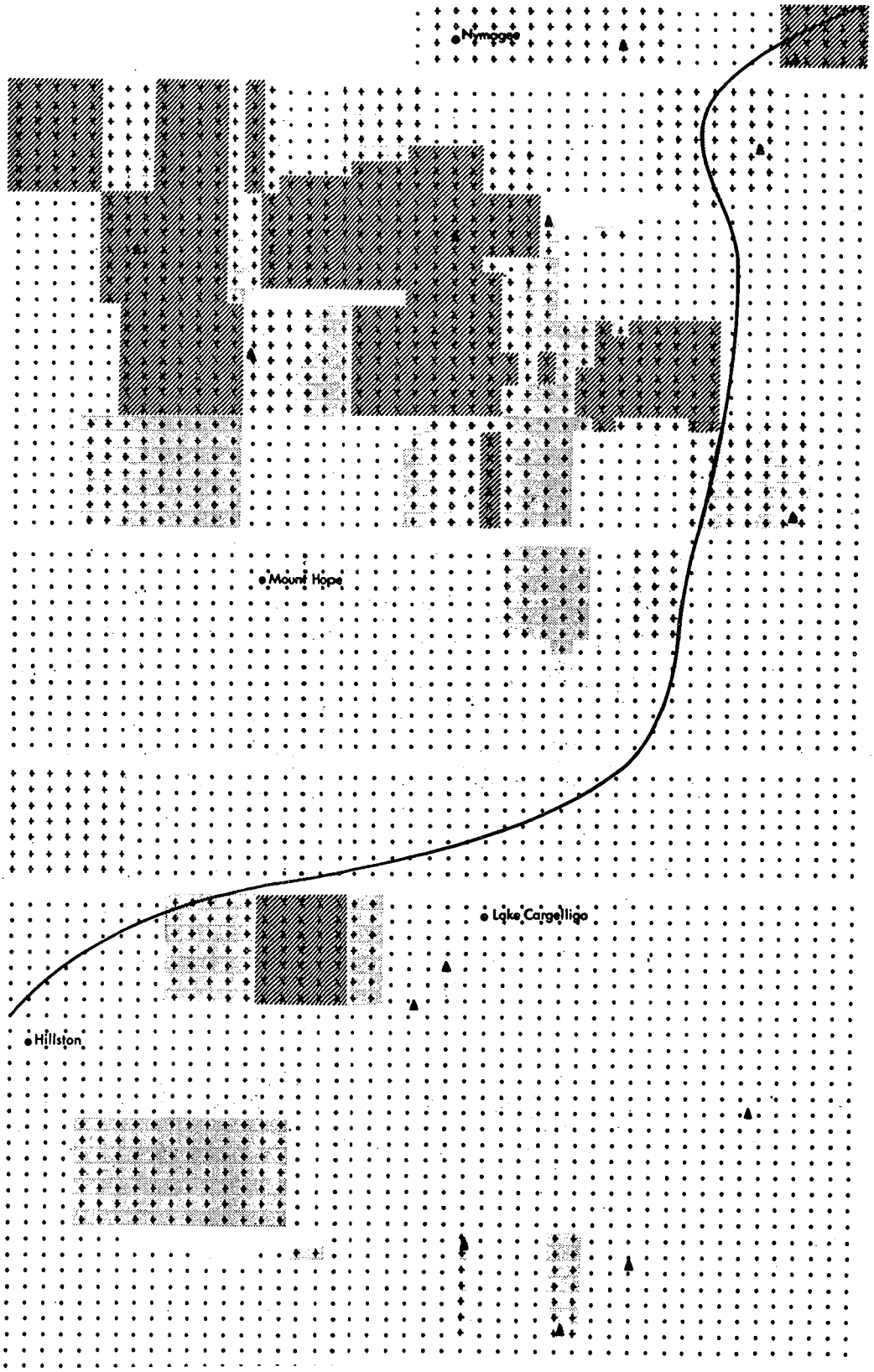
FIG 4 DISTRIBUTION OF GREY KANGAROOS NYMAGEE/LAKE CARGELLIGO MAP SHEETS



▲ STATE FOREST
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5-10 PER SQUARE KM
GREATER THAN 10 PER SQUARE KM
BLANK = INSUFFICIENT DATA

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It seems more probable that even lightly scattered cultivated paddocks provide a level of disturbance sufficient to substantially lower the density as shown in these figures. In the Nymagee/Lake Cargelligo area (Figure 4) the illustration is not so clear because the overall density was lower but the individual observed densities support the picture found for the Angledool/Walgett area. Other data from ground surveys also indicate that the higher the level of human activity the lower the density of kangaroos.

The ground surveys also suggest that there is a greater association of kangaroos with sheep than with cattle. This may be due to sheep grazing pastures lower than cattle and stimulating a small amount of green pick. There is as yet no indication of any relationship of kangaroo density and current stocking rates of either sheep or cattle.

Forestry is not a major form of land use in our survey areas but use is made of some marginal country especially for Cypress Pine. State Forests have been marked on the figures and it can be seen that many of them that are situated west of the cultivation edge line coincide with the areas of higher kangaroo density. During dry times (as at the time of our surveys) kangaroos may make use of State Forests where grazing pressure is low. The Forests probably also act as small refuges from commercial shooters.

National Parks have not featured widely in our censuses to date. In the survey of the Tibooburra area, we treated Sturt National Park as a separate stratum, but were unable to show that it supported a density much different from that of the rest of the map sheet. This is probably due to the fact that the National Park has not been established for a long time. During the survey of the Nymagee area, we censused a small portion of Yathong National Park and found there only a low density of kangaroos.

To conclude, by the end of 1975 we hope to have completed the aerial censusing of western N.S.W. and should have more information on the influence of different land-use practices on kangaroo densities. Until then, we can only indicate the range of densities likely to be encountered and show that even a partial change from a grazing regime to one that includes some cultivation does have a marked effect on kangaroo populations.

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TABLE 1

ESTIMATED ABUNDANCE OF KANGAROOS IN SPECIFIC AREAS OF WESTERN N.S.W.

Name of map sheet+	Density per km^2 Red	Grey	Number Red	Grey	± s.e. Red	Grey
Tibooburra	7.26		112,380		5,850	
Balranald) Pooncarie)*	1.59	1.64	44,900	46,100	5,300	4,400
Angledool	1.93	5.55	30,800	88,700	4,600	8,700
Walgett	5.15	13.28	81,500	210,300	12,100	20,900
Angledool) Walgett)*	3.54	9.41	112,300	299,000	12,900	22,600
Nymagee	0.10	7.22	1,600	112,200	700	11,700
Lake Cargelligo	0.18	2.56	2,700	39,300	1,100	4,700
Nymagee) Lake Cargelligo)*	0.14	4.89	4,300	151,500	1,300	12,600
Total			273,880	496,600		

\+ Each map sheet = approx. 15,000 km^2

* Two map sheets together

Area west of 500 mm rainfall isohyet = 421,800 km^2

Area surveyed to date = 106,000 km^2

RED KANGAROOS AND LAND USE ALONG THE NEW SOUTH WALES, QUEENSLAND, AND SOUTH AUSTRALIAN BORDERS

P.J. Jarman and M.J.S. Denny

Introduction

The distribution and abundance of most terrestrial mammal species will be determined, or at least strongly affected, by availability of and access to the food, water, minerals and shelter needed by each species. Access to these requisites will be affected by their intrinsic spatial and temporal distributions, by secondary factors such as the risk of predation or interspecific facilitation (one species making food available to another species), and by any intra-specific behaviour which controls resource apportionment. The past history of a population will also affect its present distribution and abundance.

We are usually less ready to recognise the components of man's influence upon a wildlife species or community than we are to recognise "natural" influences. We take an anthropocentric view by thinking that most of what we do is relevant only to us, and not to the wildlife which shares our environment. We must become aware of the all-pervading influences of our land use practices if we are going to move from the current situation of conflict (often unrecognised by us) with wildlife, to one of co-existence.

This paper is an exercise in developing our own awareness; it is a preliminary statement on research into the effects of land use practices upon the distribution and abundance of Australia's best known wild animal, the red kangaroo. The research is continuing.

Observations

Red kangaroos are widely distributed throughout the western division of New South Wales and adjacent areas of South Australia and Queensland, in open or lightly wooded alluvial plains, downs and sand dune country. Several studies have been made, in varying depths, of their densities and local distribution (e.g. Caughley, 1962; Newsome, 1965a and b, and Frith, 1964), but each of these has been confined to one or other of the states;

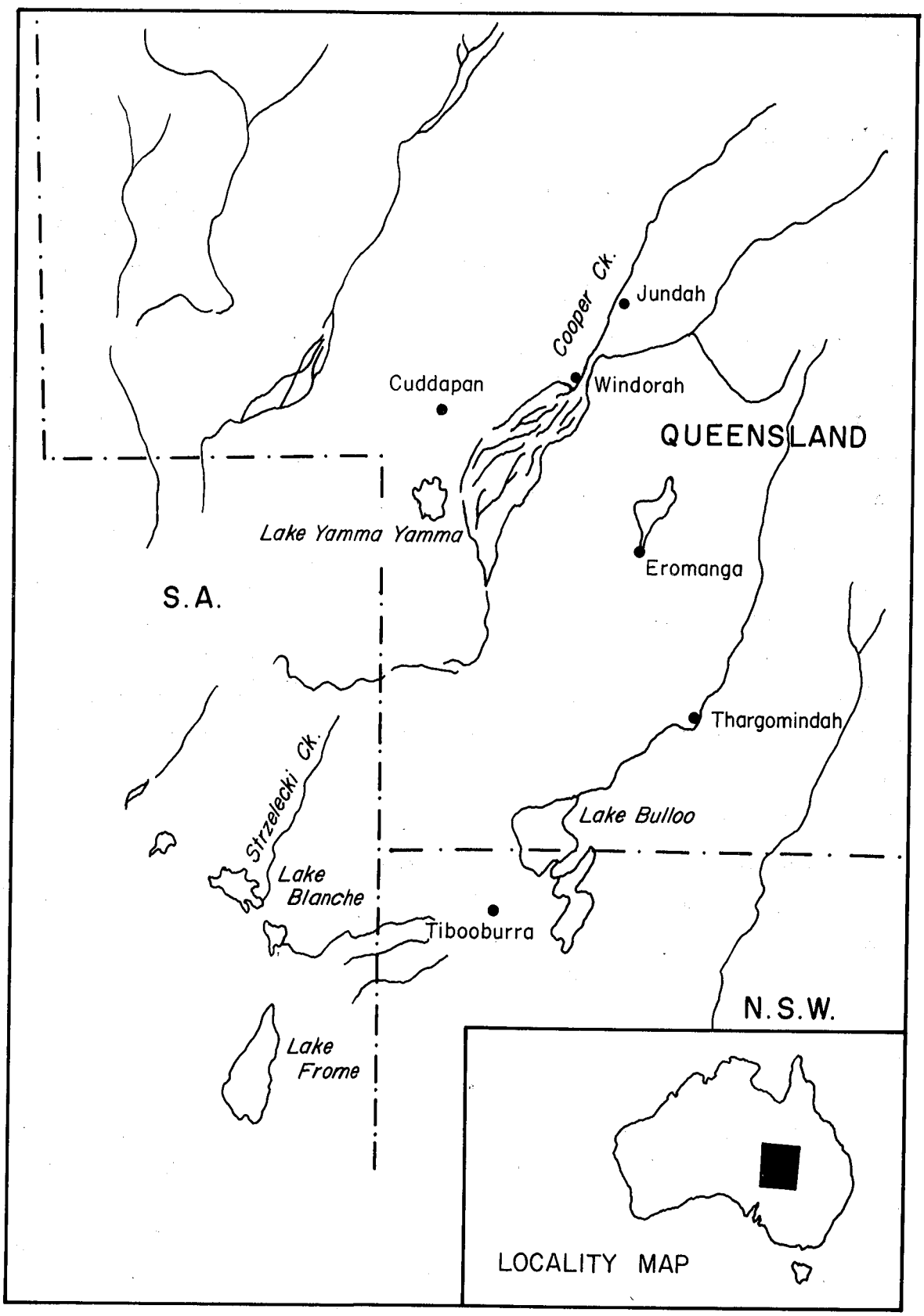

Figure 1: The study area.

none has been an inter-state study.

In February, April, and November, 1974, red kangaroos were surveyed during aerial transects across north-western New South Wales (mainly Milparinka including the Sturt National Park), south-western Queensland (Bulloo, Paroo and Quilpie Shires) and north-eastern South Australia (mainly Innamincka District). Transects were flown as part of a programme to assess the effects of flooding upon wildlife in this usually semi-arid region. The study team was led by the late Professor J. Le G. Brereton. Study methods were not designed to census kangaroo populations precisely, but we believe that the consistent flight speed, height, and observers used in each of the three sets of survey transects allow us to describe accurate distribution of kangaroos, other large mammals, and land features, and to make comparisons of frequencies of sightings, within each data set.

The survey region is shown in Figure 1. In all three surveys we noticed a consistent difference between the density of kangaroos counted in New South Wales and in the adjacent areas of Queensland and South Australia. The difference in number seen was profound, and was consistent between surveys. Numbers of kangaroos seen in the two subdivisions of the survey region are compared in Table 1, and are expressed as the average number of individuals seen for each minute's flying. We saw seventy to eighty times as many per flying minute in New South Wales as in the other states.

Red kangaroos were evenly dispersed through the sampled area of New South Wales. In 2¼ hours of survey flying over the New South Wales sub-region in November, over half of the 134 one-minute flight sectors contained kangaroos. By contrast, in nearly ten hours flying over the other two states, only 17, or 3% of the 595 one-minute sectors contained visible kangaroos, and these sectors occurred in patches (Table 2). When these patches occurred we tended to record just as many groups per flying minute in Queensland and South Australia as in New South Wales, but the New South Wales groups were significantly ($p < 0.05$) larger (Table 3).

TABLE 1

RED KANGAROO NUMBERS PER FLYING MINUTE

	N.S.W.	Q & S.A.
April	4.10	0.05
November	5.22	0.08

The most impressive feature of the density difference was that it occurred abruptly at the state borders. In whatever direction we flew out of Tibooburra we saw kangaroos until we crossed the New South Wales border, and then, abruptly, kangaroo sightings ceased. The pattern reversed itself as we flew back to Tibooburra; after long distances without a record, we would cross the border and, within a few hundred metres, would see a group of red kangaroos. The phenomenon of this abrupt change was so impressive that we made special flights along the border, one observer looking into New South Wales, the other into Queensland or South Australia, to check it. The New South Wales observer kept up a running record of kangaroo sightings; the other saw next to nothing.

A dog fence runs along these state borders, and this fence is effectively kangaroo-proof. Checking along this fence on foot confirmed the aerial survey results. There were abundant kangaroo tracks and dung on the New South Wales side and few on the other side of the fence.

There was a second, but much less obvious, discontinuity in kangaroo densities within our surveyed region; this was between the South-western corner of Queensland and adjacent South Australia, and the rest of the north, north-east and east of the surveyed part of Queensland (including Thargomindah, Eromanga, and most of the Cooper Creek channel country). We found out later that there is a dog-fence between these areas, but we do not know if it is maintained.

During the survey flight we collected information on stock distribution, windmills, dams and property improvement. Since the surveys, we have been gathering data on other aspects of land use from government agencies' records.

Discussion

The data present an apparently straightforward problem: why is there the high density of kangaroos in this part of New South Wales, the abrupt change at the border, and the low densities in Queensland and South Australia?

The high density in New South Wales apparently was not a consequence of our sampling covering the Sturt National Park. As well as flying over

TABLE 2

ANIMALS SEEN IN FLIGHT SECTORS APRIL

FIVE MINUTE FLIGHT SECTORS

% OF SECTORS RECORDING THAT SPECIES

State	N	Cattle	Sheep	Red 'roo
N.S.W.	25	52%	40%	96%
Q & S.A.	97	36%	10%	10%

ONE MINUTE FLIGHT SECTORS - NOVEMBER

% OF SECTORS RECORDING THAT SPECIES

State	N	Cattle	Sheep	Red 'roo
N.S.W.	134	3.7%	16.4%	52.9%
Q & S.A.	595	17.1%	1.6%	2.8%

TABLE 3

RED KANGAROO OBSERVATIONS, NOVEMBER.

Kangaroos seen	N.S.W.	Q & S.A.
Groups/minute where any seen	1.239	1.235
Mean group size	1.943	1.428
Group containing the average 'roo	3.874	1.667
Totals seen	375	30

the Park we sampled to the south and far to the east of it, and found no significant difference between rates of sightings of kangaroos within and without the Park.

The abruptness of the change in kangaroo density at the border strongly suggests that it was not related to the natural soil distributions, land systems, or major vegetation types. None of these changed abruptly at the state border, which is a straight line ruled unecologically across country. Indeed the abruptness of the change indicates that its causes must be in some way man-made, consequences of human land use.

The clearest difference between the states, which matched in its abrupt change at the borders the change in density of red kangaroos, was seen in the dominant stock species; the surveyed part of New South Wales was stocked with sheep, while the surveyed parts of South Australia and Queensland were mainly cattle country (Table 2). The exception to this was in the area of Queensland to the north-east and east of Thargomindah and Eromanga, where sheep were stocked. Some cattle were kept in sheep country, but very few sheep were seen in the areas we have described as cattle country.

The first inference to be made is that sheep farming, or something associated with this land use, suits red kangaroos better than cattle farming. It is probably not the actual presence of sheep, as the Sturt National Park, which at the time of the surveys had largely been de-stocked, carried the same apparent density of kangaroos as the surrounding properties which still carried sheep. It will be interesting to see if this situation persists.

We can only speculate on the differences in effect between sheep farming and cattle raising on the red kangaroo's ecological needs: access to and availability of food, minerals, water and shade, and freedom from disease and predators. Freedom from disease is most unlikely to be involved because, as far as we know, red kangaroos share an insignificant number of infections with either sheep or cattle. Shade (or shelter) also does not seem to be implicated, since shade from trees and bushes is if anything more plentiful in the cattle, than in the sheep, country. We know little about the red kangaroo's mineral

requirements, but we do not think minerals are importantly more available in the sheep farming areas.

The major predator of kangaroos in the surveyed area, other than man, is the dingo. During survey flights dingoes were seen only in the Queensland and South Australian cattle country, and of course the dog fences exist to keep them out of sheep country. Some dingoes do still appear in the New South Wales sheep country, but they are severely harassed there, and are reported to be much less common there than across the border. Destruction records for the cattle country of Innamincka District and Bulloo Shire show a sustained kill of dingoes at the rate of 0.059 and 0.043 per km^2 per year, over the periods 1957-74 and 1956-70 respectively. These suggest high dingo densities, perhaps in the order of over one dog for every 10 km^2. While it is debatable whether a predator can control the density of a prey species on which it depends, we think that in these densities dingoes may well be limiting the kangaroos' freedom of use of open pasture. This might limit the food available to kangaroos and hence limit their numbers.

Sheep stations are generally smaller (Table 4) and perhaps more intensively supervised than cattle properties, and this may contribute to a lower dingo presence in sheep country[1]. Table 4 indicates that sheep stations are also better watered than cattle properties in this region. In dry conditions this will mean more pasture remains available to kangaroos (i.e. within daily range of water) on sheep, than on cattle, country.

It is highly likely that sheep, especially under the fenced paddock conditions of the surveyed region, differ from cattle in the use of, and effect on, pasture; but whether their alteration of pasture benefits kangaroos more than does that of cattle we do not

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1. After this paper at the workshop, Mr. T. Livanes reported several instances where dog fences separated properties carrying the same kind of stock. Kangaroos were in each case more abundant on the side of the fence that lacked dingoes. This indicates an effect of dingoes on kangaroo numbers independent of, or in addition to, that of stock type.

yet know.

There remains the question of man's direct impact upon the kangaroos. In the Milparinka (N.S.W.) P.P.B. area the number of kangaroos shot fell from nearly 12,000 in 1966 to 2,600 in 1970, and shooting stopped from 1971 to late 1974. Perhaps that three year spell without cropping has helped numbers to pick up, but certainly not by the seventy - to eighty - fold needed to explain the density difference across the border. Up to 1970 in the south-western Queensland cattle country, red kangaroos were being cropped at a rate of 0.11 kangaroo/km^2/year, compared with approximately 0.3/km^2/year in Milparinka P.P.B. at that time. If density differences were of a similar order to those existing now, this suggests a relatively greater hunting pressure on the Queensland kangaroos.

So the original simple observation, that red kangaroos are much more numerous in north-western New South Wales than in the two adjacent states, leads only into a complex set of speculations. We can be sure that it is a consequence of man's land use practices in the region; but we cannot yet say which facets of which practice are producing the important effects. The physical environment (water), bio-physical environment (trees for shade), vegetation, competing herbivores, carnivores, and man himself as a hunter, could all be involved.

These questions arise for one of Australia's largest, most obvious and best studied wildlife species; and here we have considered just that one species. Yet even so we can do little more than speculate on the precise way in which man's land use has affected that species.

If the kangaroo could be said to be "representative" of all the species in its community our task would be simplified. We could evaluate the impact of land use on the red kangaroo and apply our findings to the whole community. But no species is "representative" of a community; each has unique requirements and hence is uniquely influenced by man and his land use. This needs to be emphasised, because the red kangaroo in the arid lands (like the grey kangaroo on the tablelands) is too often held to be "representative" of wildlife by

TABLE 4

INTENSITY OF PASTORAL DEVELOPMENT

PROPERTY SIZE (Q) AND TYE

Stock	Modal Size
Sheep	240 km^2
Cattle	400 - 2,000 km^2

(but 70% of cattle on 8,000 - 12,000 km^2 properties)

WATERING POINTS

State	No. Stations	Density	Nearest Neighbour
N.S.W.	23	0.023/hectare	5.5 km
S.A.	2	0.007/hectare	11.0 km

people who wish to claim, in effect, that the presence of large numbers of kangaroos means that their sheep farming (or other land use) is not detrimental to wildlife. This is false reasoning because the kangaroo may be, and often is, the only wildlife species to have benefited by their farming.

It is not to the sheep country of Milparinka district, with its thousands of red kangaroos, that one would go first to look for the many other, smaller wildlife species that occurred in the semi-arid zone when European man and stock first arrived. The bilbies, hopping mice, Antechinomys and Dasyuroides, and the smaller macropods now thought to be extinct, are all more likely to be found in cattle country, even though red kangaroos might be there in only low numbers. Big, generalist feeders, with broad and flexible habitat requirements, like the red kangaroos, are the easiest of wildlife to retain provided you have some food for them. The acid test of good land use - good for wildlife, that is - is whether many small, specialist wildlife species remain.

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THE ROLE OF THE KANGAROO INDUSTRY

T. Livanes

At the outset I will make a series of statements, which I will not attempt to argue here. They are the foundation upon which much of the interpretation to follow is based.

Firstly, I do not believe that the commercial utilisation of kangaroos does determine, or has determined, the abundance or the distribution of any species of kangaroo. The alternative view is most widely held, regardless of the evidence.

Macropods do compete with some types of commercial land utilisation at some times. I do not believe that landholders often assess accurately the consequences of this competition or the current kangaroo population in their immediate area.

Where it is possible to develop rural land intensively and profitably this development will take place, given sufficient time. Some exceptional landholders will deliberately avoid significant habitat change, but I believe this is unlikely to continue because economic pressures will tax the resolve of later generations to persist in this way. At first, grain growing in an area increases the local kangaroo population but this result of development imperceptibly changes so that populations go into decline. This decline in population is often spectacularly performed by drought-induced deaths or killings.

That this population reduction process is very much in the public view is a very important part of the politics of kangaroos. Too often the urban voter sees, or hears of, then notices the absence of, drought induced visible mobs of kangaroos. In periods of drought the industry is seen to be taking many kangaroos and the belief spreads that the consequence of drought can be satisfactorily altered by one simple expedient namely: strict control of the kangaroo industry.

Most politicians are no better informed than the public and are not able to make reasonable assessments either of the situation or of how to influence it effectively. This state of competence usually persists when ministerial responsibility is attained. The few politicians with understanding of the kangaroo problem know, or soon learn, that a misinformed electorate will not tolerate politicians or policies which do not please them.

My view is that whilst the kangaroo industry could not reduce the range of the kangaroo species, it could enable kangaroos to persist in some areas from which they will otherwise disappear. The industry would do this if it gave landholders an economic incentive to retain kangaroos rather than grains etc. I believe this could be achieved if conservationists would allow governments to pursue appropriate policies, but I believe it will not happen because conservationists will not tolerate the steps necessary to conserve kangaroos effectively. So we have the paradox of the effective extermination of kangaroos from some areas they could remain in, because conservationists are an effective political force. Since European settlement one large macropod has been exterminated. The Toolache was exterminated by the misguided efforts to conserve it. I regret that more are to follow for the same reason (Finlayson, 1927).

Consequently, I believe the kangaroo industry is unlikely to be able to help conserve kangaroos. The industry will be hard pressed to make some use of a small percentage of the kangaroos that are being killed. Most kangaroos that die will not be used in any way, but will be killed by farmers in pest extermination programmes.

Governments have been regulating the kangaroo industry so that its costs rise and its ability to contribute is adversely affected. The politics of kangaroo conservation is based in many places on the fact that steps that would assist in the preservation of kangaroos would put the government's future at risk, but that steps which adversely affect the kangaroo industry will gain the support of conservationists. No thought has to be given to the effect on the survival prospects of kangaroos; conservationists willingly swallow placebos. Understandably, political voters rather than macropods are conserved by governments.

I see kangaroos being restricted to National Parks, forests, arid areas and areas where the topography prevents development. The industry will not play an important role in this process. The inexorable spread of grain growing and intensive land use will, wherever such agricultural practise is possible.

For the rest of this talk I will take a brief look at the reasons why I believe this outcome is unlikely to be avoided.

Kangaroo policies of governments result from the pushing and pulling of interested groups and of public opinion. When the public are uninterested, policy is usually determined by people with some professional interest and competence. When the public become involved, usually as a consequence of the activity of the media, the decision-making process moves into hands that are emotionally involved but which are quite unable to determine policy with any competence.

The public will continue to fail to require their political representatives to arrive at and implement sound policies because they will continue to lack knowledge and understanding of the processes involved. For it to be otherwise the public would need to know where fact ends and fancy begins. To obtain this information the public needs to be able to rely on the scientific community to determine the facts and upon the media to publicise this information. It is my opinion that in the matter of kangaroos the record of both the scientific community and of the media is mixed and will continue to be so.

In the area of kangaroo conservation the reaction of some scientists to the consequences of the drought of the mid 1960's gave rise to political pamphleteering in the form of scientific publications. As a consequence the concerned members of the public have before them this evidence of the effects of harvesting on populations, and this evidence has become a significant part of the information available today to help concerned people understand what to ask of their political representatives. I believe there is a very real need to re-examine the effects of harvesting on such populations.

The media have added to the confusion of the public and have helped to make the adoption of successful kangaroo conservation programmes unlikely. Much of the Australian media have yet to attempt to use non-sensational presentation of kangaroo news items.

Who can expect the media to educate the public about the issues involved in the kangaroo controversy? Few would continue to buy or read a paper which devoted the space necessary to educate the public to the point where they could responsibly determine policy. The press people therefore rarely seriously attempt to educate, instead they utilise kangaroo stories as horror entertainment. The A.B.C. is often no better than commercial media in this regard.

Whilst the press cannot be expected to risk their financial stability by presenting the whole truth on this, or any subject, it does appear to me that the Conservation movement has shown even less wisdom in its abandonment of interest in truth.

Most people in conservation organisations genuinely attempt to come to grips with what they see as difficult problems. The harder they try to get the facts the more they are confused. How are they to decide whether the scientific publications are mainly political or mainly scientific? Most do not appreciate that this question is relevant. Most realise that certain evidence used by some 'conservationists', who are most often reported in the media, is not strictly reliable. These untruths gain respectability with the passage of time. Even the conservationists who are responsible enough not to use deliberate untruths themselves have shown a willingness to acquiesce by refraining from putting the record straight. Because they are prepared to allow lies to be used to promote their cause they are no longer able to see where fact ends and fantasy begins. Consequently they are no longer able to help the public to become usefully involved in the political process.

The consequence is that the conservation process in Australia is either in the hands of departmental experts, when the public is not involved, or in the hands of politicians who are responding to quite strong emotionally charged pressure from the involved and mostly uninformed urban conservation groups. To date I see no reason to believe that either of these alternative groups is likely to come up with competent policy determination. The people employed in the process may change as a result of a swing one way or the other, while the future of kangaroos is left to be determined by other processes over which neither group seeks nor has control!

The public may rely on governments to always act wisely; I do not. Still less do I see the bureaucratic process arriving at, or effectively implementing, policies which conserve and/or utilise kangaroos for any length of time.

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MACROPODS AND THEIR DIET

B.A. Ellis

Approximately 45 species of the Family Macropodidae once occupied almost every terrestrial habitat in Australia. Some of their counterparts in other continents, mainly sheep, cattle and goats have been introduced into this continent and now exist in some of these habitats. Inevitably overlap must occur. However, in most areas of potential overlap very little is known about the extent to which these animals compete for food so that an objective assessment on the status of the macropods cannot be made.

In Africa, studies of potential competition between large mammalian species have shown ecological separation was due to their differential occupation of habitat types and selection of distinct diets (Lamprey, 1963; Gwynne and Bell, 1968; Jarman, 1971). The selection of different types of food could be divided into three groups. The first was a selection of different plant categories, such as trees or grasses; the second was the selection of different species within these broad categories; and the third was the selection of different parts or levels of maturity of a particular species (Lamprey, 1963).

In Australia few studies have investigated competition for the foodplants available to free-ranging macropods and domestic stock (Storr, 1968; Chippendale, 1962; Griffiths and Barker, 1966; Griffiths, Barkerand McLean, 1974; Low et al, 1973; Dawson et al, 1975). Some studies have investigated the diet of a single species (Storr, 1964; Kirkpatrick, 1965; Grimes, Watkin and May, 1965; Leigh and Mulham, 1966a, b; 1967; Robards, Leigh and Mulham, 1967; Ealey and Main, 1967; Bailey, Martensz and Barker, 1971), and others have compared the diet of two introduced species (Dudzinski and Arnold, 1973; Wilson et al, 1975). However, only three of the largest macropods (the Red Kangaroo - Megaleia rufa, the Grey Kangaroo - Macropus giganteus; and the Euro - Macropus robustus) and one small species (the Quokka - Setonix brachyurus) were included in these studies, which ranged over scattered areas in this large and diverse continent.

Apart from Kirkpatrick (1965) the diet studies of the large kangaroos and the large introduced animals were carried out over a short time period in dry rangeland areas. There are reviews available (Frith and Calaby, 1969; Leigh, 1974; Russell, 1974). In addition, Newsome (1971) reviewed food competition between wildlife and domestic livestock on the grassy plains of inland Australia. He showed that cattle have ameliorated the environment for the red kangaroos and concluded that these plains were supporting a higher biomass of livestock and kangaroos than of either alone, largely because of different diets. However, other macropods such as the spectacled hare - wallaby (Lagorchestes conspicillatus) and the bridle nail - tailed wallaby (Onychogalea fraenata) decreased considerably because stock ate out large stands of Mitchell grass and saltbush in which these animals sheltered (Newsome, 1971).

In the Pilbara region of Western Australia over a twenty year span sheep numbers suffered a very marked decline, whilst the euro population increased enormously. Studies showed that this was caused by a deterioration in the pasture vegetation, particularly the disappearance of the more nutritious native grasses. The prime cause of this deterioration was a stocking policy unsuited to the climate and conditions and not to the increased number of euros (Ealey and Suijdendorp, 1959). The numbers of euros increased because they were able to survive on the lower quality spinifex pastures which replaced the earlier plant communities. Sheep populations were reduced because they could not survive (Ealey, 1967; Ealey and Main, 1967).

The diet studies on the large kangaroos have shown that grasses were the most prominent category of food plants eaten whilst other categories such as herbs could be eaten in substantial amounts particularly by red kangaroos during a wet winter (Ellis, unpublished data). Trees and large shrubs were not generally eaten, whereas the smaller shrubs (up to 1m), such as members of the family Chenopodiaceae, were sometimes eaten. Although ecological separation of the three species of kangaroos is largely brought about by their use of different habitats, the role of food selection is still not clear. The extent to which they compete with livestock is still unresolved but long term studies in central Australia and

western N.S.W. are investigating interactions between them.

In eastern regions of the continent, there are a few brief reports about the food generally eaten by several wallaby species and by the grey kangaroo (Troughton, 1965; Kirkpatrick, 1965; 1968; 1970a, b; Calaby, 1966; McEvoy, 1970; Kaufmann, 1974a, b). Kaufmann (1974a) studied the habitat use and social organization of nine sympatric species of macropods in north-eastern New South Wales. He observed that all nine species grazed on native and introduced pasture plants, and that some species also browsed. He concluded that the successful sympatry of these species was due largely to the diversity and interspersion of habitats, and that more detailed information was needed on their food habits.

Along with the introduction of alien species, white settlement brought improved pastures and horticultural crops. On the one hand the natural habitats of some macropods were destroyed and their numbers reduced, and on the other hand the environmental conditions became favourable for other species which then have become abundant and troublesome. Elsewhere in these proceedings there are reports of the conflict between macropods and rural enterprises. These show that there is a lack of adequate information on the foodplants selected by macropods in different areas and under different climatic conditions, and hence the need for detailed dietary studies on them, particularly on all the wallaby species inhabiting forested regions.

In general, three differing opinions are held about the macropods. To some they are economic resources, to some they are pests and to others they are objects of aesthetic pleasure. In some way a compromise must be made between these attitudes of total exploitation, total destruction and total protection. Principally, it clearly has to be ascertained just which of the 45 species are pests and in what situation, and which species are endangered. Species which may be considered as pests in one area, may be very rare elsewhere. Because there are very similar species inhabiting the one geographical area, it is important to find out the precise species either competing with the domestic stock, or eating the forest plantations or eating the horticultural crops. To know this, adequate diet studies must be completed before constructive management practices can be followed.

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WALLABY BROWSING IN EUCALYPT PLANTATIONS

R.R. Horne

These observations were made during the years 1971-74 inclusive and deal with Flooded Gum (E. grandis), Blue Gum (E. saligna) and Blackbutt (E. pilularis) in the Coffs Harbour district.

