Towards a State Conservation Strategy

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PREFACE

As part of the process of preparing a definitive State Conservation Strategy for Western Australia, a wide range of aspects concerning our environment, natural resource usage and society's impacts are being considered. Some of these facets have been reviewed adequately in recent years to enable highlights to be summarised. For other aspects, there was little up-to-date information readily available in a form directly pertinent to local problems and needs.

In order to widen the baseline of local data upon which to draw, a number of people were approached and invited to prepare review papers on selected topics. While in the initial contact I discussed with each person the broad scope that might be covered, the content of each paper is the responsibility of the author. Each was encouraged to present his or her own viewpoint; some may have been tempered in varying degrees by their official positions.

I am grateful to each for their willingness to find time to contribute data and concepts upon which we can draw in shaping a State Conservation Strategy.

R.G. Chittleborough

R.G. Chittleborough
Coordinator

AN ETHICAL BASE FOR A WESTERN AUSTRALIAN STATE CONSERVATION STRATEGY

by DESMOND O'CONNOR

An Invited Review Paper as Background
for the Development of a
STATE CONSERVATION STRATEGY FOR WESTERN AUSTRALIA

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SCOPE

This discussion paper arose from the deliberations of the WA Conservation Strategy Consultative Committee and aims to:

- make a contribution to a preliminary blueprint for decision makers;
- serve as a "thought starter" for community inputs.

The paper addresses a relatively intractable aspect of environmental affairs – one that is rarely capable of precise definition yet one that underlines in an unspoken way much public debate and media attention, legislation at all levels of government, and expenditure of vast amounts of public funds.

The elusive nature of the subject should not cause it to be relegated to the background. Any solution is likely to be sensitive politically and is still in need of widespread discussion.

BACKGROUND

A Western Australian State Conservation Strategy is intended to flow from the National Strategy.[1]

The National Conservation Strategy[2] seeks to achieve sustainable development through attainment of the following principal objectives:

- To maintain essential ecological processes and life-support systems (such as soil regeneration and protection, the recycling of nutrients, and the cleansing of waters) on which human survival and development depends.
- To preserve genetic diversity (the range of genetic material found in the world's organisms), on which depend the breeding programs necessary for the protection and improvement of cultivated plants and domesticated animals, as well as much scientific advance, technical innovation, and the security of the many industries that use living resources.
- To ensure the sustainable utilisation of species and ecosystems (notably fish and other wildlife, forests and grazing land), which support thousands of rural communities as well as major industries.
- To maintain and enhance environmental qualities which make the earth a pleasant place to live in and which meet aesthetic and recreational needs.

The strategy recognises explicitly that development is essential as a means of providing the wealth necessary to ensure conservation of living resources and that implementation of the strategy must have regard for the general economic climate. This latter recognition makes the goal of achieving sustainable development more difficult, partly because our society has become dependent on economic activities which are in conflict with the above objectives, and largely because we lack a clear philosophical picture and ethical base to guide us through the maze of difficult choices confronting us. Kelvin Willoughby* makes the point that a conservation strategy which is not grounded on a solid understanding of **why** conservation is required, **what** it is that needs to be conserved and **who** ought to be responsible for conservation, is not likely to succeed. Unless we can achieve a consensus on a rationale for conservation which goes beyond the level of short-term pragmatism, progress towards a sustainable society will flounder amongst the obstacles of misdirected expediency.

WHY IS A CONSERVATION STRATEGY REQUIRED?

Apart from the purely pragmatic reasons for having a strategy for "getting the show on the road", conservation and the pursuit of environmental quality are seen as desirable, even as a right, and form one aspect of the "quality of life" which is so easy to support but difficult to bring about in terms of concrete legal and institutional arrangements. Any set of laws or institutional arrangements must, almost by definition, rest upon an ethical base. The better understood and defined the base, the more practical use the legal and institutional framework. This plainly should concern us as we proceed towards the development of an implementation strategy at state level.

Perhaps without it being fully understood, there is emerging in our society an attitude of concern based upon:

*Kelvin Willoughby, Murdoch University – personal communication September 1985. He has also provided a separate reading list on the ethical aspects, and this is attached following References at the end of this paper.

- the acknowledgement that man can inflict damage on the environment comparable with the great natural disasters of the past;
- a concept of stewardship of our finite resources for our own use and for future generations;
- an awareness that our environment has a limited capacity to absorb the debris of our society;
- the acknowledgement that a finite world with finite resources cannot support continually expanding population and burgeoning technology beyond a certainl level.

It is the difficulty of translating these community attitudes into environmental policy that concerns us today.

Not only is it difficult to translate known and established community wishes into policy, but it is becoming increasingly difficult for policy makers to gauge genuine public opinion. Environmentalists have identified important flaws in the industrial society, but environmentalism is becoming increasingly conservative, tending to cling to the past rather than to move forward.[3]

There seems to be little doubt that public opinion is being mobilised around sources of genuine environmental concern in the community, but in joining in support of environmental reform the ordinary citizen soon finds himself caught up in movements for the reorganisation of society over which he seems to have little control. The utopian vision is easily obscured.[4] It is little wonder that policy makers become confused in trying to decide who speaks for the environment.

Donald Schon[5] traced the emergence of "ideas of good currency" in the United States in the 50s. Clearly the emergence of the environment as an "idea of good currency" has affected public input to environmental affairs in Australia in the last decade.

If a cause such as safeguarding the environment espoused by an interest group is inherently an attractive aim or high ideal, that cause and its supporters have considerable advantage over any person with a contrary view or one who simply urges caution or balance. This approach is very appealing to the media. If one wishes to present a balanced argument, there is seldom time beyond a few minutes. Such snippets pass for public opinion, but in the preparation of a Western Australian Conservation Strategy, decision makers should realise that opinion is a poor basis for policy – facts are required.

Facts, however, are sometimes difficult to define in terms of the psychological and social factors which are so much a part of man.

Whilst it is easy to assert that our concerns should be addressed to maximise human welfare in terms of quality of life, this has so far proved to be an ineffective base for planning because so many aspects of it remain undefined. There are even difficulties in establishing whether an attractive environment is an intrinsic moral right, or a legal right as distinct from a political catchcry.

There do seem to be good grounds for arguing that there are no grounds for excluding humans from any opportunities to develop and fulfill their capacities in rationality and freedom. It follows that this right should become a legal right, and this then would impose on everyone an obligation to respect it. This seems to lead to the conclusions that no group can pursue its right without impinging on the rights of others.

There is a basic problem in defining a right. Having a right is to claim (and presumably to be able to assert that claim) against someone else. Whereas legal rights can be tested by interpretation through legal rules, intrinsic moral rights must result from the principles of enlightened reason. Man being unique in the possession of reason and free will must be in a different position from animals and other species in this respect. It is my opinion that the earth and its resources are for the benefit of man through the exercise of his reason and responsibility through a system of stewardship and concern for posterity. I believe a case can be made for this in the society in which we live.

The mark of our maturity as a society will be the success with which we couple ethics with the economic and legal imperatives we face.

AN ENVIRONMENTAL ETHIC[6]

John Black[7] feels that if we delve into many philosophies of conservation they fail under critical examination. Black fears there is as yet no fully worked out and satisfying philosophy of conservation,

only what he calls a collection of generalities and catch phrases. He fears that if they prove to be rejected, they may leave us with another void resulting in further over-exploitation of nature. Some feel that this is already starting to happen. I would like to join with Black in suggesting that one of the most pressing tasks facing us today is to find an acceptable basis for responsible conduct, rather than over-concentrating too soon on administrative and institutional arrangements, or on new scientific fixes.

Should we decide to implement our strategy via legislation, we might be well advised to consider some of Kelvin Willoughby's (K. Willoughby, personal communication, 1983) thoughts on the matter. He makes the point that any piece of legislation reflects, either explicitly or implicitly, an ethical bias of some kind. Good environmental legislation should be firmly grounded in a viable and enlightened ethic of nature. Such an ethical basis should be consciously and explicitly articulated, to ensure that legislation does not become unworkable because of hidden contradictory assumptions.

The paramount question when identifying a sound ethical basis is whether we view "nature", on one hand, and "human society" on another, as distinct realms with a dichotomy between them, or whether we see them as different aspects of the same system. The former view leads to "conservation" and "development" being seen as opposed with continual "trade-offs" necessarily resulting. The latter view sees "conservation" and "development" as potentially, mutually dependent activities. The former view appears to have dominated the debate in Australia to date, with the unproductive polarization between "conservationists" and "developmentalists" ensuing. There are signs that the latter view is now beginning to be taken seriously.

An ethic which portrays "nature" and "human society" as complementary aspects of the same system needs to uphold two principles:

- that nature has intrinsic value;
- that human development, and hence economic activity, has intrinsic value.

Both of these principles need to be incorporated into the rationale for environmental action without diluting them into empty platitudes under the guise of a so-called "acceptable compromise".

The realism of these dual principles is vindicated by the insights of ecological science: nature, rather than being a static and pristine conglomeration, is a dynamic, evolving and open system which thrives on the complex interplay of countless species and communities, including human beings. It needs to be stressed, therefore, that acknowledging the intrinsic value of nature does not imply that nature is sacred in the sense of it being wrong for humans to use it, or intervene in its processes.

In practice it will only be possible to implement these principles if we go beyond the superficial conceptions of economic growth which have been so prevalent. We need to understand that growth is neither "good" nor "bad" *per se*. It is only meaningful to speak of growth if the following factors are specified:

- the **content** of growth (i.e. what it is that is growing);
- the **rate** of growth;
- the **direction** of growth;
- the **quality** of growth.

To speak simply of "pro-growth" versus "anti-growth" or "zero growth" is nonsensical. As Ashby points out[8] past experience with societies in a state of zero growth is far from reassuring. He makes the point that they usually stabilise with a small dominant minority of wealthy people and a large oppressed minority of permanently poor people with a minimum of mobility between the classes.

The challenge, therefore, is to plan these four components of growth so as to ensure that the integrity nature is maintained. Hence, the pivotal question for politics and planning is not with whether or not we should proceed with industry, but with what **type** of industry and technology it would be appropriate to adopt.

Nature should not be viewed simply as a **pristine wilderness** to be revered, nor only as a **quarry** to be exploited, despite the fact that both of these perspectives have their advocates. An enlightened, ethical basis for environmental legislation, which would also be consistent with our cultural heritage, would view nature as a **fertile garden** to be nurtured and cultivated by human beings.

Since we are so vitally concerned with our environmental future, it is useful to develop a perspective on how things reached the stage they have today.

Black tries to trace features of the western philosophy of life and what he calls its uncompromising treatment of the natural environment and its resources which led us to our present state of concern over ecological crisis. He sees the four most important aspects of our western world as:

- the conviction that man's role on earth is to exploit the rest of nature to his own advantage;
- an expectation of continuing population expansion;
- a belief in progress and history; and
- a concept for posterity.

He traces the origin of these points to the origins of our culture, and makes the very important point that ideas brought into being from any particular cultural source may persist even when, with the decline of the influence of religion, the source itself is no longer important or has been forgotten – ideas once assimilated acquire a momentum. He feels that many of our views incorporate many of the fundamental concepts of the Judaeo-Christian tradition – man moved from a position of integration within nature to one of domination over nature. This emerged from two processes: the development of the technical **ability** to modify the environment, and the **desire** to do it and to intervene in natural processes for the benefit of the human race. Black claims the book of Genesis has provided the essential clues to the way in which the relationship between man and nature developed in our culture, and it is still the central component of our world view today. The two key phrases in Genesis are:

> "Have dominion over the earth and subdue it."
>
> and
>
> "Be fruitful and multiply."

There is no doubt that the driving motivations of dominion and multiplication have persisted and have intensified because they are somehow at the root of all environmental problems we are experiencing today. The question is how to evolve from this an environmental morality and an environmental ethic.

At first reading, it seems that man was set apart from nature. However, I believe it is wrong to immediately identify the idea of dominion over nature with the ideas of wasteful exploitation. It is to the credit of mankind, starting with the Hebrews, that they evolved a concept of responsibility for husbanding the earth's resources. There seems to be no doubt that the Hebrews believed that one prime reason for their presence on earth was to look after the earth and be responsible for the lower orders of creation the same way as God accepted the responsibility towards them. It is from this that a concept of stewardship and proper management emerged.

So a central part of our cultural tradition is the emergence of concepts of stewardship, responsibility, and accountability for the earth. This leads us on to the idea that we should not waste the things under our control and stewardship, and is basically compatible with what we might call today sound environmental management, leading to the interpretation that we should avoid letting things go to waste yet provide wisely for future generations.

In a "thought starter" paper of this type it is impossible to explore the subject as thoroughly as it deserves. Willoughby[9] has made a valuable assessment of the man-nature relationship, and reference should be made to it. Our tradition seems to provide the basis for an environmental ethic, a basis which is very largely lacking in most of the preservation philosophies of our time which are based on self-righteous or pragmatic approaches, depending on what side you happen to be on. If we are to generate any change in our attitudes to the way we handle our environment and provide for future generations, we have to have such an ethic as a basis for action in the legal and economic fields as we make the transition from a young to a mature society.

For an environmental ethic to provide an acceptable basis for responsible conduct, it must lead to a legal framework, yet I must admit that I have only limited enthusiasm for what the law can achieve in environmental matters.

We all know that trying to come to grips with the problem via the law is not always effective. Law is essentially a coercive, abstract concept, whereas environmental degradation is a reality which requires

for its solution systematic application of scientific and engineering skills within a broad framework of human values. Although we have certainly focussed attention on problems today through environmental legislation, legislation in one form or another has been on the books for many decades, yet many of the environmental problems that we have today arose in spite of the presence of these laws. The framework of human values gets little attention.

The idea of broadening the scope of environmental quality to embrace Quality of Life concepts, on the surface of a thoroughly admirable idea, carries with it profound ramifications and the need for proceeding with caution. It will extend the range of items considered in environmental decision making and we must be sure we are ready for it – socially, legally and institutionally.

WHAT NEEDS TO BE CONSERVED?

Over the last decade, environmental quality programmes were established by all levels of government. Legal, administrative and institutional arrangements have been put in place, yet there is an emerging unease that noble goals were being pursued without a specific set of objectives or a means of measuring success.

The environment is seen as one of the great Quality of Life issues of this age. The idea of introducing the Quality of Life concept as a tool for decision makers has immediate, if superficial appeal, but it has so far delivered little of practical, as opposed to academic, value.

A comprehensive investigation of the potential of the Quality of life concept was undertaken by the United States Environmental Protection Agency[10] via the Airlie Symposium, Warrenton, Virginia, August 29-31, 1972.* The objectives of the symposium were to explore the Quality of Life concept, define it in terms of its components and to develop suggested quantitative approaches to its use in guiding public policies.

The Proceedings of the Airlie Symposium provide one of the most comprehensive reviews of the Quality of Life concept in its potential application to the environmental objectives of the State Conservation Strategy. In what follows, summaries and extracts of the principal sections of the proceedings are provided as a basis for evaluation as potential input to the definitive strategy in the Western Australian context.

OVERVIEW

For the purposes of the Symposium the term Quality of Life was seen as referring to the well-being of people, primarily in groups, but also as individuals as well as the well-being of the environment in which these people live. It means different things to different people and there is as yet no consensus as to what it means in precise terms. However it was considered of sufficient value to warrant discussion at a national symposium as a basis for policy because, to promote Quality of Life, some actions are required by government and some by individuals. Although we do not know precisely what the Quality of Life means, it is obvious that over the last twenty years the general term Quality of Life has become the subject of growing concern and this is often related back to deterioration in various environmental factors. This has become more important since the changes which appear to be decreasing the Quality of Life are taking place more and more rapidly.

Even in the context of our State Conservation Strategy, the Quality of Life still remains undefined although we have attempted to list things which are considered to affect it. Everyone seems to have their own idea, largely depending on their own life style, affluence, etc. The Airlie Symposium concluded that it was virtually useless to proceed with simplistic definitions. It was quite clear that more than economic welfare is called for.

It is difficult to define and measure the quality of life. Most attempts to deal with it relate to economic statistics in terms of such parameters as the gross national product, consumer price index, etc. Although indicators have shortcomings, it was felt that some indicators of this type were required if forward planning is to take place. Indicators are needed to assess where a nation is in relation to its values and goals, but the debate continues on what to do with social indicator data when it is gathered.

Although the literature offers no consensus on a Quality of Life definition, there is a clear consensus on the importance of the concept. This is largely stimulated and contemplated by the paradox that economic indicators can continue to progress in the face of growing discontent and unrest. At the Symposium Richard Nixon was quoted on this matter:

*In the following page portions of Section I of the Symposium Proceedings are summarised and quoted in a general manner because it is a foundation reference in this area. Section II of the Proceedings consists of a "Quality of Life Anthology". It is not extensively referred to here, but is a "must" for workers in the field.

"In the next ten years we will increase our wealth by 50%. The profound question is: does this mean that we will be 50% richer in any real sense, 50% better off, 50% happier?"

This question remains to be answered in the context of the Western Australian situation.

At the Airlie Symposium Ted Gordon, President of the Futures Group presented some startling data regarding the values and priorities of the American people, many of which apply in Australia. His data were based on analyses of polls taken over the last 25 years. These polls indicated:

- There is growing cynicism and distrust of government.
- Optimism about the future is declining.
- Cultural and political views are becoming uncoupled.
- A better standard of living remains at the top of the personal hopes list.
- Owning a house is still the number one goal of Americans. Vacation and travel come next among the priorities, and so on.

An interesting aspect of these attitudes is that Ashby[8] predicted them in another context about the same time. He detected mass feelings of helplessness and frustration in the face of uncontrollable change which continues to lead to widespread cynicism about party politics and the growing belief that we are being governed by men whose decisions rest on expediency rather than on ethical principles. What chance has an environmental ethic got?

So there is nothing new in this, but what is new is the paradox that, as confidence in our institutions declines, we seem to be looking increasingly to government for a solution to our environmental problems. It does not take a profound knowledge of recent environmental events in our own State to suggest that this confidence might be misplaced.

North American surveys found a change away from preoccupation with the traditional American dream and a shift from strictly personal problems to social problems. Financial concerns relating to money and inflation have become important, and young people are becoming more concerned about problems in general. There is an increasing concern about drugs and pollution, and about national unity, political stability, and law and order.

THE APPROACHES OF DIFFERENT DISCIPLINES

Although it was considered that each discipline has its own perspective of Quality of Life problems, the Airlie Symposium agreed that the development of some indicators was necessary for several significant environmental reasons:

- as an early warning system to head off pending disasters;
- as an educational device to arouse citizens about dangers to their environment; and
- to assist decision makers in allocating priorities.

From the environmental perspective, it was considered useful to have a definition of Quality of Life so that it could be used in environmental planning and management. It was pointed out that problems of the environment are not new, but interest in them is new. There is a dawning recognition that the values and lifestyles of a particular society will largely determine the quality of the environment in which it lives. Some numerical indicators have been developed to express environmental quality, but they relate more to the applications of various techniques for pollution removal such as the extent of air pollution, air pollution levels, the effects of air pollution on health, the number of polluted water bodies in an area, and so on. It is still difficult to relate these indicators specifically to quality of life.

Economic perspectives are also important in defining Quality of Life because the economic health of a nation is given very high priority by governments, and consideration of other factors usually follows the establishment of economic security. There seems to be widespread agreement that economic prosperity has no high correlation with quality of life and the solving of social ills. Widespread social unrest and questioning of our institutions have stimulated a major re-examination of socio-economic phenomena in relation to quality of life. Economists have been confronted by the fact that members of the middleclass and upper-middleclass – those already free from want, tyranny and ignorance, and superstition – are among the loudest declaring themselves the most oppressed and miserable.

The question of what are a man's fundamental needs is not a new one yet an answer to it remains important if a "checklist" of indicators is to be produced. Behavioural scientists, political scientists, theologians and philosophers alike have long debated the question. A consensus has formed over the years that human needs are many and varied, and that the particular socialisation process of particular groups will greatly influence the sum and substance of the needs. Whilst the Symposium concluded that the Quality of Life concept has yet to emerge as a practically useful guide to decision makers, it was agreed that consideration of it on the perspective of history would enable us to more realistically appraise our present situation.

A quote from Doorstin given in the Proceedings (1:32-33) puts it bluntly:

> "We flagellate ourselves as 'poverty ridden' – by comparison only with some mythical time when there was no bottom 20% in the economic scale. We sputter against the Polluted Environment – as if it was invented in the age of the automobile. We compare our smoggy air not with the odour of horse dung and the plagues of flies and the smells of garbage and human excrement which filled cities in the past, but with the honeysuckle perfumes of some non-existent City Beautiful. We forget that even if the water in many cities today is not as springpure nor as palatable as we would like, for most of history the water of cities (and of the countryside) was undrinkable. We reproach ourselves for the ills of disease and malnourishment, and forget that until recently enteritis and measles and whooping cough, diphtheria and typhoid were killing diseases at childhood, Puerperal fever plagued mothers in childbirth, polio was a summer monster."

This suggests that the quality of life concept as a tool for decision makers must take into consideration what has occurred in the past to be better enabled to understand the present, particularly as the present extends into the future.

QUANTIFICATION OF THE QUALITY OF LIFE

We have seen that the quality of life concept is by no means precisely defined. The multidimensional nature of the concept limits the usefulness of it in a practical sense but the Symposium agreed that there was some need for making an attempt at quantification of it. Two schools of thought developed over this – one that you **cannot** do it, and the other than you **should not** do it.

The first school felt that there are so many parameters involved and that the term relates so much to the individual, that it was impossible to project this to describe the Quality of Life for a group.

Concern that you **should not** do it relates to the apprehension of sublimation of the individual to group statistics. It was felt that a Quality of Life index could be put to harmful use.

SOME BASIC ASSUMPTIONS

The first step in an attempt to quantify the Quality of Life is the definition of what the concept actually means. Even this step proves extremely difficult although there is a big literature on parameters useful for measuring the state of society.

The Airlie Symposium participants were asked to list the conditions they felt were appropriate for Quality of Life under the following headings:

> economic environment, political environment, physical environment, social environment, health environment, natural environment.

Some underlying structure was common to all of the responses, and some concepts were emphasised repeatedly. A great amount of discussion resulted on this problem of quantifying the qualify of life, but the overwhelming problem of the selection of a comprehensive yet precise and manageable list of qualify of life factors was the most difficult problem of all, because the factors included necessarily reflect the views of the people whose Quality of Life is being measured.

The technique is so new that it is not yet possible to say whether or not the results are reliable. It was agreed that there are serious and difficult research problems to be solved before we can introduce into the planning and decision-making process a Quality of Life index that can be used with confidence. In the local context it is difficult to see that this should be pursued in association with the State Conservation Strategy, yet the result of a large-scale study carried out by the American EPA showed the eleven most highly weighted factors were, in order of importance:

1. Democratic process
2. Public participation
3. Health
4. Choice in life
5. Housing
6. Economic security
7. Education
8. Land use
9. Essential living costs
10. Economic opportunity
11. Ecosystem

The two significant conclusions from this are that:

- the factors on it come from among the objectively-based social-indicator types rather than from the class of psychological factors; and
- economic factors are well represented in the top ten, thus indicating that economic indicators cannot be ignored in developing a Quality of Life index.

One rather surprising feature of the factor-weighting results is the rather low weight given to environmental pollution factors. Housing, land use and ecosystem are the three most highly rated factors in the environmental component, and specific pollution factors are far down on the list.

In total, the economic, political, social and environmental groupings were rated to be about equal, but in the breakdown the environmental factors tended to be more towards the bottom of the scale.

However the experiment was considered to be principally valuable in the education of the participants rather than as an input to the planning process. There may be a message here for us as we go about the development of the State Conservation Strategy.

After this study the EPA Symposium concluded that the techniques for practical application of the Quality of Life criteria to society's decision-making process continue to elude us, yet there appeared to be a consensus that efforts should continue to quantify it. The question remains: What are the next steps?

Useful from the point of view of the State Conservation Strategy is perhaps the general conclusion that there is a need to ensure that long-range policy decisions be amenable to change in the light of shifting Quality of Life values and priorities. This is probably about as far as we can go in relation to the State Conservation Strategy.

The main conclusions of the Airlie Symposium were:

- That there is a need for a rigorous and precise definition of the Quality of Life.
- That selection of a comprehensive yet precise and manageable list of Quality of Life factors is one of the principal problems faced by the research community today. Once this Quality of Life index has been developed, the questions associated with the aggregation of the results to form a group index remain to be answered.

It should be noted that the whole issue is still seen as very much a research area, not yet available as a fully fledged planning tool. Out of the discussion came three possible directions for future research:

1. Further work on the pure quantification of measures, not only in defining the factors and the weights, but also in statistically manipulating them.

2. Development of an output vector for large-scale comprehensive models making use of factors used directly by the policy maker or his research staffs.

3. Development of a methodology that will allow the policy maker to use such a concept as he makes his tradeoffs between numerous conflicting resource needs.

The Symposium concluded that there were serious and difficult research problems to be solved before we can introduce into the planning and decision-making process a Quality of Life index that can be used with confidence.

It is suggested that the inability to deliver hard and fast guidelines should not be used to discount the value of the Symposium. Rather, it should be seen as focussing attention on an aspect of the search for environmental quality which fulfills the "thought starter" role which is one of the objectives of this paper.

WHERE DOES THIS LEAVE US?

Two factors are emerging which may well have a long-standing impact on the way we handle environmental problems. Hand in hand with the awareness of possible unexpected environmental consequences of human activity we have a perceived deterioration in the stabilising human, social and institutional framework which we will need to create a tolerable environment for tomorrow.

This means that we can no longer focus attention on the technical aspects of problems but must consider the decision-making mechanisms and the societal processes which give birth to them.

Because the Quality of Life concept, undefined as it is, is concerned with the betterment of the human condition, and because this seems inextricably bound up with economic development, a broadening of our understanding of "development" is needed.

Development must embrace more than mere economic growth. This is not to demean the concept of economic growth in any way – the National Conservation Strategy acknowledges explicitly that development is essential as a means of providing the wealth necessary for the implementation of the strategy. It should be remembered that the economic pressures on man can be as great as environmental stresses on other species.

If the idea of development is to be brought together with the Quality of Life concept it has to be seen to promote the development and fulfilment of the whole man in relation to the system and environment in which he lives. It will be important to pursue this in a personal **and** communal framework of responsibility.

It should not be beyond our capability to provide for the exercise of every individual's personal responsibility for his own fulfilment in harmony with nature as a member of his own society and at the same time as a part of the totality of mankind.

With his unique combination of intelligence and will, man can develop a conservation strategy built upon the knowledge acquired from past generations, caring for his contemporaries and benefiting from his association with them, and operating with a sense of obligation and duty to posterity.

Providing for posterity is a noble ideal, but there is no guarantee that posterity will appreciate any plans we might make for it. It is often easier to plan unattainable Utopias than grapple with the problems of the present.

It should be possible to accept that the world and its resources are for the benefit of man providing we see the idea of benefit extending to all mankind over the continuum of time.

I believe that the seeds of a system of stewardship for the earth's resources has come down to us largely from the Judaeo-Christian tradition. As a basis for caring and responsibility, a motive above the pragmatic is clearly required even though we might continue to debate just what it might be. A balance has to be struck between catering for the needs of posterity and redressing the problems of our own time.

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FUTURE POPULATION PRESSURES ON THE WESTERN AUSTRALIAN ENVIRONMENT

by R.T. APPLEYARD

An Invited Review Paper as Background
for the Development of a
STATE CONSERVATION STRATEGY FOR WESTERN AUSTRALIA

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INTRODUCTION

This paper explores the nature and likely magnitude of factors which, in aggregate, will determine the future pressures upon Western Australia's environment, particularly our National Parks and conservation reserves. Although an appropriate model of demand would contain many variables, none of which are easy to quantify and predict, such a model should be devised and inputs regularly updated. The main general determinants of park and reserve usage will be population growth, income elasticities of demand and the number of visitors from other Australian states and from overseas. A probable doubling of the State's population during the next twenty-five years, and significant changes in its age structure, will almost certainly increase the incidence of usage of parks and reserves. More difficult to project, but no less important in determining usage, will be the direction and magnitude of changes in average earnings and the proportion of increases used for travel and tourism, as well as changes in the number of leisure hours and the propensity for workers to retire before reaching age sixty-five. Even more difficult to project is the number of visitors to the State and their use of specific parks and reserves. The general conclusion reached in this exploratory paper is that because each of the three main determinants will almost certainly move in the direction of increased usage of parks and reserves, **total demand** will increase substantially during the next twenty-five years.