Wallaby browsing appears to have occurred sporadically to a greater or lesser degree in all jiffy pot planting areas in the Coffs Harbour District. Previously this damage, when noticed, has been passed off as minimal and even where there appeared to be an extensive effect, it was generally felt that the recuperative powers of eucalypts are such that little significant long term damage would result. However in several research experiments covering consecutive years of planting, wallaby browsing was so bad that the anticipated height growth rate of these experiments were seriously reduced.

Also, wildlife experts report that the pre-planting logging which is normally undertaken some 5 - 7 years in advance of planting will tend to increase the wallaby population and that clearfelling some of this area and planting jiffy potted eucalypts could provide much sought-after herbage for this increased population. It was with this in mind that it was decided to look more closely at wallaby damage to determine if there were, in fact, long term effects on the plantation.

The Aim of the Trial

The aim was to determine whether the wallaby browsing regularly sutained by some eucalypt plantations during the first winter after planting will have any significant long term effect.

A. The areas and species studied

1971 Planting

Flooded Gum and Blue Gum. Fertilizer and frosting trial, Cpt.111, Orara West S.F. Planted 24-2-71.

1972 Planting

Flooded Gum, Blue Gum and Blackbutt. Fertilizer and frosting trial, Welcome Flat, Cascade Management Area. Planted 23-3-72.

TABLE 1

EXTENT (%) OF BROWSING IN FOUR PLANTATION AREAS

1971-74 INCLUSIVE

Approx. age 6 months

Year Planted	Locality	Species	Fertilizer Regime	Sample Size	% Total Browse	% Browsed Dead	Ht. Loss at Time of Browsing
1971	Thompsons Road	Blue Gum	Pre-winter	76 trees	70%	2%	45 cm
		Flooded Gum	Pre-winter	65 trees	86%	2%	43 cm
1972	Welcome Flat	Blue Gum	None	240 trees	37%)	5%	9 cm
			Pre-winter	233 trees	51%) *	3%	15 cm
		Flooded Gum	None	217 trees	39%	9%	9 cm
			Pre-winter	253 trees	49%	11%	16 cm
1973	Timmsvale	Flooded Gum	None	623 trees	64%	4%	18 cm
			Pre-winter	202 trees	65%	3%	32 cm
		Blackbutt	None	306 trees	66%	5%	16 cm
			Pre-winter	201 trees	75%	12%	37 cm
1974	Timmsvale	Flooded Gum	Pre-winter	156 trees	83%	4%	28 cm

* Significantly different at 95% Confidence Level

1973 Planting

Flooded Gum and Blackbutt. Fertilizer trial, Timmsvale, Ulong Management Area. Planted 14-2-73.

1974 Planting

Flooded Gum. Browsing trial Timmsvale. Ulong Management Area. Planted 3-2-74.

B. The Data Collected

The data collected have been considered under the following headings:-

(i) Quantitative Short Term figures indicating how many trees were browsed at time of browsing and to what extent.

(ii) Palatability to wallabies of plantation eucalypts compared with accompanying weed crop.

(iii) The browsing animals, species involved, sightings, method and frequency, intensity in differing localities within the plantation, relationship between plant height and browsing susceptibility.

(iv) Quantitative long term effect of browsing on tree growth. Specifically survival, form and tree height.

C. Statistical Analysis of the Results

Of those quoted here only the 1974 trial was originally set up to be a browsing experiment, the others becoming browsing experiments by virtue of the heavy browsing that followed planting. The 1974 significance levels were obtained using Tukey's Test whereas all the earlier plantation significance levels were obtained using "Students t" values.

(i) Extent of Browsing and Growth Loss at Time of Browsing

(a) The number of trees browsed by wallabies

Browsing intensity varied. Over a four year period of consecutive plantings the range was 37% to 86% of the sample trees browsed with an average value of 65% for pre-winter fertilized Flooded Gum (Table 1).

TABLE 2

1973 TIMMSVALE PLANTATION

SEVERITY OF BROWSING IN RELATION TO DISTANCE FROM WALLABY HARBOUR

FLOODED GUM AND BLACKBUTT

	Browsing Severity	1 or more trees in 2 Browsed	3 or more trees in 4 Browsed
% of Area Affected	Near Less than 100 m from Wallaby Harbour	70%	38%
	Remote More than 100 m from Wallaby Harbour	42%	18%

(b) The Section of the Plantation where most Browsing Takes Place

Information recorded from a 1973 plantation (Table 2) indicated that areas which are 100 metres or more remote from wallaby harbour are browsed less by 20 - 30%. In 1974 an experiment was set up expressly to test this finding and Table 3 shows that the growth loss overall of edge plants was 63% of the increment compared to 19% loss of increment by edge-remote plants. Graph 1 shows the loss of increment due to browsing adjacent to various types of wallaby harbour. This loss was more than 1 mm when the unbrowsed height was under 1.5 m. So it would seem that plantation shape is an important factor and preference should be given to plantation areas where it is possible to arrange the boundaries so that there is a high percentage of "remote" areas. Long narrow clearings should be avoided.

(c) Height Loss at Time of Browsing

The height loss varied with the severity of browsing but averaged between 9 - 45 cm. In particular the loss averaged 29 cm for 1973 pre-winter fertilized Flooded Gum when the unbrowsed plant height at time of browsing was about 50 cm. So the height loss at time of browsing was in the vicinity of half the plant height.

(d) Plant Death Following Browsing

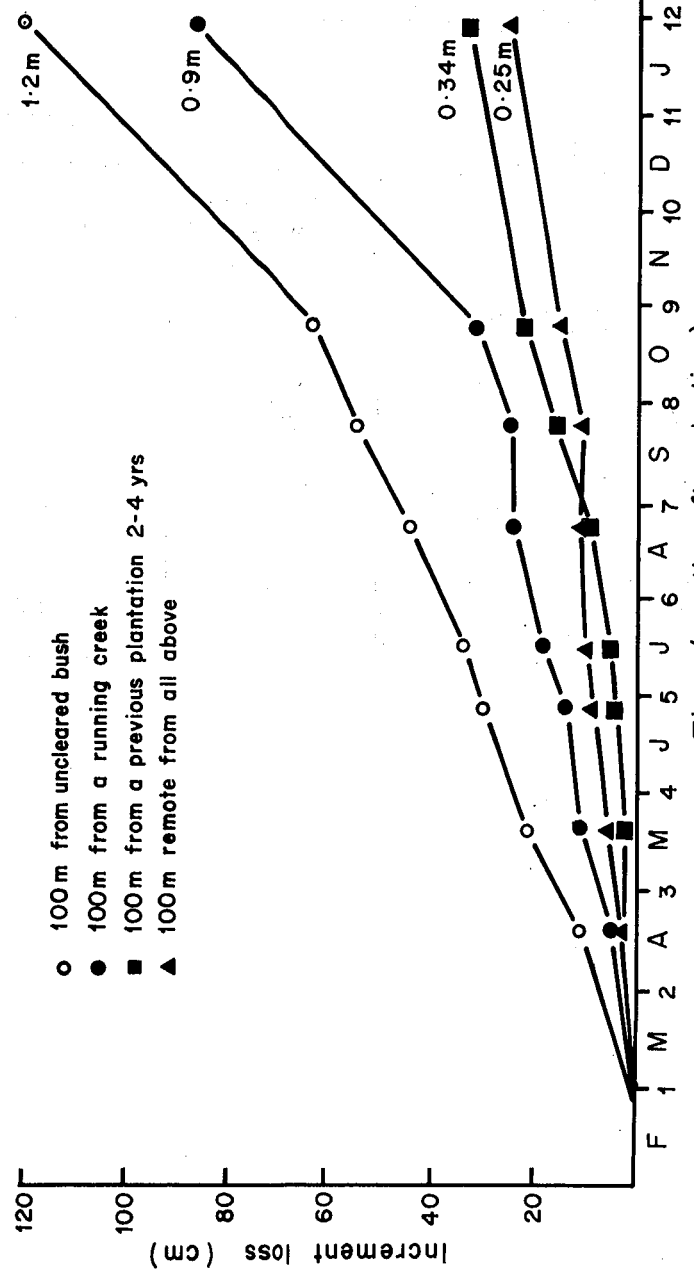
This is surprisingly small even following very severe browsing damage. As many as 10% of the trees may die following browsing but it is more usually below 5%.

(e) Increased Incidence of Browsing Following Fertilizer Application

Where it has been possible to test fertilized plants against unfertilized plants there has always been slightly more trees browsed (1% - 14%) amongst fertilized plants. However only in one of four instances was this increase statistically validated by a Chi squared test.

(f) Eucalypt Species Preference

There is little preference shown, if any, between planted Blackbutt, Flooded Gum and Blue Gum. All are highly preferred. It has however been observed that self-sown eucalypts are affected to a lesser extent.



Graph 1: Intensity of wallaby browsing in differing localities within Timmsvale 1974 plantation. Increment loss is plotted against time after planting for plants near uncleared bush, near a running creek, near a previous plantation, or remote from all these.

TABLE 3

1974 FLOODED GUM (TIMMSVALE PLANTATION)

SEVERITY OF BROWSING IN RELATION TO DISTANCE FROM WALLABY HARBOUR

Treatment	% Plants Browsed	% Plants Repeatedly Browsed	Increment Lost due to Browsing
Located close to creek	100%	79%	0.9 m
Located close to previous plantation	85%	58%	0.3 m
Located close to hard-wood boundary	100%	93%	1.3 m
100 m-plus remote from all of the above	65%	33#	0.2 m

TABLE 4

WALLABY BROWSING OF PLANTATION EUCALYPTS
COMPARED WITH WEED SPECIES PRESENT
TIMMSVALE 1973
FLOODED GUM AND BLACKBUTT

Browsed Plant		Habit	% of Plants Browsed	Av. No. Present per hectare
Common Name	Botanical Name			
1. Poison Peach	Trema aspera	Tree	83%	215
2. Blackberry Night-shade	Solanum nigra	Shrub	82%	110
3. Tick Bush	Helichrysum diosmifolium	Shrub	75%	2,165
4. Hard Corkwood	Ackama paniculata	Tree	62%	60
4. Planted Euc.	E. grandis and pilularis	Tree	62%	770
6. Callicoma	Callicoma serratifolia	Tree	57%	55
6. Geebung	Persoonia mollis	Tree	57%	510
8. Tobacco Bush	Solanum mauritianum	Shrub	50%	340
8. Austral Sarsparella	Smilax australis	Vine	50%	175
10. Inkweed	Thytolacca octandra	Shrub	49%	695
11. Two Veined Hickory	Acacia binervata	Tree	34%	1,665
12. Kangaroo Apple	Solanum laciniatum	Shrub	33%	780
13. Two Tone Supple Jack	Ripogonum discolor	Vine	28%	360
14. Cordyline	Cordyline terminalis	Shrub	24%	255
15. Ornamental Ash	Polyscias sambucifolius	Tree	20%	215
16. Corkwood	Duboisia myoporoides	Tree	13%	1,240
17. Fireweed	Senecio bipinnatisectus	Herb	7%	400
18. Gins Whisker	Solanum armatum	Shrub	6%	470

TABLE 5

WALLABY BROWSING OF PLANTATION EUCALYPTS
COMPARED WITH WEED SPECIES PRESENT

TIMMSVALE 1974

Browsed Plant		% Plants Browsed	Av. No. Present per Hectare
Common Name	Botanical Name		
1. Poison Peach	Trema aspera	100%	125
2. Misc. Grasses		99%	6,375
3. Lily of the Valley	Elaeocarpus reticulatus	91%	345
4. Persoonia	Persoonia sp.	89%	1,405
5. Tick Bush	Helichrysum diosmifolium	76%	8,500
6. Sallee Wattle	Acacia floribunda	67%	95
7. Prickly Supple Jack	Smilax australis	63%	250
8. Planted Eucalypts	E. grandis and pilularis	60%	750
9. Red-fruited Rice-flower	Wikstroemia indica	59%	1,440
10. Common Raspwort	Haloragis tetragyna	53%	1,405
10. Soldier Vine	Kennedia rubicunda	53%	595
12. Unplanted Flooded Gum	E. grandis	43%	220
13. Gahnia	Gahnia sp.	42%	1,030
13. Thistle	Sonchus sp.	42%	595
15. Cordyline	Cordyline terminalis	41%	1,220
16. Rasberry	Rubus sp.	33%	95
17. Rose Maple	Cryptocarya rigida	29%	220
18. Hairy Nightshade	Solanum densevestitum	28%	780
19. Tobacco Bush	Solanum mauritianum	25%	125
19. Kangaroo Apple	Solanum laciniatum	25%	125
21. Misc. Ferns		20%	4,940
21. Misc. Weeds		20%	3,905
23. Daisy Bush	Olearia sp.	18%	530
23. Canadian Fleabone	Erigeron canadensis	18%	3,375
25. Two Veined Hickory	Acacia binervata	10%	1,565
26. Fireweed	Senecio sp.	4%	940
27. Catsear	Hypochoeris radicata	0%	250
27. Gins Whisker	Solanum armatum	0%	63

1972	Blue Gum	44% of total plants browsed
	Flooded Gum	44% " " " "
1973	Flooded Gum	64% " " " "
	Blackbutt	70% " " " "

Summing up, it has thus been established that there has been considerable browsing activity in the wallaby-abundant areas of Cascade and Timmsvale. This phenomenon has never been fully apparent to a casual observer, the trees most affected being the least conspicuous. A generalisation can be made that if there is any evidence of browsing it is almost certainly more extensive than general observation would indicate.

(ii) Palatability of Planted Eucalypts to wallabies in comparison to associated Weed Species

Both the 1973 and 1974 plantations at Timmsvale were sampled and the planted eucalypts and weed species ranked according to most browsed % as well as stocking.

These results, shown fully in Tables 4 and 5, are summarised below:-

PLANTED EUCALYPTS (BBT. AND F.G.)

Year Planted	Browsed		Stocking	
	%	Rank - All Species	No./ha	Rank - All Species
1973	62	4/18	770	5/18
1974	60	8/28	750	14/28

In both years the planted eucalypts were browsed more than the average for all regenerating plant species. This was in spite of the fact that one year (1974) many regenerating weed species were more abundant than planted eucalypts. It would thus seem as though the planted eucalypts are a preferred food and not merely eaten because they are often encountered.

Other information provided by the weed assessment was that the species most palatable to the wallabies of all the available plants were Poison Peach (Trema aspera) and Tick Bush (Helichrysum diosmifolium) and that Gins Whisker (Solanum armatum) and Fireweed (Senecio sp.) were the least palatable.

With provision of a preferred food, year by year, plus ideal conditions to live in such as are provided by 3 - 4 year old plantations, it would not be surprising to find a rapid rate of increase in the population of wallabies.

(iii) The Browsing Animals

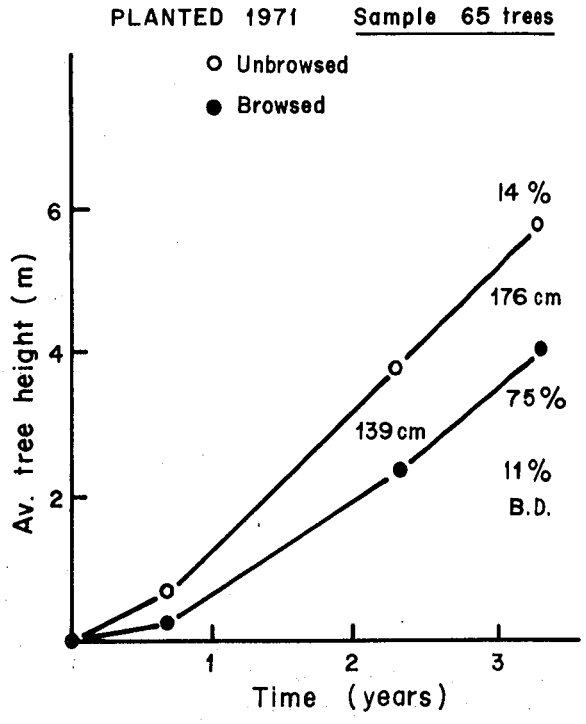
(a) Sightings and species involved

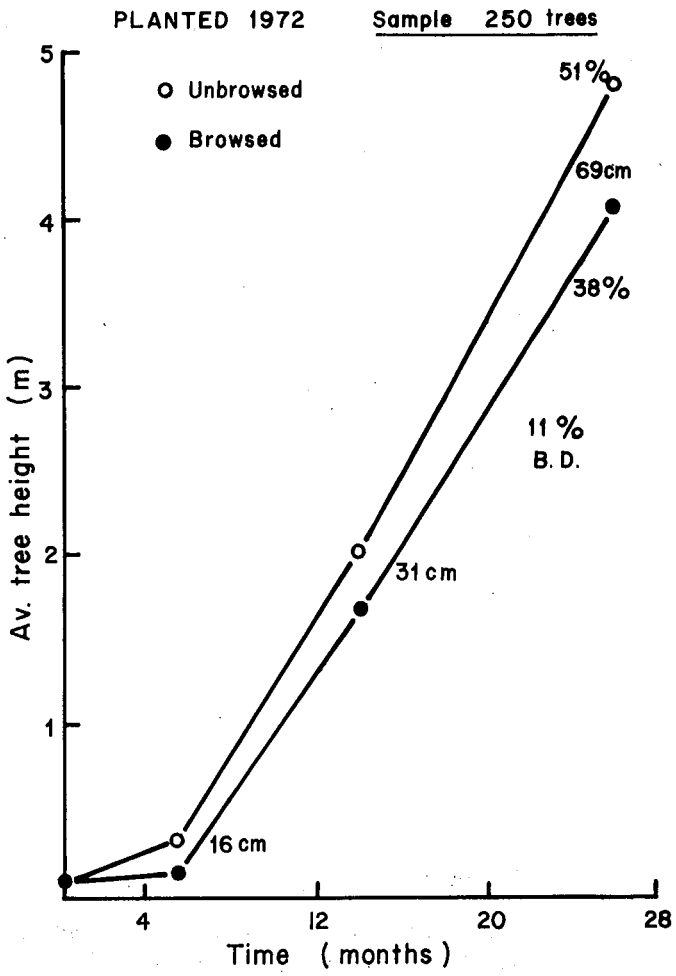
Although there has been any amount of browsing and abundant wallaby droppings in recent plantations, the culprits responsible have not been easy to identify. Numerous types of wallaby have been sighted in the bush, surrounding the plantations and on roads leading into plantations but actual sightings in the plantation have been rare indeed. These outside sightings were: the red-necked pademelon, Thylogale thetis, the red-legged pademelon, Thylogale stigmatica, and the black or swamp wallaby, Wallabia bicolor.

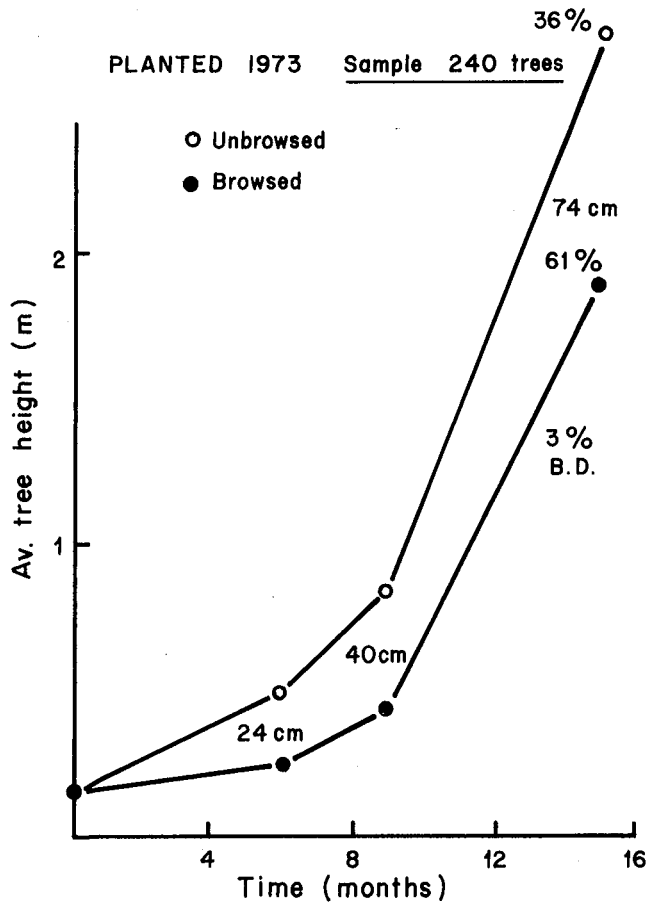
The droppings in the plantation and the non-plantation sightings in the 1973 plantation at Ulong pointed to the red-necked pademelon with the black wallaby a distant second. However in the 1974 plantation at Timmsvale, hides were constructed and evening watches were set during the mid-winter months of June and July, 1974. The wallabies proved to be extremely shy and numerous watches were necessary to determine numbers and species. The final certain identification tally of wallabies sighted at Timmsville in 1974 showed them all to be black wallabies (Wallabia bicolor) with a sighting of what appeared to be a small light fronted wallaby (Wallabia parma?).*

This evidence is enough to say that the damage done in the 1974 Ulong Plantation was due to the Black Wallaby. Surprisingly no red-necked or red-legged pademelons were sighted contrary to the preceding year!

* Ed. = Macropus parma







Graphs 2, 3 and 4:

See next page for legend.

Legend for Graphs 2, 3 and 4:

The continuing loss effect on height growth of wallaby browsing that occurred during the first winter subsequent to planting for pre-winter fertilized flooded gum planted 1971 (Graph 2), planted 1972 (Graph 3), and planted 1973 (Graph 4).

(b) Browsing methods and number of animals involved

Unfortunately less information of this type was gathered than had been hoped for, but the following statements can be made:

(i) The larger (adult) wallabies venture out of the surrounding bush first, usually singly from any time after 4.00 p.m. These wallabies range the furthest from cover, often further than 100 metres.

(ii) Smaller wallabies (e.g. young females with babies?) follow at dusk or later and do not go far from cover, rarely further than 40 metres.

(iii) Once settled they move slowly and noiselessly around spending quite a long time (5 - 30 minutes) feeding within a small area.

(iv) The numbers involved were extremely variable but there could have been as many as 10 wallabies/ha browsing at once in some of the most populated areas.

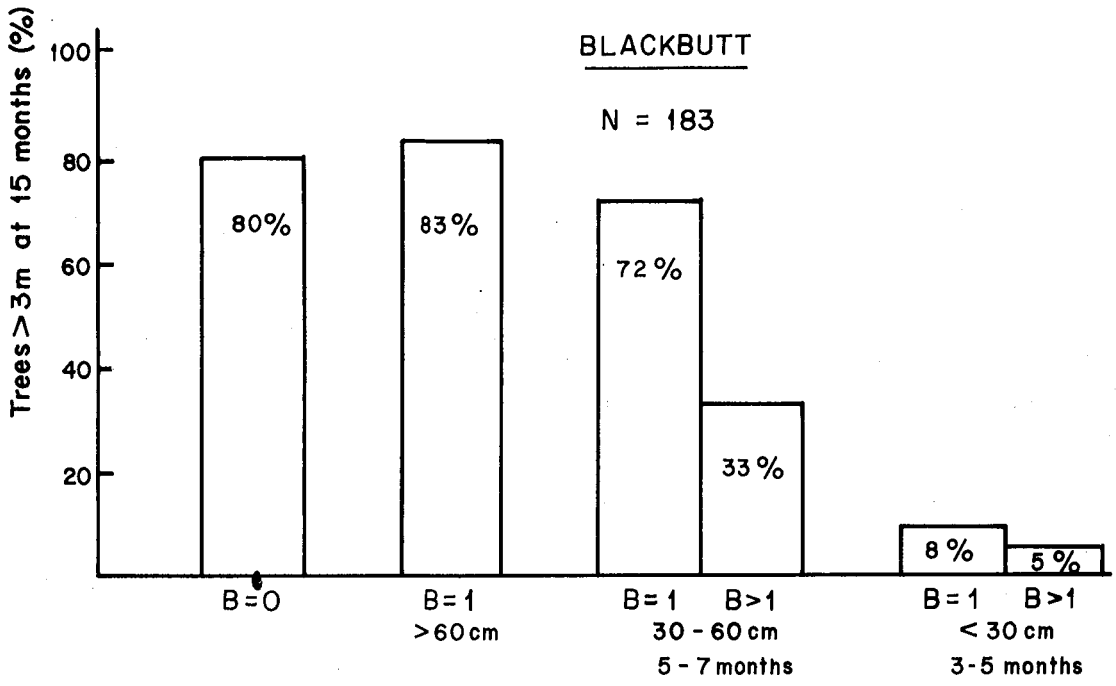
(v) Probably the most interesting observation made was that of a relation between the size of the plant and the preference of the wallaby to browse. The wallabies prefer the apical shoot and if the planted eucalypts are large (60 cm plus) then these plants often escape browsing. Side browsing is comparatively rare and in any case has little effect on the plant's subsequent height growth. Quantitative results of this effect are shown in Graphs 5 and 6. This would indicate that the taller the tree is at the onset of winter browsing, the better.

(iv) Quantitative Long Term Effects of Browsing

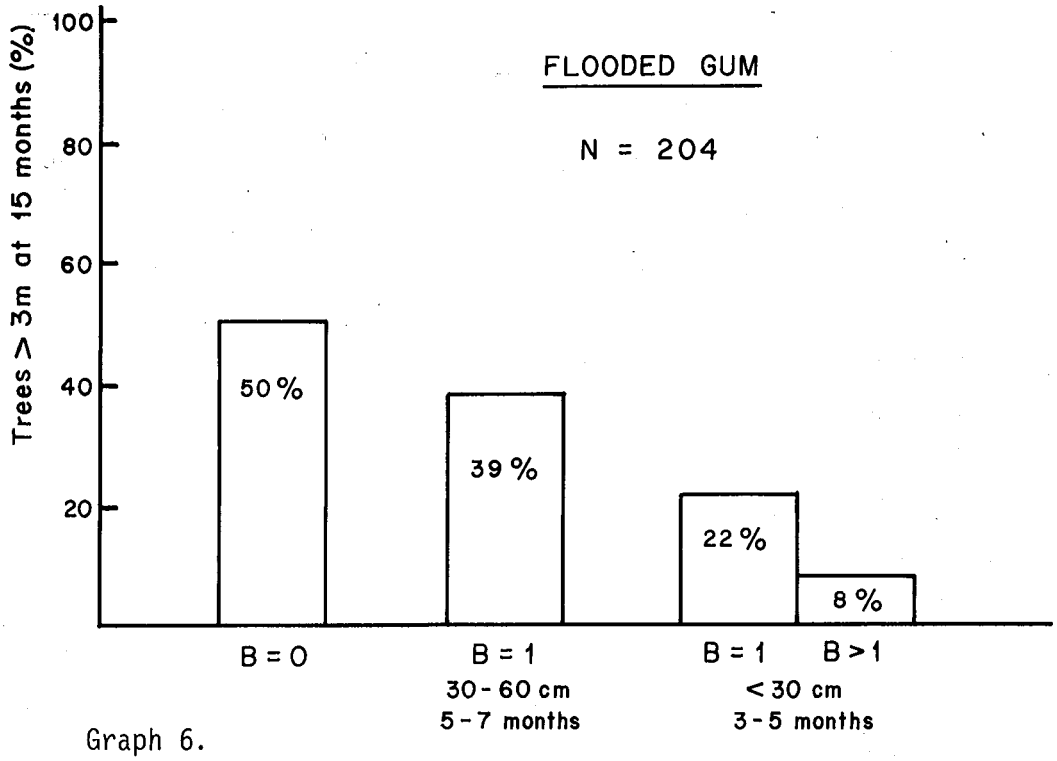
(a) Long term effects on tree height

This appears to be the greatest cause for concern.

Very different height growth is evident when comparing trees which have suffered browsing to those which have remained unbrowsed. There appears to be a continuing falling behind in height of browsed trees for at least 2 to 3 years after the browsing has taken place (Graphs 2, 3 and 4). In one area sampled the height loss is approaching 2 metres at age 3½ years when the height loss was less than 0.5 m at the time of browsing (2 - 7 months).



Graph 5.



Graph 6.

Legend for Graphs 5 and 6: The effect on subsequent height growth of wallaby browsing on pre-winter fertilized plantations of Blackbutt (Graph 5) and Flooded Gum (Graph 6), in terms of frequency of attack (B = 0, never browsed; B = 1, browsed once; B > 1, browsed repeatedly), and height of plant and age at time of attack (height and age below bar graphs).

This trend is evident for all 3 planting species Blackbutt, Flooded Gum and Blue Gum, but is certainly more significantly marked in the case of pre-winter fertilized plants (see Table 6).

Briefly for the pre-winter fertilized Flooded Gum:

Age	Loss of Height at Browsing	% Browse	Total Loss in Height	Sig. Level
15 mths.	24 cm	64%	0.7 m	Highly Sig. (99%)
26 "	16 cm	49%	0.7 m	" " "
39 "	43 cm	86%	1.8 m	" " "

Hence the height loss differential is increasing with age and it will thus be interesting to see to what age and magnitude this further loss continues, for it would mean that the wallabies have largely contributed to the suppressed tree complement of the plantation.

Height losses sustained by plants that passed through the winter unfertilized appear to be less (Table 6), but the height stimulus is of course correspondingly less. That is to say plants respond better to early fertilizing but are eaten down more by wallabies because of it.

Reference to Graph 7 shows a straight line correlation between average height of a sample of trees and the percentage of this sample that has been repeatedly browsed.

The graph indicates that, at age 15 months, pre-winter fertilized unbrowsed height is about 3 metres, unfertilized unbrowsed height is about 2 metres, pre-winter fertilized height if 35% of the sample is repeatedly browsed is about 1.6 metres, and unfertilized height if 35% of the sample is repeatedly browsed is about 1.6 metres. On these figures, fertilizing under conditions of extensive browsing would be an extra plantation cost without having the desired effect.

(b) Long term effects on tree form

Although bent and kinked stems are commonly a direct result of browsing, the practical significance of this malformation is probably low. This form fault is usually located about 30 cm above the ground and if it does not grow out it will certainly not impair any future use of the trees.

TABLE 6

LONG TERM EFFECT OF BROWSING ON PLANT HEIGHT

Year Planted	Locality	Species	Fertilizer Regime	Age	Ht. Diff. between browsed and unbrowsed plants	% plants browsed
1971	Thompsons Road	Blue Gum	Pre-winter	3.3 yrs	1.3 m	70%
		Flooded Gum	Pre-winter	3.3 yrs	1.8 m	86%
1972	Welcome Flat	Blue Gum	None	2.2 yrs	0.1 m	37%
			Pre-winter	2.2 yrs	0.6 m	51%
		Flooded Gum	None	2.2 yrs	0.3 m	39%
			Pre-winter	2.2 yrs	0.7 m	49%
1973	Timmsvale	Flooded Gum	None	1.3 yrs	0.7 m	64%
			Pre-winter	1.3 yrs	0.7 m	65%
		Blackbutt	None	1.3 yrs	0.1 m	66%
			Pre-winter	1.3 yrs	1.2 m	75%
1974	Timmsvale	Flooded Gum	Pre-winter	0.7 yrs	1.4 m	88%

As to the formation of double leaders, field inspection at the time of browsing shows that some double leaders certainly result from browsing but results obtained seem to indicate that these trees may have been prone to double leader formation anyway.

1972 Welcome Flat

	Double Leader	Bent stem	Species
Unbrowsed	9%	18%	Blackbutt
Browsed	5%	0%	
Unbrowsed	8%	7%	Blue Gum
Browsed	8%	11%	
Unbrowsed	10%	4%	Flooded Gum
Browsed	9%	11%	

Thus subsequent malformation of the stem due to browsing does not seem to be important.

(c) Long term effect on tree survival

Browsing deaths undoubtedly occur and always represent some loss of the original stocking if browsing takes place while plants are small.

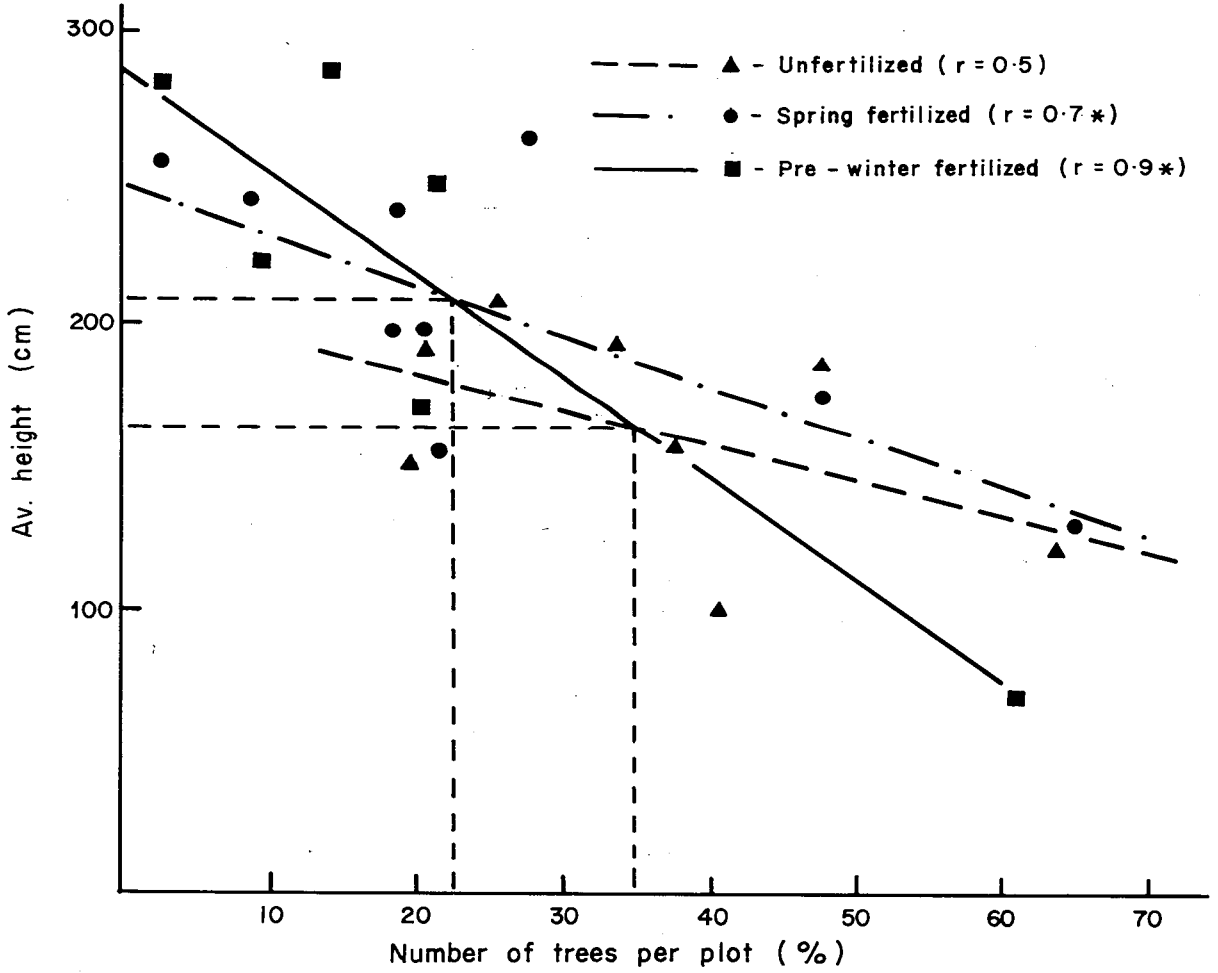
Most trees browsed (even severely browsed) recover and live on. The overall loss due to browsing is in the range 3 - 12% of original stocking.