Soon after its establishment in December 1971, the Environmental Protection Authority (EPA) recognised that an adequate conservation reserves sytem would be necessary in order to enhance the quality of Western Australia's environment. It therefore formed the Conservation Through Reserves Committee (CTRC) to:

(1) recommend adequate reserves to secure the **conservation** of representative biological and geomorphic types occurring in Western Australia, as well as other features of special scientific significance; and

(2) recommend adequate areas of **National Parks** to meet projected population growth, distribution and mobility.[1]

Following a long period of research and deliberation, including consultation with many organizations and individuals, CTRC recommended the addition of 104 000 km^2 to existing parks and reserves. The system set in place as a result of CTRC recommendations (over seventy per cent of which have been implemented) included large areas of the State's many ecosystems. In making their recommendations, members of CTRC were well aware that resources would not be available for some time to service and protect the new areas adequately. Indeed, some recommendations were made on the clear understanding that the areas would not be visited for many years. For example, in endorsing an earlier recommendation that the Chichester Range National Park be established in the Pilbara region, members recognised that they were doing little more than protecting the Park from further inroads being made into its "primitive state". CTRC's exhaustive inquiry was undertaken not a moment too soon. Many areas recommended as parks and reserves had been untouched for centuries but the so called "Pilbara boom" had recently seen their visitation by many geologists and surveyors. For this and other reasons it is unlikely that future CTRCs will be able to add much land to the conservation and reserve system. Large areas of Crown land remain, but they are "not representative of much variety". The system now set in place therefore represents essentially the **finite** mass of land suitable and available for parks and reserves.

DEMOGRAPHIC DETERMINANTS

CTRC had been especially concerned that the State provides adequate reserves to cater for the recreational requirements of present and future generations. People gain inspiration from contact with nature, it declared (p 0-11),[1] "and this can only be secured for the **future people** [my emphasis] of this State by well-managed conservation reserves containing healthy natural ecosystems of sufficient size to withstand extensive human use". The likely numbers of "future people", as well as their ages and locations within the State, is therefore a prime determinant of likely future usage of parks and conservation reserves. Population of a finite area (Western Australia) changes through a combination of **natural increase** (numbers of births less numbers of deaths) and **net migration** (numbers of persons who enter the State intending to settle less the numbers who leave it). Projections of growth through natural increase require assumptions concerning both fertility and mortality which, in turn, are determined by present and likely future population structure and, in the case of fertility, by attitudes towards marriage and desired family size. For example, a population with an unduly large number of persons in the fertile and sub-fertile age groups will increase more rapidly than one with an "aged" profile, especially if the young people have positive attitudes towards marriage and reproduction. Likewise, a population

containing a large number of middle-age and old-age people will have higher death rates than the population with a large number of young people.

Net migration is a much more difficult variable to accurately project. It does not depend solely, or even mainly, on Federal immigration policy; persons from other Australian states may move freely to Western Australia as Western Australians may move freely to other states. Recent demographic history of the State indicates that employment opportunities deriving from development of agricultural and mineral resources (plus "multiplier" impacts, especially in service sectors) have been the main reasons why Western Australia has persistently achieved net gains through migration. Indeed, during the so-called "Pilbara boom" of the late 1960s and early 1970s, Western Australia's population growth was double the Australian rate due mainly to the arrival of persons from other states and countries to fill vacant jobs.[2] In view of unimpeded mobility between states, a first step in assessing likely demographic growth in Western Australia is to note likely national trends. In 1978, the Australian Bureau of Statistics prepared population projections to the year 2011.[3] On the basis of reasonable changes in fertility and mortality, and projected net migration to Australia of 50 000 per annum, the Bureau calculated a population of 18.1 millions in 2001 and 19.6 millions in 2011; in other words, an increase of about three millions during the next twenty-five years. Short of major political events which cause unexpected massive immigration or emigration, and unpredicted changes in mortality and fertility (e.g. young couples deciding to have no children), the Bureau's projections are likely to be achieved plus or minus five per cent. Their projections were certainly "on course" in 1985.

Within this national demographic setting of an increase of three million between 1978 and 2011, similar projections were prepared for Western Australia by the Western Australian Treasury to the year 2011. These indicate that on the basis of similar assumptions concerning fertility and mortality, the State's present population of 1.2 million will reach 2 million on the basis of annual net migration gains of 10 000, 2.18 millions on the basis of net migration gains of 15 000, and 2.36 millions with net migration gains of 20 000 per annum.[4] In other words, achievement of the "medium" projection will see a doubling of Western Australia's population during the next twenty-five years.Within the general growth, there will also be a significant ageing of the State's population. Between June 1981 and June 2011 the proportion of persons aged sixty-five and over will increase from 8.7 per cent to 11.0 per cent, representing more than a doubling in the **number** of persons in this age group (Figure 1). During the same period, the proportion of persons aged 0-14 years is expected to decline from 26.0 per cent to 21.5 per cent, and the proportion of persons of working age to increase from 65.3 per cent to 67.5 per cent. These trends, concludes the Treasury report, will have significant economic and social implications over the longer term.

Important questions concerning the achievement of these projections include the extent to which the State's changing economic structure incorporates new and emerging industries, and whether traditional agricultural and mining sectors maintain their competitiveness on world markets and so contribute, as in the past, the major share of the State's output. Many economic changes have already been initiated, the consequences of which will flow on for some years. For example, the State Government's determination to develop tourism and new technology will not only contribute to diversification of the economy but, in the case of tourism, have specific impacts on the usage of National Parks and conservation reserves.

Distribution of population, whatever its growth, is another aspect which will affect the usage of specific parks and reserves. The present Government's policy of decentralisation is expressed in the "Bunbury 2000" Plan, designed to achieve "an urban alternative to Perth", and so ease "the pressure on congested city transport, public utilities and community services".[5] The expected doubling of the population of the south west division to 200 000 persons within fifteen years (not twenty-five years as for the State as a whole) will clearly place significant upward pressures on demand for parks and conservation reserves in that region. Should, as a result of government encouragement, the composition of the region's population also change, say, in favour of young families earning two incomes, then the demand for park/reserve usage in the region would differ from usage in another region which caters mainly for the increasingly aged overall population. Depopulation of agricultural areas is yet another consideration to be taken into account when attempting to assess the likely patterns of specific park usage.

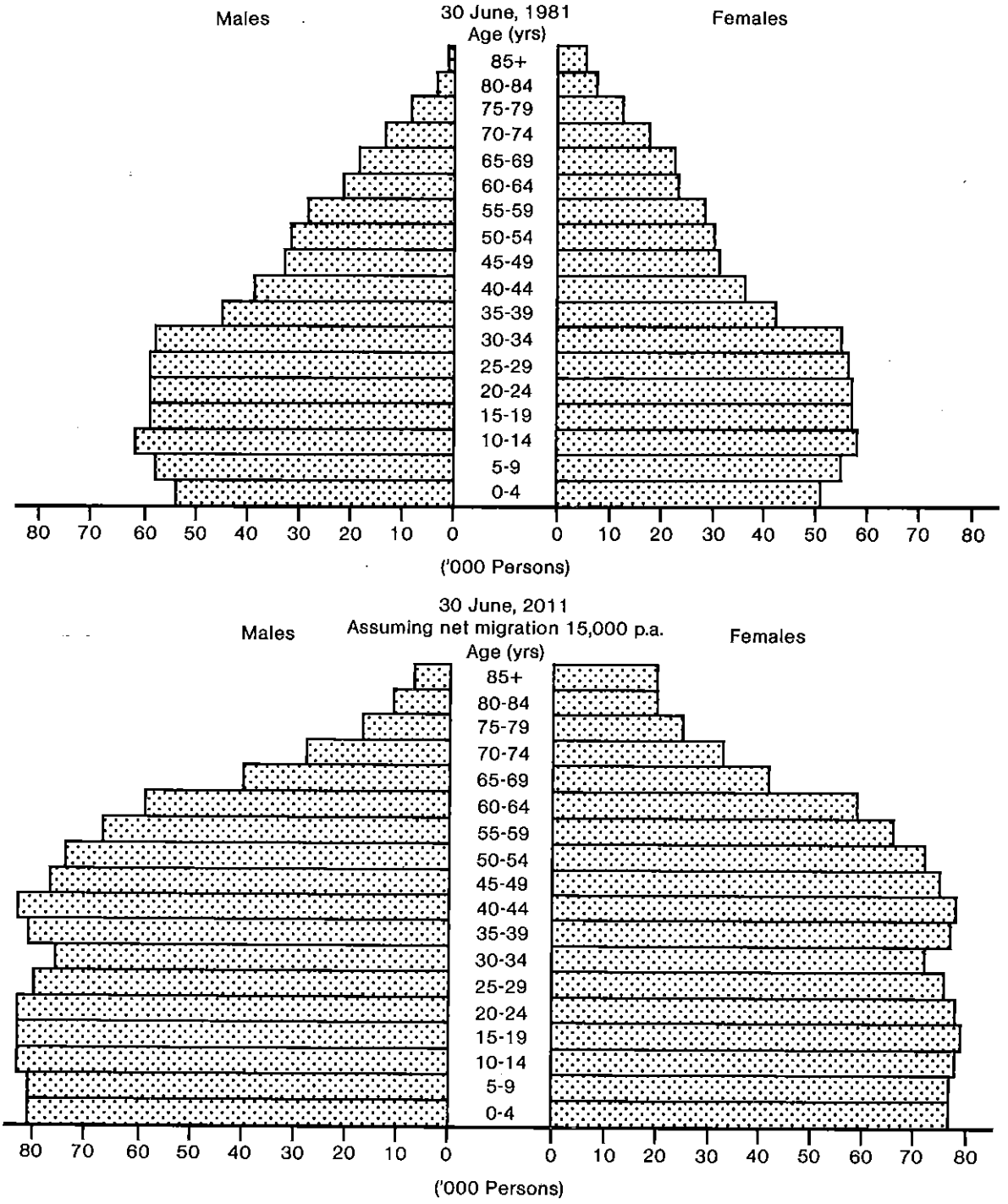

Figure 1 : Age profiles for the population of Western Australia, 1981 and 2011.

VISITORS TO THE STATE

Any significant increase in the number of visitors will place specific, and more concentrated, demands on parks and reserves, especially on those promoted by the tourism industry. Tourism has been clearly identified by the State Government as an industry which, if properly developed, will ease reliance on agriculture and mining, the traditional leading sectors. In adopting a very positive marketing profile, the Western Australian Tourism Commission has, at once, lamented the absence of exploitation of tourism in the past and predicted major new developments. The tourism industry, wrote the Commission's Director recently, "is poised on the threshold of the most important phase in its short history".[6] In the same brochure, it was declared that the State "has tremendous potential to attract and excite visitors", and elsewhere the Premier has argued that "tourism stands out as a growth industry offering exceptional opportunities".[7]

While the "demographic" potential for attracting both interstate and international visitors is enormous, **achievement** in this highly competitive industry will depend on a range of other more important variables. For example, rising real incomes (discussed below), cost of travel to and in this isolated State, attraction, range and uniqueness of desired destinations and the quality of facilities offered there. In terms of "potential", the number of interstate and international visitors to Western Australia between 1980/81 and 1983/84 was quite disappointing. In 1983/84, for example, only 130 000 international visitors entered Western Australia, about fifty per cent of whom came from New Zealand, the United States and the United Kingdom/Ireland. Not all had come primarily as tourists. A further 330 000 persons came from other Australian states. Their impact on the servicing industry, especially accommodation and shopping, was significant but figures provided by the Commission indicate that, aside from those who visited the south west, most tourists remained in Perth and its hinterland.

Australia's defence of the America's Cup to be held off Fremantle between October 1986 and February 1987 has been described as a "hallmark event" in terms of its impact on Western Australia's tourist industry.[8] Should the Cup be retained, the industry will enjoy increasingly significant long-term impacts. In view of the deemed significance of the defence, and the differential impacts thereafter of a win or loss, officials and private researchers have been reluctant to project the number of interstate and international visitors beyond 1987. If the defence is successful, then the number of visitors to Western Australia is expected to grow steadily; if it is not, then the basis of projections will be consolidation of achievements as a result of the 1987 defence. Estimates of "additional tourist numbers" to the Perth metropolitan area between 1984/85 and 1986/87 from other states indicate a rise from 350 000 to 600 000 and international tourists to increase from 200 000 to 395 000.[9] The **specific** impact on tourism of the America's Cup defence has been estimated by the Centre for Applied and Business Research (CABR). On the basis of several surveys, it concluded that the event would greatly stimulate a tourist market which, it noted, had been growing steadily for some time. Its estimates for the period October 1986 to February 1987 (the period of event) are as follows:

	1986			1987		
	October	**November**	**December**	**January**	**February**	**Total**
Interstate						
Non-America's Cup	39 605	22 720	22 585	17 255	12 280	114 445
America's Cup	70 775	33 495	47 525	96 790	114 445	363 030
International						
Non-America's Cup	13 800	15 500	19 600	13 300	13 800	76 000
America's Cup	10 410	5 770	12 730	20 470	21 130	70 510
Total						
Non-America's Cup	53 405	38 220	42 185	30 555	26 080	190 445
America's Cup	81 185	39 265	60 255	117 260	135 575	433 540

During this period, the number of visitors drawn to Perth from other states and overseas for the Cup defence will be twice the number expected for non-Cup purposes. Furthermore, the number of visitors from other states (Cup and non-Cup) during the same period will be over three times the number of international visitors. Achievement of these projections will clearly have a major impact on the tourist industry and exert considerable pressure on existing (and yet to be built) facilities in both the metropolitan area and in tourist locations outside the city. Even if the Cup is not retained, its defence will have had a significant "plateau effect" on the industry. If it is retained, growth from the established plateau will create significant upward demand, including the use of National Parks and conservation reserves. In this regard, it should be noted that the Australian Tourism Commission's *Statistical Review* for 1983/84 indicated that 71 per cent of all tourists from the United States and the United Kingdom said the "unusual birds, animals and flora" was their main reason for visiting Australia; 63 per cent of European visitors placed "some form of unique adventure style holiday" as their second reason and 75 per cent of Americans were attracted by "interesting landscapes" as their third reason for visiting Australia. It seems clear that while defence of the America's Cup is a hallmark event which will have a major impact on Western Australia's tourist industry, fauna, flora and landscape are likely to remain the long-term abiding attractions. By and large, these are to be more readily found in National Parks and reserves.

INCOME AND LEISURE

The doubling of the State's population during the next twenty-five years, combined with the expectation that Western Australians will comprise the highest proportion of visitors to parks and reserves, assures an increasing demand on existing facilities. Population growth, however, is not the only variable which will affect future demand. **Additional** income earned by Western Australians during this period is more likely to be spent on such "non-essential" items as tourism and travel than on essential consumption goods which will have already been covered by basic income. This income elasticity of demand factor could therefore increase usage of parks and reserves at a rate much higher than suggested by projected population growth alone. To this should also be added the "profound changes" which have already occurred in the number of hours worked per week, and the likely future achievement of a four-day working week.[10] Ruthven argues that leisure time can be expected to rise by magnitudes, thus creating demand for new diversions; and Sicari, on the basis that already 142 days per year are classified as "leisure days" for workers, believes that economists have only recently begun conceptualising the economic significance of leisure.[11] These incremental income and leisure factors also apply to visitors, especially from other states where similar trends can be expected to occur. Their influence on the number of visitors from other countries, though less easy to predict, will certainly be relevant to Western Australia's tourist industry.

The share of increased tourism which Western Australia can expect to achieve will depend mainly on cost competitiveness with alternative destinations as well as the degree to which the industry is successful in marketing its unique products. Successful marketing depends on substantial back-up facilities. Many of the overseas visitors who gave "unusual birds, animals and flora" as their main reason for visiting Australia probably expected to travel to the relevant areas in comfortable road and/or air transport and be accommodated at first-class hotels. The travel and hotel industries normally expect to make a profit on such ventures and these, in turn, depend largely on numbers of persons who use the facilities. Unless investors see sustained, long-term profits from such ventures, they are unlikely to be attracted. In this regard, plans recently announced for first-class hotels at Frenchman's Bay (Albany) and Kununurra (Kimberley) indicate that some investors have faith in the long-term profitability of tourism in Western Australia. The impact on usage of parks and reserves surrounding these areas will increase enormously once the facilities are in place. And to the extent that similar facilities are provided in other non-metropolitan areas so aggregate usage of the State's parks and reserves will increase further. The State's vast distances presently restrict tourist packages which include a number of regions. A network of hotels, supplemented by concession rates for internal travel, could mean that interstate and overseas visitors will stay for much longer periods than in the past. In this event, careful planning of facilities will be required in order to protect parks and reserves from over-use and even abuse.

MODELLING AND MONITORING DEMAND

In view of the medium- and long-term potential demand for usage of parks and reserves, a strong case can be made for careful monitoring of contributing factors. Western Australians will almost certainly be the main users, and the nature and frequency of their use will be different to those of visitors. Nearby parks such as John Forrest, which can be visited during one day, require different facilities to those in remote areas which are visited less frequently and usually during annual holidays. Nor can one assume with confidence that public interest in those aspects of "quality of life" which focus on visits to (and appreciation of) natural reserves will remain static. The estimation and monitoring of demand for use of parks and reserves, though a difficult exercise, can be done with the aid of an appropriate model which incorporates the general, and many other minor, determinants noted in this paper. Because of the likely future importance of tourism, and because the number of parks and reserves presently classified are unlikely to increase, analysis of the kind proposed should be given top priority. To set the issue in perspective, Western Australia could have a population exceeding eight millions by the end of the twenty-first century (assuming annual population growth rates of two per cent). While life styles then will almost certainly be very different to those we now practise, one can reckon with some confidence that those aspects of quality of life which focus on natural reserves will still be important. To the extent that an adequate reserves system was set in place, and protected, our descendants will pay tribute to those who recognised the importance of natural reserves and did everything possible to protect them.

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POPULATION, RESOURCES AND ENVIRONMENT REVISITED: A GLOBAL AND PERSONAL PERSPECTIVE

by PETER NEWMAN

An Invited Review Paper as Background
for the Development of a
STATE CONSERVATION STRATEGY FOR WESTERN AUSTRALIA

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INTRODUCTION

How population is related to resource depletion and environmental impact is a very old debate. The Greeks discussed it as did 19th century economists like Mill and Marx[1] and more recently Paul Ehrlich's textbook *Population, Resources, Environment*[2] has been a guideline for students around the world and in Western Australia.

However the man most associated with the topic is Thomas Robert Malthus, the clergyman who in 1798 predicted that there was an inherent problem in population's rapid geometric growth rate when resources such as food supply seemed to only grow at arithmetic rates. In 1803 he expanded his ideas in "An Essay on the Principle of Population or a View of its Past and Present Effects on Human Happiness with an Inquiry into our Prospects Respecting the Future Removal or Mitigation of the Evils it Occasions". For those able to read beyond this title it provoked enormous controversy though in the end it was history that judged his thesis. There was no global famine, food production increased geometrically through new technology.

Books disproving Malthus still appear regularly. If he was so wrong how come people still feel the need to dispute with him? Why hasn't he just been added to the stockpile of crackpots who don't deserve another thought? Probably because he had a few worrying truths in amongst his general thesis of universal doom.

Certainly there have been a few times and many places where famine has struck in a deep and fundamental way leaving thousands dead. The biblical picture of the apocalyptic horsemen – war, pestilence and famine – just waiting to pick us off cannot be thrown away with a little trite joke about the marvellous ingenuity of humanity. The swollen bellies of hungry children is a spectre that we have all seen in this modern TV age and when we are honest we at least can concede that things do go awfully wrong sometimes.

So how should we view this idea of population and its relation to resources and the environment in our State of Western Australia? We all want to build a sustainable future but how do we try to incorporate policies in relation to these very broad concepts?

I want to present a rather personal account of how I have tried to grapple with these ideas, how I have changed and learnt from my experiences and where I see things going at the moment.

In 1970 I was deeply affected by a televised presentation of the state of the world's environment by Professor Paul Ehrlich from Stanford University who was visiting Australia at the time. There were many others who trace the start of Australia's environmental activism to this particular visit by Ehrlich. The author of the popular book *The Population Bomb*[3] and, as mentioned, the textbook *Population, Resources, Environment,* predicted dire straits for the world if it went on growing so rapidly in population, consuming so many resources and neglecting its environment so blatantly.

Two years after this I went to do research with Ehrlich at Stanford. It was an apocalyptic period in America with the Vietnam War reaching its zenith and with many global trends apparently pointing to the truth of Ehrlich's thesis. The Sahel drought was reaching the news and there were the first signs of a massive population migration away from that whole African region which has been overgrazed and eroded into a wasteland for too long. Then during my year at Standford the oil crisis occurred. The OPEC nations struck and the industrial world was faced with the spectre of the first resource that to all practical intents was running out. In the Silicon Valley suburbs around Stanford, I watched the social and economic life begin to collapse as the oil dried up.

To our group at Stanford the future looked very bleak. Major changes were necessary in consumption patterns of all precious resources, particularly liquid fuels. Food production was a genuine problem as grain reserves were being rapidly depleted for famines in numerous parts of the world and with fuel and fertilizer prices quadrupling in one year the prospects of increasing yields were limited. Added to this, we were discovering new dangers from pesticides with the spectre of a "Silent Spring", and clearing new land for agriculture meant the loss of natural areas the value of which we were just beginning to realise. The mood was very gloomy.

All our friends seemed to be caught up in this and most considered the global trends so severe they considered it would be morally wrong to have any children themselves and the two-child limit was the catchcry of "Zero Population Growth".

In 1973/1974 while at Stanford I attempted in my academic work to try to develop a formula that

enabled a quick overview of the degree to which a nation impacted on its natural environment. The formula I developed was:

Impact = Energy per capita x Population Density.

The basis was rationalised in terms of how energy (both fossil fuels and food energy) had direct and indirect impacts on the environment and was the most obvious general parameter by which to describe how human society attempted to control and therefore change its environment.

It was also designed to give some input into the debate over how many average poor Indian peasants were equivalent to an average rich American in terms of environmental impact. Therefore instead of just getting total energy use I split it into per capita energy use and population density so that the two aspects of environmental impact could be seen together: a factor relating to our consumption or affluence and a factor relating to the size of our population in the area on which we were impacting. (Table 1)

As can be seen the figures suggested that the average American consumed 52 times as much as the average Indian but the Indian population is 8.5 times as concentrated on its land, thus the environmental impact of the average American was $\frac{52}{8.5}$ or about 6 times more than the average Indian.

The numbers also showed how countries like Europe and Japan with high consumption and high population density had the biggest impact on their natural environments, with countries like Australia and Brazil coming out even lower than India due to their low population densities. The poor and low density third world countries came out the least environmentally disturbed.

Before you start to criticise my model too much (I will do that myself shortly), I should add that the model does not pretend to show what countries are the best places to live in, merely it should give some guidance as to how human society has changed its natural environment in various regions. The Netherlands, for example, where I had lived and studied the year before going to America, is an absolutely beautiful place but its environment is a long way from being natural. Everything is highly civilised and urbanized in Holland, it is one of the world's most attractive tourist locations but it has only a few large parks and no wilderness areas. On the other hand, Tanzania has superb wildlife in many large parks though its urban life and standard of living is poor by almost any parameter chosen to measure it.

Thus in late 1974 after experiencing something of the world's crises and attempting to analyse them academically I left America and returned to Australia via the UN Population Conference in Bucharest. My global perspective quite firmly held was that Malthus may have been wrong in 1798 but he must be close to the truth for our age. In short, curbing population growth and resource use is an essential component of achieving any sort of balance with our environment and avoiding global ecological disaster.

In the rest of this paper I want to suggest some of the ways I have modified or enlarged on these visions and how I believe they apply to Western Australia and a State Conservation Strategy. I will do this by drawing out the way that some of the themes in my Murdoch course "Population, Resources and Environment" have changed in the years since I first gave the course in 1976 and how I have changed in myself from my early days as a Malthusian environmentalist.

PERSPECTIVES ON A MALTHUSIAN ENVIRONMENTALIST

The 1970s and 80s have seen some dramatic changes and it is difficult to sort out how much of the following perspectives have been gained from:

(a) observing global trends;

(b) changes in my moral and philosophical views due to new and hopefully more complete understanding; or

(c) the sheer passing of time.

In my cynical moments I think the last factor is the most significant, i.e. I've just grown older and more settled. However I want to try and expand a little on the first two, and show firstly that there really do seem to have been some significant global trend changes and secondly there were limitations in the views I once held which needed some balance.

Table 1 Environmental Impact Information for 12 Selected Nations Using Data from 1969 (ref. 4)

Country	Fuel energy $10^{12}\frac{Kcals}{yr}$	Net exotic food energy $10^{12}\frac{Kcals}{yr}$	Total exotic energy (E) $10^{12}\frac{Kcals}{yr}$	Exotic energy per capita (E/P) 10^{6}Kcals/pers-yr	Population (P) (10^3)	Area (A) (Km^2)	% Useable Area[d]	Population density (P/A) persons/Km^2	Environmental Impact (I) i e $\frac{E}{P} \times \frac{P}{A}$ $(10^6 \frac{Kcals}{Km^2\text{-yr}})$
Netherlands	412.8	+ 28.1	440.9	34.3	12,873	40,844	99	318	10,898
U.K.	1,968	+105	2,073	37.3	55,534	244,013	95	240	8,959
Japan	1,991	+152	2,143	21.0	102,321	369,881	80	346	7,249
U.S.A.	15,063	- 169	14,894	73.3	203,213	9,363,353	90	24	1,759
U.S.S.R.	6,950	- 62.4	6,888	28.6	240,567	22,402,200	70	16	450
Cuba	59.8	- 17.6	42.2	5.12	8,250	114,524	99	73	374
India	713.9	+ 37.4	751.3	1.40	536,985	3,268,090	80	205	287
Malaysia	28.0	+ 5.5	33.5	3.72	9,000	131,313	95	73	272
Australia	439.9	- 44.2	395.7	32.2	12,300	7,686,810	70	3	92
Brazil	300.9	- 40.3	260.6	2.87	90,840	8,511,965	98	11	32
Afghanistan	3.0	+ 0.5	3.5	0.21	16,516	647,497	25	104	22
Tanzania	5.1	+ 0.3	5.4	0.42	12,926	939,703	98	14	6

GLOBAL TRENDS SINCE 1974

Global trend-watchers like me have had a lot of help from people in the Worldwatch Institute who now produce annual updates on population, resource and environment topics.[5] In their perspective 1974 was a major watershed for many global trends. In that year global trends in food, energy, fertilizer and other key materials took a sudden and dramatic turn down.

There were major famines in many countries depleting global grain reserves to record levels; the quadrupling of oil prices somersaulted industrial and third world countries into recession and a new geopolitical awareness; fertilizer prices also quadrupled and threatened the potential to solve food problems by increasing yields. It was no wonder that I was feeling a little gloomy. But since then the trends have been different in these and other important global parameters.

POPULATION

The world's population growth rate began to slow down some time in the middle 70s after increasing for around three centuries. The major countries contributing to this were: China and East Asia with dramatic birth rate declines, South Asia and South America with continuing declines and Europe, where negative population growth rates had set in.

Birthrates in Africa continue to be the highest in the world. Overall, even though we are well on the way to our fifth billion, the world's population is heading towards stability and the Malthusian horse seems not to have bolted but to be reining in.

FOOD

Food supply slowly regained some security in many areas which were once considered beyond help. India in particular became self-sufficient in food and China became virtually self-sufficient. Many other parts of Asia also became much more able to feed themselves though overall, as a region, it is a net importer. Western Europe became a net exporter of food in 1984 after three decades of being the world's biggest importer. Africa became very dependent on the rest of the world for its food as did the Soviet Union despite both being virtually self-sufficient in 1970. Overall, food security was better in 1984 than 1974 though it was threatened by Africa in particular where a Malthusian spectre hangs daily in the air. However if India could revise its trend in a decade why not Africa? It is difficult to be a pure Malthusian in the light of this sort of evidence.

ENERGY AND OTHER MATERIALS

Energy became the centre of world attention when the 1973 oil crisis was repeated again in 1979 and people began to think that maybe it was a real resource constraint. Then an astonishing changeover to other energy forms, new conservation techniques and a world recession led to huge reductions in global oil consumption. By 1985 OPEC was reduced to a mere shell of its previous powerful role. The technological optimists appeared, at least in the short term, to have won. However the continuing decline in reserves through diminished discovery rates suggests the world will need to continue to conserve oil. Despite the "Limits to Growth" predictions on other materials no obvious shortages have appeared.

ENVIRONMENT

In environmental terms the patterns are much harder to generalise. In many Third World countries with rapid population growth the pressure to find more land was leading to loss of forests and soil erosion from farms on steep slopes and marginal soils. However in many countries new trends have emerged of reforestation and reclamation of damaged land. Pollution from industry and transport measured by most indices such as particulates, sulphur oxides and nitrogen oxides, began to improve in most developed countries. Japan had extraordinary success in cleaning up its industry. Controls on toxic chemicals became more common in most countries. However the more regional and global pollutants like acid rain and carbon dioxide continued to increase and seemed less amenable to solution.

At the 1983 UN Conference assessing the global environment ten years after the Stockholm Conference which started the global environmental ball rolling, most observers claimed some significant gains for the environment though many challenges remained. The big point for any Malthusians present was that no real disasters had occurred and in fact we'd muddled through fairly well.

SOCIETAL DIMENSIONS

At the same time as these trends were being played out on the global arena I was also finding that there was much for a Malthusian environmentalist to learn on the political, social, moral and philosophical dimensions. The areas I am going to highlight are obviously personal, but I don't think I am the only environmentalist who has found such matters pressing in on their consciousness over the past decade. The main areas relate to: the primacy of politics, philosophical questions about the value of human beings, attitudes to nature and attitudes to progress, and the interplay between seeking justice and seeking to improve the environment.

These concerns have grown out of my reading and in this regard the Population Resources and Environment course uses Passmore[6] and Schumacher[7] to help provide a little more of these dimensions. They have also been learned from involvement in the actual social and political process of seeking a more sustainable and environmentally sensitive society.

I present my views in a personal way because, although my journey over the past 15 years is not that unusual, they reflect the sort of changes felt by many as they have had to come to terms with being "green" and being sensitive to other human beings.

THE PRIMACY OF POLITICS

In a few decades India and China have managed to produce enough food for their millions of inhabitants – in fact nearly ⅓ of the world. Yet Africa and some Sahelian countries in particular are failing dismally. Japan's remarkable decade of industrial cleanup is contrasted with the industries of some South American countries where no controls on effluent to air or water are exercised. The common thread to these environmental successes and failures is politics.

India and China have totally different political regimes but they have shared a common political quality in the past few decades – relative political stability and a commitment to solve their problems. **Where a country can achieve a direction that is shared by the majority and worked towards at all levels then there can be resolution of the problems feared by Malthusians.**

Where a country is divided and throws its resources and energy into confrontation and fighting then there is little hope of change. Ethiopia's plight can be traced to induced climatic change and depleted soils through overgrazing but the resolution of its problems cannot occur while there is a civil war in progress. Emergency aid can prevent massive starvation but there is no real hope until the country's political future is settled.

On a less dramatic level but nevertheless important to Australia, we will only tackle our environmental problems when they become a part of consensus politics rather than being used for confrontation. Some political leaders in the early 70s sought to make environmentally concerned people into the whipping boys of politics. In such a context little progress towards resolving environmental problems is possible.

Politics is the process of achieving change. To solve the problems of population, resource depletion and environmental deterioration requires change, therefore it requires politics. A simple enough conclusion but to a Malthusian it means there is a source of hope wherever political will is turned to the resolution of these issues.

HUMAN RIGHTS AND POPULATION

> "There shouldn't be another person allowed on this planet until we have shown we can feed, house, educate and give a good life to those we've already got."

So stated a student in one of my early Population Resources and Environment classes as a conclusion to a discussion on population. I remember it well because our first child had not long been born – an immoral act in the perspective of the student above. It is remarkable what having children does for one's own perspective on the population question!

Views about population inevitably involve views about the worth and value of people as my student and my daughters soon taught me. To summarise the literature on the nature of man (or humanity as I soon learned to call it in the UN decade of women) is a little beyond this paper but it does seem that there are two extreme views which are reflected in the population debate.

One is represented by someone like Ian McHarg who wrote a booklet in 1971 called *Man: Planetary Disease.*[8] In it he states:

"Man is an epidemic, multiplying at a super exponential rate, destroying the environment upon which he depends and threatening his own extinction."

In this perspective a human being is purely someone who eats, produces wastes and takes up space or as Passmore calls this view, "people are pollution". Human beings are thus seen purely as biological entities. There is great danger in this view from a moral and philosophical standpoint.

It can easily be used to justify an acceptance of major disasters like wars and famine as natural acts which balance up the population. Even worse it can be used to foster all kinds of genocide in the name of population control not unlike the "master race" theorists who tried to justify improvement to the genetic stock. It can be used to deny human rights ('life is cheap in a Third World country') and it can be used to justify not providing aid for starving people in the Third World.

I would certainly not support any view of population which did not at the same time assert that everyone born is a unique person. Humanity is personal and each person demands respect.

On the other hand there are those who suggest that the more people the better, that there are no implications in populations growing forever that human potential is so vast there needs to be no restraint on human activity. Colin Clark predicted in the 1940s that India would be the greatest nation in the world due to its population. Others say that the more people the more potential for geniuses to be born to solve the problems created by having so many people.

It is not difficult to answer this in purely practical terms. If the early 70s growth rates continued for a few hundred years there would be standing room only on the earth. For many of the earth's trouble spots such as the Sahel there are real population limits which have clearly been exceeded. For every area an increase in population does have some implication for the environment. Thus it is necessary to try and steer between these extremes – we need to stress justice and human dignity for every person born on this earth and we need to be able to exercise restraint and not be infatuated with population growth.

Passmore resolved this by expanding on the concept of man as the responsible steward of creation.[9] We must seek to manage the resources of the earth not leave it to blind optimistic luck. **Humanity is personal but it is also responsible.**

In practical terms there are many implications in this view where the personal and responsible are brought together, but there are at least three that I would stress as far as population is concerned and which have grown in my consciousness over the past decade.

First, population policy should mean the availability of family planning for every family. Excess population may be a debatable concept but there seems to be little if any justification for having unwanted children. In developed countries throughout the world the major difference in population growth rates relates to the availability of family planning. In most developed countries, where it is available to all levels of society, then the two-child family, which means populations begin to stabilize, is the norm. In developing countries the role of family planning is more controversial as it can be a highly Western invasion of a culture. Nevertheless where a Third World country seriously adopts family planning programmes there is a significant drop in birth rates.

Second, economic development in the third world is essential. At first this may seem a strange statement in relation to population policy; however, it is now an accepted theorem that there is a close link between population and development. Desired family sizes in agricultural societies, based around manual labour, are large (8 to 10 children frequently). This is because wealth depends on the children's ability to work the land, and security, particularly in sickness and old age, depends on a large extended family. As economic development draws children into education (thus making them consumers of wealth from the family rather than producers) and as programmes to provide health care and old age security are developed, the desire for large families diminishes.

This point is an important one if we in the developed world are to have responsible attitudes towards population control in the Third World. It means that we must support economic development if we want to see the global population stabilize.

Wherever a disaster occurs in a Third World country such as a war or a famine or pestilence, leading to large loss in life, the population is rapidly made up again afterwards – families soon replace lost children. Thus aside from the human implications, it is never an answer to try and suggest that disasters in the Third World should be allowed or even encouraged to try and facilitate a more stable population. There is only one responsible way towards stabilizing a population in a poor country and that is to remove poverty.

Evidence is now available that a rapid decline in birth rates can occur in countries where development has extended to grass roots village life and particularly if there is an assured food supply. Australian foreign aid, both government and non-government, should be seen at least in part as our contribution towards a globally more sustainable population.

Third, as western nations like Australia stabilize or decline in population from natural increase, we should be more open to accepting population from troubled parts of the world and ensuring that our resources are available where needed.

There are always places where refugees are on the move, whether from war or famine. Australia has been built by migrants and any global perspective must indicate a certain responsibility to take our share of those who through no fault of their own must leave their homeland. A view of Australia or Western Australia which sees us preserving our environment by not allowing population growth through migration is difficult to justify morally. There is little doubt that Australia's growing multiculturalism has enriched the population base.

The same argument can be applied to WA as an important global resource supplier. Morally we have an obligation to supply the world as efficiently as possible with resources such as food and minerals when we are so richly endowed and so much of the world has comparatively little. It is not an argument that has much validity when people say our environment should be preserved rather than exploiting our resources for export. We cannot be an island insulated from global needs. This concept of maintaining the joint aims of social justice and sustainability will be developed further later.

These more personal insights were a little longer coming to me in the apocalyptic surroundings of California in the early 70s. A quiet city like Perth with a chance to read a little more widely, a home in cosmopolitan Fremantle and the presence of my own children were more salutory teachers. At the same time the population issue became less and less urgent as the data from the 70s showed rapid declines in birth rates occurring throughout the world.

The other element that came home very rapidly concerning population was that in terms of the environment the level of population is largely irrelevant in this State. Western Australia with its sparse 1.4 million population and huge area the size of Western Europe should be a land that has few environmental impacts to cause fundamental problems. My environmental impact index would have predicted that this part of the world was the least disturbed anywhere. Western Australia should be a Malthusian's dream.

But it is not without major environmental problems. The huge tracts of pastoral land have very few people but overstocking and feral animals can and have led to major soil erosion and loss of native species. The wheatbelt has only a few tracts of bushland among its endless wheat fields and growing saltpans. The forests are threatened by a few people who with off-road vehicles may spread a tiny exotic fungus that devastates the major tree and under-storey species. The delicate coastal fringe is similarly placed under threat, not by the hordes of tourists in resort centres but by the owners of four-wheel drives and dune buggies that tear up the fragile dune vegetation.

This does not mean that we should allow an endless build up of population but it does mean that solving WA's environmental problems is largely a question of managing the environment directly rather than blaming the number of people. Such an awareness makes it difficult to be a strict Malthusian. It also suggests that we need to look at some other attitudes and values associated with the environmentalism of the 70's.

NATURE AND ENVIRONMENTAL MANAGEMENT

The second area of values which needed some perspective concerns our view of nature. In the early 70s when environmental problems seemed so out of hand there was a rash of analyses which suggested that our western models of thought were deeply at fault. Lyn White[10] went as far as to suggest that we should throw aside our Western Judaeo-Christian dualistic view that sees man as a despot who can and should dominate and subdue nature; he suggested we should move to a more Buddhist view where man is merely a part of the cycles of nature or even to an Animist view where nature is seen as sacred and untouchable.

There is much now written on this and the Deep Ecology movement has many followers who are motivated to seeking answers at this level.

Certainly the Lyn White hypothesis has had very widespread acceptance in the environmental

movement as most Readings in the 1970s on environmental questions contained his paper. My own search particularly after a few years of study back in Australia suggested that the Judaeo-Christian view as outlined by White and others did little justice to the richness of the biblical account where man is given responsibility to "till and care" for nature, where environmental mismanagement is judged by the prophets with as much ferocity as any other moral error[11] and where sensitivity to nature is a key moral virtue.

I also found much to be wary about in the alternatives being suggested. Eastern religion did not prevent Japan from creating an industrial society with more environmental disasters like Minimata than any other country. The fact that it has now largely cleaned up its industry appears to be due to its extremely active environmental groups and its ability to adopt new technology which seems based more on an American model than a Buddhist one. As well a view of nature which regards it as sacred would mean the end of science as it requires experimentation on nature to substantiate objective truths. This would mean that scientific ecology itself would not be an acceptable activity.

Thus I found myself moving more towards a view which suggested **nature was sensitive but not sacred.** There are a lot of implications in this view but I would tend to draw them together into one key phrase: **The environmental cause is primarily furthered only when an environmental management programme is in place.** This needs further explanation.

If it is believed that nature has superior mystical qualities then a person's primary role must be to withdraw from and preserve nature wherever possible. The major goal of environmental action is therefore to exclude land from human use. To quarantine land and keep people out of it is indeed seen by many people in the environmental movement as their primary function. I tend to only see it at the very most as a preliminary step and that the really important step is when an environmental management programme is in place.

This management programme begins by understanding the processes which shape that land – the soil, the climate, the geology, the geomorphology, the ecology. When that is known the constraints and opportunities can be developed into a management plan. The fragile, the unusual, the scenic can be set aside for conservation but a clear plan for management is still required even if only to specify practices for access, fire and feral animals. If land is just "set aside" then irresponsible access, irresponsible fires and uncontrolled feral animals can easily degrade a piece of land. But what is worse the 'set aside' mentality suggests that other land, which **is** used by us for productive purposes like agriculture and cities, somehow need not be subject to close environmental scrutiny and management. All land is sensitive and needs to be understood and then managed. The "set aside" mentality can lead to a management vacuum which fosters exploitation.

To wave a green flag in the cause of saving some piece of land is certainly necessary at times but it merely scratches the surface on environmental matters. It may have helped in the early 70s as the environmental movement sought to assert itself, but it does little to help now where environmental awareness at this level can be virtually assumed. What we need now is to build a more sustainable society which requires us to make sensible decisions on how we use **all** our land.

One of the encouraging things about training environmental scientists at Murdoch over the past ten or so years has been to see them get jobs all through society and to see their expertise being used in many areas of professional life. It is out of these processes that a sustainable society will be forged.

I think that when I first came back to Australia in 1974 as a firebrand Malthusian environmentalist I was much happier to just wave a green flag. It could be that I'm just more middle-aged now, but I tend to prefer to see things done, to see management programmes instituted. I think it's also because I have thought a lot more about my view of nature.

PROGRESS AND ECONOMIC DEVELOPMENT

Another moral and philosophical dimension to a Malthusian view of the world which was important to clarify is the attitude to progress. In the early 70s progress was a dirty word. It became synonymous with growth of cities beyond acceptable size involving further traffic congestion, loss of bush areas, loss of privacy, growth in crime, and increased pollution, particularly industrial pollution. Most negative factors in society were blamed on economic growth which was seen as being driven by consumerism that inevitably requires more resources and produces more waste. Gross National Product was renamed Gross National Pollution by the more cynical, and progress was seen at best as a myth and probably a destructive element in the future of the world. Certainly sustainability was not seen as a concept that sat easily with progress.

In many ways progress, as a concept, did go off the rails. A North American city had as its logo belching chimneys, intended to symbolise jobs and greater wealth. The symbolism was unfortunate in terms of pollution control, which was a lesson to be learnt by industry in a painful process of confrontation with environmentalists and government.

This process is still continuing though it is now much more an accepted norm that industry must be clean and safe and responsible. There are examples where industry fails such as Bhopal but the success stories of massive cleanups in America, Japan, Europe and Australia are easily demonstrated by pollution indices. The spectrum has shifted more to international pollutants like acid rain, which are more difficult to address but within each country there is demonstrable progress in cleaning up industry.

The philosophical dimension to progress is more difficult to assess. Certainly it didn't take long for economists to show that economic growth also includes new universities, new housing, new pollution control devices, new National Park ranger services, new bicycles and other new technology that is seen by the anti-progress group as being fully acceptable. In **other** words **economic growth in itself cannot be accused of being an anti-environment force – it is how it is used and directed that counts.***

Schumacher makes a plea in his famous essay on progress in "Small is Beautiful" to have the words progress and development given back their qualitative human dimension rather than just being seen as dependent on the sheer level of production in the economy. Quality not quantity is a theme taken up by Ernesto Sirolli elsewhere in these papers.

I now find myself firmly committed to progress and development. Not that this means anything that causes economic growth is good, but it does mean that most of the changes I want to see in society, including environmental improvement and management projects, require progress. This is not just on the obvious level that government acquisition of land for parks or government environmental management programmes require money that can only be raised by taxing economic growth, but also because economic decline has many severe implications for the environment as well. To expand on this I need to outline a significant experience in my life.

In April 1984 I went to Liverpool in England on a two week British Council course called "Urban Regeneration". There I was able to study at first hand a city in decline and to examine the options facing old cities as they try to prevent similar urban decay.

Liverpool was once one of the great cities of the world – its grand Victorian buildings bear witness to an age of confidence and wealth. Today it is one of the most rapidly declining cities in modern history: its population has dropped from a peak in the late 60s to what it was in the 1920s, it is losing 1000 jobs a week and those who are left are generally the old and the unemployed. Economic decline in Liverpool is not a pretty sight. Whole areas of grand old housing lie derelict, many of them burnt in the riots of 1981 and 1985. The environment of the City is no longer blighted by smoking industries but it is little compensation for the sight of so many derelict abandoned industries. The City's sewage still pours untreated into the Mersey River and, as it would cost £3700 million to solve this environmental problem it is, of course, out of the question in such an economic climate.

A very important stage in my personal growth has been to recognise that:

> **the environmental problems from economic growth can be considerable but the environmental problems from economic decline are far worse because they are accompanied by so much human misery and hopelessness.**

I have attempted to analyse[12] the causes of Liverpool's decline on economic, political, social and moral dimensions. Out of all the policies and techniques of urban regeneration examined at our seminar none of the experts and participants would have even contemplated the concept of challenging the need for economic growth in Liverpool. Progress and development are so obviously needed in Liverpool. The lack of growth is in fact reaching such a point that the best strategy may be to abandon the City – the first City to go through such a cycle since the latter days of the Roman empire. One thing is certain, Liverpool is not sustainable in its present direction.

I had to face the same dilemma as a member of the Fremantle City Council in the late 70s. All the statistics showed an area going through an economic decline phase as its port-based industries and warehouses became redundant, people shifted to outer suburbs and modern shopping centres followed

* The Labor Party in Australia during the Whitlam years started a debate within their policy groups on whether economic growth was a necessary factor in society; after several years the conclusion was that most economic growth was necessary if the problems in society were to be solved but that it must be directed.

them. We welcomed developers but we had a strong sense of Fremantle's unique environment so it was never a sense of development at any cost. The guidelines were clearly set to emphasise the historic and urban qualities of Fremantle's environment. The result has been the revival of Fremantle with a renewed economic base but a strong environmental ethos. In fact Fremantle's environment has become its key economic resource. The America's Cup event is building on those years where progress was defined and embraced willingly and confidently.

SOCIAL JUSTICE AND ENVIRONMENTALISM

Timothy O'Riordan[13] suggests there are two kinds of environmentalism: one that seeks to optimise the environment for a particular group or individual and one that seeks environmental reform as a part of wider social justice. I believe this distinction is one that has to be very seriously addressed by anyone involved in environmental change. For me it brings together most of my other points in this paper and represents probably the most all embracing perspective I have gained on Malthusian environmentalism.

Paul Ehrlich came back to Australia in 1985 to Murdoch to give the Roby Lecture on "Extinction: the implictions in the loss of our biological heritage". The same global picture was quickly drawn stressing the Third World places where the Malthusian spectre is strongest together with some hopeful signs elsewhere. In question time someone asked what an individual should do personally to contribute to the necessary global changes. A part of the response was that at every possible opportunity you should try to stop the environment being changed. Every little win helps the overall environmental cause. I would want to qualify this as it is possible that waving some environmental flags will do little for the sustainable society and only provide a further entrenchment of an elite. This requires some expansion.

Change is needed if the world is going to be more sustainable. Almost all of the changes I have mentioned so far as being essential for sustainability could also have been rationalised in terms of social justice or human rights.

Population – Population growth will stabilize when (a) economic growth occurs at a grass roots level providing future security for everyone, and (b) when individuals are given the choice of their family size through effective family planning programmes. These seem to me to be basic rights as well as essential elements of sustainability.

Food – An adequate food supply is a basic human right. There is no option of starving down a population to a more sustainable level either in human rights terms or in the physical reality of what occurs after famines. The only possibility is to increase global food supply as a part of the overall process of stabilizing population growth. This must mean land is cleared for agriculture and intensively cultivated using the most appropriate means. Although this must involve large-scale environmental change it is not a soft option but an essential component of sustainability.

Energy and Materials – Most of the environmental impact from resource use is due to its end products in the form of air and water pollutants and solid waste. Sustainability therefore is to try and minimise resource use. This tends to be the thrust of economic good sense as well, particularly with a resource like oil. Lifestyle and urban planning changes like those discussed by Jeff Kenworthy in these papers play an essential role but so too does technology. The importance of technological change which allows better energy use is that sustainability and social justice are both assisted. A declining resource like oil can become so high in price that it makes access and warmth only available to the wealthy. Technological changes that enable more sustainable usage and yet widespread availability would appear to be better all around.

Natural Resources – Sustainable usage of natural resources like water and forests makes good ecological sense and is good social justice when planning for future generations. In general when a society is misusing its natural resources it is not exercising social justice either. The early rape of the forests in NSW where all the best red cedar was cut out in a few decades corresponded to the same period when Aborigines were herded around like cattle and treated as sub-human.

Parks and Reserves – The preservation of landscape and the conservation of flora and fauna can be justified in social justice terms due to the need for future generations to have access to the full range of biological genetic diversity. It is also an important recreational component for all members of society.

These concepts add up to the following conclusions:

Sustainability and social justice are closely linked. Environmentalism which seeks these broader goals seems to have a completely acceptable framework and vision for the future. It is not however what a lot of environmental issues in a modern wealthy society like ours are always about. Instead these issues frequently are limited in scope and tend often to be elitist.

For example they can concern a small piece of the environment that a group or individual want for themselves. Maybe it is some bushland adjacent to houses that a few people enjoy but which is planned to be demolished for other houses or a school. Maybe it is a small section of the river that is enjoyed privately but a cycle path is planned to go through it. Maybe it is a small piece of beach enjoyed by a few residents for which a public marina is planned. Maybe some residents don't want a new train station placed near their houses. The list can be easily extended by a quick read of the newspaper. Invariably such issues are championed by an articulate spokesperson, usually with a professional background who wants the development "anywhere else but not here".

There is no doubt that everyone has the right to object to development which impacts on them but decisions on where to develop should not lapse whenever protest is made. Otherwise little change would occur, and I hope I have argued sufficiently that that is not an option. Also the decision should not be based on who makes the loudest noise as that generally means the articulate and wealthy get their way and the poor are lumped with the problems. **Decisions should be based on what provides the most sustainable and the most just solution.**

There is a real task ahead to find greater clarity about how sustainability and social justice can be further integrated. In my experience too much time and effort is being expended by environmental activists in narrow, somewhat elitist causes, and too little attention is thus directed by all levels in society to the more important issues of sustainability. We need community groups and government agencies that are constantly reviewing policies to see how they contribute to social justice while achieving a stable global population. We need a more just provision of basic needs like food, more optimal use of resources (particularly energy), and an environment that is not overstressed and has clear and well grounded management programmes.

PICKING UP THE PIECES

When you begin to temper an environmental vision of the world by considerations such as human rights, the need for management and economic development and the overriding concern for social justice, it is possible to wonder whether there is anything much environmental left. Despite the broader view it is certainly still my strongly held belief that our environment is of fundamental importance to society. Along with many of my contemporaries who have a positive approach to development, I am still a greenie.

There are two areas in particular in which environmental perspective needs to be continually, forcefully and creatively applied. These are in the area of public administration and in the area of lifestyle.

PUBLIC ADMINISTRATION

Despite the obvious necessity for a strong private sector in the economy the environment is an area that most can see should not be privatised. Every private business from small to large must involve themselves in the necessary move towards a more sustainable social system, but it is the public administrators who must provide the goals, the guidelines and the incentives.

Western Australia's environmental legislation and the administrative framework that has developed in its wake are like all public administration machinery – in need of review and overhaul. It is not the purpose of this paper to enter into debate on how that should occur but merely to stress the importance of the environmental machinery. There has been much achieved in the past decade or so since the first Environmental Protection legislation. But the vision of a more sustainable society requires a continual grappling with the economic, social and political process. Sometimes environmentalists are accused by politicians of never being satisfied, of always wanting more. Having been on the other end of the decision-making process I can see why the constant demands can become rather wearing. However, like justice, the vision of sustainability is not easily solved.

Public administration needs to take environmental concerns seriously, to build them into societal processes so that a more sustainable future can be forged.

May I suggest without a great degree of elaboration that there could perhaps be a shift in emphasis in

public administration as it concerns sustainability. The past decade has seen a strong and necessary emphasis on:

- environmental procedures as part of the development process;
- setting aside land for parks and reserves;
- pollution control.

Now I believe we should begin to try and provide more creative emphasis on:

- managing the land, particularly rangeland and forests, in a more sustainable way;
- providing new methods, goals and machinery to utilise our two most important resources – energy and water – more efficiently.

Managing the land in a more sustainable way will require some hard and creative work. The new Department of Conservation and Land Management is clearly a step in the right direction. When a Forestry Department is absorbed in a broader conservation context, both in reality as well as in name, there can be a clear win for sustainability.

New enterprises that begin to utilize the native plants and animals of our land will also play an important part in developing a more sustainable land. There have been some important new developments along these lines in recent years including the Emu Farm at Wiluna and the growth of native plant farms in the South East of the State. An important first step in this process will be an awareness by farmers that their land has value both biologically and economically when it is 'developed' using native plants and animals. My experience has been that farmers can make this transition and will welcome it, as outlined by Ernesto Sirolli in his Review Paper.

The other areas of energy conservation and water conservation are controversial. There will always be engineers and economists who say that there are no real shortages of resources, money is all that is needed and both will continue in any conceivable quantities.

However even in an era of huge gas surpluses an important argument can be made for conservation. For many it is a social justice question as they cannot afford their power, fuel and water, so finding creative ways to use less is of direct assistance to them. But in terms of public expenditure the infrastructure costs for energy and water are enormous and to find ways of society achieving their economic goals by using less resources is in my definition real progress.

The water shortages of the 70s saw some creative enterprise by public administration to lower water usage on a per capita basis. The 20 to 30% drop has been a major achievement towards sustainability as new incentives and guidelines for the public were introduced. As we become less aware of the State's water shortages due to the availability of ground-water usage in difficult summer months, there will be a tendency to neglect conservation. The result could be a temptation to squeeze the environment harder either by over-use of ground-water or the building of further dams. **Setting goals for reduced water usage should be a key part of our strategy for a more sustainable state.**

LIFESTYLE

There is a limit to how much public administration can set goals and directions for society. They need to be as much as possible building on a process that is coming from within society. Thus goals for sustainability need also to be part of our own lifestyle.

It is very easy to say this and much harder to really come to grips with lifestyle changes. In my Population Resources and Environment course at Murdoch I usually get students to analyse their resource consumption patterns. How much energy they use in transport and in the home; how much water their household consumes; how much garbage they produce, throw out or recycle; how much they use household and garden toxic chemicals etc. It is usually quite a shock, especially for those who consider themselves to be environmentally sensitive and who are working towards a more sustainable society. Invariably there is not a great deal of difference between them and those who are blissfully unaware of their environmental responsibilities.

Lifestyle is an area that everyone who is seeking a more sustainable society needs to work at and review continuously.

Energy conservation and its lifestyle implications is addressed in much detail by Jeff Kenworthy in this document. The basic idea of living in a more public transport and walking-oriented way with urban land use that facilitates this is a strong personally-held belief of mine. It also should entrain through the smaller and more compact housing less electricity use, less water use and less household garbage. Less urban and household space means less resource requirements. After 11 years of attempting to live this lifestyle with a normal two-child, two-cat family I am convinced that it is a better and more interesting way to live, though I hadn't reckoned on the little cottages of Fremantle and other inner city areas becoming quite so trendy so quickly.

There are strong movements from within society that are trying to come to grips with how we build our houses, our land use, grow our gardens, recycle our rubbish etc. so as to use fewer resources. Some are motivated purely for economic and social justice considerations and some for a more sustainable future – both are important rationales that are drawing up the agenda for West Australians over the next 20 years.

Despite my earlier statements about the environmental movement too often taking on elitist issues that contribute little to sustainability, I must also put in a strong word for the importance of the grass roots environmental lobby. Where people are seeking a lifestyle that is more sustainable there will inevitably be conflicts with those seeking short-term gains. Our society cannot afford to see this longer-term view drowned out, nor does it want to, as revealed in a wide ranging survey I supervised a few years ago.[14] In this study it was revealed that there is substantial support for those seeking to provide more emphasis on our WA environment with a view to achieving a more sustainable society.

CONCLUSION

It is not hard to gather from this personal journey over the past 15 years or so that my Malthusian fear has been substantially replaced by hope. There have been some hopeful global trends – though some people could have looked at the same events and ended up just as negative. There has been some significant expansion of the societal dimensions of my Malthusian perspective which tends to give a greater emphasis to politics and to human rights; to the management of the environment rather than just preservation; to the need for progress and economic development; and overall, to a clearer emphasis on a social justice framework in environmentalism. However others could look at these as further complications and causes for frustration rather than hope. Maybe I just personally prefer to be hopeful. What it does leave me with is that although I can still see that a Malthusian spectre is possible, I can also see that the visions of a sustainable and just society are possible as well. Such a vision requires idealism not cynicism. And my particular vision is strongly based around the need for a forceful and creative public administration as well as a strong grass roots lifestyle movement.

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TOURISM AS A SUSTAINABLE USE OF NATURAL RESOURCES

by RESEARCH AND PLANNING DIVISION
WESTERN AUSTRALIAN TOURISM COMMISSION

An Invited Review Paper as Background
for the Development of a
STATE CONSERVATION STRATEGY FOR WESTERN AUSTRALIA

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TOURISM AT PRESENT

The significance of tourism has been recognised throughout the world. This can be seen in the establishment of government tourism authorities, widespread encouragement and sponsorship of tourism developments, and the proliferation of small businesses, and multi-national corporations contributing to deriving benefits from the tourism industry. There is widespread optimism that tourism is a powerful and beneficial agent of both economic and social change. Indeed, tourism has stimulated employment and investment, modified land use, economic structures and made a positive contribution to the balance of payment situations in many countries throughout the world.

Tourism is of major economic and social significance. More than 270 million tourists spend around $92 billion (US) annually in places outside their own countries. This is one of the largest, if not the largest, of the world's foreign trade. With a world growth in visitor arrivals rate of approximately 6% per annum, tourism is also one of the fastest growing economic activities. It is the most important export industry and earner of foreign exchange in many countries.