Increasing the original stocking slightly could rectify this if considered sufficiently important.

Conclusions

(1) During the years 1971-1974 wallaby browsing, particularly in plantations in the Ulong sub-district, has been very extensive, commonly affecting well over 50% of the trees planted.

(2) Browsed trees suffer a height growth setback which continues to increase for at least 2 - 3 years after the browsing damage has been done. In the 1971 plantings the browsed trees were about 2 metres less than their unbrowsed counterparts when measured in 1974. This difference was less than 0.5 m in 1971.



Graph 7: Effect, on height, of repeated wallaby browsing. Average height of trees repeatedly browsed plotted against the number of trees repeatedly browsed per plot. Trees are 1973-planted Flooded Gum, browsed at ages 0-7 months, and measured at 15 months.

(3) The most severe browsing takes place at the edges of the plantation and along creeks within the plantation. Judicious manipulation of planting area shapes could significantly reduce the amount of "edge" exposed to severe browsing. One hundred metres or more away from wallaby harbour the browsing frequency is less by 20 - 30% and increment loss is reduced by around 50%.

(4) It is probable that some plant deaths result from browsing, the range being 3 - 12% of the original stocking in browsed areas.

(5) Fertilizer appears to slightly increase the number of plants attacked (1% - 14%) but has a definite effect on the severity of browsing. The fertilized plants, larger and more lushly leaved, are often eaten back to the same size as the browsed unfertilized stock thus nullifying the fertilizer effect altogether.

(6) Plantation eucalypts, Blackbutt, Flooded Gum, and Blue Gum, are very palatable to wallabies. Plantation surveys show that these eucalypts rank high in palatability amongst the list of available herbages found in plantations. Self-sown eucalypts are more rarely browsed.

(7) The wallaby identified without doubt as the browser of the plantation at Timmsvale is the Swamp or Black Wallaby (Wallabia bicolor). There is also some evidence that the red-necked pademelon (Thylogale thetis) may have been partly responsible in previous years.

In the 1974 plantation at Timmsvale the wallaby population density at dusk could have been as high as 10 wallabies/hectare.

(8) Wallabies prefer to browse small plants, there being a large reduction in the number browsed, and effect on, plants taller than 60 cm, viz. in 1973 83% of trees browsed when 60 cm or more exceeded 3 metres high at age 15 months whereas only 8% of trees early browsed when less than 30 cm exceeded 3 m high at age 15 months.

(9) Wallaby browsing in eucalypt plantations tends to be more widespread and more deleterious to growth than casual observation would concede.

Recommended Control Measure

(1) Careful selection of the area to be planted to avoid where possible, known population of wallabies. Special attention should be given to the shape of the plantation to reduce as far as practicable the "edge effect" which is maximised in elongated, narrow-width type clearings.

(2) Early planting and fertilizing so that plants are as large as possible by the onset of winter.

(3) In addition experiments have been laid down to test the cost and effect of:-

(a) Electric Fencing

(b) Systemic repellent applied in the nursery

A PRELIMINARY EXAMINATION OF THE IMPACT OF HOOP PINE PLANTATION MANAGEMENT ON THE BIRDS OF THE YARRAMAN FORESTRY DISTRICT, QUEENSLAND

W.J. Fisher

The Yarraman Forestry District is centred in the ranges approximately one hundred and fifteen kilometres to the north-west of Brisbane, in the upper reaches of the Brisbane Valley. Forest management in this District is concentrated upon the establishment and maintenance of plantations of hoop pine (Araucaria cunninghamii Ait.), a high quality softwood timber species which occurs naturally in the area as an emergent in rainforests. The sawmilling industry in Queensland in the late nineteenth and early twentieth centuries was based on the exploitation of high quality natural stands of hoop pine, bunya pine (A. bidwillii Hook.), and kauri pine (Agathis robusta F.M.B.), supplying all of Queensland's softwood requirements and most of Australia's plywood and high quality sawn timber requirements (Hawkins and Muir, 1968). Hoop pine plantation establishment commenced just prior to 1930 to cater for an expected continuing demand for high quality softwoods in the context of depletion of natural stands of pine and clearing of rain forest for agriculture.

The Yarraman environment, at an elevation of approximately 500 metres above sea level, represents the cooler and drier limits of the natural occurrence of hoop pine in Queensland. Mean annual rainfall is 830 mms and the mean temperature of the coldest month 11^{o}C. In this environment, mixed notophyll evergreen vine forests (classification of Webb, 1968) have developed mainly on the kraznozems formed on the basalt capped ranges. The Queensland Forestry Department's policy has been to limit hoop pine plantation establishment to forest types originally supporting hoop pine, or wet sclerophyll forests with a strongly developed rain forest understorey (Q.F.D., 1963). In other parts of south-east Queensland and to a limited extent in the Yarraman district, dry sclerophyll forest types, with a young understorey of more mesic species developing in the absence of fires, are now being converted to plantations of hoop pine.

Plantation Design

Commencing with the first plantations established in the District, continuous strips of rain forest have been retained around and within the hoop pine plantations. These strips of natural vegetation, known as 'scrub firebreaks' or 'scrub breaks' were retained as a protective buffer against wildfires, based on the premise that rain forest vegetation will not carry or will at least slow down a wildfire. Fires could thus be excluded, contained or controlled more readily.

The stated policy of the Forestry Department, (Q.F.D., 1963) is to retain wherever possible external scrub breaks 100 to 145 metres wide on all external boundaries, and to divide the contained areas into units of from 160 to 240 hectares by internal scrub breaks 100 metres wide. In situations where for example a section of a planned firebreak is found to be damaged or unsafe, such sections are planted at a wider spacing than usual with either hoop or bunya pine and regrowth of coppice and seedlings of rain forest species allowed to develop without interference.

In the Yarraman group of State Forest Reserves (S.F.R.'s 289, 316, 379 and 466), twenty-five percent of the original rain forest vegetation has been retained in the form of scrub breaks (excluding areas in which there may be further clearing in the future). The proportion of scrub breaks is generally higher in smaller reserves where the perimeter is relatively greater (e.g. S.F.R. 316 - total area of original rainforest 243 ha. of which 119 ha. has been planted, i.e. 51 percent of the original rainforest has been retained, which does include tongues and pockets of rain forest outside the formal scrub break design).

Table 1 contains a breakdown of the above group of reserves according to periods of plantation establishment. It can be seen that there has been a trend reducing the proportion of retained natural vegetation in more recent years: a slight reduction in the proportion retained in the period 1955 to 1970 (compared to pre 1955 plantings), and a drastic reduction in areas retained since 1970. Since the mid 1960's many previously planned scrub breaks, particularly internal breaks, have been deleted from plantation design and cleared. The 1970-1974 figure (3.2 percent) is somewhat unrealistic in that the final proportion retained on the current planting front will be higher, but nevertheless indicates a real trend, apparent in other reserve groups as well.

This trend may be akin to the "involuntary-conservative" and later "productive intensive" phases of exotic pine plantation establishment in the Beerburrum complex of coastal south-east Queensland described by Bevege (1974).

In addition to scrub breaks, relatively small scientific purpose areas and beauty spots have been delineated for preservation.

Considerable areas of rain forest remain in State Forest tenure in the Yarraman Forestry District. Virtually all of the accessible portions of these forests have been logged for hoop and bunya pines and some cabinet timbers and are apparently destined for conversion to plantations of hoop pine.

Bird Populations

It is readily apparent on walking through the older hoop pine plantations in particular that a considerable variety of birds are active within these plantations. This paper examines some of the results of a census of birds in a range of age classes of hoop pine plantations, in retained scrub breaks, in logged rain forest and in other native forests in the Yarraman State Forest area. It is stressed here that the data presented are by no means complete, but rather are part of continuing field investigations and are offered here mainly to contribute information to this Workshop.

TABLE 1

PROPORTION OF ORIGINAL RAIN FOREST RETAINED AS SCRUB FIREBREAKS IN THE YARRAMAN GROUP OF RESERVES (S.F.R.'s 289, 316, 379 AND 466)

Establishment Period*	Area Planted (Ha)	Area of Scrub Breaks and ** Ancillary Rain forest	Area of Original Rain forest+	Percentage of Retained Rain forest
Up to 1953-54	2,801	983	3,784	26.0
1954-55 - 1969-70	1,566	431	1,997	21.6
1970-71 - 1974-75	262	8.6	271	3.2
Total	4,629	1,423	6,052	23.5

* In some cases, because of contiguous plantings, these periods are not clearly separated.

** Approximate only

\+ Excluding area which may be cleared in the future

Methods

All census data presented here are derived from line transects on foot through the various vegetation associations indicated in Table 2. These transects have almost all been carried out on narrow tracks through the various forest types. Attempts have been made to proceed with line transects away from tracks in an attempt to avoid possible edge effects but except in very young plantations and in regularly burnt sclerophyll forest, observations were unreliable because of:-

(a) the difficulty of traversing through the thick and tangled undergrowth, requiring the observer to divert most attention to progress rather than to bird observations, and

(b) the greatly increased noise in moving through the forests, frightening away the more timid species and individuals.

The use of tracks may be introducing a bias in observable number of birds through edge effects. Tracks were however selected as far as possible for minimum disturbance to overhead canopies and consequent minimum apparent edge effects in the lower vegetative strata.

On each transect, every bird positively identified was recorded by:-

(i) species

(ii) sex for sexually dimorphic species

(iii) distance

(iv) angle from observer to the position of the bird when first noticed (whether visually or aurally)

(v) height of the bird above ground level (not recorded for the earlier transects).

For this paper, density estimates ($\hat{D}$) of each species encountered on line transects in each forest type or plantation age have been calculated according to one set of assumptions discussed by Eberhardt (1968) in relation to line transects, that the probability that an animal is sighted decreases exponentially with distance from the observer's path. (The probability that an animal at distance x is sighted = $e^{-\beta x}$. Based on this assumption, $\hat{D} = \frac{n}{L\bar{x}}$ where n = no. of sightings, L = length of

transect, $\bar{x}$ = average right-angle distance determined from a sample of n sightings). Density estimates per unit area were thus calculated for each species. To avoid interpretation of these estimates as absolute populations, they have been converted to fractions of the density estimate for a given species in the most natural habitat sampled. Such density indices or indices of relative abundance should be more readily acceptable for line transects.

Bird species diversity has been calculated for each forest type using the formula adopted by MacArthur and MacArthur (1961):-

BS.D. (H') = $-\Sigma_i \; p_i . \log_e p_i$ where p_i is the proportion of all the bird individuals which belong to the ith species.

Equitability and species richness have been estimated using the methods suggested by Kricher (1972):-

Equitability (J' - the distribution of individuals within species) = H'/H' max.

H' max is the maximum diversity possible for the sample, when all species are as evenly distributed numerically as is theoretically possible;

Species Richness (S) is the mean number of species per census (in each forest type).

Results

1. Density Indices

Density Indices calculated as above have been aggregated for species grouped on the basis of broadly similar behaviour and/or habitat usage and are shown in Tables 2A and 2B.

Table 2A lists relative density indices in each forest type for groups of species which have been encountered on line transects in logged rainforest and which general observations suggest regularly utilize such forest. In most of the sixteen groups of species listed there appears to be a clear pattern of increasing density with increasing plantation age. Densities in logged rainforest are generally much greater than in the older plantations, and the highest relative densities are in the rain forest retained as scrub firebreaks within designed plantations. These high relative densities in the scrub breaks are probably a reflection of inherent edge effects associated with the relatively large perimeter per unit area of scrub break. Species with lower density indices in scrub breaks seem to be those with more exacting habitat requirements

TABLE 2A

RAIN FOREST SPECIES

Density Indices of Bird Groups as Observed in Line Transects

(Ratio of Density Estimate in a Given Forest Type to that in Logged Rainforest)

	Hoop Pine Plantations Age (yrs)				Scrub Breaks	Logged Rain Forest	Rain Forest	Sclero-phyll Forest
	3-4	7-9	20	35+				
A. Larger Flycatchers (10 species)	0	.05	.11	.39	2.68	1	1.18	.09
B. Scrub-Wrens of Forest Floor (2 species)	0	.12	0	.52	2.41	1	.60	0
C. Small Insectivorous Birds of Low Mid Crowns (6 species)	.15	.55	.40	.39	2.58	1	.40	.01
D. As for C but excluding Silver-eyes	0	.04	.16	.32	1.90	1	.22	0
E. Pigeons (5 species)				.70	1.27	1	1	
F. Fruit Eating Pigeons Only (3 species)				.09	.84	1	1.29	
G. Honeyeaters (3 species)		.04	.10	.13	2.98	1	1.72	.16
H. As for G, but excluding Lewin Honeyeater (in (A) above)				.02	1.78	1	0	.19

(Continued next page)

TABLE 2A (continued)

RAIN FOREST SPECIES

Density Indices of Bird Groups as Observed in Line Transects

(Ratio of Density Estimate in a Given Forest Type to that in Logged Rainforest)

	Hoop Pine Plantations Age (yrs)				Scrub Breaks	Logged Rain Forest	Rain Forest	Sclero-phyll Forest
	3-4	7-9	20	35+				
I. Cuckoos (4 species)				.37	7.27	1		
J. Larger Birds of Forest Floor (3 species)				.79	.98	1	.45	
K. Larger Birds of Trunks & Branches (2 species)				.22	1.81	1		.76
L. Bower Birds (3 species)				.03		1		
M. Larger Birds of Mid Crown (6 species)	.24		.36	.31	.39	1	0	1
N. Parrots (2 species)	.52			1.21	4.66	1		.41
O. Small Birds of Upper Crown (2 species)				1.13	.24	1		.01
P. Doves (3 species)	1.01	.18	2.49			1		
Total	.14	.03	.25	.47	2.05	1	.40	.19

* excluding groups C, F, H

TABLE 2B

NON RAIN FOREST SPECIES

RATIO OF DENSITY ESTIMATE IN A GIVEN FOREST TYPE TO THAT OF THE HIGHEST DENSITY

	Hoop Pine Plantations Age Yrs				Scrub Breaks	Logged Rain Forest	Rain Forest	Sclerophyll Forest
	3-4	7-9	20	35+				
Q. Birds of Heath, Grasslands and Open Spaces (7 species)	1	.04						.09
R. Wrens (3 species)	.12		1	.25	.24			.23
S. Grey-Breasted Silvereyes	.14	.47	.25	.13	1	.20	.21	.01

(fruit-eating pigeons, larger birds of the rain forest floor - with the exception of brush turkeys -, bower birds). The available data indicate that these species do not readily find suitable habitat within plantations either.

Density Indices of these sixteen groups of species in the older plantations are higher and far more consistent than in adjacent sclerophyll forest, suggesting perhaps that these older plantations are developing suitable habitat for the rain forest birds rather than being randomly utilized as would appear to be the situation in the sclerophyll forests (with the exception at least of one species in group K, the white-throated treecreeper which according to available data is well adapted to both logged rainforest and sclerophyll forest). Of course most if not all available niches in the sclerophyll forest could be expected to be already occupied.

Table 2B lists density indices for two further groups of bird species. Group Q could be considered to be a group of species introduced to the environment by virtue of the presence of young hoop pine plantations. Species involved are normally associated with heaths and grasslands and appear to utilize the younger plantations until approximately the age of canopy closure. Density indices were calculated as a ratio of the density estimate in the 3 - 4 yr old plantations. Group R, the wrens (three Malurus spp.) appear to be able to utilize a range of available conditions, apparently most favoured by the relatively simple undergrowth available in plantations of about age twenty years. Density Indices listed are thus ratios of density estimates in that forest type.

Silvereyes have been listed separately as an individual species because of their evident ability to utilize all forest types censused, and to utilize a complete range of vertical strata within each type.

An aggregated density index of all groups shown in Table 2A, and density indices of the three groups in Table 2B are presented in graphical form in Figure 1. This figure reflects a changing pattern of bird habitat in hoop pine plantations with age, as indicated by changes in usage of these plantations by various groups of bird species. This changing environment is being examined but sufficient data are not available to report here.

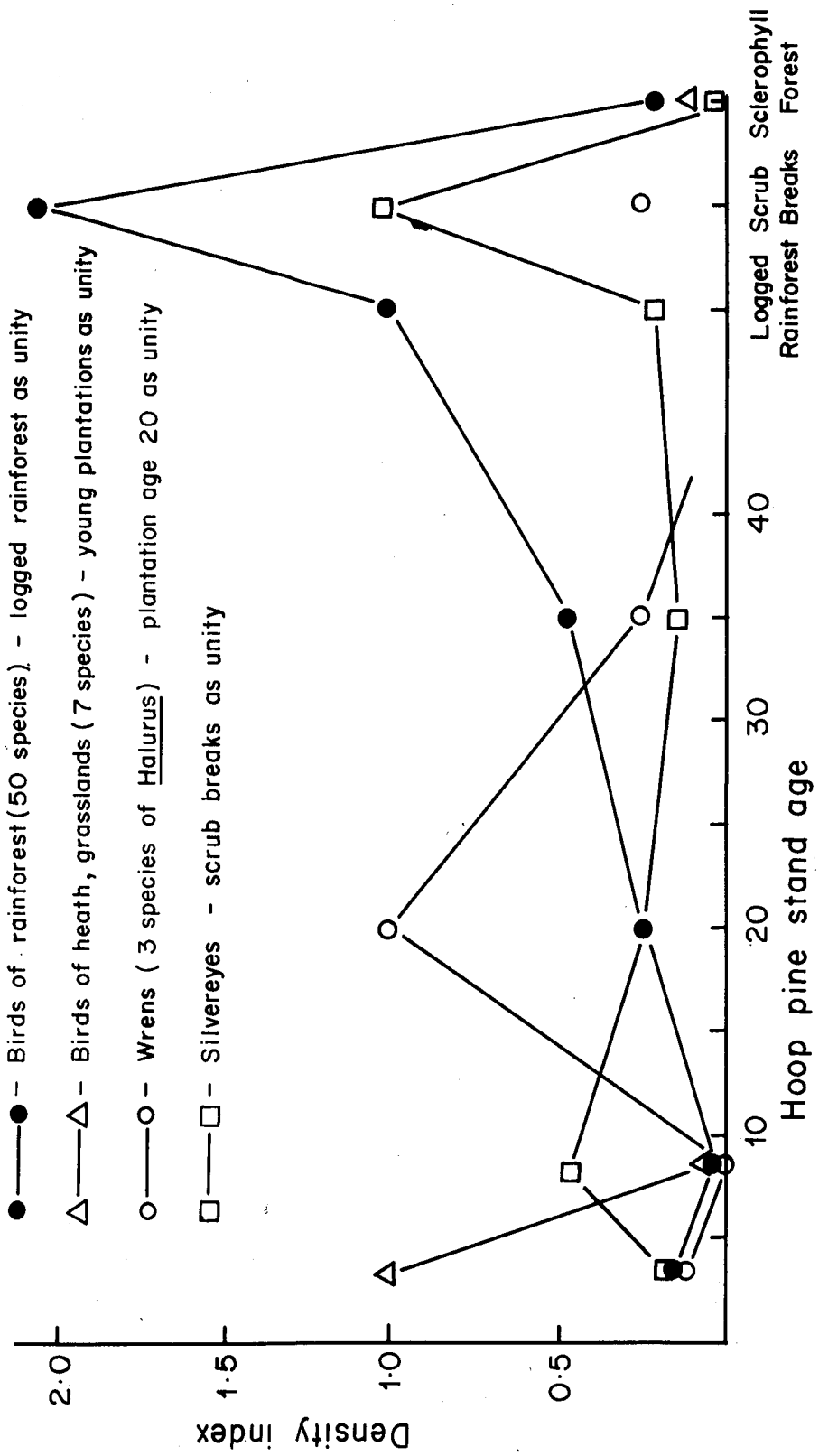


Figure 1: Relative densities of birds in hoop pine plantations and retained natural vegetation.

The changing habitat can be demonstrated further for individual species. Indications with limited data are that the eastern whip-bird is active in older plantations in comparable densities to logged rain forest. Brown pigeons and wonga pigeons appear to find old plantations more suitable for their requirements than rain forest. (This latter finding could be a reflection of lower visual detectability in rain forest, although both species flush readily and noisily).

2. Diversity

Bird species diversity for each forest type is shown in Table 3. (All species encountered on line transects are included here, (except for aerial feeders) whereas species primarily of sclerophyll forests are excluded from Table 2). These data demonstrate greatest diversity in the sclerophyll forest areas. Diversity is reasonably uniform in the three forest types of old plantations, scrub breaks and logged rain forests while the assemblage of species in these types has already been shown to be quite similiar. Diversity decreases with decreasing plantation age down to a minimum in the 7 - 9 year age class. Plantations of this age have achieved canopy closure, but have not been pruned or thinned and offer very little suitable habitat for animals. Canopies are dense and fairly uniform, undergrowth is quite sparse and trunks are virtually clothed in shed branchlets and needles. A measure of floral diversity would also be very low. Diversity of bird species is higher in the younger plantations which contain a wide range of weeds, grasses and young coppice.

Excluding the small area of virgin rain forest sampled, equitability of distribution of individuals follows a similar pattern for the different forest types to diversity. Sclerophyll forest has the highest J' value, and is the least disturbed forest type in the area. Somewhat surprisingly, equitability is greater in the older plantations than in the logged rainforest. This feature could well be in response to two factors,

(i) the degree of disturbance in logged rainforest (regrowth on log ramps, breaks in the canopy), and

(ii) variation in the structure and to a lesser extent floristics of the different rainforest areas sampled by line transects.

TABLE 3

BIRD SPECIES DIVERSITY

Data from Line Transects in Yarraman Forestry District State Forests

(BSD = $\Sigma_i p_i \log_e p_i$ where p_i = proportion of individuals of ith species

Vegetation	Hoop Pine Plantations Age (yrs)				Scrub Breaks	Logged Rainforest	Rainforest*	Sclerophyll Forest
	3-4	7-9*	20	35+				
B.S.D. (H')	2.289	0.920	1.921	3.088	2.909	3.062	2.514	3.336
Total No. of Individuals	163	71	98	513	412	611	35	175
No. of Species+	20	10	14	38	35	48	14	41
H' max	2.996	2.303	2.640	3.638	3.556	3.872	2.640	3.714
Equitability ($J' = \frac{H'}{H' \text{ max}}$)	.764	.400	.728	.849	.818	.791	.952	.898
Species Richness (S)	11.3 (56.7%)	10 (100%)	6.4 (45.4%)	18.5 (48.7%)	26.3 (75.2%)	22.1 (46.1%)	14 (100%)	29.5 (72.0%)

* Small samples only

\+ Species encountered and positively identified on line transects only

Species richness is not a useful statistic for the data presented here. Most of the variability in species richness can probably be accounted for by variations in the number and length of transects and again by variation in the types sampled.

3. Vertical Distribution of Species

Detailed examination of the usage of different vertical strata by various species in relation to available habitat has not yet been carried out. It could be expected, and has already been implied by the grouping of species in Table 2A, that different species have particular requirements from various strata in forest vegetation. All that is shown with available data at this stage is that records do suggest that such vertically stratified activity levels do exist, and that different species appear to have more or less rigorous limits for their activities. The development and existence of such strata is of course an important factor in determining the suitability of plantations as fauna habitat.

Discussion

Line transects as applied in this incomplete study have demonstrated quite major differences in the diversity and relative density of birds in different associations within the Yarraman Forestry District plantation systems. In response to an increasing development of rain forest trees and shrubs with age in the plantation, a high proportion of the birds of the local rain forests utilize these plantations to some extent. By age 40 years the relative abundance of individuals of most species are still lower than in the scrub breaks and original rainforest, but measurement of the distribution of individuals within these species suggest that these populations appear to be reasonably stable.

It is not yet known to what extent the relative densities of these bird species in the plantations are dependent on the existence of retained natural vegetation for some of their requirements. Some species appear to adapt completely to quite young plantations; e.g. brush turkey mounds have been located in 9 year old plantations. Other species, particularly bower birds, paradise rifle birds, ground thrushes, log runners, black breasted quail and frugivores, do not appear to utilize plantations to any real extent, although all these have been observed in scrub breaks. One of the problems with line transects is that records of

less common species are difficult to secure in any of the forest types. Excluding water-birds, the seventy-eight bird species recorded on line transects to date is only slightly more than half of the total number of species known from general observations to occur in the Yarraman State Forests.

Scrub breaks appear to be reasonably comparable to logged rain forest as habitat for birds according to the data provided above. The number of species recorded on line transects is significantly lower, although densities are generally higher, but general observations of birds in the area point to the fact that only two species of birds recorded in expansive areas of rain forest have not yet been recorded in scrub breaks.

The hoop pine plantations do have significant wild life values. Scrub breaks provide more favourable habitat however, and the persistence of many species within the plantation systems is probably dependent on the retention of scrub breaks. Although the results are not discussed here, similar observations of arboreal mammals indicate that scrub breaks are critical if many of the native species are to be preserved on State Forests.

The wildlife values that plantations have are related to the development of rain forest vegetation in the lower strata. It is not known at this stage how much of this vegetation will be able to continue into the second rotation. If such difficulties do arise and if the continuation of wildlife values is desired, then it may be necessary to carry out enrichment planting with suitable species, as suggested by Curtis (1974) in relation to exotic pine plantations.

Of importance also in relation to fauna habitat in plantations may be the high usage of hormone weedkillers in the control of lantana in the older plantations. One of the traditional objects in fostering undergrowth of rain forest species in hoop pine plantations has been to render conditions less favourable to lantana. While no quantitative information is as yet available, casual evidence suggests that a proportion of the rain forest understorey may be seriously threatened by lantana misting operations. Tentative results of this study would indicate that a significant reduction in the diversity and density of this understorey would have comparable effects on birds.

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FLORA AND FAUNA RESEARCH WITHIN THE FORESTS COMMISSION, VICTORIA

G.C. Suckling

The Forests Commission, Victoria, is involved in major flora and fauna investigations at Myrtleford, in the north-east of the State, and at Boola, south-east of Melbourne. On average two research officers have been employed full-time on each of these projects, but many people have been involved in carrying-out the research reported here.

1.0 MYRTLEFORD.

The Myrtleford research began late in 1971 and was initially aimed at defining the suitability of radiata pine (Pinus radiata) habitats for the various plants and animals which occur in peppermint forests in north-eastern Victoria. Study areas were chosen in native forest (the control area) and in plantations representing three stages of development: young pine (8 years); intermediate-aged pine (20 years); and mature pine (40 years). Because the exact flora and fauna of the pine study forests prior to planting are unknown, one area of native forest was chosen for long-term study. It is intended that this area be converted to radiata pine when calibration work is completed.

1.1 Vegetation Studies — G. Suckling and A. Heislers

These studies were aimed at determining the general composition and structure of the vegetation in each study forest. Vegetation was assessed at four levels above ground on plots along transects. Thirteen transects were located in each study forest; eight on slopes and five in gullies.

The vertical distribution of vegetation in eucalypt forest was found to be more uniform than in the pine plantations and the distribution was more uniform along creek banks than on slopes. In the young plantation tall shrubs were found to be particularly luxuriant along the creeks. This tall understorey was virtually absent in the intermediate-aged plantation but reappeared to a lesser extent along creeks in the

mature plantation.

Sampling for hollow logs, stumps and trees in the study forests revealed that the number of stumps was much greater in the two older pine areas that were cleared manually than in the native forest or the machine-cleared young plantation; that hollow trees were confined to the native forest; and that the availability of hollow logs in the manually-cleared older pine areas was at least equal to that in the native forest.

Eucalypt forest contained by far the greatest variety of vegetation. Within sample transects in eucalypt forest 114 species of plants, including 11 introduced species, were recorded. The least variety (59 species including 13 introduced species) occurred in the dense intermediate-aged plantation. Most plant species were less common in the plantation areas than in the native forest, with the exception of several introduced species which had increased in abundance.

1.2 Mammal Studies — G.C. Suckling and A. Heislers

These studies were aimed at identifying the variety of mammals and the relative population density of each species in each study forest. Small mammals such as the brown antechinus Antechinus stuartii and the bush rat Rattus fuscipes, were studied by trapping, using the capture, mark, release technique. Larger mammals, such as the arboreal species and the macropods, were studied by observation during the day and by spotlighting at night. Stomachs and scats (droppings) of foxes Vulpes vulpes, feral cats Felis cattus and wild dogs Canis familiaris, were analysed to detect hairs of mammalian prey, thus giving additional information on mammal species inhabiting the study forests.

At least 21 species of native mammals are now known to inhabit eucalypt forests representative of the types being converted to radiata pine in north-eastern Victoria. These are nineteen marsupials, one placental and one monotreme; bats and aquatic species are excluded from these totals. The placental and the monotreme occurred in all ages of pine plantation studied; in addition a total of seven marsupials were recorded in both the young and mature plantations and nine were recorded in the intermediate-

aged plantation. In all, nine marsupial species were not recorded in any pine plantation; six of these are rare in the eucalypt study forests and were not located there during this research.

The abundance of a mammal species present on planted sites appears to depend largely on the age of the pines and the development of native vegetation within the plantation. Small native mammals such as the bush rat and the brown antechinus are well adapted to survival and reproduction within all ages of pine plantations, particularly where native vegetation persists along creeks. Numbers of these species were generally highest along creeks both in the native forest control area and in systems of retained native vegetation. Larger species, such as the black wallaby Wallabia bicolor and the wombat Vombatus ursinus, were abundant in the young pine plantation where dense native vegetation persisted but were seldom seen in older more open plantations. Both of these species were abundant in the native forest control area. Arboreal mammals such as the greater glider Schoinobates volans, and the sugar glider Petaurus breviceps, which inhabit hollows in trees and are dependant on eucalypts for their food, were absent from all ages of pine plantation. These species were found to survive, at least in the short term, in systems of retained vegetation adjacent to planted areas.

1.3 Bird Studies

E. Backen

Bird studies have been aimed at determining the variety of species and the relative population density of each species in each study forest. Information on the numbers of species present has been collected in all the study forests. In addition, detailed studies of numbers of breeding pairs, location and size of breeding territories, and the effects of predation on breeding success, have been carried-out on gridded areas in the mature and intermediate-aged plantations.

Eighty-one species are known to occur in native forest areas around Myrtleford and sixty-six of these have been recorded in the eucalypt study forests. Of this sixty-six species, a total of thirty-four occur regularly in the pine study forests; 19 species in the young pine, 23 species in the intermediate-aged pine and 28 species in the mature pine.

Twenty-one of the 29 species occurring regularly in the mature and middle-aged pine study forests were found to breed in these areas. Four other species were observed feeding flying young which were probably raised within the stands, and four species were not observed breeding. Studies in the young pine plantation were confined to the non-breeding season, however results indicate that about 16 species breed in the area. Five of these species are not present in the older pine plantations. In all, 30 of the 34 species occurring regularly in the pine study forests are likely to breed in at least one of the three different aged stands.

Territory mapping studies and observations in the two older pine areas indicated that most (if not all) of the nesting species live entirely within the pine stands. The territories of the following six species were completely identified for a number of pairs and found to be located entirely within the stands: the yellow robin Eopsaltria australis, the blue wren Malurus cyaneus, the white-browed scrub wren Sericornis frontalis frontalis, and the brown thornbill Acanthiza pusilla are found in both study forests; the flame robin Petroica phoenicea is found in the middle-aged stands; and the scarlet robin Petroica multicolor is found in the mature stands.

Although the territories of other species were not completely identified, the nests of these species were located so far from the perimeter of the pine stands that there was little chance of any but the four largest and most mobile species obtaining their requirements outside the stands.

Forty-three of the 81 species occurring in native forest obtain a significant amount of their food from the eucalypt canopy. Of these, 34 species are unable to live in pine plantations because suitable nest sites are absent and either the pine canopy lacks a suitable insect fauna or these birds are not adapted to feeding from pine limbs and foliage.

1.4 Insect Studies

F.G. Neumann

Insects have been studied with the overall aim of determining the population characteristics (diversity, abundance, insect size) in each

study forest during different seasons. Diurnal insects were sampled in each study forest during each season for two years. Nocturnal insects were also sampled, but not as intensively. The specimens collected have all been identified to order level; the Hemiptera (bugs, leaf hoppers) have been further identified to family level and the Coleoptera (beetles) have been fully identified to species level.

Twenty orders of airborne insects have been found in the region. A total of nineteen orders were observed in mature eucalypt forest; seventeen orders in the mature pine plantation and respectively fourteen and thirteen orders in intermediate-aged and young stands of pine. The Diptera (flies) were predominant in both the eucalypts and pines. Next in abundance were Hymenoptera (Wasps) in the case of eucalypts, and Coleoptera in the case of pines. The Hemiptera and the Lepidoptera (moths, butterflies) were also common in both forest types. In plantations of mature and young pines only, the species of Coleoptera and the families of Hemiptera appear to be substantially more abundant and diverse than in mature eucalypts throughout most of the year. This may have been due to sampling error and further research is required to clarify these findings.