Within Australia, International Visitor spending for 1983/84 was $1196 million. For every one million international tourist dollars received in Australia, another $731 thousand are generated. This means that international tourist expenditure is currently worth in excess of $2070 million to Australia's economy.

In 1983/84 alone there were around 500 000 international and interstate visitors to Western Australia, and they spent in excess of $268 million. For Western Australia every one million tourist dollars spent generates a further $598 thousand in the Western Australian economy and results in the creation of 27 jobs. The number of travel movements by Western Australians within the State during 1983-84 was 4 847 000 and their expenditure was in excess of $750 million.

Western Australian tourism and the revenue created from that tourism can best be described by the following table:

Comparative Data 1979/80 to 1983/84 (Financial Years)

	1979/80	1980/81	1981/82	1982/83	1983/84
Visitor Total	5.2m	5.2m	4.9m	5.5m	5.3m
Visitor Spending	$652m	$685m	$774mr**	$989mr**	$1021m
Visitor Markets					
Intrastate	4 783 000	4 788 000	4 374 000	4 987 000	4 847 000
Interstate	272 600	272 600r	313 800r	309 600r	332 300
International*	143 500	143 500r	173 800r	170 800r	167 200
Visitor Spending					
Intrastate	$457m	$472m	$521m	$728m	$753m
Interstate	$101m	$104mr	$133mr	$144mr	$166m
International*	$ 94m	$109m	$120mr**	$117mr**	$102m
(Dollar Values CPI Adjusted)					

* International data includes US Navy visitors.

** International Visitor Spending data for 1981/82 and 1982/83 excludes expenditure from the Japanese Market as this information was not available at the time of printing.

r = Revised figures due to reweighting of the Japanese sample in the International Visitors Survey to make allowance for the high proportion of group travel in this market. This procedure has had the effect of reducing the numbers of Japanese visitors to Western Australia for the years 1981/82 and 1982/83. It also affected the calculations relating to interstate visitors, and some 1980/81 calculations.

You can see by the following Table that 6.3% of the State's employment is in tourism related jobs:

Tourist Expenditure, Income and Employment by State, 1981-1982

State	Expenditure by tourists (a) ($m)	($m)	Income (b) Per head of population (c) ($)	Employment		
				Direct (persons)	Total (persons)	% of employment in State (d)
N.S.W.	3 291	2 372	448	82 300	113 800	5.0
Vic.	2 047	1 531	385	47 800	69 900	4.1
Qld.	2 270	1 544	643	57 700	76 600	7.7
S.A.	787	562	423	18 600	26 500	4.6
W.A.	1 080	728	550	26 400	35 700	6.3
Tas.	306	225	523	7 600	10 700	6.2
Total (e)	9 878	7 051	467	246 600	337 600	5.2

Notes: (a) Expenditure made by tourists while travelling, plus expenditure on equipment, motor vehicles, holiday homes, etc; less transfers, allocated according to State of expenditure.

(b) Based on value added at 1977-78 prices as required by the input-output table, but re-inflated to 1981-82 values using the implicit price index obtained for Australian tourist expenditure (see Appendix 5.1).

(c) Based on population in March 1982 – Australian Bureau of Statistics, Australian Demographic Statistics Quarterly, Cat. No. 3101.0.

(d) Based on persons employed in March 1982 – Australian Bureau of Statistics, The Labour Force in Australia, Cat. No. 6203.0.

(e) Total exceeds the sum of the States because of expenditure in the Northern Territory. However, no conclusions should be drawn about the economic significance of tourism in the Northern Territory from these figures since the difference between the sum of the State figures and the Australian total includes the effect of errors and approximations associated with the State estimates.

Source: Tourist Expenditure in Australia. Bureau of Industry Economics.[1]

Many of the activities undertaken by visitors to WA involve outdoor recreational activity. It can be seen from the following table that sustaining the natural environment in its present condition is beneficial and vital to tourism at all levels:

Activities Undertaken in Western Australia by International Visitors to Western Australia 1983/84

Activities	% of Visitors
Watersports	38.0
Bushwalking	19.5
Horse Races	8.3
Fishing	7.0
Safari	6.6
Farm Holiday	5.9
Cricket/Football	9.0
Golf	4.1

Total Visitors 130 000

Source: International Visitors Survey.[2]

Visitors to Western Australia, staying for the purpose of a holiday, result in 68.6% of visitor nights in commercial accommodation. Business results in 15.5% and 16.0% for other. Their average length of stay per group is 4-6 nights and their average expenditure per Visitor Night is $40.90. The main means of transport used (on average) when travelling within Western Australia is the private vehicle (58.7%), 23.9% air, 4.9% coach, 2.2% rented vehicle and 10.3% other.

WESTERN AUSTRALIA

Main Attractions & Origin

Holiday/Recreation Visitors
By Origin

	% of Groups			
	Scenery	Beach Water	Relax Quiet	Sunny Weather
Western Australia	16.3	17.2	17.6	8.1
New South Wales	55.1	4.6	0.4	1.7
Victoria	42.9	4.7	3.8	5.1
Other Australia	36.9	4.3	0.6	2.4
Overseas	29.6	2.2	5.0	10.5
Total	25.4	12.5	12.1	6.7

(Numbers may not add up due to multiple choices)

The largest proportion of visitors to this State find the Scenery, Beach and Water a major attraction to coming to Western Australia.

As can be seen from the attraction statistics for Perth, 14.3% of visitors to commercial accommodation found the scenery of Perth the main attraction.

PERTH

Main Attractions & Origin

Holiday/Recreation Visitors
By Origin

	% of Groups			
	Night Life	Scenery	Passing Through	Visit Friends Relations
Western Australia	33.3	9.1	7.3	6.4
New South Wales	0.0	9.6	7.3	5.0
Victoria	0.0	31.1	16.8	8.0
Other Australia	3.5	16.2	17.7	18.0
Overseas	0.0	18.7	25.7	15.6
Total	17.0	14.3	12.8	9.7

Other Attractions & Origin

Holiday/Recreation Visitors
By Origin

	% of Groups			
	Scenery	Build. History	Nearby Activity	Good Shopping
Western Australia	6.9	5.4	17.9	20.1
New South Wales	33.7	38.3	0.0	0.0
Victoria	43.9	11.9	10.6	0.0
Other Australia	60.4	8.9	4.5	0.0
Overseas	48.3	3.2	9.8	0.0
Total	31.5	11.1	10.9	7.8

Source: Western Australian Regional Tourism Monitor, July 1984 – June 1985.[3]

31.5% of visitors to commercial accommodation found scenery another attraction to Perth whereas 11.1% found the Buildings and History another attraction. The natural environment can be seen to be of vital importance to visitors coming to Perth.

The number of visitors to natural attractions such as Wildlife Parks and National Parks in Western Australia has increased since 1983 by 4%. The following table is an aggregate summary of attractions:

Attraction Statistics 1982 – 1984

	1982	1983	% Change	1984	% Change
Man-made (including theme parks, Perth Zoo)	–	758 612	–	–	–
Natural	844 685	516 585	-10	725 165	- 4
Historical	602 981	324 639	-14	538 151	+ 4
	328 126	–	- 1	363 097	+12

Source: Western Australian Tourism Commission.

The number of visitors to attractions has generally decreased, with the exception of Historical attractions.

TOURISM AND CONSERVATION

Many government bodies and authorities include environmental and conservation principles within their Acts. This ensures that the State Government is involved with environmental issues and is aware of the need to ensure a protection policy for the State. The Environmental Protection Act (1971-1980) under section 30, includes in its Powers of Authority these points specifically concerning the conservation and protection of the natural environment, to:

(a) consider and make proposals as to the policy to be followed in the State with regard to environmental matters;

(b) co-ordinate all activities, whether governmental or otherwise, as are necessary to protect, restore or improve the environment in the State;

(c) establish and develop criteria for the assessment of the extent of environmental change or pollution;

(d) promote, encourage, co-ordinate and carry out short-term and long-term planning and projects in environmental management.

The Wildlife Conservation Act (1950-1979) under section 11 outlines in its functions the following:

(a) The Authority shall inquire into and report to the Minister on any matters referred to it by him or by the Conservator of Wildlife in relation to the conservation of fauna or flora in the State, and may advise the Minister and make such recommendations to him in relation thereto as it thinks fit.

(b) Without prejudice to the generality of the provisions of the last preceding sub-section the Authority shall inquire into and report to the Minister on the effect or likely effect on the conservation of the fauna and of the flora of this State, of the importation into the State of the flora or fauna of any place outside the State when required by him or by the Conservator of Wildlife, and may advise the Minister and make such recommendations to him in relation thereto as it thinks fit.

Another Government body showing its concern for the natural environment is the Department of Conservation and Land Management, in its 1984 Act (section 33) showing the Department:

(a) to be responsible for the conservation and protection of flora and fauna throughout the State, and in particular to be the instrument by which the administration of the Wildlife Conservation Act 1950 is carried out by the Executive Director pursuant to Section 7 of the Act;

(b) to be responsible for such study or research as the Minister may approve, into the management of land to which this Act applies; and into the conservation and protection of flora and fauna.

State protection of the environment is complemented by local concern for specific environments. Tourist attractions, whether man-made or natural, especially in recent years, have been vigorously

protected by local communities in an attempt to reduce excessive wear, degradation or vandalism. Communities at large are now more than ever themselves well aware of the value of the tourist dollar, and that the protection of their natural resources is economically and socially beneficial to them.

TOWARDS A TOURISM CONSERVATION STRATEGY

Tourism is of considerable significance to the Australian economy and has direct or indirect effects upon almost every Australian industry. Therefore it must be vitally concerned with the products and infrastructure it is selling and the resources on which they are dependent.

Tourism is heavily dependent on the natural environment and on historical/cultural heritage, but, unfortunately, the resources in question – the attractive qualities of our natural or cultural heritage – risk degradation by those who use them. It is necessary to undertake careful planning and management to optimize usage, minimise damage and ensure the long-term stability of the natural assets on which the industry depends.

The intentions of the Western Australian Tourism Commission, given that tourist activities in natural areas are dependent on the conservation of living resources, is to minimise the impact of these activities on sensitive environments, essential ecological processes and life support systems.

It should be recognised that income can be derived from tourism and recreation, and this income in turn can be used to maintain and manage tourism in sensitive environments.

Whilst the Western Australian Tourism Commission's Act does not specifically identify aims regarding conservation and the protection of the environment, it does underline the need for professional planning, research and management in its objectives, which are:

- **to increase** the number of travellers to Western Australia, the period during which travellers or tourists stay at destinations in Western Australia, and the use of tourist facilities in Western Australia;
- **to improve** and develop tourist facilities in Western Australia;
- **to support** and co-ordinate the provision of tourist facilities in Western Australia.

Taking into consideration these aims as included in the Act, and the conservation requirements of the natural environment, the Western Australian Tourism Commission's preliminary Tourism Conservation Strategy includes these aims:

- Conservation and management of the natural resources throughout the State, ensuring the protection of the unique and irreplaceable features of the Western Australian environment.
- To encourage tourism development which does not damage the environmental features of Western Australia, but which is in fact in harmony with, and preserves and enhances the State's environment.

The Western Australian Tourism Commission's tourism development plans, currently in progress, will address the issues of effective land use and the conservation of natural resources for each region in WA. The development of the plans will determine the optimum usage of tourism resources in accordance with the aims mentioned previously. The information obtained from each regional plan will allow the Western Australian Tourism Commission to analyse the needs of each individual tourist area and determine a regional, sustainable approach to conservation requirements for the short- and long-term.

OBJECTIVES OF THE TOURISM DEVELOPMENT PLANS

Each Tourism Development Plan must primarily address the specific objectives. They are listed below in order of priority:

(a) Determine the existing tourism situation in the region by assessing the capacity and usage of accommodation, transport/tours, attractions, retail and hospitality services and identify day-tripper, visitor and local resident flows through the tourist centres in the region.

The capacity of many major tourist attractions is being controlled by management plans that protect, preserve or enhance the historical, cultural and environmental characteristics of the particular attraction or region. Such plans are currently being developed for Wave Rock near Hyden and other pilot studies are envisaged for Bungle Bungle, the Hamersley Ranges and Ningaloo Reef. When completed these studies can be adopted by other agencies to establish limits to ensure these valuable natural landscapes and ecosystems are exposed to the minimum effects resulting from tourist pressure.

(b) Identify potential and future demand for tourism resources in the region in terms of facilities, services, capacity and employment.

(c) Identify and evaluate potential, site specific, tourism projects that emerge during the course of this study in both the public and private sectors with a view to taking key projects to pre-feasibility stage. Such findings should be placed in order of priority and scheduled.

(d) Determine the opportunities and constraints of regulatory authorities that may affect the implementation of recommended tourism plans.

(e) Identify constraints associated with the development of the tourism industry and suggest means of overcoming them.

(f) Evaluate the supply and demand of visitor information servicing outlets receiving Government funding.

(g) Identify and clearly define the target markets for the region including their matching with potential tourism resources.

(h) Undertake a community impact assessment to ascertain the positive and negative effects of tourism on the local communities.

(i) Examine the potential involvement of the Aboriginal culture/community in tourism.

(j) Identify means of financing recommended tourism development projects.

(k) Identify a set of criteria which could be used to monitor the performance and implementation of the Tourism Development Plan.

The consultants involved in the design of the tourism development plans are required to meet all these objectives whilst ensuring all conservation requirements of the Western Australian Tourism Commission are met.

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ENERGY CONSERVATION AND ALTERNATIVE ENERGY SOURCES

by R.J. DUNSTAN, T.S. CRAWFORD and
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An Invited Review Paper as Background
for the Development of a
STATE CONSERVATION STRATEGY FOR WESTERN AUSTRALIA

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INTRODUCTION

WORLD ENERGY SCENE

The oil crisis of the early and mid-1970s led to major, although relatively short-lived, interest throughout the world in the implementation of energy conservation programs and development of alternative energy technologies.

The energy conservation and rationalisation programs put in place in the late 1970s and early 1980s led to reduced demand for oil from the developed countries and a subsequent glut on the world oil supply market. However, it is generally agreed that oil supply and demand will come into balance in the early 1990s and that oil prices will resume their upward trend relative to other costs from the mid-1990s unless extensive conservation steps are taken.[1] Furthermore, the need for more effective use of the world's finite and environmentally deleterious fossil fuels remains important in ensuring security of energy supply and minimising pollution problems in the long term.

Although expenditures to date on energy conservation programs and alternative energies have been modest in comparison with outlays on research into nuclear and fossil fuel power generation, significant progress has been made in several areas:

- Governments, industry, commerce and the general public now have heightened awareness of the impact on the individual economy that manipulation of fuel supplies can have on communities and recognise the need for development of alternatives.
- The recycling of energy rather than running it to waste is an integral consideration in present day engineering design practices.
- Effective use of insulation to minimise undesirable heat loss or heat gain is now commonplace.
- A large body of research information now exists to facilitate improved harnessing of solar energy in buildings for lighting, and room and water heating.
- Major improvements in the energy efficiency of motor vehicles have been introduced.
- More energy efficient strategies for operating diesel engines and mechanical systems in general have been developed.
- Photovoltaic cell development has taken major strides so that they are now a very reliable power source for numerous applications.
- Knowledge of the behaviour of different fuels in engines has been substantially increased.
- Prospects for the development of specialised equipment to cater for small-scale power supply requirements have opened up new markets for large and small industry.

ENERGY ISSUES IN WESTERN AUSTRALIA

Western Australia occupies more than 2.5 million square kilometres. Approximately 80% of the population of 1.4 million is located in the south west of the State where it is serviced by the State Energy Commission of Western Australia's interconnected electricity grid and reticulation of North West Shelf natural gas. A further 15% live in large towns serviced by the State Energy Commission's non-interconnected grids. These are powered from heavy oil, gas or distillate. However, an estimated 60 000 people live on remote farms and communities which are almost solely reliant on distillate powering small diesel generators for their energy requirements.

The costs of energy supplies differ considerably. This is highlighted by a review of energy prices as at October 1985:

- Domestic consumers on the State Energy Commission's electricity grids pay approximately 9 cents per kilowatt hour, irrespective of where located in the State. The actual cost of fuel expended in generating this energy however, varies from around 2 cents per kilowatt hour from the coal-based power plants located in the south west of the State to more than 14 cents per kilowatt hour in the north and south east of the State where distillate fuels the electricity generators. Farmers and

small communities too remote to connect to the State Energy Commission's electricity grids are almost solely reliant on diesel generators which use distillate for their electricity requirements. The cost of electricity generated from distillate delivered to the consumer's premises ranges from 20 cents per kilowatt hour from large, well managed plant to more than 40 cents for the smaller plant serving individual isolated farms.

- Natural gas, although substantially cheaper per unit than electricity for both the State Energy Commission to supply and the consumer to purchase (ranging from 4.8 cents per kilowatt hour down to 1.89 cents per kilowatt hour depending on the particular tariff and the number of units consumed), is available only in major centres located in relatively close proximity to the Dampier to Wagerup Natural Gas Pipeline. Liquified petroleum gas is available throughout the State at between 3.4 cents per kilowatt hour and 6.2 cents per kilowatt hour.

- Distillate fuel costs range from 52.4 cents per litre in areas close to major ports to 57.6 cents per litre in areas remote from distribution centres. However, fuel used in agriculture, fishing and mining attracts a rebate of the Federal Excise Duty of 7.4 cents/litre.

Although Western Australia is relatively well endowed with reserves of fossil fuels, having adequate coal reserves in the south west for the foreseen power requirements into the next century and a current surplus of natural gas from the north west of the State where large unexploited additional reserves have also been found:

- Western Australia is not self-sufficient in the liquid fuels that are essential for powering transport vehicles and for stationary engines. Oil represents about 65% of the total energy demand.[2]

- Combustion of fossil fuel brings with it potential pollution problems.

- The installation of costly new electricity generating plant can be delayed by curtailing the demand for electricity and by shifting part of the electricity demand from periods of peak electricity demand to off-peak periods.

- The supply of electricity to remote area dwellers represents a significant cost to the State. In 1983/84 the State Energy Commission of Western Australia incurred a loss of $61.9 million on supply of power to areas not serviced from the coal fired interconnected-grid.[3]

- Consumption of distillate by individual diesel systems represents a high cost to the many remote farms and communities throughout the State.

- New techniques associated with energy conservation and renewable energy systems open opportunities for technology development by local industry.

The future development of Western Australian industry and commerce and growth in the population will result in increased energy requirements. This can be met by either more intensive (efficient) use of primary energy resources **or** by proportionally increased consumption of the resources. However, the most socially desirable and economically attractive approach requires a balanced combination of these options.

Hence, the Western Australian Government has supported and encouraged renewable energy programs and now proposes to broaden this support to encompass energy research in its widest sense thereby also encouraging energy conservation and selective fuel usage. A new energy research organisation proposed by the Western Australian Government will have a wider mandate than the current Solar Energy Research Institute, enabling it to consider all aspects of energy usage.

THE CONCEPT OF AN ENERGY STRATEGY

Effective energy management calls for both energy conservation and rational energy substitution. It involves:

- efficient use of energy so that the minimum energy required to achieve a task is utilised;

- use of the most suitable primary energy source from the viewpoint of efficiency, cost and least detrimental environmental impact;

- use of renewable energy where practical and economic.

Energy conservation, energy substitution and renewable energy systems, although technically quite distinct, are complementary rather than competing technologies in ensuring the best use of our available energy resources. The most desirable mix in the long term is that which will result in the least draw on the finite fossil fuel supplies and the least deleterious impact on the environment. However, the extent to which this can be achieved will largely depend on the economic value of energy management procedures as perceived by commerce, industry and consumers.

Overseas studies suggest that, within the realms of current technology, it is possible to increase energy efficiency more than threefold over a 50 to 75 year period.[4,5]

Significant beneficial results can be achieved in the short term by addressing individual applications. However, the full potential benefits of energy conservation and substitution will only be realised if energy conservation and substitution policies are developed as part of an overall long-term energy strategy.

ENERGY CONSERVATION

GENERAL

Substantial opportunities exist for more effective and efficient use of energy throughout the State in commercial and domestic buildings, industry, transport and remote area power applications.

This is particularly so in those areas served from the State Energy Commission's or mining companies' diesel-powered plant in which the consumer does not meet the full cost of the power supply. Approaches that will expose consumers to the real cost of the power consumed without adversely affecting their standard of living need to be assessed.

BUILDINGS

In considering the prospects for more efficient energy usage in buildings, clear recognition must be made of the climatic conditions prevailing in the location of the building and the use to which the building is to be put.

To the north of the State the high ambient temperatures prevailing year round mean that cooling is the primary consideration, whereas in the south of the State, both heating and cooling must be provided.

In domestic situations the freedom to move about, to open or close windows and blinds and to locate oneself in the most comfortable area contrasts with the restrictions of movement and relocation, and individual freedom to independently manipulate ventilation and lighting in commercial buildings.

Also the relatively small plan area to the building envelope of domestic buildings makes them more susceptible to external envrionmental effects than in the case of modern commercial buildings. In modern commercial buildings the plan areas are typically larger in respect to the envelope (necessitating more extensive artificial lighting but resulting in less heat transfer between the building interior and the external environment) and considerable heat is frequently dissipated into the building from lights, computers and from the large number of occupants. These all contribute to isolate the building interior from the effects of ambient temperatures and to make cooling the prime requirement throughout a greater portion of the year.

The occupancy time of buildings is a key factor in the energy usage. To a significant degree it dictates the strategies for most efficient energy use. In the south of the State domestic buildings which would be unoccupied for a significant part of the day, but which are occupied for extensive evening and night periods, will normally utilise more energy for heating than for cooling. Facility to utilise solar energy is most appropriate in these instances. In contrast, cooling energy requirements become a more important factor in commercial buildings that are occupied primarily during daylight hours and infrequently at night.

Whilst these are fundamental issues, it was not until comparatively recent times that the implications of these factors in respect to design of energy efficient buildings has been recognised to any marked extent. The misapplication of design features to locations where they clearly do not apply and, in perhaps the majority of cases, a complete lack of concern for energy costs can be seen in the majority of buildings designed before the mid-1970s.

This reflected the worldwide approach of considering energy costs as insignificant and hence concern for energy conservation unjustified, together with a lack of design information relative to the Western Australian situation.

Since the mid-1970s increased emphasis on energy design issues in graduate courses, increased local research in the area and increased dissemination of information on the topic have made architectural designers increasingly aware of the need for building design philosophies that consider the energy demand for interior temperature control and lighting. At the same time increasing numbers of products designed to control heat transfer through building fabrics and to minimise the energy used in heating and cooling have become available. The complexities of selecting the optimal mix of these products to achieve economic and energy efficiency criteria have been eased with the development of computer simulation programs. Access to these programs and ease of use have improved considerably since 1980.

Whilst there has been a very substantial increase of interest in design of more energy efficient buildings in both the domestic and commercial sector, with initiatives such as the annual Undergraduate Architect Design Competition and the Kingsley Solar Housing Estate heightening attention to the issues, a much greater adoption of the principles needs to be encouraged. In far too many instances the principles of design of buildings to be energy efficient continue to be overlooked or the full benefits of design of buildings to be energy efficient are not taken into account by designers.

Emphasis on research, testing, dissemination of information, and education of building owners and designers to issues relevant to Western Australia will be broadened to take into account the overall situation in commercial buildings with the establishment of the new energy research organisation currently proposed by the Western Australian Government.

Specific issues relevant to domestic and commercial buildings are considered hereunder.

(a) **Domestic Buildings**

In the temperate areas in the south west of Western Australia, temperatures within dwellings can be kept comfortable at between 20°C and 28°C for the majority of days throughout a year by incorporation of relatively simple and inexpensive features such as:

orientation of the building on an east-west axis so that a substantial area of windows can be orientated in a northerly direction to provide natural heating in winter;

use of materials of high thermal mass such as concrete and brick within dwellings to act as a buffer to temperature changes;

minimising glazing in east and west walls to avoid glare throughout the year and to avoid excessive heat gain in summer;

providing 800 mm wide eaves over the northern wall and awnings directly over east and west windows to minimise heat gain in summer;

insulating the roof space to minimise internal heat being lost in winter and the entry of heat in summer;

effectively sealing around doors and windows to limit the loss of heated air from the dwelling in winter and the entry of hot outside air in summer;

installing heavy, close fitting curtains with pelmets inside all windows to insulate the windows; and

provision of openable casement or sliding windows for natural ventilation.

In the north of the State, the prime consideration should be minimising internal heat build-up in summer. Whilst most of the principles for temperature climate design still apply, it is desirable to minimise total glazing as much as possible, to place as much of that which is required for lighting on the southern face, and to insulate wall cavities.

Whilst the measures will not eliminate the need for air-conditioning in all instances, they will substantially reduce the operating costs. This is a major consideration in the north of the State where air-conditioning units are the largest single energy consumer in domestic situations.

Where air-conditioning is required, consideration should be given to the use of evaporative cooling where climatic factors, and the water supply are suitable, and to selection of higher efficiency

vapour compression units, where capital costs are similar. Irrespective of the selection of unit, the thermostat should be set no lower than 25°C in summer and no higher than 20°C in winter. Considerable savings can be made by switching the plant off completely when cooling is not required.

(b) **Commercial Buildings**

The complexity of energy use in commercial buildings necessitates a broader approach to energy conservation than for domestic dwellings. The key considerations in the design and operation of commercial buildings are:

building orientation to control direct solar energy heat gain to that required for lighting and heating;

appropriate selection of materials used in the building fabric to minimise heat transfer between the building interior and the external environment. The use of heat absorbing glass versus reflective window treatments needs to be assessed (the problem arising from glare from reflective surfaces to surroundings needs to be thoroughly assessed). Chromatic glazing in which the solar transmittance can be controlled is an exciting possible development in the near future which is likely to have a major impact on solar control;

sealing of buildings against uncontrolled air leaks. This necessitates a fabric design which can be readily sealed as well as strict construction supervision;

recovery of waste heat from computers and other electrical and electronic equipment for heating when required in the building, and of condensor heat for water heating in summer. The prospects for transfer of energy between adjacent buildings and for combined electricity and heating systems justify consideration;

utilisation of natural lighting where practical, uniform distribution of natural lighting, and switching of lights to augment natural lighting to satisfactory lighting levels;

use of high efficiency lighting. The penalty from low efficiency lighting and excessive lighting levels is twofold – it results in both unnecessarily high electrical draw for the lights and additional heat load on the building cooling equipment;

provision for full ventilation of buildings so that outside air can be used in lieu of recycling indoor air when it is closer to the required supply air temperature than the latter. Whilst this is a frequently used strategy (termed an "Economy Cycle") there are many suitable situations where it is not used or where it is misapplied. The need for effective control of the ventilation cycle to ensure that it does not result in the uncontrolled leaking of outside air into a building when the "Economy Cycle" should be off is frequently overlooked;

control of air and water flow by speed control on fans and pumps rather than by throttling with valves;

selection of efficient air-conditioning plant;

setting of thermostat set-point temperatures for air-conditioning plant to the highest comfortable temperature in periods when cooling is likely to be required and to the lowest comfortable temperature in periods when heating is likely to be required;

incorporation of heat-recovery systems on exhaust air from buildings where large quantities of air are exhausted from buildings;

use of evaporate coolers where suitable low cost water is available, and the climate is suitable. Indirect evaporate coolers provide for heat recovery and relatively inexpensive cooling of large quantities of outside air;

use of solar water heaters or dedicated instantaneous/semi-instantaneous or small storage gas water heaters in lieu of larger boilers for domestic hot water requirements; and

provision of equipment to permit convenient and regular monitoring of the energy consumed in buildings. The cost of purpose designed monitoring systems has declined substantially over recent years making their installation relatively inexpensive.

Whilst the options for energy conservation in buildings are considerable, it is clear that there is need for substantially more innovation in this field. However, this by its nature implies experimentation. Designers of commercial buildings in particular are normally neither able to afford, nor able to risk experimentation during the building design process. Some facility needs to be established to fund and carry out field trials to evaluate new energy conservation design strategies.

Despite the wide body of material currently available on these topics, the relevance of much of it to the Western Australian situation is vague. There is need for preparation of clear guidelines. However, with commercial buildings, the complexity of the various interactions between the numerous factors makes the use of computer techniques necessary in many instances. Access to suitable, easy to use programs is essential for designers.

In addition, there is need to establish target energy consumption figures for particular building types and uses and to provide examples of how these may be achieved.

The development of the Guide for Design of Energy Efficient Buildings for the north of Western Australia, which is currently in hand, is the first step in this direction. This is seen as a discussion document which may then form the basis for legislation to ensure efficient energy use and to provide a model for design guides for the remainder of the State.

INDUSTRIAL SITUATIONS

Industry is a major user of energy. The potential for implementation of energy conservation strategies is considerable. Whilst wastage of energy has been significantly reduced over the last 10 years, awareness of techniques for efficient use of energy is still inadequate. In the majority of industries significant energy savings can be achieved at small cost by considering the following factors:

- correct matching of motors to the load – the current practice of oversizing motors leads to inefficient operation;
- selection of high efficiency motors;
- switching of motors and the use of variable speed control on motors where motor loads vary and in particular in lieu of throttling of fluid flows;

  (N.B. In addition to direct electricity savings for the consumer, the approaches referred to above can also significantly improve the power factor in a distribution system and thus reduce distribution and generation losses);
- effective use of insulation on hot fluid and chilled fluid pipework;
- regular effective tuning of boiler combustion systems;
- use of small high efficiency boilers in lieu of maintaining large quantities of stored hot water, and effective insulation of boilers,
- regular maintenance of boiler controls, of insulation on boilers and pipework, and steam traps – inadequate maintenance procedures continue in many industries;
- return of condensate to boilers;
- optimum sizing and layout of pipework, particularly that used for grounds reticulation;
- control of reticulation pumps to avoid over-watering of grounds;
- preparation of soil to maximise moisture retention and planting of vegetation requiring minimal water;
- use of spot watering of plants (e.g. trickle systems) in lieu of sprays;
- adjustment of thermostats to avoid overcooling and overheating;
- selection of high efficiency refrigeration plant – the use of evaporate cooling and condensing systems should be considered, and fans on evaporators should be cycled with the compressor;

- control of air spillage through incorporation of air locks and the like on cold rooms and maintenance of seals on all refrigeration enclosures;
- recovery of heat from furnaces gases;
- use of modern refractories and close supervision of their installation;
- emphasis on detailed commissioning of plant and implementation of performance monitoring on a regular basis;
- prospects for use of total energy plants for co-generation of heat and power where suitable demand exists for heat and electricity.

Consistent education of industry personnel to the prospects for energy conservation, the production of industry standards for energy use and the provision of relatively cheap energy audits are approaches which need to be adopted.

TRANSPORT

Statistics available show that 51% of the State's consumption of petroleum products during 1981/82 was for transport applications. Estimates suggest that this figure may be as high as 75% by 1985/86 as transport fuel use rises whilst natural gas from the North West Shelf assumes some of the industrial load from petroleum products.[6] Hence, energy conservation measures in transport applications justify detailed consideration in any energy strategy and they are therefore the subject of a separate discussion paper. Key issues which require consideration are:

- efficiency of vehicle engines and vehicle aerodynamics (e.g. the selection of air spoilers, etc.);
- driver training to minimise fuel wastage;
- optimum scheduling of deliveries and traffic routes;
- design of roads and co-ordination of traffic controls;
- fuel substitution (discussed further in the section on transport).

REMOTE AREA POWER

Remote farms and communities are almost exclusively reliant on diesel-powered generators for electricity supply. With regular routine maintenance diesel generators provide a reliable power supply. However, the potential for substantial saving in the operating cost of diesels is considerable. Although diesel generators operate most efficiently at or near full load and very inefficiently at light load, investigations indicate that most small diesel generator sets are lightly loaded for the majority of their operating life.

Considerable energy savings can be made by:

- the correct sizing of diesel sets to the load they are to serve;
- the use of batteries to store extra energy generated when diesels are called upon to run and to service small electrical draws such as lights at other times, thereby avoiding the need for the diesel to operate simply to serve a small load;
- the effective management of electrical loads so that items such as coolrooms and water pumps are only required to operate when other equipment requires the diesel to run. Electronic controls provide for effective load management without any inconvenience to the consumer.

Wide-scale programs aimed at educating those who sell and purchase diesel generators for remote area use are to be implemented.

ALTERNATIVE ENERGY SYSTEMS

GENERAL

The term alternative energy refers to energy sources which are renewable within an average human lifetime and non-nuclear fuels developed to displace conventional fossil fuels in particular applications. It includes direct solar energy for room and water heating, electrical energy derived by photovoltaic cells, wind energy, hydro-power, energy derived from plant materials and fuels derived from other more plentiful fossil fuels. Tidal, ocean thermal wave and geothermal power are also potential energy sources.

BUILDINGS

Direct solar energy can be readily and economically utilised for heating of building interiors and for low temperature water heating (up to 80°C).

The harnessing of solar energy for heating of building interiors relies on the effective use of traditional materials and components and therefore need not involve additional costs in the case of newly designed buildings. Whilst retrofitting of existing buildings normally involves additional expenditure, this can frequently be justified on economic grounds. Specific items to be addressed are covered in the preceding section on Buildings.

Solar water heating calls for the use of special systems. The higher cost of these systems compared to conventional gas and electric hot water units can in many situations be offset against the net financial value of the energy saved. However, the climatic pattern of an area and the hot water demand of the users have a significant impact on the economics. In the south west of the State domestic hot water costs are estimated by the State Energy Commission of Western Australia to draw more than one-third of the total energy used by an average family (a four to five person family).[7] The use of solar hot water units can reduce the demand for electricity or gas by 80%. However, in situations where only small requirements for hot water exist (e.g. in dwelling units occupied by only one person) instantaneous electric hot water units may however represent the most economical domestic hot water appliance.

The criteria for economic selection of solar hot water units are well understood for the south of the State. The situation is not as clear for the north of the State where the climate is more conducive to operation of solar hot water units, yet the total energy requirements for heating water are less as the mains water is normally warmer. A study of the energy demands of the various types of hot water units used under the north west conditions is to be initiated to help quantify this situation.

Locally manufactured solar water heaters have achieved wide acceptance throughout Australia and overseas and the local manufacturers are at the forefront of world developments in the industry. Nevertheless they face strong competition from manufacturers of conventional hot water units who have made significant improvements in the efficiency of their products over recent years. There is therefore need to encourage development of lower cost solar water units, to improve the energy storage capabilities of the units, to extend the life of units and to improve the temperature control if the local solar water industry is to expand.

Timber represents a renewable resource. The combustion of timber for heating of rooms and water is traditional technology which has received a considerable boost over recent years with the availability of what are termed "air tight" stoves. The controlled burn of these units not only increases the heat extracted from the timber but also reduces the pollution problem. Very intensive use of such units for heating could, however, generate pollution problems and bring pressure on the available timber, its cost and hence its economics. Therefore promotion of heating by burning of timber needs to be cautious. In situations where timber is readily available as waste, its use is to be encouraged, preferably in "air tight" stoves. However, as extensive use of wood for heating in circumstances where it is not so readily available may eventually be detrimental to the environment, the harvesting of wood needs to be closely monitored as do pollution problems which may arise from intensive use of wood heaters in confined locations.

INDUSTRIAL SITUATIONS

The use of solar energy for drying of timber and produce, and for heating of fluids to low temperatures is economically and practically viable in a number of specific situations. Many lend themselves to system modifications to enhance their performance. The most economic applications are those requiring temperatures below 100°C, in which the heating requirements are primarily during daylight hours and where peak heating demands correspond to periods that typically experience clear skies. If current

Australian research at the Sydney University and being undertaken by Rheem Australia Ltd in New South Wales[8] is successful in lowering the cost of evacuated tube collector systems capable of generating temperatures up to 150°C, the number of applications for industrial use of solar energy will be increased substantially. Ongoing information programs are required to generate awareness of suitable applications.

The major constraint to the widespread adoption of solar heating systems in industry, however, remains the limited capacity of thermal energy systems (both in terms of the quantity of energy storage per unit volume and the longevity of that storage). However, development work proceeding both locally and overseas on phase change storage systems appears promising. These may well provide reliable and cheap high density, long life thermal storage (in comparison with current mass storage systems) enabling use of solar heating systems to extend to many industries. Continued encouragement of efforts to develop phase change storage systems is to be encouraged.

TRANSPORT

The high reliance of the State's transport system on imported oil suggests this as a key area for special research effort to find alternative fuels. The findings of this research would be equally applicable to stationary engine applications.

There are a number of prospective alternative fuels:

(a) **Ethanol** – which can be produced by fermentation of a wide variety of crops, may be used as a blend with petrol and distillate (a 20% blend is used in spark ignition engines in Brazil) or as a sole fuel in spark ignition engines (provided auxiliary petrol or liquid petroleum gas systems are installed to provide for cold starting). The cost of producing ethanol is, however, approximately twice that for petroleum so that the short-term prospects for its use are poor.

(b) **Methanol** – can be utilised in a blend with petrol and distillate or as a sole fuel for spark ignition engines. Natural gas can be processed to methanol and then to high grade petrol over a zeolite catalyst although about half the energy in the gas is lost in the conversion process. There is little likelihood of this process being competitive with petroleum or distillate in the near term.

(c) **Liquified Petrol Gas** (LPG) – marketed as "autogas", is currently in wide usage in Western Australia by taxi fleets. LPG is a by-product of the oil production and refining process. Currently availablility of LPG is constrained by the oil throughput of Kwinana Oil Refinery and at Barrow Island. However, the establishment of a plant to strip LPG from the North West Shelf natural gas will quadruple the supply situation and lead to export of LPG from Western Australia. LPG is approximately 50% of the cost of petroleum and distillate. Although it provides approximately 30% less energy per litre than petroleum the conversion cost of cars (typically $1400) can usually be recovered within 20 000-40 000 km depending on the fuel efficiency of the vehicle. The low pollution level of LPG powered engines favours its more widespread use.

(d) **Compressed Natural Gas** (CNG) – can be used as a sole fuel in petrol engines and as a supplementary fuel in diesel engines. However, the storage vessels required are bulky so that the range of CNG equipped vehicles is normally limited to less than 150 km.

Liquified Natural Gas (LNG) – which is considerably less bulky than CNG will provide a comparable driving range to LPG given similar volume storage vessels. It does, however, require storage in cryogenic tanks at -162°C. It therefore requires more expensive equipment to handle than CNG which itself is uneconomic to use at the current retail prices in Western Australia for natural gas. However, if special gas prices are made available to potentially large users of LNG or CNG such as the Metropolitan Transport Trust both could represent economically viable options. Consideration is being given to the use of LNG as a supplementary fuel in diesel power stations. The infrastructure developed for this purpose could also service heavy transport applications.

(e) **Vegetable Oils** – can be used in most diesel engines in up to 30% blend with diesel oil. They can also be converted to esters which have very similar properties to light distillate oil and are almost interchangeable with it. However, the cost of vegetable oil is twice that of distillate so that there is little prospect for its use in the near term.

(f) **Oil Bearing Shale** – occurs as small deposits at the southern end of Western Australia's Officer Basin. However, the economics of production of oil from this source are not attractive at the present time.

(g) **Synthetic Oil** – can be derived by solvent extraction from brown coal. The process may be suitable for application to the large lignite deposits proven between Norseman and Esperance and near Balladonia. However, this process is not competitive with the present price of petroleum oil nor likely to be so in the near term.

The best options for the utilisation of alternative transport fuels in the short to medium term are LPG, CNG and LNG.

Greater use of LPG will result from normal market forces as improved supply results from the establishment of the LPG stripping plant associated with the North West Shelf Natural Gas Project.

Ongoing research aimed at developing cheaper equipment suitable for adapting CNG and LNG for use in otherwise conventional vehicles is to be encouraged.

REMOTE AREA POWER

The most promising medium-term prospects for alternative energy systems are in remote areas where the primary energy source is distillate (which is a relatively expensive and insecure energy source), the loads are relatively small and the more significant loads (refrigeration, water pumping and desalination) are not time dependent. In some of these situations photovoltaic cells and wind turbines can provide an economic alternative to the consumption of distillate, and the extent of economic applications is expected to rise significantly in the future.

Photovoltaic cells have been shown to be reliable, long-term power generators requiring minimum maintenance. Field trials suggest that about 20 years life can be expected from the panels. In many small, remote applications (such as navigation lighting, communication systems, cathodic corrosion protection systems, and small community power supplies) requiring panels up to 750 watts peak capacity, stand alone photovoltaic systems are the most suitable and economic type of power supply.

Whilst photovoltaic panels are not yet economic in larger applications, development programs worldwide promise substantial reduction in their cost in the next 5 to 10 years. By the early 1990s it is expected that photovoltaic systems will be competitive for use on most remote homesteads. However, the high cost of energy storage represents a major constraint to photovoltaic systems displacing diesel generators.

The present generation of batteries is relatively expensive per unit storage capacity and they require replacement within five years of field use. Thus, except for water pumping, refrigeration and desalination applications where electrical energy storage and the need for batteries can be eliminated, it is normally more economic to install only a small amount of battery storage and to rely on an existing diesel set to provide auxiliary electricity requirements when there is insufficient incident solar energy and the battery has been discharged.

However, the widest use of photovoltaic and wind turbines would ultimately result if economic, high performance, long life batteries were available. Research work taking place in Western Australia independently by the W.A. company, Sherwood Overseas, and the Murdoch University company, Murmin, to commercialise a zinc bromine battery with the potential to offer these benefits, shows promise.

Wind turbines are currently competitive with distillate costs on large diesel generator applications in regions experiencing average wind speeds of 6.5 metres per second. Such conditions exist on the southern coast of Western Australia, at several locations along the west coast and at elevated inland sites such as Mt Magnet.[9] The prospects for installation of wind turbines at Esperance to feed into the diesel-powered electricity grid are under investigation and there are prospects for installation of individual turbines at several locations elsewhere in the State. Trials by the State Energy Commission of Western Australia of wind turbines produced by a local company have proved the units to be reliable and high output performers with considerable market potential in Australia and overseas.

The topography of Western Australia relative to the energy demand centres (for industry, commerce and community) does not generally favour the establishment of hydro electricity systems. Exceptions to this general pattern, however, exist in the north of the State where feasibility studies suggest potential for hydro electricity schemes on the Ord River. These studies are currently considering a 6 Megawatt hydro electricity development at the Bandicoot Bar Diversion Dam to serve the Kununurra township and a larger system at Lake Argyle to serve the diamond mining activities in that vicinity. At present, however, a 2.2 Megawatt hydro electricity unit at Wellington Dam near the south west town of Collie (which generates only when the dam overflows) remains the State's only significant application of hydro electricity.

The north of Western Australia experiences very substantial tidal movements which could be utilised for power generation. However an extensive investigaton in 1974 by the Fuel & Power Commission of Western Australia of the tidal power resources at Secure Bay and Walcott Inlet near Derby concluded that the high capital cost and lack of a nearby energy market made tidal power systems uneconomic.[2] The lack of a nearby energy market remains a major impediment to development of tidal systems. However, the potential for tidal power should be kept under review.

The tapping of ocean thermal gradients and the harnessing of wave energy for generating electricity are technically possible, although these systems are now only in a research and development stage. Whilst recognising that the severe rigours of the environment in which they are required to operate are a major obstacle to their becoming economic in the medium term, international attempts to commercialise these technologies need to be continuously monitored.

The existence of hot (60°C plus) artesian water at many locations throughout the State suggests that there are prospects for generation of electricity from geothermal sources. However, the major constraint to the widespread use of such systems lies in the low conversion efficiency of the generating plant operating at what are in reality only small temperature differentials and hence the high capital cost of the systems. Furthermore, the cost of re-injecting water ejected from the bores back into the ground to avoid water wastage further detracts from the system economics. Continuous monitoring of development of this technology is however justified.

The provision of power to the State's remote areas is of high priority and is expected to continue to remain in high profile in the future.

PRIORITIES

Energy conservation and alternate energy options can readily be misconstrued as quite separate from power generation possibilities, although in reality all three are inextricably inter-related. Hence, long-term energy planning needs to address directly the impact of energy conservation measures and alternative energy systems, the extent to which they should be encouraged and promoted, and to formulate strategies to guide research, development and the adoption of selected options. The approach needs to look beyond simple policy statement to clear strategic planning.

The implementation of energy conservation measures and alternative energy systems must address the economics of the competing options. However, in doing so, it must clearly consider factors which artificially impact on the market place. Taxes and duties, and subsidies (whether by governments or mining companies respectively) on fuel and on energy generation, conservation and alternative energy equipment can dramatically affect the economics of options as perceived by a consumer. The value of the options to the community may be quite the converse.

There is also a need to consider the prospects for local industries to develop energy conservation and alternative energy systems, noting in particular the overall benefit to the State.

Specific initiatives which need to be addressed in the strategic planning include:

(a) **Energy Conservation**

facility for building designers to trial new concepts;

development of design guides for energy efficient design of buildings throughout the State;

development of a data base to determine the particular economics of various hot water systems throughout Western Australia;

implementation of energy standards for industry and encouragement of energy audits;

review of energy use in transport applications to highlight approaches that will improve efficiency;

development of procedures to increase the efficiency of operating diesel engines.

(b) **Alternative Energy**

promotion of research aimed specifically at further reducing the cost and/or extending the life of solar hot water units;

promotion of research aimed at development of long-term thermal storage for use in industry;

development of long-term programs for the use of LPG, CNG and LNG in transport and stationary applications;

continued development of photovoltaic and wind turbine systems for remote area use;

further development of cost effective, long life batteries suitable for power storage;

regular review of all the alternative energy options.

Programs to pursue many of the initiatives highlighted above have already been instigated by the Solar Energy Research Institute of Western Australia and the State Energy Commission of Western Australia's Energy Research Group. However, the development of an organisation with a mandate broad enough to encompass all aspects of energy research and development, as proposed by the Western Australian Government, would permit priorities to be established and energy conservation and alternative energy issues to be more broadly addressed.

CONCLUSION

The continued development of Western Australia's industry and commerce, and the growth of the State's population will place increased demands on the State's energy resources.

The maintenance of safe and secure energy supplies into the future requires long-term planning. Rational and efficient use of the State's energy resources is the centre of this planning.

Since the "oil crisis" of the mid-1970s the industrial countries of the world have recognised the real and substantial contribution that energy conservation and alternative energies can make. The benefits to date, however, have been largely the result of short to medium-term responses to oil price fluctuations.

Further substantial and lasting benefits will necessitate longer-term planning as part of an overall energy strategy.

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TRANSPORT ENERGY CONSERVATION THROUGH URBAN PLANNING AND LIFESTYLE CHANGES: SOME FUNDAMENTAL CHOICES FOR PERTH

by JEFFREY R. KENWORTHY

An Invited Review Paper as Background
for the Development of a
STATE CONSERVATION STRATEGY FOR WESTERN AUSTRALIA

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INTRODUCTION

This position paper attempts to convey what I see as the major issues surrounding the conservation of energy in urban passenger transport in Perth, Western Australia. It is written from personal experience and from the results of seven years' research in the field.

It is my contention that the inclusion of energy, and in particular urban transport energy, is an essential part of a Conservation Strategy for Western Australia. This is partly because transport energy use can tell us a lot more about our urban areas than just how much oil and money we have to find each year to run the transport system; although, as explained later, these questions of supply and price are probably sufficient in themselves to make transport energy a major part of any Conservation Strategy. Transport energy use reflects how sensible, efficient and conservation-minded we are in many aspects of urban life. Just how will become much clearer later in the paper. However, it is important at this point to briefly summarise some of the issues I have found, through my own and others' research, to be intimately associated with transport energy use. This provides a necessary perspective on the approach I have taken in dealing with the subject and helps to show the broader significance which transport energy has for a conservation strategy.

It is clear from a number of studies that transport energy use and environmental quality are closely linked, with higher energy use being associated with greater environmental impact.[1,2] Patterns of transport energy use can tell us how efficiently we are planning different areas and to some extent how fairly or equitably we are building a city for its residents.[3] Familiarity with some of the per capita energy quantities involved can actually tell us a lot about the lifestyles of the people involved – how dependent they are on cars, whether they are likely to walk or ride bikes, and whether they are likely to have a viable public transport system. Not surprisingly, detailed knowledge of comparative transport energy consumption in cities can give us some indication of the overall character of a city– how densely settled it is, if it is compact or sprawling, whether it is likely to have a very large or comparatively small road network, and even the kind of central city it probably has.[4] For example, details about transport energy use are fairly reliable guides to whether the city has a drive-in, drive-out, freeway access type of city centre with lots of car parks and few people-oriented spaces for relaxation and enjoyment (e.g. Houston, Texas), or whether the city is more likely to have a "living core" with diverse urban activities, a lot more space for people, much fewer car parks and a strong rail-based public transport system (e.g. Munich, West Germany). Transport energy use can even provide a hint on what sort of pressures the land around a city might be under– whether there is likely to be continual demands on surrounding natural and agricultural areas for roads and housing, as in Los Angeles, or whether some balance may have been struck between built-up areas and land for conservation, recreation and agriculture, as in many European cities.

In other words, transport energy use can, in some sense, be used as a surrogate indicator or "barometer" of many things which people may associate with the "quality of life" or lifestyles. Energy is burned in transport to join or hold things together, providing the essential links between human activities. The more efficiently and sensibly activities are planned, the more rationally land is used in a city, the less we have to move around, particularly in cars, and the less energy we burn. Thus the built-in need to burn a lot or a little energy in a city is reflected in the many aspects of urban life which have just been touched on.

So, transport energy conservation is not just a resource and economic issue, but a lifestyle issue.

In this paper I want to reflect as much on these lifestyle factors and the "character" of cities as on the purely physical factor of energy use. I believe that it is only by developing an understanding or feeling for these broader human factors that we can really understand the fundamental issues involved in conserving transport energy. By adopting this approach it takes transport energy conservation out of what can be a cold and calculating world of technology and numbers, and places it squarely in the midst of our own lives: What sort of a city do we want and what kind of lifestyles do we want to be able to live?

This is not to ignore the physical issues surrounding oil consumption or the technological factors that are inevitably part of any transport energy discussion. This paper therefore commences with a very brief overview of the oil problem and the many new technologies and technological approaches that are being pursued to conserve, augment or substitute existing oil supplies. It then examines transport energy use in each of the mainland Australian capitals and the land use/transport factors which are behind the observed patterns, i.e. the built-in factors. Each city is then examined in the light of how these built-in factors affect its ability to respond to stresses in the form of suddenly rising oil prices and, by implication, actual shortages.

Because Australian cities provide only a limited perspective on how land use and transport patterns affect transport energy use, the issue is thrown wide open by a comparison of European and American

cities. The approach here is to compare my own experiences in these cities and how the basic structure of the urban area determines one's lifestyle, and transport energy use. It is here that we are able to see how the land use patterns, transport systems, energy use, individual lifestyles and overall character of an urban area are so tightly interwoven.

As the central issue of the paper is transport energy conservation in Perth, the discussion then focusses on some lifestyle issues in Perth which have bearing on what we as individuals might try to do to lower our energy use. Again, I have based this on personal experience. The problems associated with attempts to lower energy use at this level are followed by a small area examination of transport energy use in Perth which begins to bring out the specific urban planning issues at stake in any attempts to fundamentally lower transport energy consumption in Perth.

As well as highlighting urban planning issues, this analysis leads to a specific discussion of a major transport planning policy in Perth and its influence on energy use – the role of easing congestion in saving fuel. The final section stresses again the combined land use/transport planning factors in transport energy use by considering a small area energy analysis of Sydney and comparing it briefly with the Perth study.

The conclusions to this paper are drawn in the context of another city, Toronto, which provides a very clear picture or model of the general planning principles Perth should be pursuing to foster lower transport energy use.

THE OIL PROBLEM AND ITS TECHNOLOGICAL DIMENSION

There is little need to explain in detail how dependent Australian cities are on the private motor car and therefore how bound they are to a large continuing supply of oil (or some substitute liquid fuel) at a reasonable price. At the moment, Australia is quite well placed with regard to its indigenous oil supply; in 1984/5 total refinery input averaged 76.8% from indigenous sources, a significant increase over 1982/3 which averaged 66.4%.[5] However, most of Australia's oil comes from the large Bass Strait reserves and in the absence of further large finds we can expect that Australia will become gradually more dependent upon imported oil. But is there really a problem?

The world oil situation is not what it was in 1979, when predictions were that the price of oil per barrel would continue rising unabated into the 1980s, probably to over $US50 per barrel. This hasn't happened. World oil prices hit a peak of around $US35 per barrel in 1981 but in 1985 they were around $US27. Many analysts now are suggesting that oil prices could even slump to as low as $15 to $20 per barrel, particularly if OPEC were to be ineffective at keeping prices up.[6]

The reasons for this sudden change are complex and were not predicted by any of the major research groups, companies or governments. It is apparent now, however, that the Arab oil embargoes of 1973/4 and the Iranian revolution of 1979 stimulated many countries to pursue aggressive programmes of oil substitution (particularly in the domestic sector, power generation and industry) as well as increasing energy efficiency. These programmes began to have a real impact after 1979. Combined with a world-wide economic recession in the early 1980s, oil demand fell and so did prices. On top of this a number of non-OPEC oil producers started contributing significant amounts of oil to the world markets (e.g. Mexico, Alaska and North Sea oil), helping to keep prices suppressed. The biggest Middle Eastern producers such as Saudi Arabia have slashed their oil production since 1979 to try and keep prices buoyant (Saudi Arabia reduced production by 51% from 1979 to 1984).[7]

These favourable changes in the world oil scene are already significantly affecting the outlook of many policymakers and governments about the importance of energy conservation programmes. The Western world is, at large, no longer perceived to be in a crisis situation over its oil dependence. There is a danger however that these present conditions might lead to a false sense of security about oil supply and cost in the long term. This can be seen to some extent by a trend in many International Energy Agency countries back to bigger cars and a marked reduction in the attention given to energy conservation, and particularly transport energy conservation, in the academic and popular literature compared to the seventies. Data from the International Energy Agency show that in the ten years up to 1982, petrol consumption in IEA countries increased by 5.9%, although this was considerably slower than the growth in vehicles.[8]

The danger, as one analyst has suggested, is coping with the short-term successes of oil conservation, decreased demand and lower prices.[9] This is because the current picture does not fundamentally change the longer-term reality that oil is a finite, non-renewable resource and that the scope for finding

new oil resources of a very large size is becoming quite narrow.[10] The present increases in world oil production from comparatively small reserves in non-OPEC countries is likely to be short-lived (e.g. North Sea Oil is predicted to peak before 1990). One analyst[6] summarises the situation in this way:

> "Rising production of non-OPEC oil has added 5 million barrels per day to world oil supply and played a major role in the oil glut. But despite this recent boost, the long-term oil outlook remains dominated by Middle Eastern members of OPEC that have 56 per cent of the world's oil. In fact, recent shifts in world oil markets have some rather disturbing long-term implications: the rate of depletion of the world's most abundant oil resources has slowed, while depletion of some of the scarcest and most strategically important reserves has accelerated. At the 1984 extraction rate, US proven oil reserves will last only about nine years. Saudi Arabia's oil reserves, on the other hand would last almost 100 years at the 1984 rate of extraction ... During the next ten years, OPEC may well become a smaller, more geographically concentrated, more cohesive, and more powerful organization ... Growing independence from Middle East oil provides a false sense of security since it has occurred largely at the expense of greater long-term dependence. The lower the current Middle Eastern share of the market, the greater its share at the end of the century when many countries will be running out of oil. The danger is that the Persian Gulf may move back into the driver's seat at a time when world oil resources are more limited than at any time in recent history." (pp 32-34)

It is thus, I believe, still very much in the interests of all countries to maintain the oil conservation momentum developed in the 1970s. It seems to make good sense to continue moving away from dependence on a resource which in the long term must become scarcer and more expensive. This is particularly true of the transport sector which is overwhelmingly dependent on liquid fuels from oil. Unlike many sectors of the economy which, as already demonstrated, have been able to substitute oil for other fuels (e.g. natural gas, coal, nuclear power) and to reap very large efficiency savings, transport remains captive to the oil market.

It was this longer term picture of potential global oil shortages and the dependence of transport on oil that led me in 1979 to review all possible strategies available to conserve, augment or substitute existing oil supplies in the passenger transport sector.[11] This review was divided into two parts – an examination of the technological strategies and the land use planning strategies which might either reduce transport energy use or add to potential liquid fuel resources.

The technological options covered all the potential alternative fuels such as alcohols, LPG, oil from coal, oil shales and tar sands as well as the more peripheral options such as hydrogen, methane and even hydrazine and ammonia. It also considered secondary and tertiary extraction techniques for conventional oil wells and an examination of oil exploration studies around the world to assess the potential for new commercially viable wells. Motor vehicle technology was reviewed under the headings of small-, medium- and large-scale technological changes. Small-scale changes included items such as electronic ignitions, thermostatic fans, different lubricants, vehicle maintenance and durability issues and other "add-on" or post-production changes to engines.

The medium-scale changes embraced engine technologies such as stratified charge, rotary and diesel engines, vehicle weight reduction, aerodynamic improvements, reductions in rolling resistance (e.g. new types of tyres), new transmissions (e.g. continuously variable transmissions) and lower energy use accessories. Large-scale changes examined alternative combustion systems such as Brayton-Cycle engines (turbines), Rankine-Cycle engines (steam engines), Stirling-Cycle engines (hot air engines) as well as electric vehicles and hybrid vehicles.