Intermediate-aged pine generally supported fewer insects than the other study forests, probably because of the lower diversity and density of the native vegetation therein. The abundance of insects in each study forest, expressed as a proportion of the total specimens trapped (13,920) was:

Mature eucalypt	0.21
Mature pine	0.30
Intermediate-aged pine	0.16
Young pine	0.33

1.5 The impact of radiata pine plantations on flora and fauna

In the north-eastern region of Victoria there are 1,189,914 ha of forested public land (excluding timbered roadside and streamside reserves),

of which 820,074 ha is classed as peppermint forest of one or another structural form. Peppermint forest has been the only forest type converted to plantations on a broad scale in north-eastern Victoria.

The total area of pine plantations in this region is 25,156 ha or 3.1 percent of the peppermint forest type now remaining. Planned new plantations may eventually bring the total planted area to 67,300 ha or 8.2 percent of the peppermint forest type.

If we consider the plantation complex as a whole, encompassing all ages of pine stands, the conservation impact may be a loss of up to 50 percent of mammal, bird and plant species on planted sites. (Insect populations have not been analysed in sufficient depth to enable a similar calculation to be made). If planting goes ahead as scheduled, it can be expected that up to fifty percent of mammal, bird and plant species will disappear from 8.2 percent of the peppermint forest area. This is an over-simplification of course because if we consider plant associations within the peppermint forest type, we would doubtless find that some associations (therefore some habitats) would be reduced by more than 8.2 percent, others by less. It should also be remembered that clearing for agriculture, water storages, roads and State Electricity Commission easements has already reduced the area of this forest type substantially. Further similar reductions in the area of peppermint forest can be expected in the future.

The figure presented for the conservation impact of the plantation complex would be improved considerably if those fauna inhabiting systems of retained vegetation were included. Subsequent rotations of exotic pine may however increase the impact on flora and fauna on planted sites.

1.6 Future Research at Myrtleford

C. Ashe, E. Backen

Systems of retained native forest adjacent to pine plantations have been found to support mammals and birds which are absent from planted sites. However the long-term viability of animal populations in reduced areas of native forest is by no means assured. One objective of future research at Myrtleford is to investigate the long-term conservation value of retained vegetation systems within and adjacent to plantations. The

value of corridors linking retained areas will also be studied. A further objective is to document the specific habitat requirements of forest-dwelling mammals and birds. With this information it will be possible to make sensible recommendations for fauna conservation during any form of utilization in native forest, as well as in plantation extension programs.

2.0 BOOLA

In January 1974 an environmental study of the Boola-Boola State Forest was commenced. The forest is an area typical of silvertop (Eucalyptus sieberi) / stringybark foothill forest throughout the Gippsland region. It has been heavily logged in small coupes since 1948 and natural regeneration has resulted in a mosaic of various aged stands. The present study was designed to determine the effects of forest utilization on flora and fauna. To date the study has been mostly concerned with vegetation, mammals and birds, however studies investigating insect populations, erosion and water quality, regeneration, and pathogenicity are also being undertaken.

2.1 Vegetation Studies — A. Morton

Work on vegetation has involved random sampling of all plant species in different forest types and analysis by a DIVINF computer program. The vegetation has been classified into four intergrading plant communities. These represent silvertop/stringybark associations on the plateaux, mountain grey gum (E. cypellocarpa) / narrow leaf peppermint (E. radiata) associations in gullies, white stringybark (E. globoidea) / long-leaf box (E. bridgesiana) associations on north facing slopes and yertchuk (E. consideniana) / heath associations in areas of poor drainage. Most forest utilization has been on the silvertop plateaux and only one small area of typical mature silvertop remains. This area was not sufficient for control purposes and effects of logging on flora were specially hard to determine as plant distribution depends on a complex range of environmental variables. A comprehensive plant list of 394 species was prepared for the forest and analysis will continue. Future work will also be concerned with structural aspects of vegetation.

2.2 Mammal Studies

A. Heislers and M. Macfarlane

Seventeen native and five alien species of mammals (excluding bats and aquatic species) have been recorded for Boola - a variety similar to other mixed species eucalypt forests. However population densities of arboreal mammals and species of antechinus seemed to be inherently low.

Most species of mammals seemed to be more abundant in habitats within gullies or on slopes, where timber utilization has been absent ot light, than on plateaux. Only brown antechinus, wombats and sugar gliders were equally or more abundant on the plateaux than on slopes and gullies.

A comparison of mature forests with some similar sites cut-over and regenerated some fifteen years ago indicated that logging may have reduced the diversity of mammals present (mature forest contained five more native species than regenerated forest), lowered population densities of some species that use tree hollows, and increased population densities of some species that live in dense undergrowth. Logging did not appear to promote the spread of alien species of mammals in the forest. It is not clear to what extent the variability of sampling contributed to the apparent effects of logging, particularly as it is not known what the mammal fauna in the sampled areas was prior to logging.

In the logged areas, the hollow trees and uncut sections of forest remaining after logging undoubtedly allow mammals to survive. If the trees with hollows die out and are not replaced, or if future utilization of timber extends further into gullies, then the mammal fauna could decline significantly. Further mammal studies are continuing along similar comparative lines to obtain more accurate and detailed information on diversity and population numbers of individual species in all seasons of the year.

2.3 Bird Studies

R. Macaulay, R. Loyn

Initial work was confined to four study areas in mature and regenerating silvertop forest. A total of 65 species was identified; however the species and diversity of birds varied with the age of stands. In mature silvertop stands 34 species were recorded, with relatively high populations of eucalypt nectar and capsule-feeding species. In a

dense stand of 15-20 year old silvertop regeneration 27 species were recorded, and in an area of 4-5 year old regeneration 25 species were found. In both these areas nectar and capsule-feeding species were in very low numbers but understorey species were numerous. The lowest bird population, only 12 species, was recorded in a clear-felled study area with 3-4 year old regeneration; ground feeding species were commonly observed in this area.

Further studies are being carried-out to define the habitats of bird species within the whole forest, and to estimate populations in a number of study plots representing logged and unlogged silvertop plateaux and gullies, and several different stages of regeneration.

2.4 The Impact of utilization on flora and fauna

In general it is concluded that logging operations have altered Boola-Boola as a habitat for wildlife. Some species have benefited from this but the diversity of birds and more particularly of mammals appears to have declined in logged areas. In order to maintain wildlife in productive forest, major gullies should continue to be left unlogged, cutting coupes should remain small and clusters of over-mature trees should be left standing to provide hollows for birds and mammals. It is desirable that a silvertop community reference area be established in Victoria.

FERAL PIGS AND AGRICULTURE

J.R. Giles

Feral pigs are widespread in New South Wales, and there are populations of very high density associated with the western river and marsh systems. They are accused of damage to grain crops, fencing and stock watering facilities, predation on lambs and native fauna and damage to water fowl habitat and native floral associations in some areas. Their distribution and abundance has also caused concern that they may become vectors and reservoirs of exotic stock diseases such as foot and mouth, swine fever, rinderpest and others.

A study of the ecology of the feral pig in New South Wales was commenced by the author in 1971. A similar study in the Northern Territory by CSIRO was commenced in 1972. In all the areas studied, the general biology of the animal was similar. Pigs have tended to colonize areas where there was abundant water and shelter from high temperatures and human interference. Food consists primarily of vegetable material, but the pig is an opportunist feeder and will eat carrion, including sheep remains, and grain when these are available.

Some feral pig colonies were established in Australia prior to 1870 (Pullar, 1950). Their major distribution in 1950 as given by Pullar is substantially unaltered at the present time, although there are now numerous colonies on the Alps, Slopes and Coast. Populations have been under study on the flood plain of the Cuttaburra Creek, near Hungerford (north western New South Wales) and the southern Macquarie Marshes in the central west of the state. These populations were reduced to remnants during the drought of the mid 1960's and peaked in early 1973. There has been very little recruitment since that time.

Peak densities in the Cuttaburra were estimated from capture/recapture studies to be about 25 pigs per sq. km. (60 pigs per sq. mile) and about 80 pigs per sq. km. (200 pigs per sq. mile in the southern Macquarie Marshes. For several reasons, the estimate for the Macquarie Marshes is believed to be low.

There has been no serious attempt to determine the impact of pigs on agricultural enterprise in this state. Damage to coarse grain crops in the Moree area can be severe, particularly where crops abutt areas of dense and well watered scrub. Several irrigated crops in this area were completely destroyed, with particularly severe damage in 1972. Since 1972 there have been active pig control programmes in this area and there has been a marked reduction in the number of complaints of severe crop damage.

Predation on young lambs is much more difficult to quantify and is likely to vary markedly between properties, paddocks within properties, years, and seasons within years depending on pig population density, location of watering points and alternative food available for the pigs. Several properties on the far western flood plains, in areas of high pig population density, abandoned attempts to breed or keep sheep between 1969 and 1975.

On the flood plain of the Cuttaburra lamb marking percentages in excess of 60 percent (60 lambs per 100 ewes joined) have been recorded by several landholders. Properties in the general area of Hungerford, but away from the Cuttaburra, record much higher lambing percentages, and expect to mark in excess of 80 percent lambs. Good seasonal conditions have prevailed since 1969, and pig predation is thought to be an important cause of low lamb production in the Cuttaburra, although there are undoubtedly other contributory factors. Pigs have been observed by the author killing lambs and debilitating adult sheep.

There are several problems associated with control of feral pigs. The first is that the reproduction rate is potentially high. Sows reach puberty at 6 - 8 months if their food supply is adequate and their liveweight exceeds about 30 kg, although their first litter is generally small. From 18 months of age the mean litter size at birth is 6.5. Gestation is four months and lactation about three, and as there is normally no non-breeding season except in the southern Alps, they have a potential to wean two litters per 12 - 15 months. Number of young weaned per litter varies considerably with food supply. The mean number of piglets suckled per litter in 1971 in the Macquarie Marshes was 4.5. This is considered to be close to the potential.

Annual mortality rates have been found to be 30 - 50 percent and rate of increase about 1.056 (i.e. 287 percent per annum). A large number of pigs were shot on all of the study areas studied from 1971-5, and a high proportion of the mortality of pigs over 12 months was undoubtedly due to shooting. To achieve a reduction in population size for over 12 months (ignoring any immigration into areas of low population density), it would be necessary to remove about 70 percent of the population.

A second problem in control is presented by the nature of the habitat preferred by the pigs. The colonies of highest density are in areas that are densely vegetated and subject to inundation. In these areas it is difficult to poison, trap or shoot because the pigs need not leave the swamps for water or food. During droughts, many of these areas are however reasonably accessible.

Habitat manipulation is generally not feasible or desirable because of the impact on other fauna, although it is possible to deny pigs access to water in areas where all the water is in ground tanks or water from troughs.

The most successful control for crop and lamb protection has been poisoning with grain or bran/pollard pellets impregnated with sodium monofluoroacetate (compound 1080). Approval for Pastures Protection Boards to use this poison for pigs is granted with caution and its use in the area is subject to several restrictive conditions relating to bait type, poison concentration, bait replacement and several other factors. Prior to the use of this poison, there was widespread use of organic phosphate insecticides to poison pigs and the dangers associated with these poisons are much greater than that from 1080. In particular, 1080 has a much higher toxicity to exotic mammals than to native fauna, and a particularly low toxicity to avifauna. There has been no evidence of damage to native fauna from 1080 poisoned pig baits, despite an abundance of macropods and seed eating birds in the areas in which it has been used.

Exclusion fencing has been used for crop protection in some areas of Queensland and New South Wales. High voltage electric fencing has been found to efficiently prevent traffic of pigs if electrified strands are placed 10 to 20 cm from the ground.

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THE RABBIT - A PROBLEM SPECIES

J. Martin

There is little doubt that rabbits have been, and still are, the most important vertebrate pest in Australia, in terms of damage to both environment and agricultural values. That the "rabbit problem" still exists is surprising particularly in view of the resources which have been expended on research.

It is indisputable that rabbit populations have been drastically reduced in recent years. There is also no doubt that in some places, control efforts have resulted in the total eradication of rabbits. The "problem" is unquestionably less severe than it was 30 years ago. However, rabbits still represent a major problem in some parts of the state.

One area where rabbit numbers are presently high is the Western Division of N.S.W. Some graziers in the area maintain that numbers are as high now as they were prior to the myxomatosis outbreaks in the early 1950s. (Brennan, pers. comm.). It is this general concern over the apparent rapid increase in rabbit densities which had lead to the initiation of a research programme which is aimed at investigating the economic practicability of rabbit control in the semi-arid Western Division of N.S.W.

In the past, rabbit control has not been considered an essential land management practice in this part of the state. This was because of a number of factors which include the relatively large size of holdings, low land values, low productivity, and markedly fluctuating rabbit densities. However, rapidly increasing rabbit densities, approaching plague proportion in some areas, have caused interest in investigating the possibilities for control. Myxomatosis no longer appears to be exerting any great effect, and damage to stock food and the environment in general appears to be extensive.

Strategic control utilising natural population fluctuations and a variety of control measures seemed to provide the best potential. The aim, describing how, when, and where to exert control effort in order to get maximum value from investment, is divided in five sections.

1. To develop accurate techniques for measuring rabbit density, rabbit "condition", and a variety of other parameters.

2. To measure the rate of increase or decline in rabbit density in relation to soil/vegetation types, and specific warren types. In other words, to ascribe "survival" or "refuge value" indices to warren types depending upon the length of time they remain active during poor environmental conditions.

3. To evaluate the relationship between effectiveness of warren ripping, cost, warren type, season, and a number of rabbit population parameters.

4. To evaluate the effectiveness of a variety of bait and poison combinations in relation to other control techniques, cost, season, environmental type, and various rabbit population parameters.

5. To measure some of the rabbit/vegetation relationships, using enclosure plots.

This work is being conducted on 4 properties in the Western Division of N.S.W. One near Cobar, one just east of the Darling River near Ivanhoe, and two west of the Darling River near Menindee. Although the project has only been in progress for about 1 year, a large quantity of data has already been collected. 1300 rabbits have been autopsied, showing that there has not been any breeding since November 1974; that although food supplies appear to be dwindling, many of the populations still have reasonably high fat reserves; and that age distributions are as expected from theoretical considerations.

Over 100 rabbit density estimates from a total of 6 areas have been completed. These show that rate of decline of population is generally related to density of rabbits. That is, the dense populations have started a dramatic decline, while the light populations have remained surprisingly stable.

About 500 warrens have been marked and visited 4 or 5 times each. An estimate of size and activity taken on each occasion shows that activity and size is surprisingly stable.

Two sets of poison trials have been conducted, and a series of measurements on warren ripping is presently being collected. Data from a series of 6 enclosure plots are also being collected.

Data on population dynamics, landform, and control success by a variety of methods, will be pooled in order to find which population parameters may best be used for predicting when to control and how to control. Warren activity data will tell where to control. This approach, of being able to predict the outcome of a specific type of control under specific landform and seasonal conditions, will then be tested in a series of model operational trials. Prediction of the behaviour of control measures has added benefits in allowing more accurate costing and hence more accurate estimation of the investment value of a specific type of control.

Control or Management? Inevitably, the problem of defining a long term objective for applied rabbit research will arise. Control is the present objective, although rarely are the terms control or management defined. I believe control to mean "the reduction of animal numbers to levels consistent with the continued wellbeing of agricultural and environmental values, and their subsequent maintenance at or safely below those levels". "Control"

then, is quite different from "management" which implies the simultaneous maintenance of a yield of animals in satisfaction of recreational and/or commercial demands. Confusion between the meanings of these two terms appears to have caused confusion in legislative objectives. For example, on one hand it is an offence not to make a continuing effort to suppress rabbits, and on the other hand, there is a well developed industry based upon the exploitation of wild rabbit populations. This conflict forms the basis of the decommercialisation debate.

Management should not seriously be considered until it is demonstrated that we have the ability to reduce all rabbit populations to a level consistent with the wellbeing of agricultural and environmental values; that is, that we can control all rabbit populations. This has not been demonstrated. For example, fundamental to the business of rabbit density manipulation is the necessity to be able to measure accurately relative density; yet there is no well studied and documented method available. Also fundamental to the understanding of the rabbit "problem" is the necessity of having reliable data on animal distribution, both present, past, and potential. This information is not generally available. Most important to the understanding of control is a knowledge of rabbit/plant relationships. In other words, what effects do different rabbit densities have upon the values we are trying to protect? Little has been published on this topic. The same may be said of rabbit/native animal relationships. These are the problems to be solved if control is to become effective and management discussed as an objective.

Quite obviously, more research effort must go into "problem solving", using the vast amount of ecological information which is now available.

Potential rabbit problems: Although rabbit populations in a number of areas are being more than adequately contained, there is good reason to be concerned about the potential danger they still represent over much of the state. Complacency resulting from the previously effective "no cost" myxomatosis, and confusion between myxomatosis-induced population declines and declines resulting from food shortage, are seen as two factors which could allow rabbits to become a severe problem again. As long as graziers fail to recognise that the effectiveness of the disease is decreasing, there is good opportunity for populations to expand dramatically. Add to this the possibility that 1080 may not be available in a few years time, and it may be seen that rabbits could again become an intractable wildlife and agriculture problem similar to that present in the 1940s.

Conclusions: It must be conceded that in most areas, we have not yet completed the first step towards the effective control of rabbits - the reduction of populations to demonstrably tolerable levels. The second step will be much

more difficult - the demonstration of our ability to hold population indefinitely at or below these levels. There is, under the present research climate, no room for considering the rabbit as anything other than a species in direct conflict with agriculture and environmental stability. Perhaps far into the future when we have a complete knowledge of control, when we have greater technical expertise and financial resources, we may be able to talk about management of rabbits and their role as an integrated unit in the Australian agricultural and wildlife scene.

INFLUENCE OF DENSE PARROT POPULATIONS ON AGRICULTURE IN AN ISOLATED AREA

D.A. Campbell

The following comments are partly personal observation, partly information gleaned from farmers and partly from the Division of Plant Industry on files P.I. 64/591 and P.I. 74/361.

At Bourke two bird species are usually implicated in agricultural damage, the common pink/grey galah and quarrions.

The sequence of events leading to intense crop destruction seems to be a series of good seasons and/or large crop areas which allow bird populations to become abnormally high. When feed supply falls, e.g. when drought or flood reduces natural feed, or crop area is reduced, birds will concentrate on available crop. Considerable grain damage or complete destruction can result. Crops near timber shelter belts or other roosts, e.g. power lines, will be attacked first but absence of roosts is not a safeguard.

Bird numbers which can appear on susceptible crops are difficult to describe. If scared, dense clouds of birds rise and cast a shadow upon the ground. An example from a 1972 wheat crop at Brewarrina may help. An irrigated crop of Timgalen wheat was not attacked even when almost ready to harvest. Timgalen is a "bearded" or long awned variety which repels birds and also feral pigs to some extent. Seasonal conditions were poor and hay prices were such that baling of an over-mature hay was preferable to grain harvesting. When the crop was mowed birds were able to extract grain. When it was baled galah numbers on bales were so high that bales were knocked over by birds. Almost invariably each fallen hay bale squashed one or several birds; numbers were too high to allow quick escape from a falling hay bale.

Sunflowers, grain sorghum, and oats are the most susceptible crops. Standing awned winter cereals, safflower, soybean and maize, have not been attacked to date although they have been only minor crops. Cotton is the major cash crop and is not attacked by birds or pigs.

At Bourke in 1972, a particularly bad bird year, a maize crop of 142 ha stood all winter untouched by birds. The crop was highly susceptible to damage, it contained much spilled grain from feral pig attack and seasonal conditions were poor. Apparently an inventive innovative galah is needed to teach others how to peel maize husks. This galah has yet to arrive at Bourke but from accounts of other districts he is working well within N.S.W.

Agronomic controls advised are:

(i) Sow summer crops early to allow rapid maturation and harvest in hot weather thus reducing the susceptible time for bird or pig damage.

(ii) If possible, growers in the same area should synchronise their sowing time and variety so large crop areas are susceptible at the same time thus "diluting" birds. A succession of sowings, or varieties differing in time of maturity provide a series of crops for birds to attack.

(iii) Avoid known danger areas, e.g. heavy timber, power lines, extreme isolation etc.

(iv) Where possible select less susceptible crops or varieties e.g. use bearded rather than poorly awned wheats or "birdproof" grain sorghum. Reducing the attractiveness of a crop is only effective if an alternative feed source is available.

(v) Use good seed and agricultural practices to ensure uniform and rapid ripening, e.g. even irrigation layout, hybrid rather than open pollinated sunflower, avoid second growth grain sorghum.

(vi) Consider high moisture harvesting and grain drying or propionic acid treatment to reduce field standing time.

Other control measures suggested or tried have included:

(i) Chemical repellents. Bayer Morket^{R} was effective at New Angledool (north of Lightning Ridge) when aerial sprayed onto tree belts with a few strips through a crop. New Angledool is relatively close to agricultural cropping areas. At Bourke Morket^{R} strips sprayed onto grain sorghum in 1972 had no effect and 100% loss of crop to galahs resulted.

(ii) Poisons - generally not effective; not acceptable as they can destroy excessive numbers of native birds and would be poorly selective i.e. both target and non-target species may be killed. Dangerous to livestock and man.

I have seen strychnine used safely and successfully by establishing a bait station for quarrions near grain sorghum. The temptation to aerial spray with highly toxic chemicals, e.g. mevinphos, or environmentally dangerous and residue-producing chemicals, e.g. endrin or dieldrin, is present when a farmer's livelihood is threatened by birds.

The product Scat-a-bird has been suggested but not tried. It is an expensive hallucinogenic poison. Affected birds die slowly emitting distress calls which scare other birds away. The justification is to sacrifice a few birds so that the crop is saved and destruction of many birds is avoided. The need to free-feed when birds are already on an attractive crop makes the product both expensive and impractical in most cases.

(iii) Shooting is completely ineffective against the bird numbers involved and can be dangerous if too many "sportsmen" start shooting from opposite sides of a paddock. In special circumstances a combination

of shotgun and scare-gun may have a place particularly in orchards. Scare guns are impracticable over large areas and ineffective after a couple of days when birds become accustomed to the periodic noise.

(iv) Helium-filled 100 gm red neoprene ballons are reported as successful but expensive. They would be limited to small areas of high value crop. The balloons are flown 18-30 m high and are 80 cm in diameter. I have no experience with this method.

(v) Recorded bird distress calls played at irregular intervals on loud speakers throughout a crop have not been tried but appear to have merit. Glenfield Agricultural Engineering Centre and the National Parks and Wildlife Service were hoping to combine resources to design and test the system in late 1972 but the project was not supported.

Sometimes high bird populations will attack dense Noogoora burr infestations and eat mature seed. This has an isolated weed control effect but is of no value to the overall *Xanthium* position.

Emus can be a large problem in crops through trampling rather than eating. I have seen very heavy damage at times in the Western Division but only rarely in the "major" irrigation area of Bourke/Brewarrina. Macropods can also cause major damage but are not generally a problem of irrigation areas at Bourke. The more isolated crops are attacked elsewhere. Feral pigs are a major limiting factor in production of crops other than cotton. Unlike birds they can be controlled by careful forethought and a trapping or poisoning programme.

Another bird problem encountered in homestead gardens usually south of Bourke in the Cobar district is lousy jack or lousy jay* damage to home garden stone fruit. Crops can be completely ruined. Economic loss is negligible but the problem concerns home gardeners. Shooting and a synthetic web over trees have no effect. The only effective control is a large birdproof cage constructed over the home orchard.

The inability to grow irrigated grains successfully because of birds has not been a real disaster so far. Cotton has been king and growers have always regarded cattle finishing as a safe alternative. There are huge pastoral areas of N.S.W., South Australia and Queensland to supply stores and a meatworks in Bourke. Current cattle prices have temporarily prevented this development. New pesticide residue legislation will be the end of cattle on cotton farms without drastic management changes.

* Ed. Currawong

NOTES ON BIRD DAMAGE IN AGRICULTURE: THE PROBLEM FROM A FARMER'S POINT OF VIEW

M.H. Cole

Cropping in the Namoi Valley, as elsewhere, takes two main forms: winter crops, which are mostly cereals, with some oilseeds and fodder crops, and summer crops, which are coarse grains, oilseeds, and fodder crops. The types of birds that affect these crops are mainly large and small members of the parrot family, crows, and ducks.

1. Winter Crops

Damage to cereals by birds in the Namoi Valley is not great. Damage can however occur in limited areas by wild ducks eating young crops around dams and near creeks; but the economic significance is not as great as that of the areas of wheat, in particular, that are eaten down around treed camping areas by cockatoos and galahs when green grain is newly formed.

Galahs damage young shoots as they emerge, but in most cases the shoots continue to grow unless soil is dry and loose. Parrots pick up any available grain around after sowing.

Winter oilseeds are mostly linseed and, less commonly, rapeseed, but birds seldom interfere with these. Fodder crops, like cereals, can suffer shoot damage by parrots and wild ducks.

2. Summer Crops

This is where the problem becomes acute, both in coarse grains and oilseeds, with the most economic damage occurring in oilseeds, particularly sunflower.

In coarse grains the damage caused by the parrots to sorghum crops is of two types, brought about by either (a) larger, or (b) smaller parrots.

(a) Cockatoos eat grain, and cut off heads and carry them off,

or let them fall while trying to. Galahs eat enormous quantities. Away from rivers (which is where cockatoos and galahs abound) and near scrubs, crimson wings and a beautiful array of king parrots, ring-necked, green parrots and others eat a large quantity of grain.

(b) Smaller birds include rosellas, quarrions, budgerigars and others. These birds cause damage by eating not only grain, but also half grains, particularly when they are in the soft dough stage. This half grain dries up and becomes light, so that it is blown off the riddles of harvesting machinery and is lost anyway. A lot of grain is lost this way, quarrions and budgerigars, each in their chosen localities, being the main offenders. Ground parrots do not cause much damage themselves, but are ever present clearing up the wastage of other species.

Corn is attacked by cockatoos, galahs and crows, which cause damage both by eating it and by breaking the weather seal of cobs when they are green, so that more damage is caused to ripening cobs by weather.

Oilseeds are damaged variously according to their nature. Soy beans, sown mostly under irrigation, do not appear to suffer much from bird damage, nor does the rarely grown safflower which is protected by the spikey nature of the plant. Sunflower is the oilseed that birds seem to like most and which suffers most enormous damage.

One reason why summer crops suffer so much damage from birds is that seed heads are edible and attractive for so long in the season. Sorghum heads have soft, relatively exposed grain in them for a long period before harvesting, as does corn to a certain extent. Sunflower heads seem attractive at all stages from emergence when the crop is half grown. The soft, fleshy head with unformed grain seems attractive to larger parrots. They bite pieces out of the heads, which become deformed and lose their natural weather protection capabilities. Less seed results, either through the deformation itself, or through the various bacterial and other rots that follow weather damage.

As sunflower heads mature, cockatoos eat grain from heads and bite

whole heads off, causing enormous loss. Galahs, crimson wings and other larger parrots mostly eat grain from the head, hanging upside down if necessary to reach it. They clear heads of grain in large areas, mostly sticking to chosen feeding areas, and extending these until 50% damage to crops becomes quite common. Some smaller crops have been rendered uneconomic to strip because of such extensive damage. Smaller birds only clean up spilled grains at this stage.

Not all birds are bad, of course. Enormous flocks of starlings are often seen flying with galahs. When heads are green the starlings feed on the Heliothis caterpillars which abound in unripe sunflowers,

3. Control of birds that cause damage

This is the most difficult part of the subject. Of the various available methods (scaring and shooting, poisoning, spraying deterrents, etc.), scaring involving shooting is by far the most effective. Shooting is included in scaring here as in my opinion each is a part of the other. Scare guns only simulate shooting and become relatively ineffective without accompanying shootings; and shooting is mostly scaring, as the number of birds shot has virtually no effect on the problem, being so few in comparison with the total flock. Some people think the dead birds are a deterrent if left lying round the area, but foxes and feral cats usually remove them.

The value of shooting and scaring can be improved by varying the firearms used. For example, shotguns kill some flying birds at close range and sound like scare guns, while .22 rifles, with their different sound, become effective when flocks are out of range of shot-guns. When birds are used to these weapons, high powered rifles, like .222, .243 or .303 calibres, are very effective, more from shock waves and different sounds than from actual birds killed. Flocks can be lifted off crops at a range of half a mile with high powered rifles. Cockatoos will often leave after lifting, but galahs, particularly when in a frenzy of feeding, will only settle again close by, which is both frustrating and expensive.

Shooting may not solve the overall problem, but it is the most effective way for an individual to do something for his own crop, even though it may only scare the birds on to someone else's crop. It is probably the only avenue available to the grower to protect his own crop.

Poisoning is ineffective as a control method in summer crops at later maturation stages. Poisoning has sometimes been successful in preventing damage to emerging seedlings, but it is hard to get birds to take bait when such a wealth of feed is available. In any case, later in the season the killing of birds does not seem to deter others much; early in the season it may do.

Deterrent sprays may be one of the hopes for the future. Available sprays seem to have some effect on smaller parrots, if not on the larger and more damaging cockatoos and galahs. Improved sprays may become available, but sunlight and weather, and certainly a rain shower, will limit the active life of the spray to 3 or 4 days in most cases. Some people have suggested that deterrent equipment will become available involving the use of sound waves, but none seems to be in use yet.

Two other methods may save some grain without necessarily controlling bird numbers. The first is the growing of sacrifice crops to attract birds away from the wanted crops. Birds could be scared from valued crops on to the sanctuary of the sacrifice crop. This seems beyond the means of most individuals, since sunflower, the most affected crop, is also the most popular with the birds. One can see the necessity to grow sunflower to save sunflower, which seems unsatisfactory.

Secondly, grain dryers are increasingly being used, as they become more available, to enable some crops to be harvested earlier, cutting losses considerably. This is not always practicable, as expensive harvesting equipment is necessary to handle green crops. This equipment is often not held on the property, and the uneven nature of maturity of most summer crops often makes contract harvesting impracticable.

BIRDS AND GRAIN CROPS IN NORTHERN NEW SOUTH WALES

A.B. Dale

In the past six years birds have become an increasing problem in grain crops especially in northern New South Wales. The pest status of birds is now regarded by many farmers as similar to insects, mice, pigs, rabbits and kangaroos.

Since the introduction of wheat quotas in 1969, summer crops have been grown extensively in northern New South Wales. In the New England region, the area sown to wheat in 1973-74 was 701,000 ha. compared with 1.11 m.ha. in 1968-69 while that sown to sorghum and sunflowers was 35,000 ha. in 1968-69 compared with 212,000 ha. in 1973-74. Peak summer crop area was 330,000 ha. in 1971-72.

While grain sorghum and sunflower production has led to farm diversification and stability of farm income, it has provided birds with virtually a year-round feed supply. This has greatly assisted the increase in bird populations especially in areas adjacent to heavily timbered country and rivers.

The birds causing most concern are galahs, white cockatoos, parrakeets and to a lesser extent crows.

Crop Damage

The types of damage caused are:-

(i) Removal of seed immediately after sowing of the crop.

(ii) Eating young seedlings.

(iii) Eating developing grain and mature grain of standing crops.

(iv) Chewing off heads of plants without necessarily eating any of the grain.

The chewing of grain and heads are the most damaging to crop yields and in fact birds can totally destroy a crop without leaving a single grain. Sunflower and grain sorghum crops have suffered 100 percent damage. However, birds exhibit quite distinct feed preferences with sunflowers being the preferred crop followed by grain sorghum, maize, millets and winter cereals. With many crops the grain has no real protection from the birds. However, some crops do have protection to a degree such as maize with a husk cover over the grain, barley and many wheats with awns, safflower with sharp bracts and soybeans with pods.

Control of Birds

Many techniques have been used with most of them having little long term success. This has only led to farmers experiencing great levels of frustration. A Boggabri farmer in reply to a recent survey by the N.S.W. Oilseeds Marketing Board said "We'll never grow sunflowers again. The birds can find their own feed some other way".

Some of the techniques that have been used are shooting, scare guns, shooing, recorded distress noises and drugs as sprays or baits. These all aim to frighten the birds away with the use of recorded distress noises being about the most effective. The covering of crops with webbing or mesh is only a proposition on small area, high value crops and may not prove entirely successful.

One practical suggestion is the harvesting of the grain as soon as it is physiologically mature and then drying the grain. This reduces the time the crop is exposed to the birds by as much as 4 weeks.

The breeding of bird "resistant" plants is a long term solution. Such plant structures as awns, husks, pods and sharp bracts do help. One theoretical suggestion for reducing the bird damage to sunflowers is to have sharp bracts similar to safflower. However, such bracts do not stop birds feeding altogether as they can be seen quite peacefully feeding on prickly heads of such plants as variegated thistles.

Another technique is to make the grain not as palatable for the birds as normal grain. Bird "resistant" grain sorghums have been bred with a high tannin content which do exactly that. As an example, near Walgett in the 1974-75 season a bird-resistant sorghum, NK300F and a normal sorghum NK266 grown under irrigation yielded approximately 8 tonnes per hectare and 1 tonne per hectare, respectively. The birds caused slight damage to NK300F but severe damage to NK266. However, this example is one of feed preference rather than resistance.

Effect of Birds on the Farming Community and Grain Industry

With the summer grain crops, especially sunflowers, being quite vulnerable to bird sttack, farmers are tending to grow less of these crops. In the case of sunflowers this has been very plainly stated in a recent survey by the N.S.W. Oilseeds Marketing Board.

In the northern part of N.S.W. with its summer rainfall, both summer and winter crops can be successfully grown to stabilize farm incomes. But with heavy bird infestations and so crop losses, farmers are being

seriously hampered by reduced incomes. Consequently, farmers are placing more reliance on less attractive crops, especially wheat.

However, much reliance has been placed in sunflowers by the Oilseeds Industry and currently much of the Industry's success depends on sunflowers, particularly the inland oilseed crushers such as North West Vegetable Oils Pty. Ltd. at Moree. Shortfalls in sunflower oil could well lead to importing of oil or seed to supply the margarine manufacturers and other users' needs.

Clearly, with birds jeopardizing the future of the sunflower industry, there is a need to examine closely bird control or management systems and possible plant protection techniques such as sharp bracts or unpalatable seed.

BIRD PESTS IN ORCHARDS

F. Hartridge, B. Clark, and N.W. Gane

The role of the Department of Agriculture in relation to birds in orchards is primarily concerned with control measures. This is inappropriate for this conference but it should be borne in mind that this is the main role expectation of departmental officers in this particular field.

Orchardists regard the fruit eating species of birds as destructive pests. Damage to fruit crops by birds varies from season to season and depends to a great extent on the availability of non-commercial crops e.g. native berries or wild foods. Migratory habits and the reoccurrence of droughts also influence the influx of birds.

All stone, pome and berry fruits (including grapes and nut crops) are acceptable foods to a wide range of birds. These destructive birds range in size from small silver eyes which feed on grapes and ripening stone fruit to crows and currawongs which feed on apples. Many kinds of parrots, galahs, cockatoos, starlings and Indian myna birds are also troublesome.

It has always been difficult to obtain an accurate assessment of bird damage to fruit crops but damage as high as 20% has occurred to apple crops in some New England orchards. Isolated orchards surrounded by natural timber, which harbour birds, are prime targets. On the other hand the activity of people and machinery in highly developed and intensive orchard areas tends to make these areas less attractive to birds. There is no doubt, however that fruit eating birds are responsible for some reduction in marketable fruit which results in a cost to the grower and a further cost is incurred in attempting to control birds.

It has been said that probably there will never be a single "magic" way to protect crops from bird damage. The problem is world-wide; it exists in Africa and Europe as well as England, Canada and the United States.

Australian fruit growers have utilized various methods over the years to protect their crops but none of them could be regarded as 100% successful. Shooting is the most common method.

It is interesting to review the attitudes of some people over a period of time.

A report from the Conference of Fruit Growers and Vine Growers, October, 1890, by the Honourable James Norton, M.L.C., states that -

"As a general rule, insectivorous birds are supposed to be the friends and helpers of man but many of the larger birds in preying on useful insects do quite as much harm as they do good by the destruction of injurious insects.

Moreover I am convinced that on the whole birds are much more injurious than insects and it is much easier to guard against the ravages of insects for nothing will protect the cultivator against birds but the expensive process of constantly shooting or driving them away or the equally expensive system of netting, while the damage done by many insects may be guarded against by various and much less expensive chemical and other processes."

In 1924, J.R. Kinghorn, Zoologist, Australian Museum, wrote "that birds are man's most valuable and yet least valued possession is a fact which is apparent to the comparatively few people who study them."

"From the point of view of Agriculture, we must realize that it is impossible to carry on for any time without the help of birds."

Coming up to 1975, a brief survey of orchardists in various fruit growing districts of the New England region has shown that the following species are the most troublesome, ranked here in the order in which they cause most damage.

Tenterfield

1. Rainbow Lorikeets
2. Currawongs
3. Crows
4. Gill birds (stone fruits)

Damage in some seasons can cause a loss of 15 - 20% of the apple crop. Constant shooting is necessary to prevent a build-up of the species listed. Most orchards in the Tenterfield area are surrounded by fairly dense timber.

Kentucky

1. Rainbow Lorikeet - in some seasons.
2. Currawongs - not active in large numbers
3. Crows - discouraged by shooting or with scare guns
4. Gill birds - not as numerous as in past years

Arding

1. Rainbow Lorikeet
2. Currawongs
3. Crows - mainly cherry and pear damage

Armidale

1. Rainbow Lorikeet - apples in some seasons only
2. Gill birds - cherries and apricots
3. Currawongs - appear to be increasing in numbers
4. Crows - nuisance only if allowed to feed unmolested

It is interesting and worthwhile noting that in the four centres listed the ranked order of damage-causing birds is much the same.

The attitude of orchardists to these bird pests is "They are a bloody nuisance". A lot of time has to be spent in shooting them to keep numbers from building up.

Except in local situations, it is impracticable to destroy birds to reduce populations because of their great potential to reproduce. In any case the fruit eating birds have an important role in assisting in control of insects. The widespread destruction of birds is generally unpopular with the community at large. The fruit growers however must be protected and this protection is restricted to the development of devices which will discourage the entry of birds into orchards.

Editorial note The scientific names of birds discussed in the preceding papers are listed below. The authority followed is, for convenience, Slater, P. (1970, 1974) A Field Guide to Australian Birds. 2 vols. Rigby

Emu	*Dromaius novaehollandiae*
"wild ducks"	Anatidae
"parrots"	Psittaciformes
Rainbow lorikeet	*Trichoglossus haematodus*
"white" = sulphur-crested cockatoo	*Cacatua galerita*
Little corella	*Cacatua sanguinea*
Galah	*Eolophus roseicapillus*
"quarrion" = Cockatiel	*Nymphicus hollandicus*
"crimson wing" = Red-winged parrot	*Aprosmictus erythropterus*
King parrot	*Alisterus scapularis*
"rosellas"	*Platycercus* species

(in this case the rosellas are usually eastern, *P. eximius* and crimson, *P. elegans*.)

Ring-necked parrot	*Barnardius barnardi*
"green" = Red-rumped parrot	*Psephotus haematonotus*
"ground parrots"	*Psephotus* spp. and *Platycercus* spp.
Budgerigar	*Melopsittacus undulatus*
"silver eyes"	Zosteropidae
"gill birds" = Wattle birds	*Anthochaera* spp.
(English) Starling	*Sturnus vulgaris*
Indian myna	*Acridotheres tristis*
(Pied) Currawong	*Strepera graculina*
"crows"	*Corvus* spp.

CORELLA AND GRAIN SORGHUM - FINDING A SOLUTION[1]

R.J.S. Beeton

Introduction

The Avian pest problems of the Ord River development have dimensions other than purely agricultural ones. Birds pose significant problems to civil aviation and human health. This paper deals only with aspects of grain cropping and refers only to one species, the little corella (Cacatua sanguinea Gould, 1842). There is some discussion of other avian species in the paper circulated (Beeton, 1973 in Anderson et al. 1973).

The Study Area

The study reported here was carried out in and around the Ord River irrigation development in Western Australia (Figure 1). The actual cropping area is located on the Ivanhoe Land system (Stewart et al. 1970) characterised by flat alluvial plains occupied by various associations dominated by annual grasses.

The climate is monsoonal with a wet season occuring between October and April. Ninety percent of the annual rainfall (770 mm) occurs during this period; the annual variability is low, but monthly variability is high. Temperatures are extreme; range are: May + June 30.6°C mean maximum to 14.4°C mean minimum, and 38.9°C to 26.7°C for the rest of the year.

The hinterland is a mosaic of land systems derived from a very old land surface. The youngest stratum in the area is of Devonian age.

The land systems are generally vegetated with a savanna woodland of varying tree density and composition. The understory is invariably annual grasses with some herbs. Annual native seed production is high and relatively reliable. However, the exact time of seed set and senescence is variable depending on the effective end of the previous wet for its synchronization

The Historic Background to this Study

The little corella problem at Kununurra followed an all too familiar pattern at the wildlife/agriculture interface (Figure 2). In such

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[1] This paper is a preliminary report of a detailed study, as such it will be updated in the near future. It presents the problem and the solution adopted in outline only. Any person wishing to quote from this paper should check with the author for the updated version before doing so.

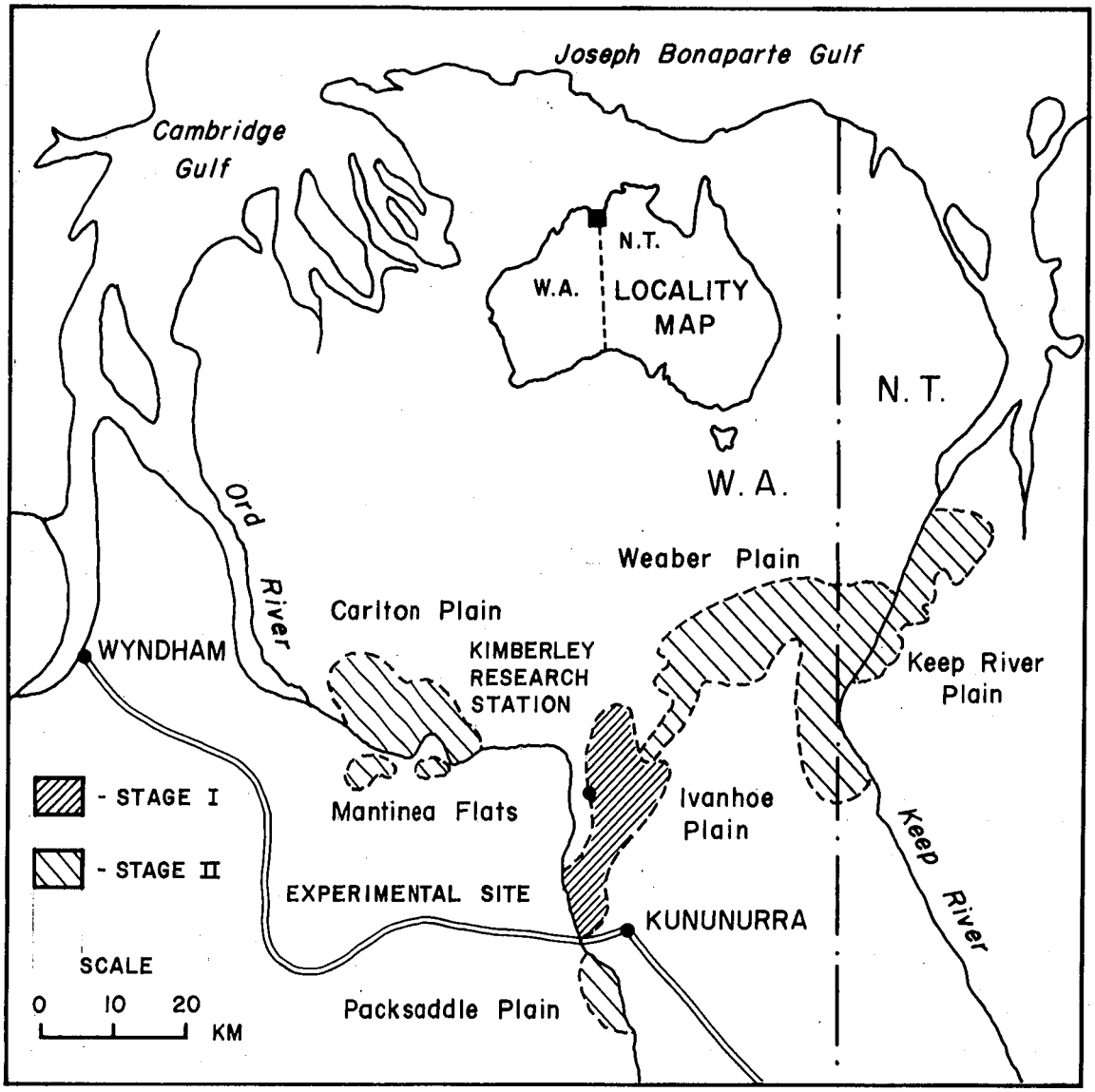

Figure 1: Locality map, and experimental site at Kununurra.

Figure 2: The scientists dilemma, caught between the grain-eating corella and the gun-toting farmer.

situations where the farmers suddenly find themselves with a very considerable problem the position of the biologist is difficult. He is invariably called in at the last minute when the problem is acute and a solution is needed yesterday. It is for this reason that we could do well to look at the background to the corella problem in 1970.

An excursion into the history of the bird pest problems of the Ord development is a salutary exercise; it represents a situation from which one would hope a whole generation of planners could learn a lot.

The first attempt to grow experimental grain crops by Kim Durack in the early 1940's resulted in the little corella being recognised as a significant pest (Durack, 1941). Durack in this 1941 paper urged amongst other things that pest research was needed as a basis for any future development.

After World War II the Kimberley Research Station was established to look into the general area of agricultural development in the region. The first record of experimental grain growing is in the 1947-48 wet season. This first experimental crop suffered from bird depredations. In fact between 1947 and 1951 70 percent of all experimental grain growing on the farm was written off due to pest attacks of various sorts; in all these pest attacks birds figured in over 90 percent.

What was the response to this problem? In 1948 Laangfield (an officer at K.R.S.) wrote to Christian his superior in Canberra:

"the only pests to do any noticeable damage were finches and white cockatoos (corella). The latter were particularly troublesome, and could only be combatted by placing a man on guard during the early morning and late evening. After the experimental section was harvested and the guard removed, the cockatoos cleaned up the remainder of the rows in a remarkably short time. I feel that they are going to prove the most serious pests to the growing of grain sorghum in the Kimberlies." (Laangfield, 1948).

This would on the face of it appear to be a realistic accessment of the situation. Many similar letters followed over the next 20 years, yet in July, 1967, the following appeared in a memo from the station:

FIGURE 3

ESTIMATED MAXIMUM LOSSES OF HARVESTABLE SORGHUM TO CORELLA

JUNE, 1970 TO NOVEMBER, 1971

MONTHLY BASIS

Month	Estimated Nos.	Loss in Long Tons
June, 1970	12,000	20
July	?	20 est.
August	?	20 est.
September	16,000	27
October	10,000	16.7
November	?	17 est.
December	18,000	30
January, 1971	32,000	53 (did not have these nos. for whole month)
February	12,000	19
March	10,000	16.7
April	?	17 est.
May	?	17 est.
June	12,000	5 (reduced by stubble feeding)
July	15,000	5.5 (reduced by stubble feeding)
August	10,000	4 (reduced by stubble feeding)
September	4,000	1 (reduced by stubble feeding)
October	1,900	1 (reduced by stubble feeding)
November	6,000	2 (reduced by stubble feeding)
	Total	291

Note

It is felt that these figures could be up to at least 30% over estimates. If a lower to upper annual range is taken for the year November, 1970 to November, 1971 the range for sorghum loss is 124 to 187 long tons for the year.

"Large numbers of the Little Corella are doing considerable damage to grain plots on the Research station and efforts to disperse them have been largely unsuccessful. No detailed study has been made of the bird habits and any control measures not devised around a knowledge of the birds habits would appear to be in vain. It is suggested that there exists a strong case for a detailed study of this bird to be made."

All that there was to show for 20 years of urging was two preliminary investigations (1 week or less) by two of Australia's top wildlife scientists (Carrick, 1956; Frith, 1955).

To those on the spot the problem was obvious. To any expert the problem was obvious, yet nothing happened. Why?

The reasons underlying this lack of action will probably never be fully known. Two things are however obvious. Firstly, the people who made the real financial decisions about the Ord development were not sensitive to wildlife problems. Secondly, those who saw the problem and wrote about it were in too weak a position politically to have any effect on how the 20-odd million dollars spent during this period were dispersed. This would only be of academic interest if it was not so often characteristic of problems in this area.

The significance of this major deficiency in the lead up to the commercial growing of sorghum may be gauged from Figure 3. This figure details the damage done by corella during the first 18 months of major commercial sorghum growing.

The response now was almost instantaneous. The research, of which this is a preliminary report, was underway by October, 1970 - a salutory lesson indeed.

The remainder of this paper concerns itself with some aspects of corella behaviour and biology. Only aspects germane to management are detailed in any depth.

Population Organisation of the Corella

The corella population is organised into two components (Figure 4). The range areas are favoured sites which occur throughout the hinterland of the Ord development. These are the sites where corella breeding tends

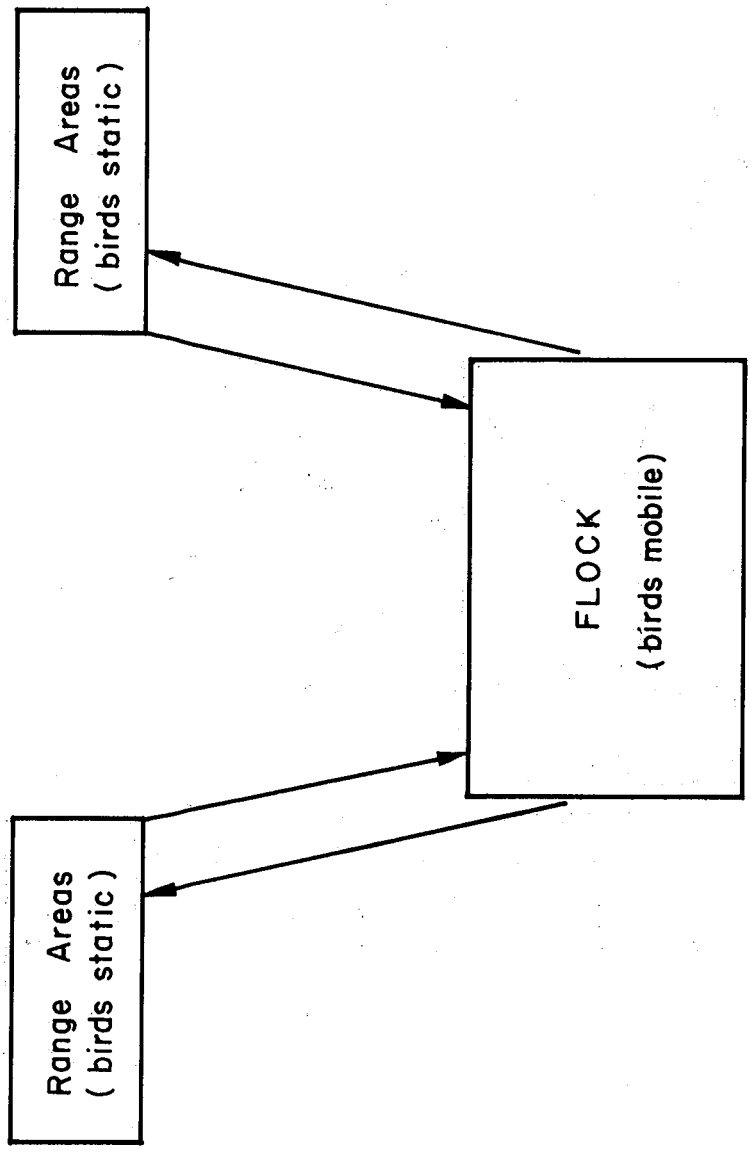

Figure 4: Organisation of the corella population.

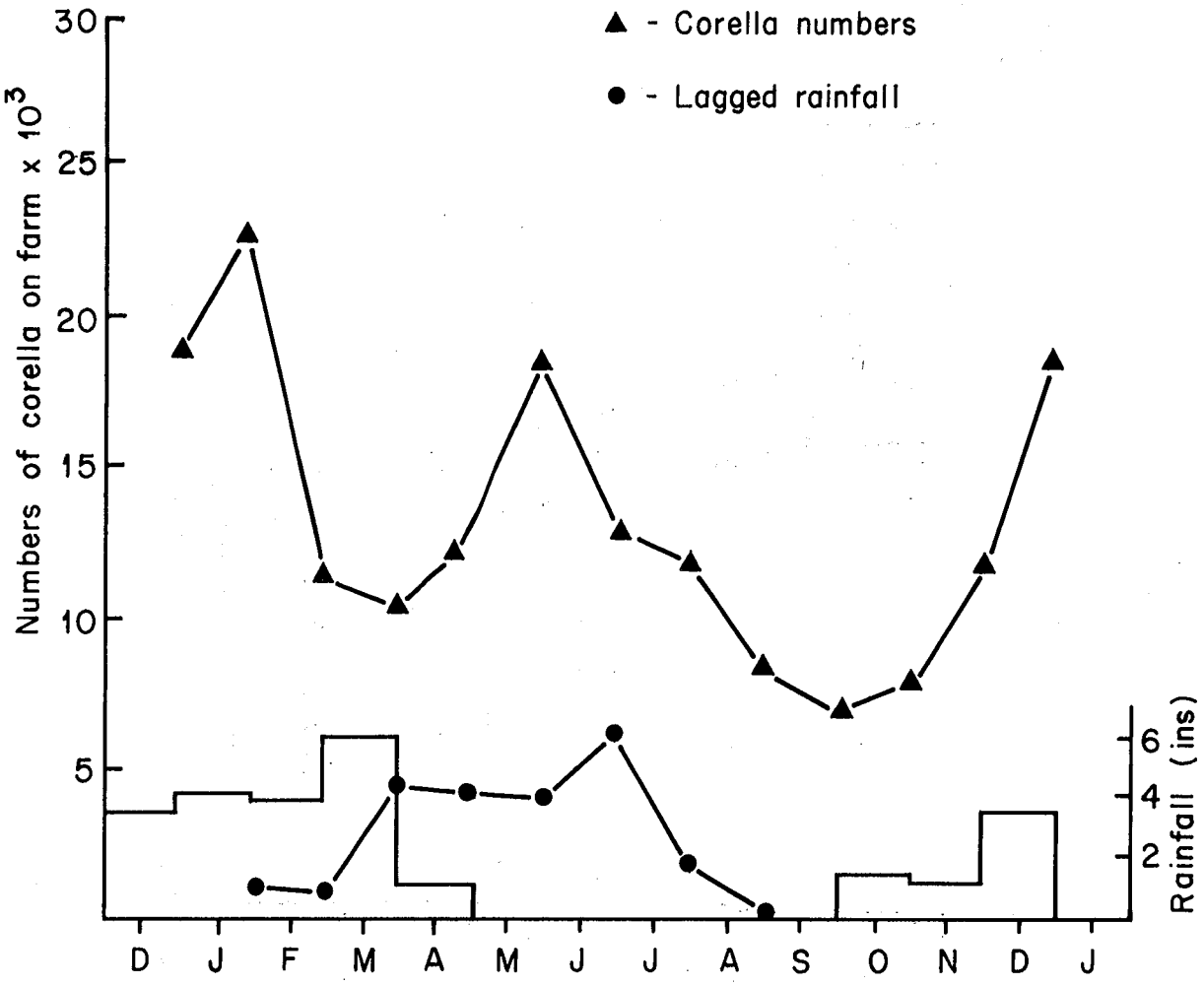

Figure 5: Corella numbers with monthly and lagged (3 months lag) rainfall means. Monthly rainfall as histograms.

to be concentrated. The flock is the component of the population which is economically significant. It is the flock which attacks the crops of the Ord valley.

The relative proportions of the total population which are in the range areas or in the flock are governed by what I have called a and b factors. "a" factors relate to food (seed) destruction at the range areas and "b" factors to food generation in these areas. The critical determinants in both cases are rainfall. Rainfall is an "a" factor in that when the first rains of the wet fall surface seeds are germinated, buried or washed away. Rainfall is a "b" factor in that the date of cessation and the amount of rain in a given wet season determine both the time of senescence and productivity of the native grasses on which corella depend for their natural foods.

Figure 5 shows the mean number of corella in the flock phase for two years. The histograms are mean rainfall for the current month ("a" factor) and the line is mean rainfall lagged for 110 days ("b" factor). This figure shows fairly clearly that the interaction of these two factors has a considerable bearing on the magnitude of the corella problem at any given month of the year.

The drop in corella numbers in February - March is noteworthy as it appears to contradict the general premise. The reason for this drop is the maturation of wild rice in the latter half of the wet season. The corella flock moved to this food source and then returned to the sorghum area until other natural food became available. This is in effect a second lag with wild rice maturing about 3 months after the first significant rains of the season.

This predictable modality in the economically significant portion of the corella population has relevance for management and we will come back to it later.

The Behaviour of the Corella Flock

The flock behaviour of the little corella has been described by the use of behavioural models. Although detailed models can be presented for all aspects of corella behaviour we will only concern ourselves here with aspects of these models relevant to the on-farm management of the corella.

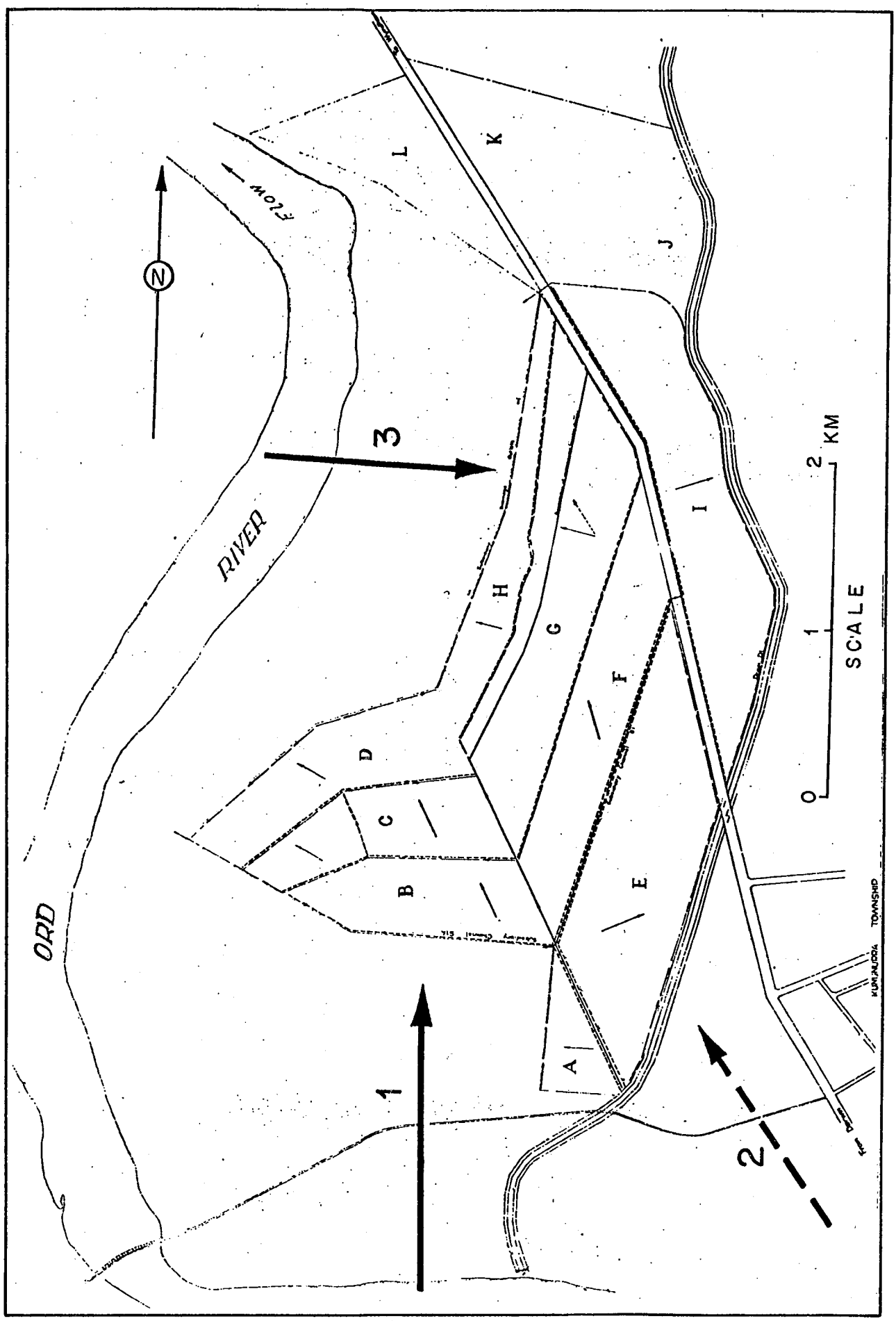

Figure 6; Flight paths of corella into the farm.

During the entire period of the study the corella showed a remarkable adherance to a pattern of roosting and subsequent flyout to the farm in the early morning (Figure 6). In the dry season flyout paths 1 and 2 were favoured with 1 being dominant in terms of numbers. As the wet season developed birds arriving in the area established flyout 3 which rapidly became dominant. The final wet season situation was that all the birds concentrated in flyout 3.

Every day the flyout, once it had crossed the farm area boundary, adhered to the pattern outlined in Figures 7 and 8 (Figure 8 is the food search subsystem of Figure 7).

Inspection of Figure 7 shows that if a small flock of corella are already established on the farm the mob following will join it and remain if the food availability in the area is reasonable. This figure also shows the futility of shooting at birds which have a low degree of satiation. The effect of such an approach is to fragment the flock of birds so that feeding occurs at several sites over the farm. The futility of such an approach is heightened if the corellas' mode of feeding on sorghum is considered.

Corella, if edge feeding, "harvest" heads of sorghum from the crop, return to bare ground, and remain there feeding on the head which they have obtained. If the birds are undisturbed one head of sorghum is generally sufficient for their daily requirements and no more is taken. Shooting at a flock of birds in this condition results in their abandoning the previously harvested head. On resumption of feeding the birds harvest another head. The nett effect is that unrestricted shooting multiplies the total damage greatly.

Figure 8 shows another effect of shooting. Under a shooting regime feeding is initiated in the centre of a crop. This is a fairly unstable form of feeding and tends to spread damage over a wide area. The damage is not as obvious but just as great.

Figure 8 also shows that if under a no-shooting regime the area adjacent to a recognised food source (standing crop) has food on the ground, feeding will commence there and little or no crop attack will occur.

CORELLA FARM CO-ORDINATION

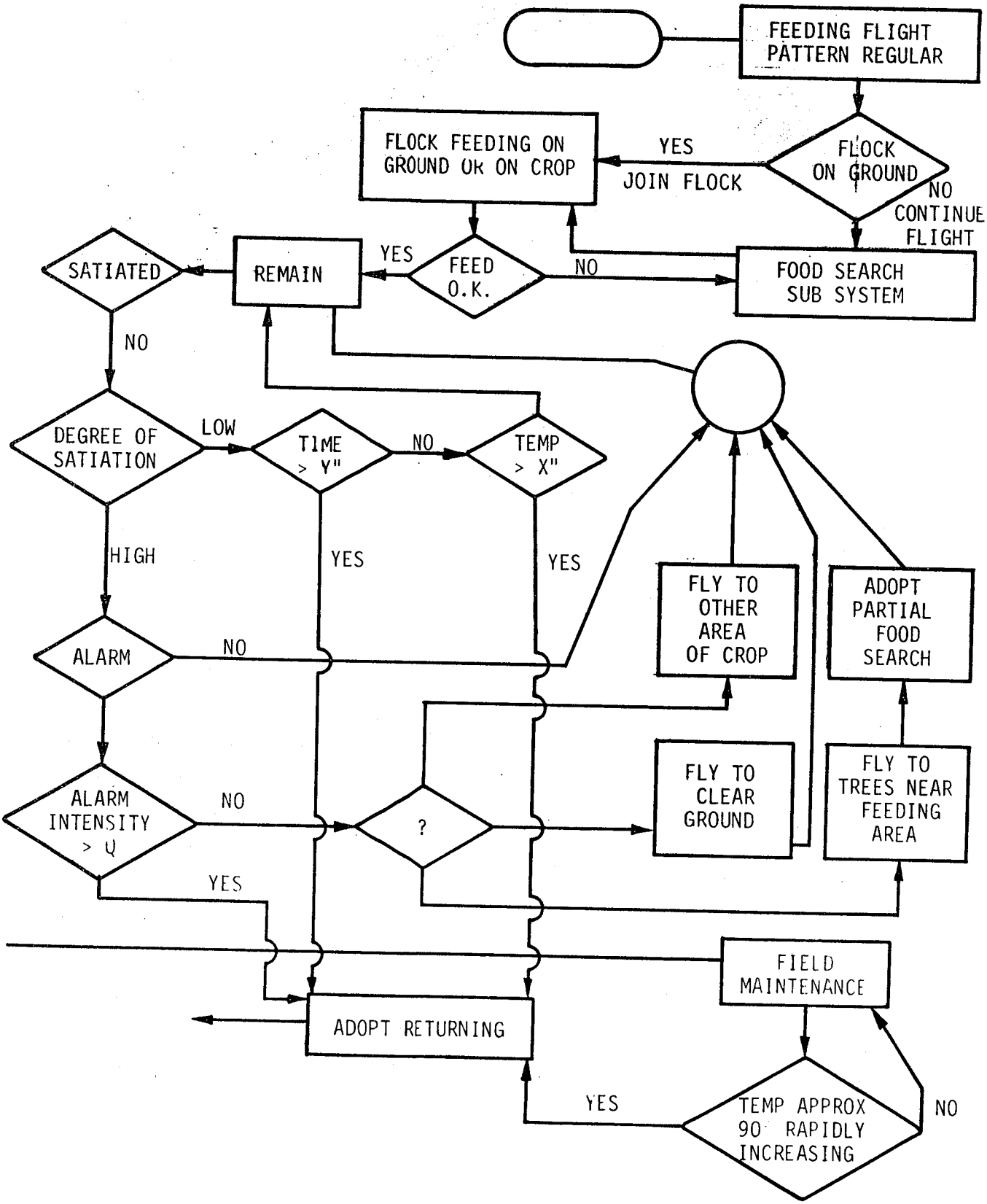

FIGURE 7

FEED SEARCH SUB-SYSTEM

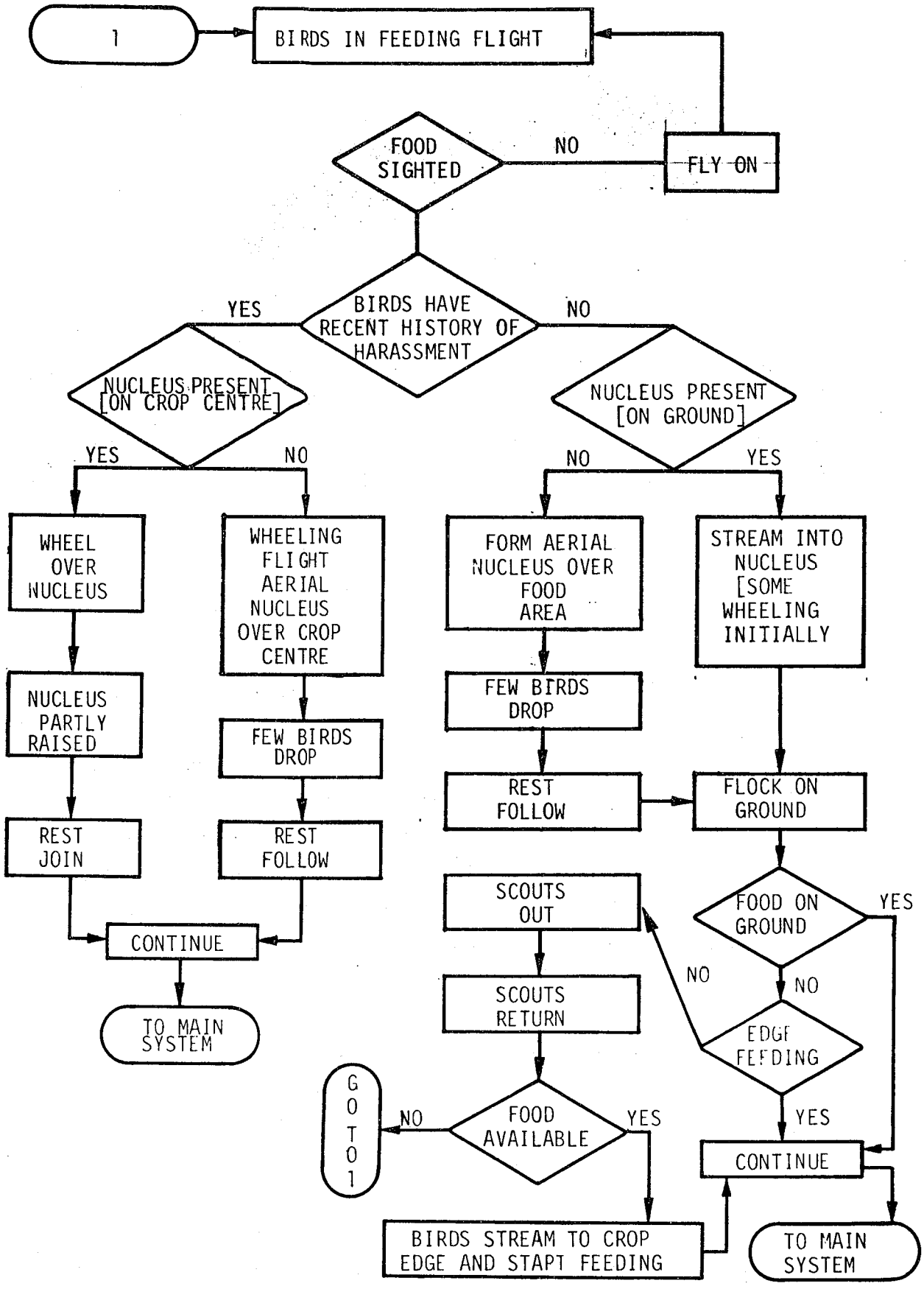

FIGURE 8

Corella Management Systems

The management system adopted for corella on Hooker farm was based on the knowledge of the behaviour and biology of the species outlined above.