New public transport technology was also considered. This included battery-trolley buses, electric busways, alternative propulsion systems for trains such as magnetic levitation, as well as Personal Rapid Transit systems such as those that are used on a small scale in a few airports around the USA and, on a larger scale, in Morgantown, Virginia. Finally, technological alternatives to travel were reviewed such as solid pipelines for transporting goods and services and the potential of new electronic communication systems to substitute vehicle trips were assessed.

It is impossible to detail here all the findings of this 350 page technological review. However, it can be said that none of the options examined, either individually or collectively, appeared to offer any fundamental solutions or panaceas to the problem of growing oil dependence in urban transport systems. Each technology was assessed according to seven important factors which affect the likelihood of the technology being introduced and how effective it would be at adding to energy supplies or lowering energy use. The factors were:

(1) technological feasibility;

(2) economic cost compared to the present system (running costs);

(3) economic cost compared to the present system (capital costs);

(4) changes in infrastructure required compared to the present system;

(5) safety compared to the present system;

(6) environmental impact compared to the present system; and

(7) human factors.

It was found, for example, that the "easy" technological options such as small- and medium-scale technological changes and better oil extraction techniques, offered little or not enough in energy production or conservation to keep pace with growth in demand. Even the quite marked change towards small vehicles in Australian cities over the past six to seven years has failed to stop per capita transport energy use growing between 1976 and 1982.[12] The "hard" options, such as electric vehicles and large-scale alternative fuels production, while looking better in their potential to alleviate the oil situation (although by no means offering complete solutions to the huge oil demand), were highly problematic in the areas of infrastructure changes, environmental impact, cost or safety. Because of these profound obstacles they were deemed unlikely to be of significance in the probable time frame of the oil issue, if at all. Indeed, many of the ambitious alternative fuel schemes of the Carter era in the United States, such as the Colorado oil shales, large ethanol production schemes from corn and other crops and oil from coal projects, have slid into oblivion or been abandoned by the companies developing them.[13] Australia's Rundle oil sands project is no longer talked about and assessments of how much liquid fuel Australia could realistically derive from various biomass sources and from coal are soberingly small, compared to demand.[14]

It became obvious from this review that a technological panacea to the oil problems of North American and Australian automobile cities was unlikely in the foreseeable future. Should some of the more dramatic technological options be pursued, it was clear that these would be "hard" not "soft" paths to energy conservation and supply. This turned us to consider in greater depth the factors that actually cause or promote higher car dependence and hence high energy use in our cities, and how these factors might be changed to reduce energy demand. In other words, how can we actually build greater energy efficiency into our cities? It also seemed that the time frame needed to make significant impact in this area was comparable to the time needed to bring large-scale technological changes into being.

TRANSPORT ENERGY USE IN AUSTRALIAN CITIES—THE BUILT-IN FACTORS

For this part of the study an initial investigation of Australian cities was undertaken.[15,16,17] Transport energy use per capita was calculated for each of the mainland Australian capital cities in 1976, along with a series of land use, transport and other factors such as income which might have a bearing on travel patterns and energy use. The results of this analysis showed Sydney to be the lowest total transport energy consumer with the equivalent of 797 litres of petrol per person each year, and Perth was the highest with the equivalent of 953 litres per person each year (i.e. Perth was about 20% higher than Sydney). Melbourne's per capita transport energy was virtually identical to Sydney's, increasing in Brisbane to 833 litres per person and Adelaide with 910 litres per person.

Using simple statistical correlations it was found that household income, a factor commonly used to explain differences in transport energy use (higher income equals higher energy use), did not correlate at all with the observed energy use in Australian cities. Vehicle ownership did however show a strong positive correlation with energy use (i.e. more cars, more energy use), but there was no pattern of income to explain the higher car ownership in Perth and the low ownerhsip in Sydney. It appeared therefore that people in Perth were buying more cars, not because they have more money, but perhaps because they need them more. This seemed to tie in well with other studies which showed that as density increased, car ownership decreased at all income levels (Sydney is considerably denser than Perth). As well, city size variables (urbanised area and population), which are generally thought to positively increase energy use, showed negative correlations with the transport energy use data. This suggested that the size of a city per se is not a fundamental variable in per capita transport energy, but rather the land use patterns and other transport factors within each city are the important consideration.

This led us to examine a number of variables under the headings of density factors, centralisation factors and traffic restraint factors. It became quite clear that the overall urban population density and, in

particular, the inner area density, were important factors in understanding transport energy use. Perth was quite clearly a very low density city with 12.2 people per ha and Melbourne and Sydney were highest with 18.1 and 19.2 people per ha respectively. However, inner area density differences were even more pronounced – Perth had only 16.5 people per ha and Melbourne and Sydney had 36.8 and 40.2 people per ha respectively. Thus higher density appeared to be associated with lower energy use.

In terms of centralisation, the factors of Central Business District (CBD) jobs and inner area job density were also significantly correlated with energy use, i.e. the greater the centralisation, the lower the energy use. Perth again was at the low extreme with 52 000 jobs in the CBD and Sydney at the high end with 205 000 jobs. Similarly inner area job density was only 10.7 in Perth and 64.7 in Sydney.

The other parameters examined were broadly classified as traffic restraint factors. The question which we were attempting to answer was: Does catering for private cars in terms of roads and car parks lead to higher energy use? From the data, the answer appeared to be, yes. Again Perth was at one extreme with 13.2 metres of road per person and Sydney and Melbourne were at the other with 4.7 metres and 7.0 metres respectively. Perth had over 500 parking spaces per 1000 CBD workers while Sydney and Melbourne had 143 and 314 CBD parking places per 1000 workers respectively. Other congestion factors such as the percentage of arterial roads with speeds less than 25 km/h were comparatively low in Perth (11%) and high in Sydney (24%). In cars per km of road, Perth had only 38 while Sydney had 92. Hence, in terms of the road traffic environment, Perth appeared to be much better off than Sydney and Melbourne, but its per capita transport energy was some 20% higher than both these cities.

Of particular interest in this regard was the case of Brisbane. In the density and centralisation factors Brisbane was more akin to Perth and Adelaide, being very low in both these characteristics. However, its transport energy use per capita was closer to Melbourne and Sydney than to Perth or Adelaide. It appeared therefore that there was some other factor dominating the picture in Brisbane. The available data seemed to point to the comparatively strong traffic restraint characteristics in Brisbane. Brisbane had only 5.8 metres of road per person, 261 parking places per 1000 CBD workers and 80 cars per km of road – all values close to those of Sydney. It was concluded that this traffic restraint factor may not be a conscious policy, but rather an indirect result of the tortuous Brisbane terrain with its many creeks and valleys making road building difficult and expensive compared to Perth's sandy, flat terrain (particularly long, direct links to the city). On the other hand, Brisbane had a fairly comprehensive radial train service (now mostly electrified) which did provide direct links to the city centre. It is of note that Brisbane's trains are somewhat unique in Australian cities in that their patronage increased right through the decade between 1966 and 1976 from 23 million passengers annually to 32.5 million. The same period saw a marked overall decline in public transport throughout Australia.

Public transport in fact emerged as a key item in understanding the transport energy patterns in the Australian cities. Not only were Perth and Adelaide much higher than Brisbane, Melbourne and Syndey in the amount of private car travel (e.g. Perth was 11 900 passenger kms per person per year compared to 9700 in Sydney), but public transport use was much lower. In Perth and Adelaide there were only between 590 and 680 passenger kms per year per person on public transport, whereas the same figure for Sydney was 1420 passenger kms. The differences became even clearer when the train component was separated. Perth and Adelaide had between 120 and 190 passenger kms per person per year on trains (i.e. 18% and 32% of the total public transport task) whereas in Melbourne and Sydney the figures were 600 and 870 passenger kms per person per year, or between 61% and 65% of the public transport task. In terms of public transport's contribution to total passenger travel (i.e. total passenger kms per person per year), in Perth this was only 5% whereas in Sydney it was 13% (over 2½ times more). Most importantly, public transport in Sydney used only 3.4% of total transport energy in performing 13% of the passenger task, while in Perth the comparison was less favourable – 5% of the passenger task using 2.3% of total transport energy.

It became clear from this analysis that the cities with higher densities, particularly higher density inner areas, and greater centralisation, have well-developed radial electric rail systems (and in the case of Melbourne, a good tram system). They also cater much less for private cars in terms of road availability and parking facilities. This combination of factors adds up to a significantly lower use of energy than in the less centralised, lower density and more car-equipped cities of Perth and Adelaide, where buses are the main form of public transport and the rail systems are still not electrified.

All these patterns have important ramifications for how well each city will cope in the event of oil shortages and rapid price rises in oil. Some indication of this is provided in the next section.

The implications and importance of these patterns were driven home to us a few years later when we analysed the effects of the 1979 oil price rises in Australian cities, due to Australia's world parity prices policy.[18] For the previous thirty years or more the real price of petrol had declined steadily. Then suddenly, in the space of three years, petrol prices were higher than their 1955 level in real terms.

Oil company data for 1979 and 1980 showed how Sydney, Melbourne and Brisbane responded to these large rises in the price of petroleum fuels by reducing their total transport energy consumption by between 1.9% and 5.1%. Adelaide's consumption, on the other hand grew by 0.5%, but Perth's consumption rose unabated at 5.4%. At the same time 1979 marked an historical turnaround in a three decade trend of declining public transport patronage throughout Australia. In particular, Sydney's public transport passengers rose sharply (6.7%), followed by Melbourne (1.8%) the year after. This is in contrast to 20% declines in these cities between 1971 and 1976. Perth showed modest gains of 1.1% and 0.5% in the two years following the price rises while Adelaide grew more steadily at 3.7% and 5.5%.

These changes were perhaps not as noteworthy as the growth in rail patronage which really led the public transport revival; percentage gains in rail passengers over the two year period following 1979 were between 4.7% and 12.6% in Sydney, Melbourne, Brisbane and Adelaide. By contrast, Perth's rail passengers declined 19.4% in the 1979-80 period (due in part to closure of the Fremantle line) and then a further 8.8% in the 1980-81 period.

The continued growth of transport energy consumption in Perth and Adelaide at a time when Sydney, Brisbane and Melbourne managed to reduce theirs is of considerable significance. It suggests that the basic structure of these latter cities allows people a certain degree of flexibility in reducing their energy use, which is not available in Perth and Adelaide. In times of rising prices (or perhaps actual oil cuts), the higher density centres of Sydney and Melbourne, with their comparatively good public transport systems based around electric rapid rail, allow people to switch to public transport, or in some cases walk or ride a bike, with a greater degree of ease than is feasible in Perth or Adelaide. In other words, residents of Melbourne and Sydney are afforded greater diversity in their choice of lifestyles than are residents of Perth and Adelaide. This has important implications for transport energy conservation as will be seen later.

This analysis also brought forth two other major points: that of the economic implications of rising real prices in transport fuels and what these mean for the way we plan our cities.

Transport is the economic lifeblood of a city as well as having an essential role in the quality of life experienced by all urban residents, whether they are part of the productive process or not. Increasing petrol costs cut into every aspect of the economy, from the householder to industry, from the shopkeeper to all Government public services. As petrol prices continue to rise the economic benefit of better accessibility flows to those able to locate nearest to the main urban destinations, i.e. to the inner and central city areas where most of the work and nearly all the urban facilities are located. But for many people and firms the cheaper outer suburbs continue to be their only affordable location.

In a time of decreasing transport costs outer suburban locations can be the basis of economic development as transport budgets by the householder or business can be kept constant (e.g. household expenditure surveys show a fairly fixed percentage has been spent on transport prior to the steep increases of 1979 and later years). In a time of increasing petrol costs economic development must incorporate the intensifying of land use patterns if transport is not to become a drain on the family or business budget. If the redevelopment of central and inner city sites does not proceed at a rate which can offset the loss by people having to travel further in outer area locations, it would seem that the city as a whole will decline economically. If Perth continues its urban development and transport patterns along the same lines as those from 1950 to 1979 it will begin to price itself out.

There may already be some indication that this is occurring. Perth's growth in petrol use during the last few years, while the other Australian cities managed to conserve fuel for a period, is reflected in the consumer price index. The transport consumer price index rose 170.8 points in Perth from September 1975/6 to December 1981 compared with Sydney, Melbourne, Brisbane and Adelaide which rose between 157.9 and 166.6 points. Because transport affects everything else this is also reflected in the all-index consumer price index which rose 123.1 points in Perth from 1975/6 to 1980/1, compared with all other Australian cities which rose between 117.8 and 121.8 points during the same time.[19] That is, the cost of living in Perth in the five years from 1975/6 increased more than in any other Australian city.

It appeared from this analysis that petrol costs can no longer be assumed as a declining proportion of the economy and this suggested that the city must now be planned with new assumptions.

A change in planning emphasis has been seen in most Australian cities and in particular Sydney and Melbourne. Their new plans concentrate on consolidation of the city, higher intensity of development in the central city and in regional subcentres, especially on train lines. Nunawading, a local government area in Melbourne is attempting to implement a "cluster and connect" model of urban development designed to make the area more self-sufficient in all its urban activities and to maximise foot, pedal and public transport access to most facilities.

The previous two sections have provided a clear perspective on differences between Australian cities and the way different land use and transport patterns can significantly affect how much energy is needed to keep a city going. They have also given an indication of whether the city's structure permits its residents flexibility to manoeuvre around a difficult time of high fuel prices or shortages. Of course the different patterns described here are comparatively minor, because in a world context Australian cities are fairly homogenous. It is therefore important to expand our thinking about these issues by considering an international cross-section of cities.

TRANSPORT ENERGY CONSERVATION: AN INTERNATIONAL PERSPECTIVE ON URBAN LIFESTYLES

Despite the clear differences outlined here between Australian cities, they are all good examples of "automobile cities". By world standards, they are all very low density and rely overwhelmingly on private cars and a steady flow of liquid fossil fuels. The differences between them in transport energy consumption, which can to a very large degree be attributed to differences in central and inner area densities, therefore only hint at the potential which land use planning holds to reduce transport energy use.

This realisation provided the idea for a world comparison of cities, their land use patterns, transport and traffic systems and transport energy use, over the period 1960 to 1980. It was considered that such a study would provide concrete insights into the way development patterns affect transport energy use and would give a clear idea of how transport energy use can be reduced over time by following specific land use and transport planning policies. It would also highlight the different degrees of flexibility built into other cities with regard to their dependence on oil – why in Los Angeles people assaulted each other to get petrol during the 1973/4 oil crisis and in Holland they had car free days, closed the freeways and roller skated on them!

At this point I propose to address some of the broader issues raised in the introduction to this paper. These issues, I believe, are crucial to any attempts we might make in Perth to fundamentally change our patterns of transport energy use. The approach I have taken is one of personal experience, because it was partly through this experience that these ideas unfolded to me.

To gather the data necessary for the comparison of world cities and to ensure the exercise was not just "academic", my wife and I travelled for seven months to twenty-five cities in Europe, North America and parts of westernised Asia.

EUROPEAN CITIES

While collecting data in the European cities, it soon became clear that their total per capita transport energy use was between a third and a half of that in Australian cities. Obviously smaller car sizes in Europe contribute to these lower energy values. However, it was also clear that the savings reaped by smaller cars would be eaten up to some extent by the more congested traffic conditions and colder climates which cause bigger cold start fuel penalties. In fact, data collected in Munich for the 1980 West German car and station wagon fleet showed an average consumption of 10.9L/100 km (or 25.8 mpg).[20] In Australia in 1976, the average consumption for cars and station wagons was 12.4 L/100 km (or 22.8 mpg).[21] So, there was a lot more to the low transport energy consumption in European cities than just smaller cars. Our own lifestyles in the cities we visited began to show us the difference.

In the European cities there wasn't a single trip we couldn't comfortably and easily do on a bus, tram, subway, surface electric train, or on foot, and in a few cases on bikes. Our travel included radial and cross-city trips from lodgings located in central city pensions,inner city flats, suburban units, outer suburban houses, and in one case a small village 25 km out of Frankfurt. In no case was a car even remotely considered, and only in the instance of the village did we have to consult a timetable for off-peak travel on the local train. In all other cases, where we weren't walking, there was always a regular public transport service of some sort and this extended right into the night. Most of our travel during the week was for business, but on weekends we wanted to visit other attractions and this is where European cities came into their own right. For example, in Copenhagen we walked from our room in a private house about

seven kilometres from the city centre to a station in Copenhagen's electric train system. The walk took around five minutes. We travelled for around 25 minutes, through the heart of the city to the end of a line located near the famous Jaegersborg deer park. Here we were able to hire bicycles and spend the entire day in a 2500 acre prairie/woodland area. There were people riding horses, strolling, picnicking, bicycling and enjoying horse-drawn carriage rides. Cars are banned in the park, which is well within Copenhagen's built-up area. Most people arrive on bikes or public transport.

In Munich the U-Bahn or S-Bahn (German equivalents of the subway and surface electric train) took us to inner city parks and gardens which were big enough to get lost in. Here too were large numbers of people enjoying the spaces right within the city, but nearly all arriving by foot, bicycle and public transport. On other occasions we took one of the city's electric trains and found before the end of the line that we were in the midst of small villages with countryside all around. Going back we could see how comparatively well defined were the city's boundaries.

It was in fact the spaciousness of European cities which really drove home to me how compact and sensibly developed they are. It was possible to see how they have used their higher density, compact form to achieve tremendous balance – balance between private and public transport and balance between urban space and natural space.

It is important here to briefly explain what I mean by spaciousness. The sense of space we have in Australian cities is chiefly a view through the windscreen – wide, open roads, widely spaced houses, corner parks and land in outer areas waiting for the developer's bulldozer. Our urban areas are divided into mini-spaces – backyards, frontyards and large enforced setbacks. In European cities the view is different. The city is built upwards, traditionally to four or six storeys and the lower density developments which have become more common since the sixties are also more compact and conservative of space – they tend to be at a human scale and so the local distances are minimised for foot and bicycle access. People accept a higher density personal environment but all around them they have large, exciting and usable open spaces, and the countryside is generally only 20 to 30 minutes away.

It is this higher density, compact nature of European cities which gives them their lower transport energy use. All the essentials of urban life are more at hand and mixed together in a much smaller area. Residences, offices, shops, theatres, restaurants and other small businesses are not rigidly zoned apart as they generally are in Australian cities. Apartment houses line the streets with shops and other businesses at ground level. Courtyard style residential developments are common right within the heart of other urban activities. This makes for easy foot and bicycle access and for longer trips it means that public transport has the necessary focus and density of people to offer a frequent, convenient service. Overall, most trips are much shorter than in Australian cities, and, as will be seen further on, this is an essential element in determining transport energy use.

This type of urban planning in my view makes for much more liveable and "living" cities – cities with gentler human scale public environments where people can comfortably meet and stay. For the most part European cities have controlled cars in their central and inner areas. They now have sizeable inter-connected pedestrian areas where a "cafe" or street culture prevails, at least in summer. This activity moves inside or underground in winter, as most cities in Europe have extensive underground networks of shops, cafes and restaurants associated with their many subway stations.

All this creates a vibrant and vital sense of the city as a "place" – to be enjoyed, and lived – not a "passage" or somewhere to drive to or through and to get out of as fast as possible. Important elements of this atmosphere are the many street entertainers, and traders who attract and make people want to stay in the city's public spaces. Semi-permanent street markets in the pedestrian areas are also common. The different areas of the city became identifiable neighbourhoods with their own distinctive characters. Very strong local social and business networks develop, visitors come and go in safety because of the critical mass of activity on the streets, and there is a sense of true urban community. When much of this happens within a framework of foot, bicycle and public transport access and travel distances are much shorter, it is not hard to see how it all adds up to a much lower transport energy lifestyle.

Stockholm in particular showed us what can be done when land use planning and transport planning are sensibly integrated. To accommodate its growing population after the Second World War, Stockholm embarked upon an ambitious programme of satellite or new town developments based around an extensive subway system. These towns consist of high rise apartment buildings, medium rise, walk up style apartments of three or four storeys, single and two storey cluster houses and single family dwellings. Densities are highest around the subway stations with the lower density housing scattered further away. There are thus a large proportion of people who can walk or ride a bike to the subway and for those further away, there are extensive feeder bus systems with bus/rail exchange terminals. Each town has its own central area with a good supply of local shops, entertainment and other facilities such

as libraries, community centres, and "free time" areas which have trained staff to assist young and old people with various arts and crafts. In some cases there are even small farms where children are taught about caring for domestic and farm animals.

The emphasis in these towns is on foot and bicycle movement. The town centres are pedestrianised and are usually based around a central square or plaza where a regular summer market is set up. Three- and four-storey apartments face onto the square. The residential areas, subway stations and other urban facilities are knitted together with extensive cycleway/walkway systems. Bicycle racks are seen everywhere, and near the subway stations and central areas they are always full of bikes. Motorised traffic and pedestrian/bicycle traffic is totally segregated. The roads tend to be in cuttings with small bridges crossing them at regular intervals.

Again, the common sense in this type of development is seen when one gazes from the town centre at the surrounding wide open spaces. Southern Sweden is a land of small lakes and coniferous forests and with just a short bicycle ride from the town one can be right in these natural areas.

One of the ideas behind the development of these new towns was that people should live and work in the local area as well as find a reasonable proportion of their other needs in the local facilities. To a great extent this has been achieved. However, the old centre of Stockholm is still a large magnet in terms of employment, and planners knew they could never duplicate the magic of Stockholm's mediaeval centre in any satellite town. Thus, old Stockholm remains the major historical, cultural, business and entertainment focus of the city, and the subway is the most convenient way of getting there. None of the satellite areas are more than about 25 minutes away on the subway system.

With the need to use a car kept to a minimum, it is not difficult to see how Stockholm's planners have succeeded in building strong transport energy conserving characteristics right into the fabric of the city.

AMERICAN CITIES

Moving straight from Europe to New York, it was interesting to see some of these same elements in a city which has the lowest per capita transport energy use of all the major US cities.[22] We stayed in a neighbourhood called Brooklyn Heights, a part of New York City, just over the East River on the doorstep of Manhattan. The area consists of four to six storey brownstone apartments, and a seemingly endless variety of shops and small businesses at street level – all mixed together. This was a genuine walking neighbourhood. Our friend from Perth who has lived there eighteen years has never owned a car and never needed to. She walks to work and to most other activities and catches subways and buses for everything else. This is the rule rather than the exception in this area.

We arrived about 9.00 pm and the street was alive with people walking to the many eating places, sitting alongside their apartments talking with neighbours and friends or going to look at the magnificent Manhattan skyline. Socially, Brooklyn Heights is like a small country town where people call each other by first names on the street and in the shops. Its residents enjoy the friendly, diverse and secure atmosphere of their local community, while being only a short subway ride from the excitement, opportunity and entertainment of the world's most immense central city. Certainly not all parts of New York City are like Brooklyn Heights. But car ownership is lower in New York City at all income levels, than anywhere in the USA.[23] So in some sense Brooklyn Heights is a caricature of the sort of lifestyles possible in this dense urban area. We can understand even further why this area should have such low per capita transport energy when it is realised that New York City (essentially the inner city area of the New York Metropolitan Area) had a population of 7 072 000 people in 1980 and an urbanised land area of only 66 220 ha. The entire urbanised area of Perth in 1976 was 67 300 ha but Perth only had a population of 820 100 (i.e. the density of New York City is about 107 people per ha or nearly nine times that of Perth).

Compared to other US cities, however, New York is an exception in just about every avenue of urban life. In most US cities one or two cars per household is virtually compulsory. We were plunged radically into a more typical American urban lifetyle when we moved to Boston and stayed with friends in an exurb 30 miles from downtown Boston. The daily routine revolved around getting to and from the city – about an hour each way. Up at 5.00 am, hurried breakfast, out to the car and before sunrise, be on the freeway heading downtown at a frenetic pace to avoid the 6.30 am traffic crush. Evening was similar as we had to leave the city no later than 4.00 pm for fear of being stuck for hours.

This style of life is becoming more and more common in the United States as people depopulate the large urban centres, particularly on the east coast, in preference for a small rural or semi-rural town on the urban fringe, as far away from the inner city as possible. The motives for this lifestyle in the US seem to be primarily a quest for the wide open spaces, the safety of a good neighbourhood (as opposed to the high crime neighbourhoods characteristic of the majority of US inner cities), good schools for families with

children, and, of course, cheaper housing. Quite clearly however, one of the big costs in this style of life is a high petrol bill because most people still depend very strongly on the established urban centres for many services, facilities and also employment, and the only way to get there is by car.

Reflecting on this after fifteen weeks in convenient, spacious (and safe) European cities, it was difficult not to feel a little awry at the paradoxes built into this kind of living. There we were, 30 miles from Boston in the wide open spaces and almost no time to appreciate it because we were forever in a car needing to be somewhere else.

It would seem that the very least a city should offer its residents is affordable, convenient access to work and open space, a good level of personal safety and security for property and sound educational institutions at all levels. A trend has been set in the United States however, where families are being forced to seek most of these qualities further and further from the established urban area, but in a sense are being defeated in this search on nearly all levels. They are achieving neither the convenience, diversity and excitement of city life, nor the solitude and peace of rural life, but are spending a lot of time and energy frantically trying to knit together elements of both, in a sort of suburban no-man's land.

Quite clearly Australian cities do not suffer from the same inner city crime problem as US cities and we tend to have a mixture of high and low income inner city areas. In the US the general rule is that the poor inhabit the very rundown inner city and the wealthy live in the suburbs. On the other hand, it is undeniable that we are inheriting the same pattern of explosive outward growth, and as a consequence, our urban areas are becoming scenes of "disintegration" rather than "integration". In Perth in particular, massive investments are being made in motorised transport (especially new roads and freeways) simply to overcome the inefficiencies in the placement and density of activities. There is quite clear evidence (see later), that in all aspects of urban life, people are having to travel further and further to achieve the same end. This trend does not augur well for transport energy conservation. We don't seem to have learned that transport is not an end in itself but a means of obtaining access to urban services. In any urban system the aim should be to minimise transport because access is best achieved by strategic articulation of activities that maximises foot and bicycle access, or at least concentrates activities enough to make public transport a viable mode.

To have any hope of coming to terms with these issues I believe we have to first of all start thinking creatively about the meaning and potential of city life. This must inevitably involve some sort of urban containment or consolidation policy so that the proximity between people and urban facilities is maximised. The review of Perth's corridor plan and the decision to electrify the suburban rail network are golden opportunities to set this process in motion. However much we would like to think otherwise, these issues and our own associated lifestyles are fundamental to any attempts at lowering the very high cost and consumption of transport energy now characteristic of Australian urban life, and, in particular, Perth.

To some extent we can try to tackle these lifestyle issues on an individual basis. We can ask ourselves, how can I change my lifestyle so that I use less petrol? This is an approach my wife and I have taken on several occasions. The next section is provided to highlight some of the problems one can encounter in trying to tackle the issue at this level in a city like Perth.

CHANGING OUR LIFESTYLE FOR LOWER TRANSPORT ENERGY USE: SOME PERSONAL EXPERIENCE IN PERTH

Returning from overseas we were determined to try and make do with one car and to use public transport as much as possible. Our enthusiasm was defeated within four months. We were beaten by the basic structure of Perth. Being just too far out of reach of a comfortable walk to Swanbourne railway station, I would take the car to the highway to pick up a bus to Fremantle. Lack of good bicycle facilities at the railway station made leaving an expensive bike for ten hours an unattractive proposition. The highway bus also linked in better with the Murdoch bus at Fremantle in the morning. My wife, who needed the car at home, would have to ride to the highway on her bike, put the bike in the back, drive home and have a shower before going out.

Coming home from Murdoch would involve very exacting manoeuvres to be at the bus stop on time to get the "every half-hour" bus to Fremantle. When not convenient, I would get understanding friends to go out of their way to drop me at the railway station at Fremantle. With a little more time to spare coming home, I would make a dash to catch the train at Fremantle and either walk from Swanbourne station or make a phone call to be picked up. All this was very arduous, complicated and time consuming. A 20 to 25 minute car trip became a 45 to 55 minute, jogging, driving, dashing public transport trip. The quality

of suburban trains was also infuriating – snail-like acceleration, noisy, smoky and rundown. This was all too much after the swift, frequent and efficient European subways and light rail systems.

We caved in, bought a second car and in the meantime started the search for a better location to purchase a dwelling. Como seemed like a good proposition. A 30-minute cycle ride would get me to Murdoch and some of it was along a cycleway. Como was also well situated in relation to the central city. The idea never quite fell into place however. It was Como's suburban character that deterred us. Where were the street cafes? Where were the walking scale environments and the intensive mixed activities?

Much searching was done in and around Fremantle, but trying to buy the right property at the right price in the right location for getting the bus proved more difficult than we thought. Coming in on the crest of a real estate boom and after 11 or 12 years of fairly steady renovation of many of the best located properties made things even more difficult and expensive. It seems that there are more people in Perth seeking inner city lifestyles than the planners recognise! Of course anything that is said about Fremantle can be said doubly about the Subiaco/Shenton Park area, which is another area that was considered, but was far too expensive.