The system has two basic approaches. Firstly Figure 5 provides a basis for predicting the likely times of greatest potential corella depredations. The agronomic and farm management systems adopted on Hooker farm (Anderson et al. 1973) is based on a year-round 3-cycle sorghum cropping system. Such a system had sufficient flexibility to allow for harvests in late April, late August and early December. Reference to Figure 5 shows that these are the periods when the expected corella numbers would probably be least. Thus damage could be partially minimised.

The second approach to management is based on the knowledge of flight paths and on-farm behaviour of the corella. The most rational economic approach to sorghum growing is to organise farm operations so that all the machinery associated with one operation is concentrated on one or two bays (fields) at a time. This means that in any given cycle one or two bays will reach the soft dough stage and hence become attractive to corella before all the others. The management system called for these bays to be the first in the flight path expected for corella in the given season. The result of this is that the corella commence farm feeding on the first bay they encounter. Under the management system the corella are allowed, and if necessary encouraged by controlled shooting, to feed on these bays exclusively. The cost of grain lost to the birds at this time is written off as a cost to management.

As soon as possible the bay under corella attack is harvested and immediately slashed for recycling but not watered. This process immediately makes a large amount of waste grain available as corella feed. On-farm studies have shown that this supply of feed will last for a week or longer depending on corella numbers. During this period shooting on the farm is restricted to ensuring that the vanguard of the flyout settles on the stubble and hence attracts the main flyout.

FIGURE 9

ECONOMICS OF MANAGEMENT

(from Anderson et al. 1973)

(1) Maximum Grain Losses, Average Year[1]

April	30 days susceptible	13.0 tonnes
August	40 days susceptible	14.6 tonnes
December	25 days susceptible	13.3 tonnes
	Total	41 tonnes

Value (at $40/tonne) $1,640

(2) Labour Costs[1]
60 days, 2 hrs per day, $2.10 per hour $252 per year

(3) Vehicle Costs[1]
60 days, 20 miles per day, 10¢ mile $120 per year

Total cost per average year $2,012

Cost of no management and year round cropping $6,500

Thus value of management system $4,488 per year

[1] Based on numbers from Figure 5 and an average consumption of 57 gm per bird per day.

Subsequent harvesting on the farm follows a pattern moving away from the first bay harvested thus ensuring a continuous supply of feed for the corella at no cost to the farm. In fact this process is beneficial in that the corella cut down the amount of self sown sorghum occurring in the recycled area. Self sown sorghum poses problems for irrigation.

Economics of Management

The ultimate test of any management system is does it pay? In the case of the system outlined above the answer would seem to be yes. Figure 9 outlines the economics of the system based on 1973 costs.

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A STATEMENT ON THE EFFECTS OF WILDFOWL ON AGRICULTURE IN THE IRRIGATION REGIONS OF THE RIVERINA

Irrigation Research and Extension Committee

1. Duck damage to rice crops

The duck situation generally

Each year ducks cause considerable damage to rice crops in N.S.W. A rice crop provides a natural attraction for ducks (and other water fowl) as it grows in water from Sept./Oct. through to Jan./Feb. In combine sowing the rice seed is sown into the soil with a drill or combine and after the seedling has reached a height of 4 to 6 inches, permanent water is introduced and gradually deepened as the plant grows until a depth of about 8 inches is reached. The plant then grows in water until rice bays are drained in Jan./Feb. prior to harvesting in March. The crop is vulnerable to attack by ducks during the whole of the permanent water period, but more so in the early stages where infestations of ducks pull out the young rice seedlings in order to feed on the roots and shoots of the plant.

The acceptance by growers of the use of aerial sowing as a means of shortening the growing period and of quickly establishing rice crops on heavy soils has worsened the duck problem.

With this method, pre-germinated seed is sown directly into flooded rice bays and the large expanses of water with rice seed on the soil surface prove irresistible to ducks. It is common for large quantities of ducks to invade these crops on the same day as the crop is sown, and heavy damage results to the extent where even in years of 'normal' duck numbers, some crops have to be re-sown.

Regardless of the sowing method used, all crops are vulnerable, with most damage being done at night, and once ducks have established themselves in a crop, they will continue to return even though some of their numbers may have been shot the previous night. In sufficiently large numbers, ducks have been known to destroy an entire crop in two or three nights.

The National Parks and Wildlife Service has recognised the problem of duck damage in rice crops, and for some time now a special "out of season licence" has been issued to growers to allow them to legally protect their crops and their livelihood. The 'open season' on ducks usually runs from mid-February till Easter, and is of no use in the growing period, although it does help keep the population down in most years. The use of poison to

destroy ducks and other waterfowl is illegal as well as dangerous to humans and predators, and the only legal method of effectively combating the menace is by shooting. (The use of scare guns and such devices, while offering some protection, has proven inadequate).

The duck situation last season

After the close of the open season on ducks in April, 1974, ducks enjoyed the best breeding conditions in years. Heavy rainfall and flood situations filled breeding grounds not used in the immediate past, and ducks bred in numbers which caused the N.S.W. Rice Industry grave concern as far back as July, 1974.

Ducks bred 3, 4 and 5 times in the one breeding season, and hatchings of over 20 chicks were common. In 'normal' seasons, one breeding with a hatching of less than 10 chicks would be the general rule. Similar patterns were reported from other areas in the State, and also from interstate where the Queensland rice suffered. (The N.S.W. rice growing areas are well within the migratory limits of interstate ducks).

Dr. Frith in his publication "Waterfowl in Australia" indicates that under wet conditions (such as those already experienced in N.S.W. last year with floods and abnormal rainfall) there is an enormous surge in the breeding of ducks and other waterfowl.

The worst year on record for duck damage was the 1956/7 season. In that year whole crops were devastated while those more fortunate growers saw only part of their crops destroyed. Although there are no statistics available on crops which were completely destroyed, the following table of yields of crops actually harvested clearly indicates the extent of the damage:-

Harvest Year	Yield in tons per acre	
	Murrumbidgee Irrigation Areas	Murray Valley
1954	2.14	1.40
1955	2.54	2.29
1956	2.34	1.80
1957	1.74	0.99
1958	2.46	1.94
1959	2.75	2.35
1960	2.73	2.28

Although production statistics for the 1974-75 rice crop have not yet been finalised, the crop generally was down by 90,000 tonnes on expectations. Reasons for the poor crop have been attributed to 3 main factors:-

- The wet sowing season which brought about inadequate ground preparation and late sowing.
- The damage caused by ducks and bald coots as well as other water fowl (swans etc.).
- Cold weather at flowering time.

Although it is not possible to attribute any specific tonnage to any single factor there is no doubt that the damage caused by ducks and other water fowl was a significant factor in the loss of income to the grower of around $9 million last season.

Last year the Rice Marketing Board purchased cartridges for rice-growers to help combat the duck menace and distributed over 400,000 cartridges during the Aug./Oct. growing period. Growers were still enquiring for cartridges after the Board's supply had been exhausted and it is conservatively estimated that in excess of one million cartridges would have been used in trying to protect rice crops.

Current legislation

As explained earlier for the 1974-75 season rice growers could obtain a Section 25 licence which allowed them to shoot ducks to protect rice crops. Other shooters could also be invited to help, provided that certain authority forms were filled out by the grower. Generally this system worked reasonably well, and its implementation was greatly assisted by the fullest co-operation from the local Rangers from the National Parks and Wildlife Service.

However, many rice growers do not willingly accept the need to obtain a Section 25 licence, claiming that as ducks are vermin to rice crops, shooting should be allowed without restriction. They are concerned that the general attitude to ducks appears to be one of "blind" conservation, and that control for rice crop protection is regarded by many authorities as being an extension of sporting shooting. For a rice grower with his crop under attack, this view is totally unacceptable.

Since last season the new Act and Regulations have been introduced and the situation is seen to have seriously deteriorated. Every shooter who now goes on to a property to assist a rice grower to shoot ducks will have to have a Trapper's Licence. Currently it takes 9 weeks to obtain trappers licences and with many hundreds of shooters normally involved in helping to protect some 2,000 rice crops it appears that the situation could well develop into a farce.

If ricegrowers have to shoot ducks (and this is the only effective method of control available) to ensure their livelihood, then shooting will take place regardless of what legislation is in force. Ricegrowers are deeply concerned that the new Act loses sight of the fact that in some instances shooting is necessary for crop protection. The N.S.W. Rice Industry believes that this whole matter will have to be reviewed before the start of the coming rice sowing.

Method of control

To date shooting is the most effective method of control, but it is only effective when sufficient persistent firepower is available.

Alternative methods

Alternative methods of control could perhaps be developed, if adequate research were carried out.

Growers' organizations, including I.R.E.C., have tried to attract research organizations to tackle this problem with a view to developing alternative control methods. However, the approaches have been unsuccessful. It does appear that the "conservation movement" has prevented studies of control of wildfowl for crop protection being developed. The N.S.W. Rice Industry believes that research work on the problem of ducks in rice should be undertaken to obtain accurate assessments of the problem, and also to investigate objectively various possible methods of control.

2. Bird damage to coarse grain crops

Severe damage to coarse grain crops, particularly sunflowers, has been caused by finches, galahs and cockatoos. In severe cases, areas of up to 50 acres have been completely destroyed, this type of damage being more likely to occur in isolated crops. Many instances of such damage have been recorded in the Minutes of the I.R.E.C. Grain Crop Sub-Committee. It would appear that a build-up in numbers of

these birds is at present occurring. Farming practice in the irrigation region is turning more and more to cropping, and because grain crops of one type or another are grown all year round, a food supply is available for the birds all year round.

Many growers believe that galahs and cockatoos are the factors which most limit yield when growing crops in areas along the rivers adjacent to the timber belts. Growers have used many methods of control including shooting, scareguns, scare-sirens, scare-crows and chemical repellents. However to date, all have proved to be virtually ineffectual.

Once again, I.R.E.C. believes that objective research into control of birds in this situation could lead to the definition of effective methods of control.

3. Blackbird threat to horticultural crops

In the last couple of years the appearance of the English blackbird has been noted in the area. At this stage population levels are very low, there being no more than a few nesting birds on any one farm. However horticulturalists have expressed concern at the appearance of the bird, which has been responsible for considerable damage to fruit crops in South Australia. Current feeling is that if eradication can be achieved at this early stage of infestation, then potentially serious losses in the future will be avoided.

I.R.E.C. believes that a detailed study of possible methods of eradicating the blackbird could prevent the development of a serious situation.

WETLANDS AND THEIR USE BY WATERFOWL

S.V. Briggs

Regions of waterfowl habitat in Australia

Australia extends from the tropics to the southern mid-temperate region and thus has a wide range of environments. Nonetheless, it is the poorest continent in the world with respect to the number of different waterfowl species that it supports (Frith, 1967). The main reason for this is the lack of waterfowl habitat. Much of Australia is flat and dry, so that evaporation often exceeds precipitation, and even when rain does fall it is usually lost into the dry ground fairly quickly. Therefore most of the continent does not have surface water except after heavy rain.

Australia's isolation also contributes to the paucity of waterfowl. The wetlands of Australia on their own must produce the nation's entire waterfowl crop and must supply the areas of food, fresh water and shelter that maintain the breeding stock between reproductive seasons. Unlike North America, Asia, Africa and Europe, Australia has neither adjacent continents nor widely distributed wetlands to which its ducks, geese and swans can move when local conditions become inhospitable. Thus the survival of Australian waterfowl rests directly in the hands of Australians.

The distribution of waterfowl habitat in Australia can be considered in the four main regions (Frith, 1967) shown in Figure 1.

(i) The Central Region

The central region occupies more than half the continent and is virtually useless to waterfowl, most of it being desert with no permanent surface water.

(ii) The Southern Region

The value of the southern region to waterfowl varies with the particular area being considered. Much of this area was formerly very good waterfowl habitat, but it is the region that has been most affected by man.

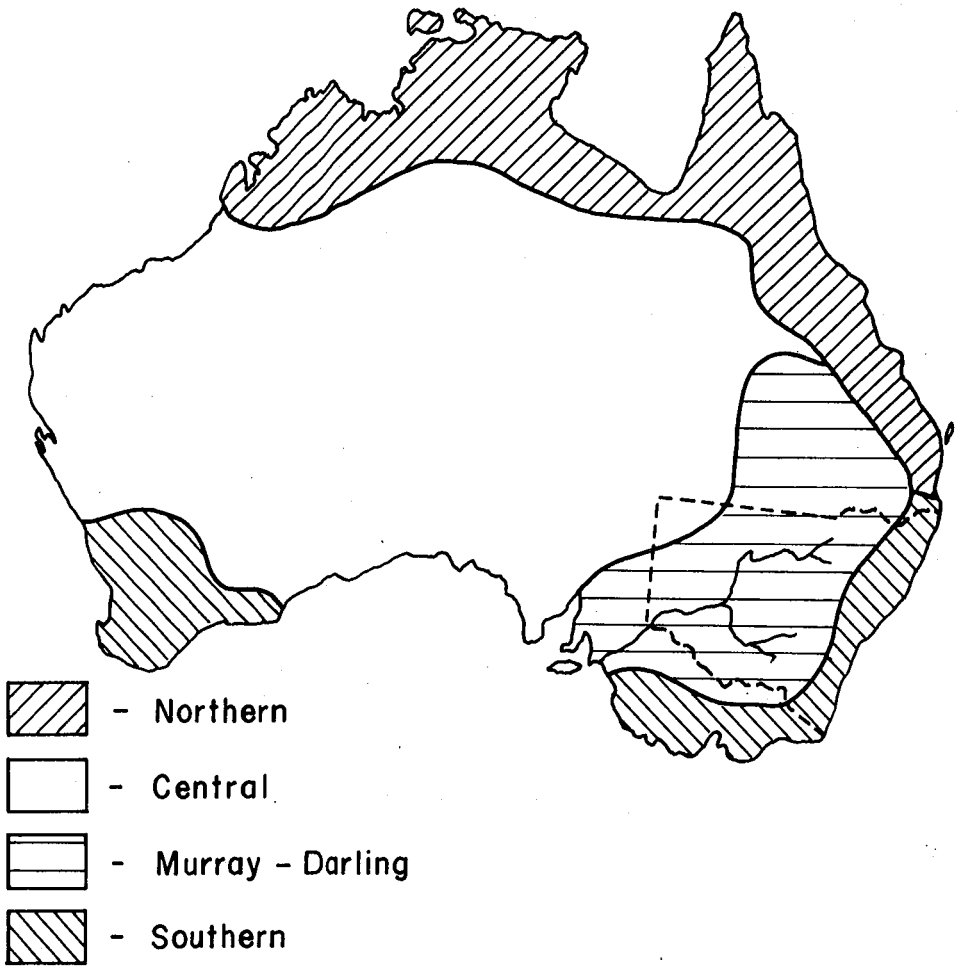

Figure 1: Waterfowl regions of Australia

(iii) The Murray-Darling Region

The Murray-Darling region contains the best waterfowl breeding areas in southern Australia. As the Murray and Darling rivers meander across their flat flood plains they have developed large areas of billabongs and swamps which provide ideal waterfowl feeding and breeding habitat.

(iv) The Northern Region

The northern region produces very large numbers of tropical ducks as well as providing drought refuge for birds from the Murray-Darling area. Much of this area is still relatively unaffected by man, and its value for waterfowl varies throughout the region. It is not represented in New South Wales.

Occurrence of wetland habitat in N.S.W., and the threat from agriculture

The Southern, Murray-Darling, and Central Regions of waterfowl habitat occur within N.S.W., with the largest part of the State being taken up by the Murray-Darling Region. Within each of these broad habitat regions several different wetland types occur.

The Wetlands Classification Committee of the United States Fish and Wildlife Service developed a classification scheme for wetland types which can be applied to N.S.W. (Martin et al. 1953). In this scheme wetlands are classed according to water depth, salinity, permanence, vegetation, and usefulness to waterfowl. The classification is presented in Table 1.

The relative occurrence of these wetland types varies between the regions in N.S.W. In the Central Region the only wetlands present are the inland saline flats which flood only after heavy rain. Man has not affected these wetlands as the area is hardly used for agriculture, being too arid. The overall contribution of this region to Australia's waterfowl populations is low and hence this lack of man's influence in the area is of little significance.

The wetland habitat of the Murray-Darling system in N.S.W. is mostly of the inland fresh category and ranges from reservoirs, permanent lagoons and lakes to occasionally flooded agricultural land. No survey of the available areas of each wetland type in the Murray-Darling has been carried out (to the writer's knowledge). But from descriptions of the area by Frith (1967) and Cowan (1970) it is possible to list the kinds of wetlands which are likely to be available. These are inland shallow and deep fresh marshes, inland open fresh water, seasonally flooded flats

TABLE 1

Wetland Category and Type	Water Depth
Inland Fresh Areas	
Seasonally flooded basins or flats	Few cm in upland; 1 m along rivers
Flooded Agricultural Land	Few cm in upland; 1 m along rivers
Inland fresh meadows	Few cm after heavy rain
Inland shallow fresh marshes	Up to 15 cm
Inland deep fresh marshes	Up to 1 m
Inland open fresh water	Up to 3 m, marshy border may be present
Permanent: Open Water (Reservoirs)	Up to 3 m
Shrub swamp	Up to 15 cm
Wooded	Up to 30 cm
Bogs	Shallow ponds may be present
Inland Saline Areas	
Inland saline flats	Few cm after heavy rain
Inland saline marshes	Up to 70 cm
Inland open saline water	Up to 3 m; marshy border
Coastal Fresh Areas	
Coastal shallow fresh marshes	Up to 15 cm at high tide
Coastal deep fresh marshes	Up to 1 m at high tide
Coastal open fresh water	Up to 3 m; marshy border often present
Coastal Saline Areas	
Coastal salt flats	May have few cm at high tide
Coastal salt meadows	May have few cm at high tide
Irregularly flooded salt marshes	Few cm at wind tide
Regularly flooded salt marshes	Up to 3 m at high tide
Sounds and bays	Up to 3 m at high tide
Mangrove swamps	Up to 70 cm
Estuarine lakes and other enclosed waters	Variable

and agricultural land. In addition to these types there are also quite large areas of shrub and wooded swamps and permanent open water. Most of these depend upon heavy rains creating floods across the billabongs, lagoons and vegetated swamps of the meander zones of the two major rivers and their tributaries.

Man has affected the Murray-Darling area, and in some ways has improved its waterfowl value. The irrigation schemes have increased the available areas of inland permanent swamp, usually dominated by "cumbungi" (Typha spp.), and these permanent swamps are of extreme importance as refuge areas during drought (Braithwaite and Frith, 1969). Man has also created useful waterfowl habitat by building artificial inland lakes (e.g. at Menindee) which provide good permanent open water wetlands. The construction of earth tanks in the inland has also favoured some species of duck.

Many of the actions of man in this area have had, and are having, negative effects on the waterfowl populations, not only of this region but of the whole of eastern Australia. The most profound alteration in the waterfowl environment in this area has been that imposed by flood control measures and irrigation schemes. These schemes have involved the construction of numerous river works to divert and hold water, as well as mountain reservoirs, and the effect of these has been to reduce the frequency of filling of swamps, lagoons and billabongs, with a consequent decrease in the breeding habitat available for ducks in Australia's major duck "factory". This situation in the Murray-Darling Region need not exist, as it is quite possible to use waste irrigation water to flood billabongs, and the inland weirs and canals could be modified to take the needs of the waterfowl into account.

The Southern Region is the part of Australia that has been most extensively settled, and developed for agriculture and industry. Much of it was formerly very good waterfowl habitat, but this has been greatly decreased by drainage and flood mitigation schemes (Frith, 1967). The largest rivers in this area are on the north coast. They flood almost annually forming many swamps behind the levees in the middle and lower regions. However, these swamps have been drained and flood mitigation channels have been constructed; consequently the waterfowl habitat in

the area has been severely reduced. Goodrick (1970) reported that 60% of good quality wetland habitat in coastal N.S.W. had been drained by 1969. The value of the coastal wetlands lies mainly in their usefulness as drought refuges for waterfowl during dry times in inland Australia, although there are important breeding areas also.

Thus agriculture in general, but particularly flood mitigation and drainage schemes, has severely affected N.S.W.'s main duck breeding areas in the Murray-Darling region as well as the main drought refuge areas on the north coast of N.S.W.

Use made of wetlands by waterfowl

The use that waterfowl make of a wetland area may be considered in four categories:-

1. Breeding
2. Feeding
3. Loafing and Resting
4. Drought refuge

Waterfowl need wetlands to supply all these needs; different wetlands may often supply different needs. Too many species of waterfowl occur in N.S.W. for all to be considered here, so this discussion is limited to the wetland needs of four species: black duck, grey teal, hardhead and black swan. The three duck species are continental in their distribution, whilst the swan generally occupies the southern region of Australia (Frith, 1967). The three duck species are each popular game birds, and all four waterfowl are common in this area.

The black swan is distributed throughout the Southern and Murray-Darling Regions, and is most numerous in large, fresh or brackish, shallow, permanent lakes. Swans feed usually whilst floating on the water, and eat mainly submerged, emergent, and floating leaved plants. As they can secure food only to about 1 m below the surface, they require large beds of aquatic plants in shallow lakes or the shallow edges of deeper lakes and rivers. Therefore the black swan is found mainly on coastal and inland open fresh or saline water, although it often visits seasonally flooded land and is frequently seen on marshes and reservoirs.

The birds breed mainly in inland and coastal deep fresh marshes, although almost any permanent or seasonal wetland may be utilized following sufficient rain. The swan is one of Australia's waterfowl least affected by man. Except in Tasmania, it is not hunted to any extent. Drainage and flood mitigation schemes do not usually affect it as the swan is not

dependent on seasonally flooded land for breeding. In fact, in some instances man may have created new swan habitat by constructing dams and reservoirs.

The black duck is distributed throughout all regions and is found on all types of wetland. They prefer shallow, vegetated water or open water with well colonised margins for feeding purposes as they are mainly vegetarian, feeding on aquatic and marsh vegetation, particularly on plants with large seeds. The inundation of large areas of seasonally flooded flats and meadows in addition to flooded marshes and bogs is needed to provide the extra food required for breeding to occur in this species. Drainage, water conservation, irrigation, and flood mitigation schemes have greatly reduceed the amounts of these habitats available. Such schemes, whilst not necessarily affecting present black duck populations, prevent inundation and filling of meadows, flatlands, lagoons and billabongs, and thus effectively destroy the black duck breeding habitat.

The drainage of the coastal fresh marshes and open fresh water has also disastrously affected the black duck population. These are needed as drought refuges to sustain numbers during dry times, enabling breeding to occur again when the drought breaks. If there are no refuges, then the population can be almost wiped out by a drought. At present, so long as more extensive drainage is not carried out, either on the coast or inland, the position of the black duck is reasonably secure. The black duck is still Australia's premier sporting bird, although numbers have declined greatly in the coastal areas. With the demand for black duck as a sporting bird on the increase, it is worthwhile to act to maintain, if not increase, its numbers.

The hardhead is distributed throughout all regions; however, its habitat requirements are fairly specific. It prefers deep marshes and open water. This species feeds by diving in deep water and by dabbling and stripping seeds from plants in shallow water. The birds are mainly vegetarian, eating large quantities of sedge and grass seeds.
The hardhead has the ability to feed in deeper water than the black duck and is therefore found more often in this habitat. Therefore its feeding requirements are less specific than black duck and it can adapt to some extent to man-made lakes and dams. It has however suffered greatly from

TABLE 2

PREFERRED WETLAND TYPES (after FRITH, 1967)

Species	Food	Feeding	Resting	Breeding	Drought Refuge
Black swan	Vegetarian. Rooted, emergent and floating aquatics	Permanent open water. Inland and coastal open fresh water. Flooded pasture.	All wetland types.	Inland and coastal deep fresh marsh.	Coastal deep fresh and brackish marshes. Coastal open fresh and brackish water.
Black duck	Mainly vegetarian. Emergent and floating leaved aquatics and edge plants.	Inland and coastal deep fresh marshes. Inland and coastal open fresh water.	All wetland types.	Inland and coastal deep fresh marsh. Seasonally flooded land. Inland and coastal open fresh water.	Coastal deep fresh marsh. Coastal open fresh water.
Hard-head	Mainly vegetarian. Submerged, emergent, and floating leaved aquatics. Edge plants.	Permanent open water. Inland and coastal open fresh water.	All wetland types.	Inland and coastal deep fresh marsh. Wooded and shrub swamps.	Coastal deep fresh marsh. Coastal open fresh water.
Grey teal	Aquatic plants and inverte-brates.	All wetland types. Very adaptable feeding habits.	All wetland types.	Inland and coastal open fresh water. Inland and coastal deep fresh marsh. Seasonally flooded land.	All coastal saline and fresh areas.

agricultural developments, having been once the most common coastal duck. The swamps of the lower reaches of the north coast rivers were very heavily populated with hardhead, but its numbers have been much reduced as a result of drainage and flood mitigation works. It requires flooded swamps in order to breed, and if these do not fill or are drained, then the bird does not breed. This species frequents deep mountain lakes, but does not breed in them, but also can utilize drainage swamps and water storage areas, especially if these latter are designed with some care. Dams with deep, but not too deep, edges capable of supporting dense vegetation make ideal hardhead habitat.

Thus whilst hardhead numbers have been reduced drastically, particularly by coastal drainage schemes, new habitat could be created for them with a minimum of effort. If drainage of swamps continues and some consideration is not given to the preservation of this bird when creating new storage reservoirs, then the remaining populations will further decline, perhaps to seriously low levels.

The grey teal is distributed throughout all regions, being the most widespread duck in Australia. It is common in all wetland types, but its preferred habitats are the billabongs, lagoons and floodwaters of the inland rivers. It is also able to utilize saline habitats and deep highland lakes during times of drought. The grey teal has very adaptable food habits, and is able to feed on any shallow wetland, no matter how temporary. Grey teal are extremely quick to take advantage of freshly flooded areas and often move with the flood waters, feeding as they go. Rising water levels and the consequently increased food supply stimulate breeding in this species. The birds' main breeding habitats are the seasonally flooded inland flats and meadows and the open fresh water swamps which are full during times of flood.

The irrigation and water conservation schemes of inland N.S.W. have had a major effect on the grey teal, severely reducing their breeding grounds through lessening the frequency and extent of flooding on the inland river flats. If grey teal are to remain numerous their needs must be considered during the planning stages of water conservation schemes in order to insure that their important breeding areas are not needlessly destroyed.

TABLE 3

WETLAND TYPES AVAILABLE IN N.S.W.

Region of Waterfowl	Wetland Categories
Central Region	Small amount of inland saline wetland. Virtually useless to waterfowl except during extensive inland floods.
Murray-Darling Region	Inland fresh wetland, mainly shallow and deep fresh marshes, open fresh water and seasonally flooded land with some areas of permanent open water and shrub and wooded swamps.
Southern Region	Coastal and inland fresh wetland, mainly shallow and deep fresh marshes and seasonally flooded land. Also areas of coastal saline wetland available.

In this discussion I have tried to show some of the ways in which modification of the land for agricultural use has affected our waterfowl populations. Often numbers are not affected quickly as plenty of resting sites remain. The thoughtless destruction of breeding and drought refuge areas must seriously deplete waterfowl populations over the space of a few years. Some species of waterfowl are favoured by the construction of deep reservoirs, e.g. musk duck and blue-billed duck; however, these are not game species. In a country which is lacking in game fauna, conservation of our only major group of sporting animals is important. Drainage and irrigation schemes can be designed with waterfowl in mind; the decision as to whether they will be is a public one.

Actions taken in a small part of the country may determine the size and composition of the waterfowl populations of the whole of eastern Australia. We can influence those actions to ensure that there are still waterfowl in the future to be enjoyed by nature lover and sportsman alike. And the maintenance of waterfowl is not incompatible with agriculture. It only needs a knowledge of factors governing waterfowl numbers, common sense, and the desire to co-operate.

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RECLAMATION OF WETLANDS: THE AGRICULTURAL VIEWPOINT

P.A. Witschi

In the past, drainage and reclamation of wetlands in New South Wales has been carried out in a rather ad hoc manner as the need arose, often with several quite independent objectives in mind. Along coastal lands, where wetlands are more common because of their climatic situation, some Councils have been very active in drainage and reclamation measures.

In the context of this workshop wetlands may be classified as:-

1. Swamp Lands - low lying areas of tidal influence along coastal areas containing mostly brackish and salty water. These areas are seldom of use for agriculture and could only be developed at considerable cost.

2. Swamp Lands - low lying areas subject to inundation from intermittent flooding by freshwater rivers and creeks in high rainfall coastal areas. These areas are of some use agriculturally but the cost of development is high.

3. Backwaters and Watercourses - which remain permanently inundated from intermittent flooding and rainfall run off. These areas become very much diminished in area during periods of severe drought.

Lakebeds could be classified in this category along with watercourses such as the Macquarie Marshes, Narran Lake and Gingham watercourse.

4. Marginal areas which are subjected to intermittent inundation but are considered flood liable and are usually adjacent to backwaters and swamps. Land in this category is often used for agricultural purposes but the farming risks are high because the land is flood prone. Wetlands adjacent to this type of country are the areas most often drained.

5. Wetlands resulting from irrigation development and drainage effluent from irrigation areas. Wetlands in this category may result from rising water tables and are often salty in nature.

The Aim of Drainage and Reclamation of Wetlands

(a) Flood Mitigation

Flood mitigation has been the primary reason for the drainage of wetlands and swamps. The aim has been to reduce the damage to rural land and consequently the payments for flood relief due to loss of agricultural production. This has been achieved by the construction of levees and associated drainage works. Many of the drainage measures included are not intended to prevent flooding but merely to improve the flow of water back to the watercourse so as to reduce the period of inundation and consequent damage to agricultural production in low lying areas.

Some councils have been very active in this regard and expenditure for flood mitigation works have been considerable.

Until recently, the policy has been to reclaim the swamps and provide drainage where submissions to the Department of Public Works by local councils have shown the need. I understand that more recently, Environmental Aspects are being taken into consideration and approval must be sought from the State Planning and Environment Commission before any works proceed.

Although past policy has resulted in the depletion of many swamp areas it now appears that the environment, conservation and wildlife aspects will receive more attention.

(b) Property Improvement

Private landholders cannot be blamed for protecting their land from flooding. The Drainage Act, 1939, was enacted to "make better provision for the drainage of land and the mitigation of the effect of floods and the control of flood waters within certain areas; to facilitate the administration of drainage unions and of drainage trusts."

Numerous Drainage Unions are in existence. Once a flood mitigation drain has been installed, farmers are at liberty to form Unions to drain their properties collectively and dispose of the excess water into the flood mitigation drain.

Drainage at farm level is a private matter for the landholders concerned and proposals for the formation of Drainage Unions are submitted to the Minister. The Minister will then notify the proposal in the Government Gazette and local newspaper and appoint a time and place at which objections may be lodged. At least 80% of the owners must be in favour of the proposal before the Governor may constitute a Drainage Union.

From an agricultural viewpoint, drainage is essential for farming of agricultural land. In the Clarence River Valley, for example, considerable land has been brought into agricultural production by the reclamation of wetlands. One may ask the question, has this been economical? In many instances depending on the type of production, the answer would be yes. In other instances it could be said that the benefits have been very small. The main consideration in many instances has been the reduction of the period of inundation.

A farmer's decision to drain his land is not taken lightly. It is a decision often made after considerable thought has been given to the advantages and of course the economics of the proposal. After all, it is going to cost him considerable amounts of money. Quite often, the land is the limiting resource on many properties in these areas and a farmer is forced into a decision by economic circumstances. The farmer must increase his production to ensure a satisfactory level of income and he needs to utilise the whole of his limited land resource to achieve this goal.

Another major factor in draining wetlands from the farmer's point of view has been the appreciation of land values, following reclamation. In many instances land values have doubled following the implementation of drainage which has rendered the land more suited to "safe" agricultural production.

In many areas, where high value crops such as sugar cane are grown, great benefits have been obtained. More grazing land has been brought into production and livestock production has increased. One big disadvantage on purely grazing situations where wetlands have been reclaimed, has been observed during dry periods.

Wetlands permitted good grass grazing on the perimeter which gave stability for grazing during dry times. Once drained, this grazing is no longer available and unless irrigation is established conditions deteriorate during dry periods. I need not elaborate on the advantages that areas like the Big Leather, Macquarie Marshes, Gingham watercourse and the Maude and Redbank schemes, have on the availability of grazing in these areas.

Co-operation for the future protection of wetlands

It is not possible to return many areas which were once wildlife habitats to their natural state.

What is needed is more understanding and co-operation in the future so that all interested parties are in agreement with a proposal. The submission of construction works to the State Planning and Environment Commission is a step in the right direction.

In South Australia, a resolution was unanimously accepted to introduce the Control of Water Act Amendment Bill, 1975, which deals specifically with permission to drain land. The Bill means that the Government can refuse permission for swamps, rivers or backwaters to be altered if flora and fauna will be adversely affected.

The original resolution introduced in September, 1973, called for substantial areas of remaining wetlands in South Australia to be reserved for the Conservation of wildlife and, where possible, former wetlands to be rehabilitated.

Wetlands - problems they pose to agriculture

(a) Flooding

The problem of flooding and inundation on agricultural production have already been covered in considerable detail.

(b) Salinity

Wetlands, whether as a result of natural occurrence or from irrigation, can produce rising water tables bringing salt problems to the surface of soils, rendering the land useless. High water tables also make cultivation of agricultural land impossible.

In many areas e.g. Tullakool, Kerang and the Murrumbidgee Irrigation Area, both water table and salinity problems are being partly handled by surface drainage and tube well pumping.

Disposal areas, either natural or man-made evaporation basins, have enabled limited areas to be reclaimed. At the same time drainage disposal areas such as Fivebough, Tuckerbill and Barrenbox swamps, Lake Hawthorn, Lake Tyrrill and many others, are providing excellent habitats for wildlife. Some of these areas are proclaimed wildlife sanctuaries.

Whilst the agriculturist in these situations is faced with the problem of disposing of the drainage effluent from his property, the engineer is faced with the problem of disposal and prevention of the effluent polluting the Murray River. Closer co-operation between the agriculturist, engineer and conservationist will be needed in the future to satisfy all three in the interests of the three states concerned.

(c) Weed problems

Wetlands, whilst being a suitable habitat for wildlife are also particularly suitable for the spread of aquatic weeds which in some instances have rendered areas unsuitable for wildlife.

The main problem species are:

Water hyacinth (Eichornia crassipes)

This dangerous weed infests many coastal swamps and watercourses and threatens water use generally. Water can be rendered unfit for domestic and stock use; irrigation systems can be choked; it blocks drainage, interferes with navigation and seriously interferes with wildlife.

It is a serious weed in the Gingham watercourse near Moree where it has infested some 15,000 hectares in a period of about 20 years. It is feared that water hyacinth could move west and south into other watercourses unless controlled. The Boomi Shire was allocated $50,000 from an allocation of $850,000 this year to assist in an eradication programme. Other infestations have occurred in watercourses and back-waters along the coast from the Clarence River to south of Sydney.

One infestation which occurred in swamps near Mascot Airport was controlled by the Metropolitan Water, Sewerage and Drainage Board who engaged the Army to clear the weed. The wildlife, particularly ducks and seagulls, proliferated only to become a serious problem to aircraft.

Aligator Weed (Alternanthera phyloxeroides)

Aligator weed is present in seven watercourses and reservoirs in N.S.W. from Grafton to Albury. It occurs in both still and flowing water situations.

Salvinia (Salvinia auriculata)

Salvinia is a free-floating fern found on freshwater dams, ponds, lakes, lagoons and sluggish streams usually where high organic matter levels are present. It is found in many areas north of Nowra.

Elodea (Elodea canadensis)

This weed thrives in water varying in depth from about 0.3 to 3 metres and is confined largely to south western N.S.W. It presents a serious threat to lakes, reservoirs, irrigation and drainage channels.

These aquatic weeds if unchecked could spread rapidly, posing a serious threat not only to watercourses but to irrigated agriculture, stock and domestic water supplies and wildlife habitats.

(d) Problems from birds

The effect of bird damage to grain crops has already been discussed at this workshop. However, it is pertinent in the context of discussing wetlands that mention be made of the problem that can exist for crops growing near wetland situations.

Whilst wetlands provide a satisfactory habitat for the proliferation of birdlife and other wildlife, the nearby crops can suffer appreciably from attack.

Rice crops

In the past two seasons, reports of attacks on rice crops from wild ducks and bald coots have increased greatly because of the two wet seasons experienced. Aerial sown crops have suffered more damage than combine sown crops because of the expanse of water available for birds.

The Rice Industry are very concerned about the problem and estimated that an 80,000 tonne loss ($8 million) in rice yields this year was due to bird damage, the wet sowing period and cold weather during flowering time. It is realised that poor management, weeds in crops, low spots etc., have contributed and it is not fair to attribute such a loss to one single factor. Nevertheless great concern is being shown in the problem and there is an urgent need for methods to combat the problem.

A report from one Swan Hill property stated that bald coots and wild ducks damaged 60% of a 40 hectare crop of rice despite up to 40 shooters using 5,000 cartridges, killing 4,300 ducks and 1,400 bald coots.

It is pleasing to note that the National Parks and Wildlife Service propose to commence a major study of ducks in rice crops during 1975-76.

Other crops

Isolated crops such as grain sorghum and sunflowers have been severely damaged by wildlife particularly in isolated situations close to watercourses and swamps. Attempts at control in these situations have been costly and far from satisfactory. Galahs, white cockatoos, feral pigs and mice have created havoc in many of these crops and damage ranges from 15% to 80% in certain situations.

It is obvious that the problem cannot be solved by shooting alone. Poison has been used in some situations but this is unsatisfactory, not only from the wanton destruction of wildlife, but because of the danger to human life from the possibility of eating ducks which may have had contact with a poison. Many chemicals, materials and repellents have been developed. Limited success is being achieved but some of the costs are prohibitive. Various devices, such as scareguns, whistlers, alarms, can be used in conjunction with repellents and shooting but rarely can the problem be solved where large infestations occur. The farmer has to protect his interests because he and his family depend on the crops for their livelihood.

Planning for the future

It is hoped that this workshop will create awareness of the problems confronting the conservationists, engineers and agriculturists. A satisfactory solution can only be achieved by a better understanding of the problems and greater co-operation between the three groups.

Flood plain zoning and the acquisition of farming land may be a part solution in the future to preserve wetlands for flora and fauna habitation. This may also have an additional benefit in reducing the flood relief compensation to farmers. Consideration needs to be given to the type of development and land use which should be permitted on flood-liable lands having regard to the social, economic and environmental factors.

It might be possible to construct future drainage measures that are deemed necessary so as to bypass swamps and preserve the wildlife habitat. In other instances it might also be possible to rehabilitate areas which were previously available for wildlife.

Flood-prone land can have worthwhile recreational and environmental value. The development of the Albury-Wodonga area is being planned with the aim of providing parklands, recreational areas as well as conserving the important bird breeding and nesting areas. This is the type of joint approach that is needed for the future.

Research

Studies of suitable control measures are needed to protect the agricultural crops and to stop the uncontrolled slaughtering of wildlife.

Restricted licences and trapping licences introduced under the new Fauna Protection Act would permit destruction of ducks in rice areas. Special permits would also be issued where bald coots were a problem.

Plant Breeders have a role to play in the protection of crops also by breeding characteristics into the plants which are less attractive to attack by wildlife. Examples include, bearded wheats with long, stiff awns; pendulent heads as opposed to erect head making the seed harder to extract; spines in the seed bracts; protuberances as opposed to smooth capitulum.

Another possibility is the breeding of plants with repellent substances e.g. bird resistant sorghums with high tannin contents.

More research into all these aspects are needed in the future.

FUTURE DEVELOPMENTS IN AGRICULTURE IN THE NEW ENGLAND REGION

G.R. Godden

"We cannot and must not turn off the switch on technological progress. Only romantic fools babble about returning to a 'state of nature'. A state of nature is one in which infants shrivel and die for lack of elementary medical care, in which malnutrition stifles the brain, in which, as Hobbes reminded us, the typical life is 'poor, nasty, brutish and short'. To turn our back on technology would not only be stupid, but immoral.

At the same time, it is undeniably true that we frequently apply new technology stupidly and selfishly. In our haste to milk technology for immediate economic advantage we have turned our environment into a physical and social tinderbox." Toffler (1971: 387, 388).

Conflict with Wildlife

There is nothing new about this. It has been going on since man first began to upset the "balance of nature"; since he first domesticated animals; since he first began to till the soil. My reading suggests that so far as agriculture is concerned, the problem of conflict began about 10,000 years ago, give or take a few thousand years.

What we are looking at now is a situation in which population pressures, affluence and technology increasingly threaten all aspects of the environment. Agriculture happens to affect extensive tracts of country, and as wilderness areas shrink so its impact becomes proportionately greater.

The problem seems to be one of reconciling the need for production of food and fibre for an increasing local and world population, with that of preserving sufficient suitable habitat for the preservation of threatened or likely to be threatened species, and I am thinking of native species. There is also the matter of useful and pest species. I guess it is a matter of resource management to achieve this.

Certainly there is nothing sacred about the particular present situation - change of itself is not wrong. An efficient and progressive agriculture must bring change, and this need not be for the worse.

Future Trends in Agriculture

The direction and magnitude of change from the present will depend on political, economic, social and technical factors, so that one can really do no more than offer suggestions as a basis for consideration. For the purpose let's consider trends in three headings:

(i) Farm Size

One significant trend, presently halted, which will undoubtedly continue in the future, is that of subdivision of holdings into hobby farms, particularly

in the Armidale and Tamworth areas. These seem likely to provide more headaches for Local Government and Agriculture than for other groups.

Elsewhere rural adjustment will see the aggregation of non-commercial units into economically viable holdings, whilst tax laws and inheritance may have some effect on the size of very large holdings.

It is suggested that holdings of continuing marginal viability can through over-grazing and/or over-cropping adversely affect wildlife. One also wonders about the results of the subdivision of large holdings. What will this mean in terms of timber clearing?

(ii) Production

Tablelands. I believe that for a long time to come agricultural production on the tablelands will be dominated by the grazing industries. There is great scope for increased production of root crops, summer and winter oilseeds, horticultural crops and feed grains. Development will be regulated by market requirements, by production costs relative to the alternative forms of production and to costs in other areas, and by managerial interest and ability.

The implications of any trends which develop are pretty obscure. The kinds of things which can happen are protrayed in a most interesting paper written by Mr. Bill Cameron for the Glen Innes Historical Society. He refers to the disappearance of koalas and kangaroo rats, to a kangaroo population explosion, and to rabbits; to ring-barking and clearing and the effects on bird life; to grain cropping and galahs.[1]

Slopes and Plains. Dryland production trends on the slopes and plains will similarly be governed by the relative profitability of alternative forms of production - sheep and beef cattle, winter and summer cereals, oilseeds.

The region has a much greater irrigation potential than many people realise, with main emphasis on the Namoi and Gwydir Valleys. The area irrigated in 1973/74 amounted to 59,374 ha. Having regard to expansion on the Gwydir, the potential total is in the order of 100,000 ha.

I do not expect the cotton area to increase. If anything, it may stabilise at a lower level in response to insect and disease factors. I do expect sorghum, maize and soybeans to be the principal irrigated grain crops in the region, whilst there is potential for the expansion of vegetable production and dairying under irrigation as required.

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1 See the paper by A.W. Cameron on pp. of these proceedings.

Intensive livestock husbandry in respect of pigs, poultry and cattle will be a feature into the future. Poultry production will expand in the Tamworth area as producers continue to move in from the metropolitan and central coast areas. There will also be relocation of some existing production units away from urban areas.

Pig production is expected to become progressively restricted to intensive housing, so that, other things being equal, the better control applied could assist in reducing the feral pig problem.

(iii) Social Aspects

Rural adjustment will continue to cause a fall in the number of properties and therefore in the number of managers. Perhaps more importantly, labour will continue to be replaced by capital so that the farm labour force will further decline. This has implications for rural/urban centres.

Technology

Trees. One of the things that concerns me is that I do not think we have yet outgrown the axe and fire-stick mentality of the 19th century. Too often one still sees ill-conceived or irresponsible clearing. Over extensive tracts no natural regeneration is occurring, nor is likely to occur under present land use. What sort of a landscape will this leave succeeding generations in 50 or 100 years time, if we don't do something about it? And what will be the implications for bird and animal life as shelter and food is increasingly denied or changed?

I believe there is an urgent need for this generation to do much more about tree planting on farms for a variety of reasons, of which wildlife maintenance is one.

Soil. The trend to increased protection of sloping land, particularly of arable areas, will continue with the inputs of Soil Conservation Service in particular, and greater awareness and expertise on the part of managers.

At the same time production pressure on soils of marginal units will continue until relieved by farm amalgamation or some other channel of economic relief.

Water. As a people we take water pretty much for granted until a crisis occurs. Increasing agricultural and urban development will put pressure on resources. In respect of agricultural development I see potential dangers to these resources through the effects of pasture improvement and increased stocking of catchment areas, and through drainage from intensively housed pigs and poultry, and from feedlots.

Perhaps more serious is the effect of pesticide use and any significant return to river systems of irrigation tail water. The situation is currently being monitored in the Wee Waa district.

Pesticide Use. It would be unreal to place a blanket embargo on the use of pesticides by farmers because there are dangers to wildlife. They have become essential to efficient farming and the production of quality produce. But are we investing enough in researching biological control of weeds, pests and diseases? Are we spending enough in developing integrated pest management systems? Are we too often looking for eradication when we should be satisfied with control?

I believe that one of the future developments in agriculture in the region will be in the area of integrated pest control and that this will not only benefit wildlife, but increase the efficiency of production.

This will apply to pests and diseases. It might also apply in the control of some weeds. There is, for example, some interesting work going on in the central west in respect of blackberry control by goats. Some of you may well say that goats will present more problems than they solve, but I suggest that there may be a place for them in some parts of the northern tablelands.

There are two other aspects of pesticide use I would like to mention.

Regional apiarists have suffered some serious losses of bees in recent years either through careless application of insecticides, or through failure of landholders to warn apiarists of plans in time for bees to be moved. This isn't good enough, and there is need for more generous recognition of the importance of the honey bee as a pollinator in many situations.

The other matter refers to pesticide residues in meat. Legislation has been passed which will, when it comes operative, provide restrictions on the use of pesticides, and potentially severe penalties for misuse leading to excessive residues in meat. This has come about because of increasingly high standards imposed by importing countries and a need to protect our export industries. Good agricultural practice in the use of pesticides will enable producers to meet the limits imposed.

Reference

Toffler, A. (1971) *Future Shock* London, Pan.

EVOLUTION OF FOREST POLICY IN NEW SOUTH WALES

K.J. Phillis

1. Early History

The early settlers of Australia in their urgent need for food and shelter found the forests around them to be something of a barrier to the development of a good standard of living. Forests had to be cleared before agricultural development could take place. The utilisation of the native hardwood timbers with the tools available was never an easy task.

Much of the earliest land development in N.S.W. centred on the discovery and exploitation of red cedar (Toona australis). Red cedar was much prized for its easy working and is still regarded as one of the finest cabinet timbers in the world. The tree is one of the few deciduous hardwoods in the Australian flora. Originally it was found in great groves in rainforest formations along the coastal rivers and escarpment of N.S.W. and Queensland. Exploitation began on the Hawkesbury River in 1790, but the cedar-getters rapidly expanded their endeavours north and south till virtually the entire coastline had been opened up by 1860. Although most of the cedar had been cut by the beginning of this century, the industry had already opened the way for more stable settlement.

Of course, the colony had also expanded westward across the Great Dividing Range. It is obvious that the clearing of some forest was essential to the development of a new nation. Towards the end of the last century, however, there was increasing alarm at the rate of depletion of the State's timber reserves, both through poor cutting practices and through clearing for settlement.

From as early as 1820, prospective timber getters had to obtain permission to operate, and the quantity they were to cut was specified. Then in 1839, the Governor gave the Crown Lands Commissioner authority to issue timber cutting licenses under certain rules and regulations. More stringent regulations were introduced in 1850 but the problem of enforcing them in the forest remained. The timber getters were notoriously wasteful. They cut the best timber from the log and left the rest on the forest floor.

In 1871, the Government took action to halt the destruction of the State's diminishing forest area: the first timber reserves were notified. In 1877, a small branch was formed charged with the administration of forest regulations. At the time, timber getters were being charged a small licence fee but a few years later the licence fee was increased and royalty on the timber was gradually introduced.

By 1902, the licence fee had become purely a matter of nominal registration fee for timber getters, and a much higher royalty on timber actually removed from the forest had become common practice. After 1877, the young Forestry Branch passed back and forth like an unwanted child, one year under the Department of Lands, the next under the Department of Mines.

In 1908 the Royal Commission of Inquiry on Forests in N.S.W. in its report to Parliament had this to say: "Probably no section of business under government control has experienced greater vicissitudes in its management, or less consideration, than that connected with our forests. No attempt appears to have been made to lay down a policy of management and apparently as each responsible department became tired of the business or failed to succeed with it, it passed to another." As a result of the Royal Commission report a Department of Forestry was established in 1909 and, though inadequate in many ways, it functioned until 1916.

2. Development of the Forestry Commission of N.S.W.

The Forestry Commission was set up as a statutory authority under the Forestry Act of 1916. It was charged with the management of 5 million acres of forest land and was given responsibility for providing for the dedication, reservation, control and use of State Forests, timber reserves and Crown land for forestry purposes. The Commission could dispose of timber from these lands and was allocated half the monies received from royalties and licenses for reforestation, afforestation, forest surveys, etc. In those days the Commission was even empowered to construct, purchase or rent sawmills. Under Section 10 of the Act the Commission was given the power to employ all casual and general employees for casual work. It was allowed to provide for the training of forest officers, the conduct of research work and the collection of statistics in connection with forestry.

Something of the condition of the more accessible forests inherited by the Commission in 1916 can be imagined from the notes of the previous section. The most pressing task was to dedicate State Forests as quickly as possible to build up to the statutory minimum of 5 million acres. The security of the State Forest tenure is protected by the following provisions for revocation.

"a) The Governor shall lay on the table of each House of Parliament proposals for such revocation or alteration.

b) After such proposals have been so laid before Parliament, the Governor, on a resolution being passed by both Houses that such proposals be carried out may, by notice in the Gazette, revoke or alter such dedication as aforesaid ....."

Amendment of the Act in 1935 provided for the dedication of some State Forests as National Forests, revokable only by Act of Parliament.

Having secured the forested land the next task was to institute improved management. Assessments and surveys were begun, working plans were written and attempts were made to achieve a tighter regulation of logging through the restriction of sales and the supervision of operations. With manual felling and still fairly primitive transport in many areas, most logging was still a selection of the better trees. Sometimes in the best blackbutt stands, particularly those accessible to a logging tramway, something nearer a clear-felling was achieved.

Attempts were also made to improve the growing stock for the future. The silvicultural treatment which sometimes followed logging in the better quality accessible forests involved the ring-barking of large, overmature unsaleable trees that would have suppressed regeneration. By today's standard much of the timber destroyed in this way would be saleable, but there is no doubt that this Timber Stand Improvement treatment has provided us with some fine regrowth stands. From the early twenties the Commission also began to look at the introduction of exotic conifers. Small experimental plantings were begun - but more of this in other notes.

Alongside the silvicultural work was the task of fire protection. Early efforts were necessarily confined to suppression of fires on only the most accessible and valuable forests. With great difficulties

in access and communication, and a none too sympathetic attitude from much of the farming community, these efforts were often in vain.

The end of the second World War in 1945 saw the beginning of quite a change in the pace of the Commission's activities. The War had brought great developments in the technology of machinery, communications, aerial photography etc. These developments led to considerable increases in the accessibility of forests and the intensity with which they could be logged and treated. Professional foresters were trained in increasing numbers. Capital was more freely available for plantation establishment and other silvicultural works. Perhaps it may one day be said that the speed of development caused some aspects of the Commission's activity to stray a little from the best principles of long-term resource management. But the tempo was generally in keeping with many other developments in a rapidly expanding postwar economy.

In all these notes the emphasis has clearly been on the use of forests for timber production. This is reasonable, since this theme has dominated the Commission's active management. The forests, however, have long been in use for other purposes such as soil protection and recreation. And foresters have long been aware of many of the principles of preservation, conservation and multiple-use management, long before Paul Ehrlich and the Club of Rome began to fuel the fires of the environmental movement. But there is no doubt that the environmental movement has come as something of a shock to some foresters in bringing home the urgency and priority which must be accorded these needs. For some it has been an intrusion on their established plan of action. For many others it has been a welcome change of political climate that allows the implementation of policies their professional training would have suggested them to pursue. There is no doubt, however, that the implementation of the highest standards of environmental protection will be a cost to all present day users of the forests. But more of this later.

3. Present Policy and Objectives

An amendment of the Forestry Act in 1972 provided the following specific policy basis:

Objects of the Commission

1. "The objects of the Commission shall be:
   a) to conserve and utilise the timber on Crown-timber lands to the best advantage of the State;
   b) to provide adequate supplies of timber from Crown-timber lands for building, commercial, industrial, agricultural, mining and domestic purposes;
   c) to preserve and improve, in accordance with good forestry practice, the soil resources and water catchment capabilities of Crown-timber lands;
   d) to encourage the use of timber derived from trees grown in the State; and
   e) consistent with the use of State forests for the purposes of forestry and of flora reserves for the preservation of the native flora thereon -
      (i) to promote and encourage their use as a recreation; and
      (ii) to conserve birds and animals thereon.
2. In the attainment of its objects and the exercise and performance of its powers, authorities, duties and functions under this Act, the Commission shall take all practicable steps that it considers necessary or desirable to ensure the preservation and enhancement of the quality of the environment.
3. The Commission may make recommendations to the Minister with respect to any of its objects, powers, authorities, duties and functions and shall, when requested by the Minister to do so, make recommendations to him with respect to any matter relating to its objects, powers, authorities duties or functions."

It is quite clear that the prime task assigned to the Commission is the timber production management of the forested Crown lands set aside primarily for that purpose. Lest that statement should be as red rag to a bull-conservationist let it not be taken out of the following context. Item 2 of the statement of statutory objectives makes it mandatory to take all practicable steps to preserve the quality of the environment. The general intention of the Government in this regard is probably clear enough. But of course there can always be arguments over what steps are "practicable" and the final resolution of such problems is sure to be bound up in current

economic thinking - what is society prepared to tolerate, what is it prepared to pay for? Quite clearly it is difficult for an all-embracing Act of Parliament to be specific on this sort of point. The best that can be hoped for is the sort of statement used here, but knowing that Government actions must in time reflect the political effects of changing thinking in society.

It must also be appreciated that timber production is certainly not the only aspect of forestry that the Commission is entitled to pursue. The Commission is specifically charged with soil conservation, catchment management, the promotion and encouragement of recreation and the conservation of birds and animals. Moreover it quite often occurs that these land-uses will become dominant in some areas administered by the Commission, sometimes over large areas and sometimes as smaller adjuncts to timber producing areas. On many more occasions these non-timber values can be obtained in conjunction with timber harvesting programmes. It is a fact, however, that it is virtually impossible to achieve the optimum realisation of every individual value simultaneously on the one area. With this in mind it is useful to consider what other forested lands are available to yield the various possible benefits.

4. Other Forested Lands

An inventory of forested lands conducted in 1971 for the Forwood Conference in 1974 revealed the following data:

Area of Forest by Ownership Classes
(thousand ha)

	N.S.W. & A.C.T.		Australia	
State	2,897	18.6%	11,725	27.6%
Other public	6,487	41.8%	19,913	46.8%
National Park	864	5.6%	1,830	4.3%
Private	5,228	34.0%	9,036	21.3%
Total	15,536	100.0%	42,504	100.0%

State forest was defined as "publicly-owned land, permanently reserved or dedicated primarily for timber production." The "other public" land was defined as "publicly-owned land, vacant or occupied under lease, not specifically secured for permanent timber production, but on which control of timber rests with the Crown."

Firstly, it is interesting to note in this table the considerable area of privately owned forest in relation to public forests, particularly in New South Wales. In 1973/74 these private lands yielded 61 million of the 205 million cubic metres of sawlogs cut in N.S.W., and 141 million of the 606 million cubic metres of pulpwood. Although most of this yield is obtained from areas not intensively managed for long-term sustained production, the size of the cut is nevertheless a very significant factor in the Commission's planning for timber production.

The second important feature of the table is the large area of public forest in relation to the forested national parks. This relationship reflects the considerable importance that forests outside the parks have in supplementing the wildlife protection and the recreation management roles of the parks. In many cases, for example, the State Forests can offer recreational outlets for, say, camping or trail-bike riding, when these may be unacceptable in the more "pristine" settings envisaged in the National Park tenure. The area of national parks is by no means insignificant, however, and the converse must also apply, that the special role of national parks in preserving certain wildlife habitats be taken into account when there appears to be a similar demand on nearby State Forest. The problem here is that it has not yet been possible to take detailed inventories of national parks to ensure that all important habitat types have been satisfactorily safeguarded.

Whilst on this subject it should be noted that the Commission has set aside 108 "forest preserves" with a total area over 12,000 ha. It is intended that these should be kept free of logging as reference stands for all the major vegetation types within State Forests. The programme is continuing.

5. Species Type Resources

5.1 Resources Inventory

The need to provide resource information for FORWOOD was the basic reason for carrying out a forest resource inventory of New South Wales in 1971. In 1951, 1963 and 1970 various subjective and speculative estimates of the forest resource were made. These

estimates were based on available assessments of State Forests, together with subjective estimates for State Forests without assessments, and private property. In order to provide a more objective data base the FORINS System (FOrest Resource INventory System) was developed. This system involves the evaluation and recording of the values of several parameters on a systematic square grid of points covering the area of interest. The data are computer edited and stored on magnetic tapes in a logical sequence. Computer routines have been developed to analyse the data and provide tabular summaries or maps.

For the State resources inventory the grid interval was varied to give a more intensive sample in the eastern part of the State where forestry interest is greatest. Three intervals were used, 3,000 yards in the east, 6,000 yards in some central areas and 12,000 yards in the west. The areas corresponding to each point (or grid square) are respectively 752.5 ha, 3010.1 ha and 12040.3 ha.

Although the inventory was forest resource orientated it did provide data on the broad scale land-use pattern of the whole State. For every sample point 21 parameters were evaluated, in two broad groups. Firstly there were those which could be evaluated mainly from existing maps. These included the various administrative sub-divisions of the State as well as factors such as altitude and rainfall. The second group included vegetation and land-use variables which were evaluated by aerial photo interpretation.

5.2 Vegetation Structure

The following vegetation structures were recognised:

Timbered	Not Timbered
Rainforest - subtropical	Heath
- dry	Scrub
- warm temperate	Saltbush
- cool temperate	Natural grassland
Wet sclerophyll forest	Bog, fen, herbfield
Dry sclerophyll forest	Sand ridge
Swamp sclerophyll forest	Rock
Tall Woodland	Agriculture - pasture
Savannah Woodland	- crop
Mallee	- plantation etc.
Forestry plantation	Settlements, roads etc.
Windbreaks, shelterbelts etc.	Water, lakes, etc.
	Dry lakes

5.3 Species types

The following species types were recognised:

Rainforest - subtropical
- dry
- warm temperate
- cool temperate

Maritime and swamp
Blackbutt
Tallowwood/Blue Gum
Moist Hardwood - gully
Dry Hardwood
Spotted Gum
Silvertop Ash
Stringybark
Scribbly Gum and others
Snow Gum
Alpine Ash
Messmate/Brown Barrel
New England Blackbutt
Yellow Box, White Box
Western Box, Ironbark
Black Cypress Pine
White Cypress Pine
River Red Gum
Plantation - P. radiata
- Slash Pine
- Hardwood
- Poplar

Non-forest

A summary of results, with some regrouping of types is given in the attached table.

6. Approaches to Management of State Forests by Types

6.1 Rainforest

The general objective to be pursued for all rainforest areas is to phase them out of general purpose timber supply production as soon as practicable under the constraints of existing market commitments and demands. That is to say there should be no increase in commitments, rainforest should not be cut to fulfil commitments that are not specifically for brushwoods (i.e. from gully pockets associated with hardwood logging) and, if the opportunity arises, hardwood should be used to substitute for rainforest commitments. Ideally, the level of harvesting should be reduced to occasional very selective fallings for specialty logs at a rate low enough to maintain good canopy and rainforest structure.

It can be expected that substantial logging of rainforest will continue for some time at Casino, particularly Wiangarie S.F., and at Wauchope in the Doyles River Subdistrict and, to a lesser extent, the Bellangry Subdistrict. At Casino most rainforest logging is now on a selection basis, with the residual canopy to be no less than 50 percent of maximum. At Wauchope studies have shown that the selective prescription was not particularly successful. Accordingly certain areas have been reserved from logging. The remaining areas will be logged with maximum utilisation to meet the commitment and the stands will be given a low intensity hardwood regeneration treatment.

N.S.W. INVENTORY OF FOREST RESOURCES - 1971

(hectares)

FOREST TYPE	Publicly Owned			Privately Owned		TOTAL
	State	National Park	Other	Investment	Other	
Rain forest	136,200	23,300	64,700	800	75,200	300,200
Cypress Pine	510,200	30,900	777,300	0	589,200	1,907,600
Moist Hardwood	489,100	72,200	256,600	12,000	286,000	1,115,000
Spotted Gum	179,900	3,000	81,300	3,000	229,500	496,700
Dry Hardwood	726,200	368,700	3,779,900	18,800	3,013,000	7,906,600
Red Gum	100,800	0	162,500	0	177,600	440,900
Snow Gum	15,100	227,300	134,700	2,300	257,400	636,800
Alpine Ash	21,100	42,100	3,000	0	800	67,000
Silvertop Ash	91,800	28,600	258,900	1,500	53,400	434,200
Stringybark	541,800	295,000	1,102,400	3,000	805,200	2,747,400
Plantation	97,300	0	0	19,700	800	117,800
Total	2,909,500	1,091,100	6,621,300	61,100	5,488,100	16,171,100

6.2 Cypress Pine

Most cypress pine management areas have been under management for sawlog production for a relatively long period. Although located in climatic regions which mitigate against high productivity per unit area, these forests can, if aggregated in large enough units, sustain viable sawmilling industry. Unfortunately, many of the cypress pine forests are now small scattered isolated units, separated by agricultural clearing and they are no longer economically attractive as long-term timber production units.

The ability of cypress pine to regenerate has now been demonstrated for most of its range and, in fact, the widespread regeneration of the 1950's has resulted in a surplus of younger age-classes in most management areas.

Cypress pine forests can also play an important role in production from their grazing values and, for their hardwood component, in apiary production. Through their occurrence in a part of the State which tends to be otherwise relatively unforested, they also have a role as windbreaks and as wildlife habitat.

From the Commission's management viewpoint the cypress pine forests can be thought of in two broad groups, those capable of forming part of a long-term supply zone and those too isolated for such an aim. Within the former group the primary management objective is best served by logging and silvicultural treatment aimed at producing even-aged stands, predominantly of cypress pine, in paddocks or grazing units. Within pine management complexes, however, there will be areas more naturally suited to hardwood species. These are to be managed predominantly for their non-wood values including particularly grazing, apiary and wildlife values, with perhaps only a small component of timber production such as railway sleepers.

The forests not forming part of long-term wood supply units will be managed jointly for wood production and grazing. Grazing will be controlled in order to ensure regeneration in those areas likely to remain as forest, but any other silvicultural treatment will be minimal.

6.3 Red Gum

These forests have a major environmental role as flood buffer areas for the inland river systems. They are also important wildlife habitat areas, particularly for aquatic birdlife, and play an important role as breeding and feeding grounds for the fish populations of inland streams. These values have also led to a strong demand for the forests for recreation purposes.

Growth rates of River Red Gum are dependent upon the receipt of regular flooding. The regularity of flooding along the Murray is being significantly reduced from the natural rate by regulation of the inland rivers for irrigation. Indications are that whilst future regulation will allow sufficient water to maintain the Red Gum forests as an ecological entity, the reduced regularity of flooding will restrict future commercial timber production

These forests will continue to be managed on a multiple use basis. Timber supplies to the extent of current commitments will be obtained by selective logging, but opportunities should be taken to reduce commitments where possible. Investment in silviculture will be confined to the ring-barking of some large cull trees in the course of logging, so as to promote growth on trees likely to yield logs in the next 30 years or so. Extensive grazing will continue to be allowed but only to the extent that it will not prejudice the continuation of the type by excessive destruction of regeneration. The recreational potential of this forest type should be developed through some provision of amenities and through control of recreational activities.

6.4 Snow Gum

As the table indicates, only a small fraction of the snow gum type falls within State Forest. These stands are not producers of commercial timber but they are important for soil protection and water production, for which values they will be protected. They should therefore also continue to serve their natural role as wildlife habitat.

6.5 Alpine Ash

Although not an extensive type in New South Wales, Alpine Ash is nevertheless one of the best commercial production types because of its ease of management. The most substantial block of this type is in the Bago Management Area near Batlow. This area has long been managed for sustained sawlog production through selective logging. This approach is to continue in the future. Alpine Ash type is not converted to conifer plantation, except where it occurs as very small pockets in major clearing blocks.

6.6 Silvertop Ash and Eden Chipwood Logging

The most important stands of Silvertop Ash occur near Eden where they form a significant part of the South East Hardwood Sawlog and Chipwood Management Area. The percentage composition of the Management Area by species types is as follows:-

Stringybark type	- 51%
Silvertop Ash type	- 28%
Messmate/Stringybark type	- 12%
Peppermint type	- 6%
Monkey Gum type	- 6%
Gum type	- 1%
Unacceptable species type	- 6%

The harvesting operations in this area have been much publicised because they involve clear felling on a scale not previously observed in production forestry in this State. The Management Area covers forests from north of Bega to the Victorian border and westward to Bombala. The total State forest area involved is 317,000 ha. Within the same region the following areas are under the control of the National Parks and Wildlife Service:-

National Parks		Nature Reserves	
Nungatta	6100 ha	Nadgee	14774 ha
Nalbaugh	3764	Egans Peaks	2145
Ben Boyd	8953	Bournda	5665
Mt. Imlay	3764		
Total	22581	Total	22584

From the viewpoint of logging and subsequent silvicultural treatment, the management of the State Forests in the area can be divided into three groups. In the Bega Subdistrict the prime production objective is the long term supply of sawlogs. Much of the logging is therefore of a selective nature and the chipwood harvest must have regard to log production. In the Bombala Subdistrict chipwood logging involves clearfelling but most of the subsequent planning of hardwood logging must therefore have regard to the normal principles of plantation design as discussed in a later section.