The next stage we thought of was trying to find a very small block of land (305 square metres or the old 1/12 of an acre was all we wanted) and building a house. Apart from the scarcity and price of blocks of land of this size in and around Fremantle, there was of course the high cost of construction and fitting-out compared to buying a similar, already established dwelling. In terms of buying a small block in a cheaper, less popular area or in a new land development in a well-located middle suburb, one is confronted with the reality that these size blocks are simply not provided anymore. It appears also from other subdivisions in Perth where attempts have been made to provide somewhat smaller blocks than usual, that the prices are not commensurate with their smaller size. When it is considered that much of the highly sought after and expensive property in Cottesloe, Subiaco and Fremantle is built on the old 1/12 acre blocks, it is frustrating that there is not more of these style developments today. It is in fact these small block sizes with dwellings still suitable for families, that give many of Perth's inner areas their compact, human scale and their density which is three times the Perth average. It is at these densities where one can start to have a hope of living a more energy efficient lifestyle. The key is to make such a lifestyle choice more available and in so doing make the prices within the reach of more people.

The point of this is to demonstrate how individual commitment to a more energy efficient and urban style of living can be thwarted at every turn by a system that is geared overwhelmingly to the private car and the large suburban subdivision. There are some things which simply must be tackled at a higher level (i.e. urban planning) so that individuals have the flexibility to manoeuvre within the established framework. At the moment Perth is sadly lacking in this facility.

Through a detailed transport energy analysis of Perth, an attempt will now be made to show why it is so important for transport energy conservation that more opportunities are made for people wishing to locate within the established inner and middle suburbs. This will then be followed by an outline of the general directions Perth needs to consider in trying to lower its transport energy use.

TRANSPORT ENERGY USE IN THE PERTH METROPOLITAN REGION

Using the Perth Region Travel Surveys of 1976, estimates were made of the per capita transport energy use in thirty-eight zones comprising the Perth metropolitan area.[24] These zones were made up of between one and three postcode areas. The thirty-eight zones were divided into inner, middle and outer suburbs based on their distance from the Perth and Fremantle CBDs (areas up to 6.9 km were classed as inner suburbs, 7.0 to 12.9 km middle suburbs and 13.0 km or more were called outer suburbs). Figure 1 shows each of the thirty-eight zones and their respective classification as inner, middle and outer areas. Yearly transport energy costs were also calculated based on an already outdated 48 cents per litre. Tables 1, 2 and 3 present the results for the three suburban groupings. For each zone the tables show three categories of energy use, (1) annual energy use and cost per worker for work trips, (2) the annual energy use and cost per worker (all trips made by working people) and (3) the total annual energy use and cost per person (i.e. all trips by all people five years old and over). Each zone is compared to the overall average for Perth. An average energy use and cost for the inner, middle and outer suburban groupings is also shown, along with how it compares to Perth overall. Whilst Tables 1, 2 and 3 show mean energy values per person in each zone, it should be pointed out that the sample size within each zone and category of energy use is comparatively small. Standard deviations in some zones are equal to or even slightly greater than their respective means. Much larger samples would be needed to reduce this variability. Despite this problem there are certain obvious trends within the data, which provide a meaningful picture of differences in transport energy use throughout Perth.

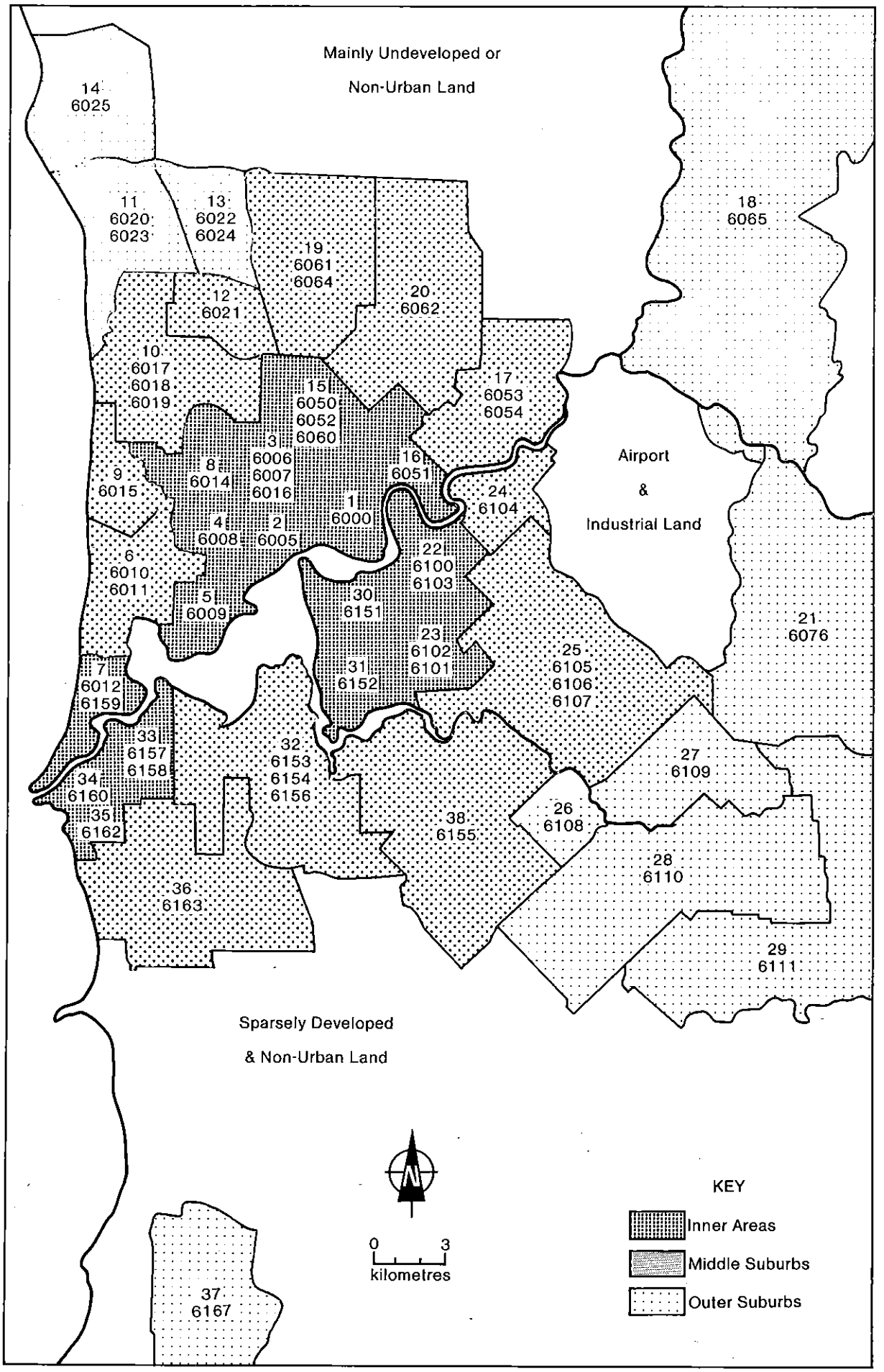

Figure 1. The thirty-eight zones used for energy calculations.

Table 1 Estimated Annual Transport Energy Use and Cost Per Person in Perth's Inner Areas

ZONE NUMBER, POSTCODE AND SUBURB	ENERGY USE PER WORKER FOR WORK TRIPS (L/year)	ANNUAL COST $ (48c/litre)	PROPORTION RELATIVE TO PERTH AVERAGE	ENERGY USE PER WORKER (L/year)	ANNUAL COST $ (48c/litre)	PROPORTION RELATIVE TO PERTH AVERAGE	TOTAL ENERGY USE PER PERSON (L/year)	ANNUAL COST $ (48c/litre)	PROPORTION RELATIVE TO PERTH AVERAGE
1. 6000 Perth, East Perth, Highgate	572	275	0.85	1208	580	0.83	836	401	0.96
2. 6005 West Perth	(428)*	(205)	(0.63)	(1854)	(890)	(1.28)	(1259)	(604)	(1.44)
3. 6006, 6007, 6016 North Perth, Leederville, Mt. Hawthorn	433	208	0.64	1015	487	0.70	638	306	0.73
4. 6008 Subiaco, Shenton Park, Daglish	312	150	0.46	855	411	0.59	615	295	0.70
5. 6009 Nedlands, Dalkeith, Crawley	667	320	0.99	1415	679	0.98	878	421	1.00
7. 6012, 6159 Mosman Park, North Fremantle	457	219	0.68	1128	541	0.78	905	435	1.04
8. 6014 Wembley, Jolimont, Floreat	487	234	0.72	1268	609	0.88	825	396	0.95
15. 6050, 6052, 6060 Mt. Lawley, Menora, Inglewood, Bedford, Yokine, Tuart Hill	448	215	0.67	974	467	0.67	734	352	0.84
16. 6051 Maylands	444	213	0.66	1118	537	0.77	958	460	1.10
22. 6100, 6102 Victoria Park, Rivervale	489	234	0.72	1072	514	0.74	657	315	0.75
23. 6101, 6102 East Victoria Park, Carlisle, Bentley, St James	480	231	0.72	852	409	0.59	566	272	0.65
30. 6151 South Perth, Kensington	618	297	0.92	1558	748	1.07	939	451	1.08
31. 6152 Como, Manning	742	356	1.10	1374	659	0.93	955	458	1.09
33. 6157, 6158 Bicton, Palmyra, East Fremantle	613	294	0.91	1155	554	0.80	611	293	0.70
34. 6160 Fremantle	515	247	0.76	1182	567	0.81	551	265	0.63
35. 6162 Beaconsfield, White Gum Valley	370	177	0.55	559	268	0.39	690	331	0.79
Average for Inner Areas	500L	$240	0.74	1034L	$496	0.71	737L	$354	0.84
Average for Perth	672L	$323	1.00	1451L	$696	1.00	873L	$419	1.00

* Note: Figures in brackets not included in average for inner areas due to small sample size.

Table 2 Estimated Annual Transport Energy Use and Cost Per Person in Perth's Middle Range Suburbs

ZONE NUMBER, POSTCODE AND SUBURB	ENERGY USE PER WORKER FOR WORK TRIPS (L/year)	ANNUAL COST $ (48c/litre)	PROPORTION RELATIVE TO PERTH AVERAGE	ENERGY USE PER WORKER (L/year)	ANNUAL COST $ (48c/litre)	PROPORTION RELATIVE TO PERTH AVERAGE	TOTAL ENERGY USE PER PERSON (L/year)	ANNUAL COST $ (48c/litre)	PROPORTION RELATIVE TO PERTH AVERAGE
6. 6010, 6011 Claremont, Graylands, Swanbourne, Cottesloe, Peppermint Grove	707	339	1.05	1520	729	1.05	975	468	1.12
9. 6015 City Beach	534	256	0.79	1183	568	0.82	824	396	0.95
10. 6017, 6018, 6019 Osborne Park, Woodlands, Innaloo, Doubleview, Karrinyup, Scarborough	578	277	0.86	1092	524	0.75	695	334	0.80
12. 6021 Balcatta, Gwelup, Stirling	626	300	0.93	1444	693	1.00	914	439	1.05
17. 6053, 6054 Bayswater, Bassendean, Eden Hill, Lockridge	796	382	1.18	1388	666	0.96	797	383	0.91
19. 6061, 6064 Nollamara, Balga, Girrawheen, Koondoola	874	420	1.30	1540	739	1.06	803	386	0.92
20. 6062 Dianella, Morley, Embleton	706	339	1.05	1688	810	1.16	958	460	1.10
24. 6104, 6105 Belmont, Redcliffe, Cloverdale, Kewdale	558	268	0.83	1501	720	1.03	884	424	1.01
25. 6106, 6107 Welshpool, Queens Park, Cannington, Beckenham, Kenwick	727	349	1.08	1712	822	1.18	955	458	1.09
32. 6153, 6154, 6156 Applecross, Mt. Pleasant, Ardross, Booragoon, Myaree, Alfred Cove, Attadale, Willagee, Melville	553	265	0.82	1075	516	0.74	580	278	0.66
36. 6163 Hamilton Hill, Spearwood, Coolbellup, Hilton, Kardinya	547	262	0.81	1364	655	0.94	795	382	0.91
38. 6155 Riverton, Shelley, Rossmoyne, Willetton, Lynwood, Ferndale, Langford	783	376	1.16	1330	638	0.92	880	422	1.01
Average for Middle Suburbs	673L	$323	1.00	1356L	$651	0.94	823L	$395	0.94
Average for Perth	672L	$323	1.00	1451L	$696	1.00	873L	$419	1.00

Table 3 Estimated Annual Transport Energy Use and Cost Per Person in Perth's Outer Suburbs

ZONE NUMBER, POSTCODE AND SUBURB	ENERGY USE PER WORKER FOR WORK TRIPS (L/year)	ANNUAL COST $ (48c/litre)	PROPORTION RELATIVE TO PERTH AVERAGE	ENERGY USE PER WORKER (L/year)	ANNUAL COST $ (48c/litre)	PROPORTION RELATIVE TO PERTH AVERAGE	TOTAL ENERGY USE PER PERSON (L/year)	ANNUAL COST $ (48c/litre)	PROPORTION RELATIVE TO PERTH AVERAGE
11. 6020,6023 Trigg, North Beach, Carine, Waterman, Marmion, Duncraig	801	385	1.19	2006	963	1.38	1133	544	1.30
13. 6022, 6024 Hamersley, Warwick, Greenwood	852	409	1.27	1887	906	1.30	1228	589	1.41
14. 6025 Hillarys, Padbury, Craigie, Kallaroo, Mullaloo	1196	574	1.78	2236	1074	1.54	1489	715	1.71
18. 6056 Midland, Bellevue, Middle Swan, Swanview, Greenmount	737	354	1.10	1685	809	1.16	1084	520	1.24
21. 6076 Kalamunda, Lesmurdie, Gooseberry Hill	1115	535	1.66	2444	1173	1.69	1232	592	1.41
26. 6108 Thornlie	851	409	1.27	1329	638	0.92	864	415	0.99
27. 6109 Maddington, Orange Grove	836	401	1.24	1414	679	0.98	888	426	1.02
28. 6110 Gosnells, Huntingdale	973	467	1.45	2185	1049	1.51	1265	607	1.45
29. 6111 Kelmscott, Roleystone	1181	567	1.76	2260	1085	1.56	1228	589	1.41
37. 6167 Orelia, Kwinana, Medina, Calista	888	426	1.32	1839	883	1.27	906	435	1.04
Average for Outer Suburbs	937L	$450	1.39	1871L	$898	1.29	1164L	$558	1.33
Average for Perth	672L	$323	1.00	1451L	$696	1.00	873L	$419	1.00

The tables show that inner area residents have considerably lower energy use than the average for Perth, while outer area residents pay comparatively heavy energy penalties for their location. From Table 1, total energy use per person in inner areas is 16%, lower than the average for Perth, while for workers it is 29% lower. For work trips only, workers in inner areas use 26% less energy than Perth workers overall. This is in sharp contrast to the outer suburbs where total energy use, and hence expenditure on petrol, is 33% higher than the Perth average. In these areas energy use by workers is 29% higher and for work trips only is 39% higher than for Perth as a whole. The middle suburbs, as might be expected, are close to the Perth average being only 6% lower in total energy and energy use per worker and equal to the Perth average in energy use per worker for work trips. These differences are summarised in Figure 2.

Comparisons between inner and outer areas show that there are large differences in expenditure on petrol within the Perth region. In the inner areas, the estimated average expenditure per person on transport energy is $354 while in the outer areas it is $558 (58% higher). For total travel by workers, and specifically their work trips, the differences are even more pronounced; outer area workers are estimated to pay approximately $900 per annum for petrol each year while working people in inner areas pay around $496 or nearly half. For work trips alone, inner area workers pay on average $240 a year on petrol while outer area workers pay $450. In inner, middle and outer areas, however, the ratio of work trip expenditure to total annual petrol expenditure by workers is almost constant at about 50%.

The following detailed points are of interest:

- In terms of total energy use per person, Fremantle (postcode 6160) appears to be the lowest transport energy area in the Perth region, with residents spending an average of $265 each per year on petrol. This is 37% less than the average for Perth and 2.7 times lower than the heaviest transport energy area, postcode 6025, incorporating Hillarys, Padbury, Craigie, Kallaroo and Mullaloo. People in these northern areas are estimated to spend, on average, $715 each year for petrol (including children five and over).

- For an average household in Fremantle with 2.5 people/house (not including those under five), the annual cost for petrol is $663, while an average household in Hillarys with 2.8 people/house the annual cost is $2002. The average for Perth overall is $1131 per household.

- For energy use per worker, postcode 6162 (Beaconsfield, White Gum Valley) appears to be the lowest, being 61% less than Perth workers overall. Workers in the Beaconsfield/White Gum Valley are estimated to spend about $268 each per year on petrol while in the Kalamunda/Lesmurdie area (postcode 6076), the highest energy use area for workers, the figure is $1173 or nearly 4½ times more.

- In the category of energy use for work trips, the lowest area is postcode 6008, covering Subiaco, Daglish and Shenton Park. The average annual expenditure on petrol for work trips in this area is estimated to be $150 per worker whereas in the Hillarys/Mullaloo area it is $574 or almost 4 times more. The Subiaco/Shenton Park figure is also less than half the estimated average expenditure for work trips by workers in the metropolitan area.

- In the middle suburban grouping (Table 2), the rather large, mixed socio-economic area (Zone 32) comprising postcodes 6153/4/6, has surprisingly low energy use per capita in all categories, relative to its average distance from the Perth CBD. The suburbs include high income areas like Applecross, Mt Pleasant and Booragoon and lower income areas such as Willagee and Myaree. For work trips the energy use per worker is 18% below the Perth average, energy use per worker is 26% less than Perth overall, and total energy use per person is some 34% below the Perth average.

  A number of factors may contribute to this situation. (1) The area is located midway between Perth and Fremantle with good access to both centres by bus. (2) A 1976 social atlas of Perth[25] shows that the area is one of high familism (a large proportion of households have children) which tends to reduce the total per capita energy term. However, this is not any higher than most outer suburbs. (3) The area has good access to blue collar employment areas in Myaree and O'Connor. (4) It is well situated for recreation, having over 14 km of river foreshore within its boundaries. (5) It has one of the largest regional shopping and office complexes located close to its geographic centre (Garden City, Booragoon). (6) The area has Perth's second university located within its borders, and (7) Canning Highway, which runs for nearly 7 km through the area, contains a good mixture of urban functions. These factors combined appear to lead to shorter trip lengths and hence lower energy use for people living in these suburbs.

- Zone 19 in the middle suburbs (Table 2) covering the low socio-economic suburbs of Nollamara, Balga, Girrawheen and Koondoola (postcodes 6061 and 6064) shows much higher than average

energy use for work trips; it is 30% higher than the Perth average and the average for the middle suburbs. The centroid of the zone is almost 11 km from the Perth CBD and two-thirds of the zone lie adjacent to an outer area. Hence much of Zone 19 is akin to the outer suburbs, and this factor appears to contribute strongly to the high energy use for work trips. However, there is certainly nothing like the same quality and variety of nearby blue collar work places, commercial and educational centres or recreation sites as in Zone 32. There are obvious equity implications in this sort of urban development.

- Zone 5 (Table 1), comprising the high socio-economic suburbs of Nedlands, Dalkeith and Crawley is the closest to the Perth average in all categories of energy use. The effect of higher income increasing energy use (see later) appears to be somewhat offset by the area's prime location close to the city centre (approximately 6.5 km), and its proximity to educational institutions, recreational opportunities (especially the river) and a diverse range of local shopping and entertainment areas. Compared to the other areas in Table 1 however, Zone 5 is one of the higher energy use inner suburbs.

- Referring to Table 3 it can be seen that all the extreme outer areas in Perth , namely the northern suburbs like Mullaloo/Padbury (6025), the Kalamunda/Lesmurdie area (6076) and the Kelmscott/Roleystone area (6011), have very high energy use in all categories relative to the averages for Perth. These areas range from 66% to 78% more in work trip energy per worker, 54% to 69% in energy use per worker and in total energy use per person, between 41% and 71% higher than Perth as a whole.

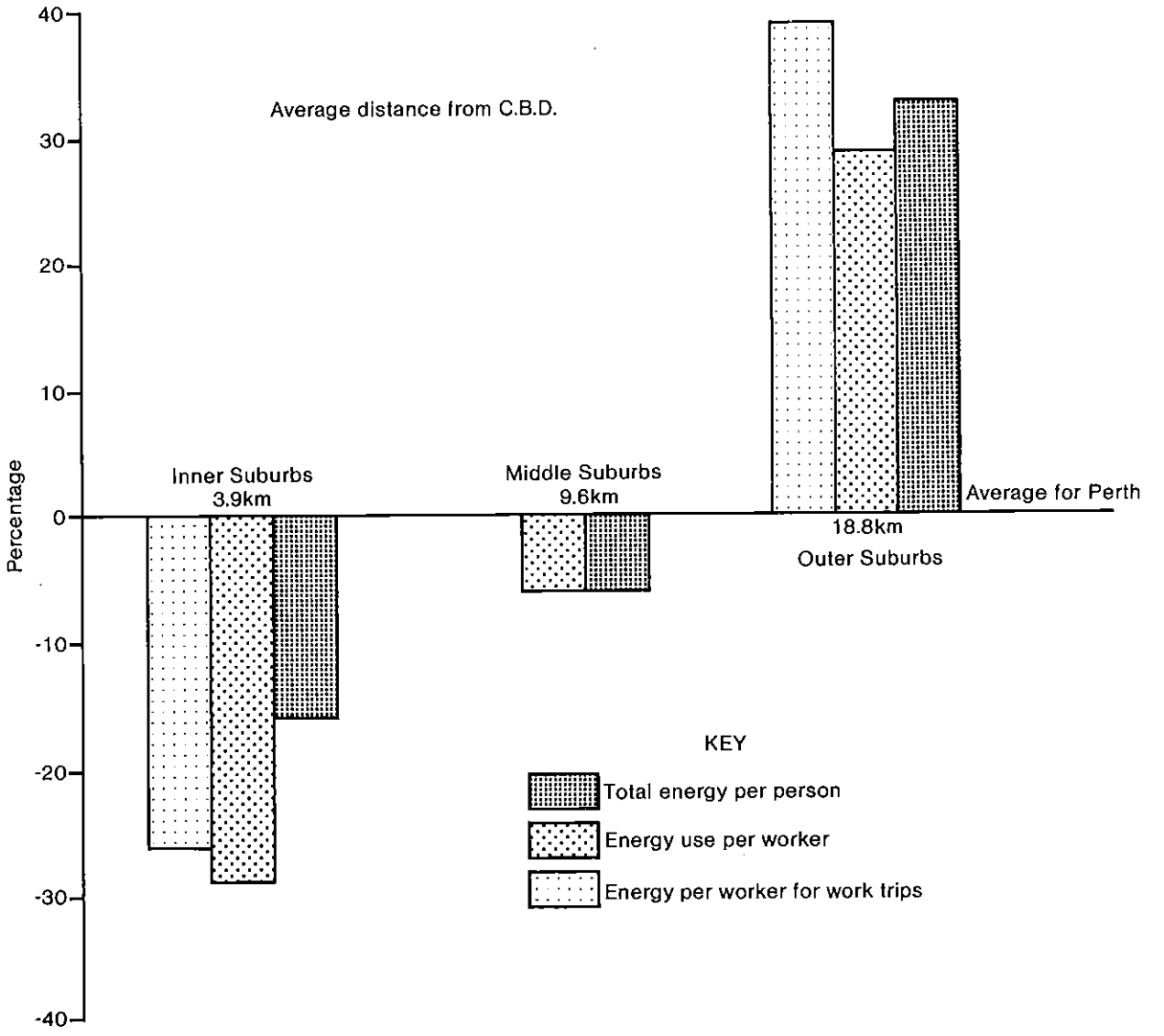

Figure 2. Transport energy use in Perth's inner, middle and outer areas in relation to the Perth average.

However, the Midland/Greenmount area (6056), which is about the same distance from the CBD as the above areas (*c.*20 km), has the lowest energy use for work trips of all the outer areas (only 10% higher than the Perth average). This suggests that the Midland sub-regional centre and surrounding businesses and industries are providing a significant level of local employment for residents, whereas in comparable outer areas, residents have to travel much further for work. With reference to total energy use, which is 24% higher than the Perth average, it appears that for most trips (recreational, social, business, etc.) the advantage of Zone 18 over similar outer areas is reduced, i.e. although there is work in this sub-centre, it is low in the social and recreational facilities.

Detailed investigations were made into the factors contributing to these patterns of transport energy use in Perth. These were pursued through a series of regression analyses with some important socio-economic, land use and transport variables. Detailed results of these analyses have been published;[3] however, the following points serve to summarise the results:

(1) Higher household income was found to be associated with higher energy use to only a comparatively minor extent, i.e. it could in no way explain the marked pattern of increasing transport energy use from inner to outer areas. Quite clearly locational and land use factors were the prime determinants of the patterns involved.

(2) The most important factor examined was the distance of each zone from the CBD. It was shown that this factor embodied many of the other variables in the analysis such as the density factors and the decreasing use of public transport, walking and bicycling from inner to outer areas. It also incorporated the fact that Perth is still fundamentally oriented towards its central and inner areas for employment opportunities (e.g. The Director General of Transport showed that in 1976, 83% of all jobs were located in the urban core, an area about 8 to 10 km radius around the Perth CBD). However, it appeared that the strength of the CBD distance variable in explaining energy use was due to something on top of all these factors. This additional factor seemed to be related to "interspersion" or the extent of mixed land use in the inner areas, compared to the more rigidly zoned areas of the middle and outer suburbs.

    The greater interspersion of urban acitvities in older areas is seen to some extent in average distance to shops. A survey of two inner and two outer low income suburbs in Perth found the average distance to a delicatessen in the inner areas was 0.8 and 0.7 km, while in the two outer areas it was 2.1 and 3.4 km (2½ to 5 times more distant).[26] The equity implications in this are very clear as the inner suburb delis are within walking distance but the outer suburb delis would require motorised transport.

(3) As mentioned earlier, the sprawling pattern of urban growth characteristic of Perth is responsible for increasing the travel distances of all trips. This is seen in an analysis carried out on the average trip lengths by all modes for various purposes in the inner, middle and outer suburbs. The results are summarised in Figure 3 and show how, in each case, trip lengths for each purpose increase from inner to outer areas. Perth cannot realistically expect to start reducing its transport energy use while this pattern of increasing trip lengths is allowed to continue into the future as the city grows at the fringes.

This transport energy analysis of the Perth Metropolitan Region has clearly pointed up a need to promote an urban consolidation policy where future growth in the city's population is directed towards the central and inner areas at higher densities and with greater mixed land use. It has shown that Fremantle appears to offer a model of the low energy city with its high density, mixed land use and full range of urban facilities. The other sub-regional centres, as presently developed, are for the most part ineffective at reducing energy use, apart from Midland where there are some benefits in the work trip, Quite clearly, our sub-regional centres must become genuine high density, mixed development nodes if they are to be in any way effective in reducing transport energy use.

The Booragoon area appears to be developing into a *de facto* sub-regional centre with unusually low per capita transport energy use. An obvious conclusion from this would be that consideration be given to some innovative higher density mixed land use development projects on the vacant land remaining in the area. This could include some Homeswest residential developments to help offset the negative equity implications of high per capita transport energy use in Homeswest areas such as Balga, Girrawheen and Koondoola. These are clearly bad locations for people who feel the impact of high petrol costs much more than those on higher incomes.

The land use planning implications of the Perth transport energy analysis will be pursued in greater detail in the conclusions to this paper. However, before leaving this analysis, it is important to specifically

discuss another fundamental issue which emerged from the study. This issue is related to transportation planning policy in Perth and revolves around the oft-cited fact that Perth has the best and most free-flowing traffic system in Australia and thus wastes a minimal amount of fuel in unnecessary stops and idling periods.