In the Eden Subdistrict, involving most of the Silvertop Ash, the logging involves clearfelling for sawlogs and pulpwood, but the subsequent re-establishment will be by natural regeneration of the native species to yield pulpwood in the future on relatively short rotations.

6.7 Other Hardwood Types

The remaining hardwood types, comprising 67 percent of the total State Forest areas, are grouped together here as the backbone of the general purpose timber supply of the State. For brevity their management is probably best described according to their geographical distribution rather than by species types. By gross simplification the management approaches can be thought of in three zones, a near-coastal zone, an escarpment and foothills zone and a tablelands zone.

6.7.1

The forests of the near-coastal zones were the first to be exploited for timber production, many having received their first logging over 100 years ago. And, of course, many of the best forests in this area were cleared to make way for the agricultural, particularly dairying, settlement of the coast. Early logging involved hand felling, and extraction by bullock teams, steam tramways and later by early tractors and lorries. Quite naturally the logging was selective. Where the openings were large enough, particularly on ridges and more especially in Blackbutt types, regeneration followed logging and the forests gradually took on the irregular grouped structure they now exhibit. The ecological and silvicultural characteristics of the eucalypts are such that the irregular structure is not the most efficient structure for production. Management is nevertheless aimed at perpetuating such a structure, partly because of the wealth of growing stock already present, partly because of the multiple benefits

available from selection forests and partly because it would be most costly to convert them to any other structure such as an even-aged plantation.

Silvicultural treatment following logging has usually been relatively light, generally in the form of extension of logging openings by the removal of commercially unattractive trees in order to promote regeneration. In the period roughly between 1960 and 1970 treatment often tended to be heavier involving the use of tractors to extend openings, followed by jiffy pot planting. A review of timber production goals and plantation programmes has suggested that such treatment with very long-term production objectives is likely to be much less important than the promotion of growth on stems likely to give commercial yields in the next 30 years. Accordingly it can be expected that, with the exception of certain limited areas proposed for specific plantation projects, future silvicultural treatment will be fairly light in most areas of near-coastal forests.

The timber production policy outlined above should be easily compatible with a variety of other forest uses. It should be appreciated that forests managed for some years under similar regimes have already been set aside as National Parks. The recreational use of those retained as State Forest is high in numerous instances.

6.7.2

Between the fairly gently sloping coastal country and the higher tablelands there is a band of "escarpment" and "foothill" country, often quite steep and broken by the drainage pattern of the major coastal rivers. Because of difficulties of access most of this country remained unlogged or only lightly logged in parts until after the Second World War. Developments in logging equipment, particularly the very powerful crawler tractors and the chain-saw enabled large tracts of this country to be opened up for logging over the last 30 years. Some areas have now also been set aside in National Parks such as Barrington, New England, Dorrigo and Gibraltar Range.

Because of the costs and difficulties of access the aim has been to obtain close to the maximum harvest at the first logging. The defective nature of many of the trees and the fairly high quality standards for sawlogs (as opposed to chipwood at Eden) have usually meant a result well removed from a clear felling. The new stands which have developed are therefore of a two-level structure comprising large native trees of the residual stand interspersed through a matrix of younger regeneration.

Silvicultural treatment has not been applied in most instances because of high costs and poor revenue expectations, but, with the exception of very moist sites, natural regeneration is prolific. In some areas "snag trees" have been felled close to major roads as a fire protection measure.

Although utilisation standards have improved to the extent that some of the trees previously left in logging may now be saleable, it seems likely that most areas already cut in this fashion will not receive a further logging for many years, if indeed they are ever logged again, particularly where the country is very steep.

The management of fire in the escarpment and foothill forests is important both for the protection of coastal settlements and the protection of the more intensively developed coastal forests. Because of scattering of regeneration of all ages from selection logging, hazard reduction burning in coastal forests is largely confined to narrow strips along key fire lines. The same restriction does not apply to the escarpment and foothill forests. In these forests the Commission practices broad scale hazard reduction burning, often using aerial ignition techniques. Fire plans are drawn up to ensure that areas are selected for burning on a rotational basis, so that the same area is not burnt year after year. It should also be appreciated that control burns are not intended to and never achieve complete coverage of the areas in which they are applied.

6.7.3

The commercial productivity of the tableland forests varies very considerably. The production management regimes applied are equally diverse. In limited areas of some of the better quality stands the Commission will endeavour to sustain timber supplies through a selective logging system. In many other cases the management will resemble that already described for the escarpment and foothill forests but, because of the lower commercial desirability of many tableland species, the logging will often be somewhat lighter. Some areas have been converted to plantations of exotic conifers and this programme is continuing, as discussed in the next sections.

6.8 Eucalypt Plantations

The eucalypt plantation programme in N.S.W. has never been large relative to the conifer planting programme or the area re-established by low intensity silvicultural treatments. Over many years there were experimental plantings of one kind or another, but it was only from about the early 1960's that these grew to be of any significance. With greater availability of money, machinery and the jiffy-pot planting technique foresters moved gradually to evolve plantation techniques as a means of restoring to commercial productivity areas of heavily logged country particularly in the "moist hardwood" types.

In many cases this type of technique is probably the only way of achieving a return to a good stocking of vigorous potentially commercial trees. But it is being increasingly appreciated that the initial investment is high, the returns remote and the interference with some other forest values fairly great in some cases. Accordingly, the Forestry Commission is moving towards a policy of restricting the development of large areas of eucalypt plantation to a few projects with specific markets in mind. The current major projects are Coff's Harbour/Kempsey and Bulahdelah/Dungog for pulpwood and Wyong/Cessnock for mining timber. At the moment there is no firm continuing annual planting target and it can be expected that the current financial restrictions on Government spending will have some effect in this area.

6.9 Pine Plantations

Pine planting shares with woodchipping the wrath and fury of the conservationist or preservationist movement. Pine planting is not a new phenomenon. Between 1920 and 1935 small plantations of exotic conifers of a number of species were established in various situations along the coast and tablelands of the State. Because of the spectacular failure of several of these all planting was halted in 1936 pending a Commission of Inquiry. The successful plantations which remained, although small in area, until very recent times supplied the bulk of the softwood sawlogs cut in this State.

Planting resumed in a much bigger way in 1946 and increased parallel with the general expansion in the postwar economy. Based on the experience up to 1935, plantings were now mostly in *Pinus radiata* and were concentrated in a limited number of tableland sites generally with rainfall in excess of 750 mm and at altitudes between 700 and 1200 m.

The formation of the Australian Forestry Council in 1965 was followed by the Softwood Forestry Agreement Act of 1967 in which the Australian Government financed a greatly expanded planting programme by the States, aiming at self-sufficiency in wood products by the turn of the century.

The national FORWOOD Conference in 1974 produced a new Production Forestry Development Plan, still aiming for self-sufficiency, (though with very different justification), but using the greatly reduced population forecasts of the national demographers and revised consumption forecasts. Since 1974, even the demographers are forecasting even slower population growth and many conservationists are calling for further immediate reductions in the planting programme.

The situation is in something of a state of flux, particularly since the FORWOOD Plan did not specify the contribution of individual States to the national programme. The Forestry Commission tried to resolve some of the difficulties in its evidence to the recent Inquiry by the House of Representatives Standing Committee on Environment and Conservation, and had hoped that some further resolution of the interstate co-ordination difficulties may have come from the Committee itself. Such was not the case.

Given reasonable finance it now seems that the Commission will be aiming for an annual planting programme for the next five years of something like the following:-

Tumut	2,000 ha
Bombala	800 ha
Moss Vale & Tallagada (in total)	200 ha
Bathurst	1,600 ha
Nundle/Nowendoc	400 ha

Finally, it must be said that the Forestry Commission is far from unaware that there are some environmental problems associated with the establishment of a monoculture and with clearing some native forest to make way for pine. However, it is a question of perspective. At present, pine plantations occupy just over 100,000 ha in a total State Forest area of nearly 3 million hectares, and total forested area of some 16 million hectares, taking into account National Parks, other Crown Lands and private property. The planting programme will be reviewed from time to time, but if the above planting rates were continued to the year 2000, the total plantation area at that time would still only have reached 225,000 ha, a fairly small percentage of the total forest estate.

The argument proposed by some that the planting programme will result in the destruction of all "cool moist mountain forest" cannot be substantiated. Nevertheless, in its evidence to the Softwood Inquiry the Commission did acknowledge that some individual narrow species associations may perhaps be at risk and therefore advocated further resources for research both in State Forest and National Parks.

The use of "marginal agricultural" lands for the programme is to a large extent a question of economics, although there are further problems in defining what people mean by the term. There are obvious advantages for the Commission in planting on previously cleared country but the purchase price of such "improved" property is obviously a severe restriction. The Commission has recently conducted a thorough examination of the status of land planted in its major Tumut and Bathurst projects and has found that a very high proportion was not "original dedication" of the 1917-20 vintage, but rather acquisitions made over a number of years from agricultural interests. To the extent that mostly it was, at best, only partially cleared, it must have been "marginal" for farming at the time of acquisition.

THE FUTURE FOR WILDLIFE: CONFLICT OR COEXISTENCE?

J.S. Weir

The nature of the problem

The two previous papers have outlined future developments in agriculture and forestry in the region, as their authors perceive them. Developments in these areas will dictate their possible relationships to wildlife populations. Russ Godden indicated the impossibility of making clear predictions on the extent or course of agriculture in the future, as agricultural practise will follow the changing pressures of economics, sociology and population growth, not just in Australia but also overseas. Ken Phillis feels that the future for forestry is clearer and, indeed, has to be planned to meet certain objectives which can be defined now and which may only lend themselves to reassessment at intervals of 5 or 10 years.

How much more difficult then is it to make realistic predictions about the future status, relations, and problems of wildlife in this region. I took two approaches to this problem. One could work through all the major ecological "types" of wildlife e.g. large macropods, small macropods, gliders, seed eating birds etc., and detail the types of effects which could be expected on these groups, as far as we know, from various types of development in agriculture and forestry. Such a list (incomplete but scientifically interesting) has little value in the absence of clear predictions of future events, particularly in agriculture, and is not pursued here.

My other approach has been formulated in the course of this workshop and deals with the general nature of the problems which have arisen in the past with wildlife, and the methods adopted to deal with them. It is possible, using this approach, to outline some past approaches to the interaction between wildlife and agriculture or forestry which have worked and some which have not. Perhaps an awareness of and responsiveness to past failings will prepare us to deal with whatever problems arise in the future by using more realistic techniques with a greater chance of success. This seems to me to be the only relevant approach to take at this workshop.

Clearly agriculture and forestry present two different problems in their relations with wildlife. Perhaps one of the most appalling problems is our lack of knowledge of the present status of so many wildlife species in agricultural and forest areas. There is no economic incentive to investigate many such species, hence the effect on them of changes in land use, agricultural and forestry practices remains unknown. The forms on which we have information are almost always those which have become or have been believed to be pest species.

CONTRASTING INTERACTIONS WITH WILDLIFE

Agriculture	Forestry
Rapid change of agricultural techniques and land use practises, in response to economic pressures.	Slower change of forestry methods. Establishment of long term programmes of forestry.
Present Primary aim as regards wildlife: to control pest species and where possible eradicate them. More and more species of native fauna and flora (and introduced species) have been designated as pests, as agriculture has come to depend on more efficient use of resources. Efficient control can often lead to significant cash benefits. However, very often the state pays for the control so the individual landowner is not forced to consider the benefit-cost relationship of pest control. Pest control is seen as a right.	Present Primary aim as regards wildlife: to coexist with wildlife with minimal interruption to wood production. To the forester, only a few wildlife species can be designated as pests. Efficient control of pests has value only to the forestry department (or plantation owner) which therefore has a direct interest in the benefit-cost relationship. Coexistence with wildlife populations confers little cash benefit, but control can be costly.
As agricultural practise is more varied and flexible we may expect to see the development of new pest species in response to new techniques and crops.	As forestry changes more slowly we can expect fewer new pests to evolve in forest situations and a concentration of interest in ways both of minimising loss and of making money from wildlife in forests.

Primary aim in dealing with neutral (non-pest) species of wildlife

Little or no consideration is given at present to the needs of such species. As they are largely unnoticed and their needs are not understood, their future prospects are gloomy. For species adapted to particular niches in natural ecosystems, the ability of 20th century agriculture to take over whole landscapes and alter the physical, chemical and biological properties of the system must lead quite inadvertently to the reduction or elimination of such species. The predictable extension and intensification of agriculture will exacerbate and accelerate this process.

In many cases the forester does not attempt to convert or completely alter the natural ecosystem he works with. The changes induced are limited and may offer scope, quite inadvertently, for the survival and diversification of such neutral species, as when the frequency of occurrence of seral stages is increased by selective logging. At other times, forest management by controlled burning may seriously limit the range of seral stages. Neutral species of wildlife have usually been ignored, but there is now a growing awareness of the existence of such species and of the relative ease with which they could be managed within normal forestry practice if there was a desire to do so.

Relation of land use to wildlife "pest" populations

During the last eighty years land use in this region has changed extensively, and this is paralleled by changes in wildlife populations. The papers by Mr. Cameron and Johnson and Jarman have both detailed the nature of these changes, and in both pest and non-pest species. Whistling eagles, kangaroo rats, foxes, tiger cats, grey kangaroos and rock wallabies have all been mentioned. There is no clear explanation of why these populations have varied so extensively. Among the reasons put forward are predation, competition for food, and disease (as proposed by Harry Recher). One thing is clear: variation in numbers of many of these species is quite unlikely to have been due to agricultural pest control policies, which, however, cost substantial sums of money.

We would all agree that change in agricultural and forestry practise is not inherently bad, and there is no doubt that it will continue. Changes will therefore occur in wildlife populations. Our lack of understanding of the reasons for, and mechanisms underlying, previous population fluctuations makes it impossible to use explanations for past episodes to predict the course of future changes in wildlife populations.

General environmental requirements of wildlife

The necessity for environmental diversity (e.g. as a patchwork of burns in a forest) has been emphasised by Harry Recher, as well as the requirement of particular items by particular species (e.g. holes in trees). Man by his creation of uniform monocultures of trees or of crops often eliminates environmental diversity. We may expect such processes to spread further, with new crops such as oil seeds, new areas of plantations and new techniques of bulk management and mechanisation. Thus the general diverse environment in which wildlife survives at present is liable to alter substantially in the future, restricting the range of many species and leaving a few as pests e.g. blackbirds, corellas, galahs, and pademelons.

If there is any desire to maintain a diversity of non-pest wildlife species in any area, then it is clearly necessary to plan in advance to do so. It is both possible and desirable to integrate wildlife into the overall land use picture, but it calls for active planning to do so. On-going programmes may be partially modified to accommodate new ideas on wildlife conservation but the greatest hope for the survival, in numbers, of many species is to plan to incorporate refugia or patches of natural vegetation into mass agricultural programmes and forestry developments. The paper by Bill Fisher reveals that relatively small areas of natural forest left as scrub breaks in plantations of hoop pine can serve to maintain high species diversity as well as to perform a useful managerial role. There is, at least in agriculture, a marked lack of desire to do so at present. The present high diversity of mammals in the upper Clarence Valley may be due largely to the particular type of agriculture practised in that area. There is a need to quantify the relationships reported by John McCann so that such processes can be set in motion as required in other areas to meet particular needs and

and with particular end points in view. It is one of the more depressing aspects of this workshop that I can not say more on this sort of topic. The information has not been brought forward because it is not available. Yet the case of the upper Clarence Valley mammals exemplifies the fact that it is not at all impossible for a diverse group of wildlife species to coexist with both forestry and agriculture.

One may well ask whose job it is to plan, create and manage refugia? National Parks and Wildlife Service? Department of Agriculture? And where does the CSIRO Division of Wildlife fit into this picture? To obtain action it may be necessary to allocate responsibility.

The role of value judgements

It is inevitable that in a workshop on this topic many people should use value judgements, some deliberately and perhaps some with a lack of awareness that they were using value judgements. To quote some phrases which have been used: "sufficient habitat for wildlife", "reduction to tolerable levels", "how much wildlife do we need", and the classic "levels consistent with the well being of agricultural and environmental values". Who defines sufficient? Who defines tolerable? I may need a different amount of wildlife from others. Who defines environmental values and then who assesses the well-being of those values?

Value judgements may be necessary but it is important to recognise them as such, to try to give them some accurate quantitative basis, and to be aware at all times that one's own value judgements on a certain issue will certainly differ from those of other people with different aims. We should be passing the age of value judgements in this area. It is quite acceptable for those who are calling for new ideas and more data to ask what is sufficient habitat for wildlife. It is quite another for a government department to impose its own unquantified standards for "well being" on the management of an area. Such standards should be quantified; value judgements should not be used, or the preconceived values incorporated in them should be seen for what they are, and become available for independent assessment by others.

Value judgements underly much of the operation of government instrumentalities. Entrenched and traditional opinions and values are known to all of us - and they occur in Research Institutes and Universities as well as in Government Departments.

But the values of the public as a whole change in relation to social, psychological and economic pressures. People change. It is very necessary to ensure that there is no bureaucratic lag in response to changing public values. There is a necessity for communication, education and tolerance of the views of others, not just by the public but in the higher échelons of public administration. As situations, problems and policies change with increasing rapidity in the future, there is a need for increased flexibility and speed of bureaucratic response. What will we get? Entrenched value judgements instead?

Documentation and Recording

We may lack understanding of the mechanisms and processes underlying past events. We do at least know that they occurred. It is vital that changes, impacts, and effects of new practises on wildlife be documented.

We may note in passing the numbers of speakers who drew upon past records in a wide variety of ways:- Frank Hartridge, Ken Johnson, Bill Cameron, Bob Beeton and Ken Phillis to mention only a few. We have to ensure that recording systems are established, not just by government departments, but by individual interested persons, and by local organisations and societies, and we have to ensure that such records are made available in a number of centres.

The Department of Agriculture has detailed records of pesticides used to control spur throated locusts. Has anyone else got details of any effects noted on wildlife in these areas? Whose job is it to maintain such records?

I would draw attention to the number of workers who made statements on wildlife or pests which reflect assumptions, often unproven and unprovable assumptions, about past events. How often have the phrases "populations have increased" or "populations have declined" been used by speakers? They may well be correct, but how much better it would be if we had some data to support these opinions.

Wildlife as pests and present control measures

Taking one example from the papers over the last 3 days; wallabies are pests in plantations of young trees. Among the techniques which have been tried to prevent damage to young trees were:- repellents, systemic repellents, electric fences and poisoning, none of which achieved any marked success. These can be thought of as "big stick" control measures.

But in the end rather than indulge in expensive and ineffectual "big sticks", forestry practise moved towards new strategies to minimise damage at low cost to the forester, by seasonal planting, selection of particular plot shapes and sizes, and protection of trees until they reach a defined minimal size. These are all strategies which can be employed to minimise economic cost. Such strategies depend on knowledge of the ecology of the wallabies and constructive use of this knowledge in planning for adjustment of forest practise to fit in with the activities of the wallabies. Such situations should be particularly susceptible to various forms of benefit cost analysis and simple optimisation.

"Big Stick" Control Measures and their Consequences

The big sticks for wildlife, and they are being invented with increasing speed these days, include repellents, electric fences, poisons (including use of organophosphorus insecticides in waterholes to control pigs), hormone weed killers (some interesting long term effects of which are becoming apparent in Vietnam), and guns. How many speakers have mentioned guns and how many thousands of rounds of shot have been quoted! Let us indeed all get shares in a lead mine.

One gets the impression that these big stick control measures are often self defeating. Look at some of the examples quoted in this workshop. Dingo control programmes of a variety of kinds, including shooting and mass aerial baiting, may apparently disrupt population regulation mechanisms in dingos and lead to increased breeding as Bob Harden suggests. Is this what one is trying to achieve? Rabbit eradication rogrammes. One may well ask along with John Brereton whether such costly and ineffective programmes are at all appropriate for the Western Division of N.S.W. where in many cases the land is unsuitable for grazing. But, this apart, what is the effect of the programmes? Probably it is disruption of the rabbit social organization, again leading to increased rates of breeding. Is this what one wants? Is this what we are paying for?

Corella control on the Ord. Bob Beeton's demonstration that use of a shot gun scare merely led to double the amount of damage for each shot must be one of the clearest examples of the self defeating results of this type of approach.

Cockatoo and galahs in N.S.W. Again the use of guns to drive birds off one's own property has the result of driving them onto someone else's crop. It may be a valid practise for the individual land owner in the area but could seem to be self defeating as regards crop production in the area as a whole, as well as being costly in time and ammunition to the individuals concerned.

There seems to be scope in this country for us to learn some humility, to realise that often we cannot win by the use of the big stick. We have to investigate the fundamentals of the ecology of these animals, to select and to modify for our purposes natural behavioural and population control mechanisms.

It is appalling to note the flexibility of behavioural and population strategies used by the dingos and corellas and to compare these with our inflexible and simplistic big stick approaches.

There is a need for a revolution in approaches to pest control, particularly in agriculture. We need to see more games theory, more flow charts and more benefit-cost analyses. We need to see government pest control workers standing back and asking themselves what they are doing, why they are doing it, whether there is a better way of doing it, how much will it cost, and is it all worth it.

Alternative Control Measures for Wildlife as Pests

The use of modified forest practise in plantations has been mentioned as offering some chance of "co-existence" with wallabies. Strategies used were:- modification of plot shape, protection of young trees and selection of time of planting. Compare this with the corellas on the Ord, where again Bob Beeton offers us the strategies of:- modification of shape of field, selection of position of field, of sequence of harvesting and of time of planting, and carefully controlled use of scare guns. Again, work on ducks feeding in rice crops suggests that employment of decoy strategies successfully used in regions such as California to offer ducks a preferred alternative feeding site, may have much to offer in the M.I.A. - if anyone was prepared to do the necessary preliminary work. At present thousands of rounds of ammunition seem to be favoured.

There is no shortage of alternative control and co-existence methods for many of these pest species. What appears to be lacking in many cases is the initiative to obtain the basic information and the failure to realise the value in economic terms of cheap non-destructive control measures.

Predictions on Future Developments in Wildlife pest control

New and nastier "big sticks" seem likely to be introduced by the Department of Agriculture. New diseases may be introduced such as coccidiosis and replacements for myxomatosis. They may have substantial value but in the long term may become attenuated and allow the partial resurgence of the pest as appears to have happened with myxomatosis. The chance introduction of stock diseases from other countries may lead to widespread attempts to exterminate certain types of wildlife as potential carriers of disease.

We can look forward to more pesticides and more hormone weed killers. One most constructive line of approach is the search for pest-repellent strains of plant such as the bird-repellent sunflowers. Breeding strains of plants with particular properties designed to minimise losses to wildlife offers immense scope for the future.

Pest and Profits

When is a pest not a pest? When someone finds a way to make money out of it. Grey kangaroos in New England could undoubtedly be managed for profit, provided suitable control and supervision were used. When graziers see kangaroos as dollar assets, their continued existence will be ensured. Such rational conservation calls for guaranteed markets, sustained yields and high quality of the end product. Theo Livanes and Peter Wright have outlined the present problems and future possibilities.

Rabbits: Here we come up against the entrenched idea that rabbits are pests and must be exterminated. But why spend money on lost causes? Recall again John Brereton's view. Has any government department investigated the benefit-cost relations of intensive cropping of rabbits from the Western Division or even in the New England area? It has been done in the past in Australia. Perhaps improved methods could be devised to turn this pest into a profit maker. Who's job is it to carry out the investigation? Investigation of the problem is not helped by legislation prohibiting the breeding of rabbits on properties.

Ducks on rice fields must surely offer sources of income both for sport shooting and for the high class food market in cities. Is any effort made to see what sort of trade could be established in this area and what the return would be?

Corellas and Galahs: What would be the cash return if some hundreds of these were exported every year?

In all these cases we are faced with the problem of deciding whose responsibility it is to check out new uses for old pests. Who finds the funds for the work and what are the aims of the organisations involved:- CSIRO Division of Wildlife Research, Department of Agriculture, National Parks and Wildlife Service, and, in the case of waterfowl perhaps also the Water Conservation and Irrigation Commission? Yet considering that these instrumentalities were all established many years ago with clearly defined responsibilities and suitable aims for that time, it seems unlikely that any one of these bodies would feel that it was clearly their responsibility to look at and actively investigate methods of making money from wildlife. Values and aims may have changed over the years but bureaucratic boundaries remain.

Purpose of the Workshop

We want answers to these questions:

Can wildlife coexist with agriculture and forestry?

What problems prevent co-existence?

What investigations are called for?

Which organisations should undertake them?

Where should funds come from for this?

Who should persuade and initiate action?

Which organisations should implement the findings?

How should ideas and information be circulated to all relevant bodies?

Bob Harden's diagram on the relations of bodies concerned with dingo control pointed out that what flowed was money. There is a need for equivalent diagrams and flow charts defining the mechanisms of other types of control operations, and one may feel disappointed that more were not seen at the workshop. We need also some diagrams on the flow of information and results and on benefit-cost relations among the various bodies involved. How much information is held on file in government departments at the present time which could be used by other persons?

In a situation where new and unforeseen events may lead to the development of new "pests" from among present wildlife species, there is a need for the establishment of advance planning. We have seen the usefulness of a National Disasters Organisation. A state organisation for pest assessment and management would ensure some degree of future preparedness which we lack at the present day.

Whose Responsibility?

Throughout this workshop repeated reference has been made to the problem of responsibility for investigation.

(1) Which organisation is responsible for determination of the effects of land use on non-pest wildlife species? The National Parks and Wildlife Service might be if they had adequate staff, but their primary concern may be thought to lie at present with management of National Parks. Perhaps C.S.I.R.O. Division of Wildlife Research should be responsible. The universities certainly have a role in this provided funds are made available, but funds from A.R.G.C. are awarded on the merit of the application, not necessarily in relation to the needs of wildlife. Why should the Department of Agriculture not have some responsibility in this?

(2) Dingos. In the case of this species the research is carried out by N.P.W.S. and C.S.I.R.O. Division of Wildlife Research. Control measures are financed from outside these organisations and with scant regard for the results and information available. What should be the role of the Department of Agriculture in funding research into dingos? This may be a most illuminating example of contemporary trends. The role of the Department of Agriculture may be seen as that of financing, or helping to finance, and supporting the use of ineffective "big sticks" such as aerial baiting and scalp bounties (by shooting). Is the Department of Agriculture concerned with benefit-cost analyses of its operations, or is the exercise undertaken, despite the information available from N.P.W.S. and C.S.I.R.O. research, as a psychological and political support for graziers?

(3) Rabbits. Who should do the basic investigation; CSIRO Division of Wildlife Research, the National Parks and Wildlife Service, the Department of Agriculture, or the Pasture Protection Boards? Would their research be oriented along all possible lines, disregarding preconceived ideas? How good would be the circulation of information, and who would implement the appropriate programme?

(4) Corellas on the Ord. While it might be expected that CSIRO Division of Wildlife Research, or the Western Australian Wildlife Service or Department of Agriculture would have studied this problem, in reality, when sorghum losses became significant, it was the local growers who funded the necessary basic research into control options. Is this good enough?

(5) Cockatoos on the Namoi. Again, should CSIRO Wildlife or the N.P.W.S., or the Department of Agriculture be investigating this rapidly increasing pest problem? Perhaps the Oil Seed Marketing Board, or even producer groups, are most likely to do so, since they will be concerned with benefit-cost relations in the pest control.

(6) Ducks in rice fields. We are quoted information that CSIRO Wildlife looked at this problem in 1954 and considered it was due to poor agriculture. Is the problem still the same? Can the N.P.W.S. do the necessary basic research? The Department of Agriculture prefers the simple approach of shooting the ducks, which is good for public relations and will not improve or worsen the problem substantially in the long term though it will have substantial public costs. It is to be hoped that the Irrigation Extension and Research Division of M.I.A. might become involved since it may focus on particular problems, in a rational way, using benefit cost analysis.

The Water Conservation and Irrigation Commission seem unlikely to respond to wildlife problems, as I have been told by members of their staff that they do not consider waterfowl management to be their responsibility, and they cannot therefore use even minor sums of money to manage waterfowl populations in the interests of either agriculture or wildlife.

Sue Briggs pointed out that waste water from irrigation schemes was available and could be used at little cost to control and increase feeding and breeding habitat for waterfowl. These represent part of Australia's national heritage as well as a useful source of state income from shooters' licences. It is surprising that state government departments are so organised that they appear to be unable to perceive such rational objectives or to approach them within the limits of their authority. Surely the combination of increased state revenue and increased conservation of wildlife should not have to be considered unattainable for bureaucratic reasons.

The ecology of bureaucracies

Social organisations which conform to legislative parameters behave conservatively. One has only to note the repeated statements of treasury officials in many countries over the last 20 years that their policies are intended to eliminate inflation and stabilise international exchange rates. No government in the Western World in the last twenty years has actually achieved this.

All such systems tend to be self sustaining and self perpetuating; to be so they require constancy and stability. They are usually established to cope with a defined set of problems. They formulate policies to manage these problems and thus stabilise their area of responsibility. There is usually little desire or incentive on the part of such organisations to introduce innovative approaches which will lead to a reappraisal of their role, and possible loss of jobs.

Periodic change has been recognised as a necessity in democratic systems. So change is built into the mechanism of democracy and is called an election. However, elections produce a change of political direction, not necessarily a change in bureaucratic implementation. An election is a controlled and limited revolution; to produce an equivalent revolution in bureaucratic thinking calls for pressure on the system of government at all possible levels. Some pressures may be successful, some not.

If workshops such as this can define, as I think this one has, a problem which rests with governmental organisation and inefficiency, rather than with wildlife, then our collective responsibility is to examine ways of bringing pressure to bear to achieve change.

What to do and how to do it?

Pressure for change can be created at political levels. Obviously any voter has the right to raise matters of interest and concern with his or her state and national representatives. If we look at a typical problem such as that of the dingo then we are presented with a wide variety of organisations which could be pressured: Department of Agriculture, Pasture Protection Boards, bodies concerned specifically with dog control, and individual graziers.

In many of the cases we have heard discussed here the real need is for education and new understanding, for overcoming prejudice and preconceived, traditional ideas. There are few who would be more responsive to such new ideas than those who finance the control programmes. Therefore one basic type of move which could be suggested would be to require that a substantial portion of the cost of any control measures on any wildlife species comes from those directly affected by the wildlife, and not entirely or largely from state funds.

Although the National Parks and Wildlife Service may produce much relevant information on the ecology and behaviour of pest species one may question whether their organisation is sufficiently large or numerous or capable, financially, of dealing with the extensive wildlife problems in the state once they have obtained the basic data.

It is possible to see a role for a flexible pest control and management section of the N.P.W.S. which was concerned -

(1) to obtain fundamental understanding of the problems with which they were faced.

(2) to formulate new control options and alternative strategies based on sound economic assessment of the benefit-cost relationship involved.

(3) to implement such new control options either by recommendations to the relevant government departments or by short advisory courses and demonstrations for graziers and farmers.

One remains unconvinced that such an organisation would work well within the Department of Agriculture as at present oriented.

Dissemination of information on new methods and approaches to pest control should be the subject of a technical journal available cheaply via a government agency. An organisation such as that proposed above could be given responsibility for such a publication once the basic organisation had been created.

Environmental movements have been criticised from time to time during this workshop. This I object to. They usually comprise a pressure group with a clear objective, determination and much noise. One may in some cases differ either with their objectives or the means used to achieve them. Nevertheless, the pressure group is a valid means of achieving action in the contemporary socio-political system, and, as we can see, they have been very effective in various ways.

Therefore I suggest that one possibility is the establishment of a few pressure groups of the people and interests represented at this workshop. Bodies already exist which could function as pressure groups on particular issues if they wished to do so. The Institute of Foresters and the National Parks Association are examples.

Obviously some individuals at this workshop and groups of individuals can initiate new approaches within their own organisations. In this context one notes with interest the large numbers from forestry and agriculture organisations who have made the trip to Armidale. The N.P.W.S. has been well represented by junior members of staff but one of the more important organisations involved, the Division of Wildlife of CSIRO is unfortunately not represented here. There has been keen interest and awareness of responsibility by foresters and Department of Agriculture staff, if not always agreement. It seems clear that workshops such as this have a role to play, not merely in bringing people together to listen to scientific research papers, but to bring people together to get awareness and action.

This workshop has I believe also defined the need for the creation, perhaps informally, of small efficient working groups looking at ways of handling particular problems. In the present bureaucratic system such working groups have to be interdepartmental, and they have to have clearly defined and limited objectives. In some cases such groups may achieve the relevant action directly. In other cases they may need to bring their conclusions before a wider audience such as another workshop to take up the thread where this one leaves it.

To summarise the immediate needs for the future: As many problems and solutions in the area of wildlife versus agriculture or forestry seem to lie with present policies of control and land use practise, the future for wildlife could be greatly improved if new and enlightened policies could be formulated and employed both for species which are not pests and for species with pest status. In some cases the future outlook for agriculture would also be improved. There is a clear case for reassessment of existing policies, objectives and responsibilities in respect of wildlife by various government departments, instrumentalities, and research organisations.

Pressure for change in these areas could be brought about by:-

(1) political pressure,
(2) adjustment of the system of financing,
(3) the creation of a purpose oriented government agency designed to do a flexible job in this area, including research, policy formulation, education, demonstration, and implementation of policies where relevant using benefit-cost approaches.
(4) circulation of a technical newsletter or journal.
(5) action from existing or new pressure groups.
(6) action by individuals within organisations to achieve improved approaches.
(7) further workshops to pursue the objectives established here.
(8) creation of informal, purpose-oriented, multidisciplinary or interdepartmental working groups to make recommendations on particular problems.

Change is indeed inevitable and change is not inherently bad. New pests will arise and new dangers to wildlife will be discerned. We must be prepared to meet these problems in the interests of agriculture, of forestry, of wildlife and of the Australian public.

The success of this workshop is now in your hands. You have to decide where you wish to go from here, what action you think should be taken, and how far you think it feasible to pursue these objectives. It is vitally important that the impetus and initiative generated in this workshop should not be lost.