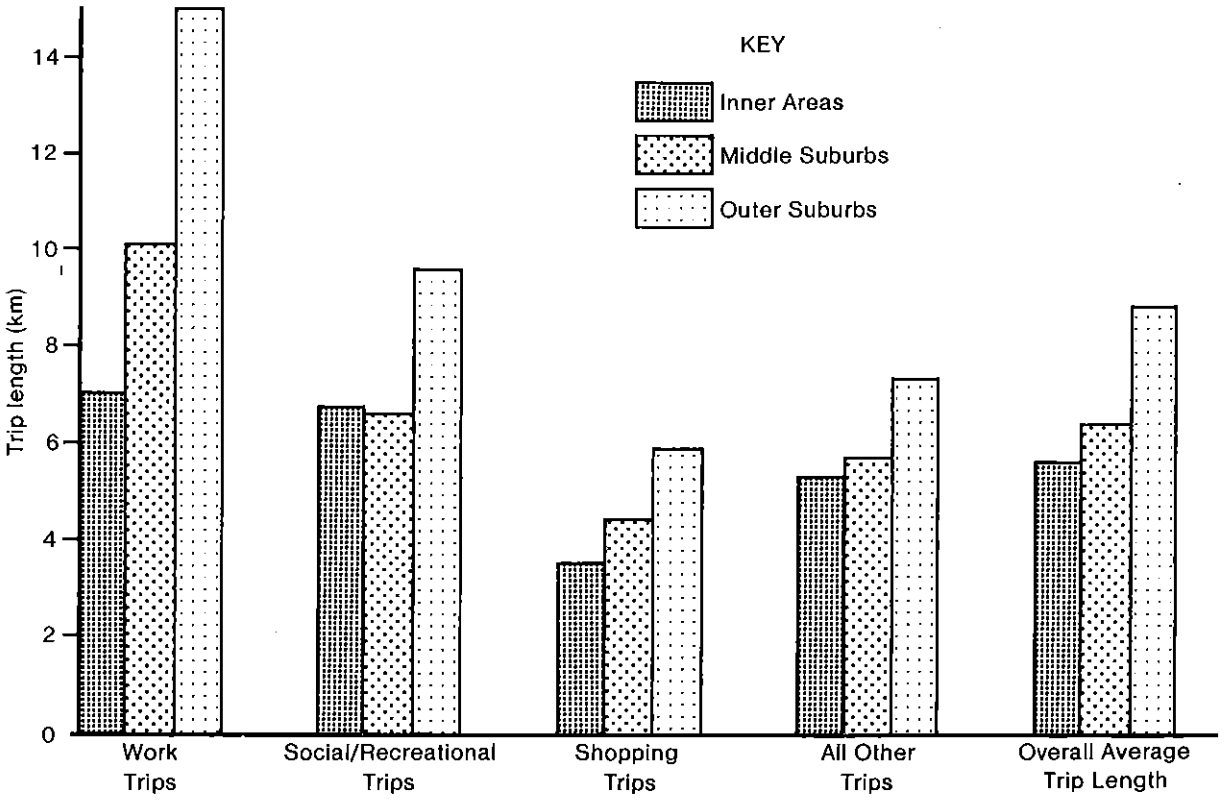

Figure 3. Average trip lengths in Perth's inner, middle and outer suburbs.

TRANSPORT ENERGY CONSERVATION AND EASING CONGESTION TO SAVE FUEL

Another very important finding of this study was the effect of traffic congestion on transport energy use. Built into the study's methodology was a way of adjusting the energy consumption of each trip according to its average speed. Average speed has been found to be the major single traffic determinant of vehicular fuel consumption on any trip.[27] Therefore energy use was increased for trips at low average speed (congested conditions) and decreased for high average speeds (free-flowing conditions), according to a relationship developed for Murdoch University's computer-instrumented Commodore sedan.[28]

The results of this analysis clearly showed that the average fuel consumption of vehicles operated by residents in the extreme outer suburbs was considerably lower than the Perth average (*c.* 12%), while for vehicles operated by residents of the most central areas, the fuel consumption was much higher than the Perth average (*c.* 18%).[29] These figures do not correspond to inner and outer areas as shown in Figure 1, but to the central core section of the inner areas and the furthest outer suburbs such as Kelmscott and Greenmount, etc.

These fuel consumption patterns are due to much better average trip speeds for residents in outer areas compared to the lower average speeds for trips by residents of the more congested inner areas. However, as has been seen in the overall per capita energy use analysis, this factor of better vehicular fuel consumption in outer areas is completely swamped by the extra travel involved, so that the extreme outer area residents in fact use 30% more total transport energy per capita than the Perth average. In the case of central area residents, although they have much higher fuel consumption per kilometre in their vehicles, they have on average 23% lower total transport energy use due to shorter distances and greater use of public transport, bicycling and walking.

This has significant policy implications when it is considered that the smoothing of traffic flows and raising of average speeds through the building of new roads is partly justified on energy conservation grounds (fuel savings of new roads are calculated using computer models and translated into economic

benefits). The results of this study would suggest that easing congetion does in fact generally increase fuel use due to its effect on model changes and greater urban sprawl. This is an important conclusion for Perth where ambitious road plans are still being pursued. It is therefore worthwhile expanding the idea with some additional studies we have done in this field.

A number of corridor-based studies have consistently supported the idea that easing congestion increases fuel use rather than reducing it. For example, it was found that the potential modal shift from buses and trains to cars in the Armadale corridor if traffic congestion were "significantly reduced or eliminated", could be enough to more than exceed the estimated fuel savings from the computer coordinated traffic signals along Albany Highway and Manning Road.[30] And yet, these issues of changes from public transport to cars and the possibility of extra generated travel when the traffic is freed up or new roads are built, are not considered in the assessments of benefits from the new scheme.

Another study of bus patronage in the corridors, where freeways are the major transport spines, demonstrated that patronage on the bus services associated with freeways has shown a marked downward trend over the past few years. This is in comparison with many inner suburban routes where patronage over the same period has shown significant increases.[31]

A study of the fuel and time implications of freeway speed limits in Perth indicated that optimal fuel efficiency occurs at cruise speeds of 55 km/h.[32] Increases in the speed limit above 80 km/h involve progressively greater fuel penalties of up to 31% at 110 km/h for an 8 km length of freeway. Our investigation into driving patterns in Perth during 1980 to 1983, found that Perth already has over a third of its daily travel at speeds above this optimal speed of 55 km/h.[33] Using some simulated urban trips under controlled cruise conditions it was found that average speed alone is actually a misleading criterion, even in assessing the energy efficiency of a road system *per se*. This is because higher average speeds are often achieved by merely increasing the potential for higher cruise speeds between stops. Thus two trips can have the same average speed with very different fuel economy, i.e. one trip achieves its average speed by higher cruise speeds to offset idle periods and has much poorer fuel economy than a trip which has low cruise speeds but fewer stops and idle periods.

It was shown that policies which encourage further increases in cruise speeds such as increasing speed limits, freeway building and road widening will be counter-productive for energy conservation. On the other hand, policies that minimise stops and idling periods while keeping cruise speeds close to 55 km/h will save fuel. This means that for energy conservation, roads and signal systems should be designed to encourage such low travel speeds between fewer stops and shorter idle periods. Policies that seek to achieve a "blanket" increase in average speeds by increasing cruise speeds (e.g. raising speed limits), will clearly be counter productive in energy terms.

The conditions under which a policy of constrained cruise speeds might be more practicable would most likely include: (1) Higher traffic levels along arterial roads with computer-linked traffic signals. It has already been shown in Perth that the conditions under which computer co-ordination of traffic signals work best are peak periods of high volume traffic flows.[34] (2) A more compact urban form such as that found in most European cities and in the inner areas of most Australian cities. Travel distances in these places are much shorter and more suitable to a reduction in cruise speeds. Higher density activity also means more intensively used roads which lower cruise speeds; if at the same time stops can be lowered it would lead to better fuel efficiency. As already explained, high density areas are also fundamentally lower in their use of transport energy because of greater walking, cycling and public transport and short trip lengths. It may therefore be possible to optimise land use and traffic systems as far as energy conservation is concerned, by pursuing the same policy of increased concentration of urban activity.

Certainly one can find many other studies which support these general observations. For example, Los Angeles has a much freer flowing traffic system than New York (1971 system average speed of 44.1 km/h compared to 33.8 km/h in New York),[35] but Los Angeles' per capita gasoline consumption was, in 1970, some 76% higher than New York.[36] The difference is that New York is a highly centralised city with a very dense inner area and an extensive, well-used public transport system, while Los Angeles is a largely shapeless urban sprawl with almost no public transport.

In summary, what we can say about all these studies is that there are no grounds at all to suggest that smoother, faster flowing traffic is promotive of transport energy conservation overall. Certainly, the fuel efficiency of individual vehicles is improved but the benefits of this are totally swamped by more fundamental factors – the orientation of the city away from public transport and strong centres which results in more and more compulsory car travel and ever increasing trip lengths.

The importance of these more fundamental factors can be seen even more clearly in the next section which provides a brief comparison of transport energy in the Sydney metropolitan area with the results of Perth's transport energy analysis.

TRANSPORT ENERGY USE IN PERTH AND SYDNEY – A BRIEF COMPARISON

A similar analysis of transport energy use has been undertaken for Sydney using data from travel diaries of residents in the 181 Sydney Home Interview Surveys. The results show a similar pattern of increasing transport energy use from inner to outer areas. Although this analysis is only at a preliminary stage at the moment and no detailed examination has been made to understand the energy use patterns, the major points can be summarised as follows:

- Inner areas in Sydney use on average 27% less total transport energy per person than Sydney as a whole, compared to only 16% less in Perth.

- Energy use per worker, which is a better basis of comparison because it eliminates family structure and age effects, is 33% lower in Sydney's inner areas compared to the city as a whole and in Perth workers living in inner areas use some 29% less transport energy.

- When Sydney and Perth inner areas are compared in absolute terms, the data show that Sydney inner area residents use the equivalent of some 470 litres of petrol each per year*, while in Perth the same figure is 737 litres, i.e. Sydney inner area residents use about 36% less total transport energy each than Perth's inner area residents.

- For workers, the absolute values are higher in each case with Sydney inner area workers using the equivalent of some 656 litres of petrol, while in Perth the figure is 1034 litres, i.e. workers who live in Sydney's inner areas use about 37% less total transport energy than workers who live in Perth's inner areas.

- In outer suburbs, Sydney follows the pattern in Perth of significantly higher total transport energy use per person, although not nearly to the same extent. In Sydney residents of outer areas use, on average, 18% more total transport energy as Sydney on the whole, whereas in Perth the figure is 33%. For workers only, however, the data are more comparable, with Sydney's outer area workers using 26% more total transport energy than the average for Sydney workers (in Perth the figure is 29%).

- As with inner areas, Sydney's outer areas are also lower in transport energy use than comparable outer areas in Perth. For example, total transport energy per person is equivalent to 761 litres of petrol in Sydney, whereas in Perth the figure is 1164 litres, i.e. Sydney is 35% lower than Perth. For workers only, the same pattern is evident with Sydney's outer areas again being 34% lower than in Perth (i.e. 1232 litres, cf 1871 litres).**

Although much more analysis remains to be done on these data, it does appear that some of the differences between Perth and Sydney explained earlier, have been substantiated in this more detailed examination of per capita transport energy use in each city. It suggests, for example, that people living in Sydney's much denser inner area can enjoy considerably lower transport energy lifestyles than in the same areas of Perth. It also points to an important energy conserving role played by Sydney's more highly centralised urban form held together by an electric rail system which extends into the outer suburbs.

CONCLUSIONS: THE CASE OF TORONTO AND DIRECTIONS FOR PERTH

The details examined in this paper suggest a number of general policy directions for transport energy conservation in Perth. It is, I believe, helpful to draw these conclusions in the context of another city, which in many ways provides a model for what Perth should be aiming towards in planning for lower transport energy use. That city is Toronto in Ontario, Canada.

Toronto is interesting for three reasons: First it brings us back to the issue which I have attempted to highlight throughout the paper and one which is inextricably linked to any attempts we might make to fundamentally lower Perth's transport energy use – individual lifestyles. Toronto is somewhat unique in the world because it has provided a framework in which just about every form of urban lifestyle exists side-by-side, from the car-oriented, single family suburban lifestyle to the walking and public transport-oriented pattern based around medium density cluster developments and high rise apartments. The point is that no particular form of development has been allowed to dominate or take precedence over the

* This includes energy expended in trips by all modes, but has been converted to petrol equivalent for simplicity.

** These figures are not directly comparable to the data in the Australian cities study presented in an earlier section. Detailed adjustments, based on the groups of people and type of travel included in each study, are required before direct comparisons can be made.

other and so all lifestyles have been afforded an unusual degree of convenience. People choosing to live in houses and own two cars can do so easily. Those choosing to have no car and live at a higher density are not relegated to a second-class way of life, but have a very good public transport system and a basic city structure which supports their needs of close proximity to urban activities.

Toronto's value as a model for future city growth in Perth lies in the fact that most Australians would find Toronto a very acceptable place to live, unlike perhaps many European cities.

This leads specifically to the second point which is that along with this intense diversity of lifestyles and mix of high and low density housing, Toronto has achieved what can only be described as a balanced pattern of land use/transport planning. Toronto's **overall** urban density is around 39 people per ha, compared to Perth with 12 people per ha. This places Toronto on the border between the higher density sections of the typical low density automobile city (e.g. the inner areas of Melbourne and Sydney) and the low end of the European city density range. Toronto's inner or pre-World War II area is around 56 people per ha.

Even with its density, which is two to three times higher than Australian cities, Toronto has, as already suggested, plenty of the typical US and Australian pattern of low density suburbia and high car ownership. However, the potential excesses of this kind of development are offset by the extensive medium to high density developments (mostly mixed with single family housing areas) which allow for a diverse, extensive and extremely well utilised public transport system. The system consists of an electric subway system, trolley and diesel buses as well as a streetcar or light rail surface transit network. While US and Australian cities have virtually all declined in public transport patronage over the period 1960 to 1980, Toronto's public transport users have increased by 44%. In one case, a proposed CBD bound north-south freeway through established residential areas was fought and replaced by a new subway line.

As well as being denser and more balanced in its transportation system, Toronto also has an emphasis on mixed land use, particularly in the vicinity of its subway lines and numerous sub-centres throughout the city. Shops, dwellings, restaurants, commercial districts, employment areas, theatres and other activities can be found interspersed with each other throughout much of the urban area. This of course maximises the potential to walk or use a bicycle for a range of purposes.

The third reason for choosing Toronto as a model for future growth in Perth is that, like Perth, Toronto is in the process of comprehensively reviewing its official metropolitan plan. In conjunction with this review, Toronto undertook a major transportation energy study designed to provide important input to the overall planning strategy review.[37] Among other things, this study succeeded in identifying high and low transport energy consumption areas in the metropolitan area. It also suggested policies which would help lower energy use in existing high energy use areas (which were mainly those without a subway line), and guide development into areas which were obviously conservative in their use of transport energy. The conclusions from this study are extremely relevant to Perth and are reproduced below from the Summary Report.

> "The following principles of land use and transportation planning at the metropolitan scale are considered appropriate in Metropolitan Toronto:

- encourage the development of the urban area in a **compact and contiguous form** – development should proceed sequentially with no major blocks of land left vacant. Land use should be intensified through infilling and redevelopment;
- achieve **high overall density** in major land uses – residential, commercial, industrial – to minimise the urban land area and therefore travel requirements;
- develop a system of **high density nodes and corridors** which will encourage transit usage and reduce trip frequency;
- arrange land uses in an **integrated pattern of activity,** whereby diverse but compatible uses are in close proximity, a balance of employment opportunities and labour force are present within each major area of the community, residential and employment areas contain retail and community uses and redevelopment projects are of a mixed-use nature." (p 20)

They then highlighted specific aspects of existing planning directions in Toronto which are already contributing to the advancement of these general principles of transportation energy conservation. This table (Table 4), presented below, gives substance to the suggestions made throughout this paper that Perth must pursue a pattern of development consistent with urban containment or consolidation principles. This should include the redevelopment and intensification of land use in inner and middle suburbs, especially around major public transport spines (i.e. the suburban rail lines) and the control of outer suburban growth, especially leap-frog subdivisions at the urban fringe. It should also involve a

strategy to diversify or mix various compatible land uses throughout the metropolitan area. In the case of sub-regional centres these should become genuine high density, diversified centres whose major local transport is walking and bicycling, and whose major connections with the rest of the city are based on public transport. This would entail extensive pedestrianisation schemes and the development of cycle-way systems and bike facilities. In the Perth metropolitan region, Fremantle has been shown to embody many of the energy conserving qualities of a genuine sub-regional centre and in this sense it provides a model for other sub-regional centres in Perth. However, even in Fremantle there is still large scope for improvement.

Table 4 Compatability of Metropolitan Toronto Planning Direction with Transportation Energy Conservation Principles

ENERGY CONSERVATION PLANNING PRINCIPLE	METRO TORONTO PLANNING DIRECTION
Urban Form and Structure	
– Compact and Contiguous Form	– No large block of land by-passed – Encouragement for redevelopment and intensification – Emphasis on transit
– High Overall Density	– Completion of development within vacant lands in Scarborough and northern Etobicoke – High density redevelopment encouraged at specific locations – Continued growth in employment
– Nodes and Corridors	– Major development strategy within Metro – Transit routes planned to support high density sub-centres – Local policies encourage higher densities at nodes and along main travel corridors
Land Use	
– Integrated Land Use Pattern	– Trend to more mixed uses at Metro scale – Housing in central areas and waterfront – Greater employment opportunites, amount and type, in suburbs – Development of major retail facilities in suburbs

Source: Reference 37 (Part (iii) p.25)

Some data in the Toronto energy report indicate how effective the above policies are at lowering transport energy use. For example, energy use per worker for work trips in Toronto only approaches Perth's average of 672 litres at outer suburban locations not near a subway line, and in no areas does it exceed about 750 litres. The average in Toronto occurs around "Mid town" with values between about 200 and 400 litres per worker. In Perth, outer areas use on average 937 litres per worker for work trips with values as high as about 1200 litres. It is important to realise that these figures have not been adjusted to reflect the considerably higher fuel consumption of Toronto's larger car fleet. If this were done the differences would be even greater between the two cities.

Modal split figures also highlight the effectiveness of Toronto's land use policies in encouraging public transport. In 1979, on an average day, nearly 30% of **all** interzonal trips were made on public transport, and in the morning peak alone the figure was 40% (these data exclude many walking trips because they do not include intrazonal travel). Even in Sydney in 1981, comparable average day data show only about 13% of trips on public transport.[38]

In pursuing the general land use planning directions which have been outlined, I believe that there is one area of Perth's planning which needs some rethinking, and that is the development of suburbs in areas far distant from central urban facilities. Transport energy conservation is clearly only one of the issues involved in any consolidation policy for the city. It is important therefore that we have a very clear idea of the full social benefits and costs of developing the city under different strategies. For example, land on the urban fringe is cheap to the first home buyer, but at the moment we don't know what the full social costs are to the community in these types of developments. Are outer area developments receiving large hidden subsidies? What are the real costs of the new road and freeway developments – sewers, water mains, schools, medical centres, recreational facilities, community centres and so on which must be continually expanded using partly public money? Do these developments add to the public transport deficit and should developers be made to contribute to the cost of providing public transport services to

these areas, the same way that they must contribute to some other services? How does continuing outer area growth contribute to inflation in urban goods and services through its increase in transport energy costs? In other words, is the government unintentionally planning the city into a less and less sustainable form through a series of hidden subsidies?

Conversely, the cost of land in more central locations is high, but what social benefits are accrued to the community as a whole by reductions in infrastructure costs, better utilised public transport services and lower overall transport costs? Is some form of public subsidy or "density bonusing" warranted in inner and middle areas to reflect their utilisation of already established and underused facilities such as schools, water mains, sewers and public transport services? Could a system be devised whereby developments in inner and middle areas are rated according to these factors and cost reductions to the buyer built into the purchase price of new dwellings?

These and other questions need to be addressed in any efforts to change the planning direction in Perth towards a more energy conserving model as outlined.

As well as general land use planning directions, this paper has suggested a need for Perth to urgently address its transport planning policies with regard to parking and road provision. For comparison, data from Toronto show that less than 200 parking spaces per 1000 CBD workers are provided and total road length in the metropolitan area amounts to only 2.7 metres per person.[39] In contrast, Perth has over 500 parking spaces per 1000 CBD workers and 13.2 metres of road per person, an extraordinary figure compared to any city in the world (e.g. Los Angeles has only 4.5 metres per person and Denver, the nearest city to Perth in road provision of those we are studying, has only 9.4 metres per person).[40]

Obviously under these circumstances Perth has little hope of encouraging high public transport use, even for the journey to work in the central city. Cars are simply too well catered for. Any attempts to address Perth's high transport energy use must therefore come to terms with these facts. There should be a definite policy to positively reduce commuter parking in the central area of Perth while at the same time improving access time and circulation within the central city on public transport. The Toronto energy report also identified the key role played by the physical availability and convenience of parking in determining public transport use among car-oriented workers. They noted that "carrot or stick measures" such as free transit and price differentials between transit and car travel are not effective in moving drivers out of cars and into public transport, but reducing parking provision and convenience is effective in this regard.

Clearly, if parking is to be reduced then public transport must be made more attractive and the best way to do this is to give it a competitive edge in travel time during peak periods. This can be done partly by providing ordinary and contra-flow bus lanes on freeways which can either take road space away from cars, or be used as a way of avoiding the need to increase road capacity where it is already reaching a limit. The former approach could be used on the Mitchell Freeway North while the latter is more applicable to the Kwinana Freeway South and the issue of increasing the Narrows Bridge capacity.

Similar opportunities exist in the Armadale corridor where a survey showed that a significant number of people specifically use the train as a way of avoiding congestion, i.e. travel times are already better on some train services in the peak periods.[41] Trains can be given a further time advantage by scrapping all plans to build any by-pass roads parallel to Albany Highway or Stirling Highway. Of course the electrification of Perth's railways will also assist greatly in giving trains a time advantage. Bus services which must use Albany Highway could also be assisted by providing some form of bus priority to improve their travel time.

In summary, these measures recognise that congestion can be strategically used to create a better balance between private and public transport, thus reducing energy demand and in the longer term fostering a more rational distribution of urban activities which reduces the need for car travel. The alternative appears to be a continual process of attempting to eliminate all traffic restrictions with the result that more cars use the roads, energy use increases and public transport becomes less and less effective. Unfortunately this latter approach is still the dominant transport policy in Peth and until it is addressed there is little hope of developing other long-term transport energy conservation policies based around land use changes.

It is therefore critically important that Perth undertake a major review of its road planning programme in conjunction with the review of the Corridor Plan. Perth already has an extremely well developed and extensive road network (second to none in the world it would appear), and so an aim of such a review should be to consider how to maximise use of the exsiting system while minimising construction of new roads.

In summary, the future planning direction for Perth might be seen as encapsulating three basic types of city in one:

The walking city – For those who wish to live within walking distance of most urban activities, the central city and a number of sub-regional centres should be developed with housing and other compatible urban functions mixed together at high density. Such housing could be for both high and low income people who do not want to be dependent upon a car and are attracted to an essentially urban lifestyle. There would be a greater emphasis on communal activities and sharing of the city's public spaces, with the result that each centre would provide a more human environment with a sense of vitality, diversity and involvement. Pedestrianisation of large areas of the central city and sub-regional centres with heavy restrictions on cars would be integral to the success of these areas.

The public transport city – The old public transport spines, especially the railways, can be rejuvenated with medium density housing and mixed use developments that allow people to be within walking distance of a fast, efficient public transport service. The electrification of Perth's railways would add greatly to the attractiveness and practicality of such a proposal. Such a lifestyle can be less intensely urban but would provide the majority of urban services without the necessity of a car. The essential characteristic of this type of development would be an attractive mix of urban activities at medium density clustered around the stations, which themselves would become mini urban centres. In these areas it would be important to develop innovative types of cluster housing which would provide acceptable living space standards for young families and good safety standards for children with respect to separation of pedestrian and road traffic.

The automobile city – Between the walking and public transport components of the city there would remain the typical Australian suburb with its low density and high car ownership. Of course, in terms of the physical area and numbers of people involved, this type of development would still be a major part of Perth for a long, long time to come. However, it would not completely dominate the urban scene in Perth, as is now the case.

The overall type of city just outlined would, I believe, provide a great deal more flexibility and choice in lifestyles as the city continues to grow past a million people. At the same time this approach to urban development has proven transport energy conserving potential, as shown in this paper.

In conclusion, I would draw attention to a concept from the biological sciences, which seems to have relevance to the growth of urban systems. As a biological system matures it increases in the diversity of plants and animals contained in it and in the complexity of interactions found between the various elements of the system. This diversity is fundamental to its stability and self-sustainability and determines how effectively it responds to changing pressures and circumstances. By way of contrast our man-made biological systems in the form of agricultural monocultures are inherently unstable and require large inputs of external resources and energy (e.g. fertilisers, pesticides and fossil fuels). Interruptions to these external inputs can cause the system to collapse or suffer extreme stress.

Similarly, as a city grows and matures it would seem important to ensure that it develops a degree of diversity and flexibility. In this way it will become more stable and sustainable in the fact of changing pressures and stresses. There is evidence to suggest that this process of diversification and a reaching of limits on monocultural growth occurs anyway. For example, there are many cities around the world which are currently installing new rail systems and revitalising their inner areas. Los Angeles, after years of automobile growth, is finding the need to install a light rail and heavy rail subway system. However, it is much better if we can consciously plan these changes instead of reaching difficult situations and then responding.

Certainly one of the biggest external inputs to any city is oil for transport. Given the ultimately finite nature of oil and the long-term character of cities and city planning, the logic of lowering a city's dependence on oil would seem to speak for itelf. If this can be done using some of the principles I have outlined in this paper, then I believe the city will also benefit in the many other facets of urban life. In other words, a change in emphasis on planning away from sprawl towards inner growth should not be seen as a restrictive or negative thing but as a positive and expansive process which has the potential to enrich and enliven the quality of urban life for everyone by creating a more diverse, convenient and interesting, human scale city.

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ENERGY AND HOUSING

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An Invited Review Paper as Background
for the Development of a
STATE CONSERVATION STRATEGY FOR WESTERN AUSTRALIA

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PRESENT SITUATION

In Western Australia there are more than 400 000 occupied private dwellings. Perth contains 64% of these households, 271 500 at the 1981 census.[1] The energy used in the average Perth home is about 15 000 kWh annually, distributed evenly between three sectors: space heating and cooling; water heating; and lighting, cooking and appliances.

Outside Perth, the proportion devoted to heating and cooling probably increases in the south due to the increased need for heating. In the tropics, the portion devoted to water heating would be much less, and air-conditioning, where used, would be much more. Within Australia the direct consumption of energy by householders, plus the energy used in the production of dwellings, accounts for between 10 and 15% of the total energy consumed.[2]

HEATING AND COOLING

The main sources of the energy used for heating are electricity, gas, wood, kerosene and oil with limited use of direct sunlight. For cooling, the main source of energy is electricity for air-conditioning.

WATER HEATING

The main sources of energy for heating hot water are electricity, gas, wood and the sun. A growing percentage of domestic hot water is heated by the sun in a solar hot water service. About 20% of homes in the State have a solar hot water service.

LIGHTING, COOKING AND APPLIANCES

Electricity is by far the most used source of energy for lighting and appliances because it is easy to use. An increasing amount of cooking is being done with gas. Wood also is used for cooking in fuel stoves, particularly in the country.

FUEL TYPES

The proportion of each type of fuel used in the above sectors is not known in Western Australia, but the following estimates can be derived from the available figures. If the figure of 15 000 kWh average energy used in the Perth home is applied overall, this totals 6.4 TWh for the 428 000 households in the State. The 1982-83 figure for average sales of electricity to all domestic consumers was 4 601 kWh, or a total of 1.9 TWh (30% of the total), and a further 0.67 TWh (10%) was provided by gas.[3] An estimate of the amount of solar energy used by hot water services is 0.34 TWh (5%). This estimate is based on 5000 kWh average use by 428 000 households by 20% with solar hot water by 80% solar contribution. This leaves about 3.5 TWh, or 55%, of the assumed consumption attributable to the other sources, wood, oil, kerosene and solar for space heating.

OPPORTUNITIES FOR ENERGY SAVINGS

Opportunities exist for the use of renewable energy and for energy conservation in all three sectors of domestic energy usage. Some of the opportunities are more easily implemented during the design and construction of a house. Other opportunities are available in the operation of the house and in the appliances used in it. In most cases making use of the opportunities does not require a reduction in comfort level or perceived standing of living.

HEATING AND COOLING

To build a passive solar house is the simplest and most widely applicable way of achieving energy savings in the heating of houses in the south west and much of the inland of Western Australia. Elsewhere in the State the principles of passive solar design can achieve big reductions in the amount of energy required for cooling. A passive solar house uses natural means for heating and cooling. A passive solar house achieves energy savings by the replacement of non-renewable energy sources with renewable sources, principally the sun and the wind, and also by conservation measures to make best use of any energy, renewable or not, that is put into a house. Of the range of principles involved,[2,4] those relevant to this State are as follows:

by using renewable sources of energy

- Winter heat from the sun through north windows. This implies the ability to orient the house on the

block, and a block of suitable dimensions for a house wide enough to get sufficient windows on the north side to collect the required amount of solar energy.

- Summer cooling by ventilation, particularly in Perth where the sea-breeze is so reliable.
- Additional winter heating using wood, either in a slow combustion stove or a fire with convective heating around the firebox.
- An even temperature throughout the house from the layout of the rooms

by conserving energy

- Insulation of ceiling to keep heat in during winter and out in summer.
- Weather sealing and draught exclusion to keep cold wind out in winter and hot wind out in summer.
- East and west windows minimised so that summer sun is excluded.
- North eaves or other shading of the correct width to exclude summer sun.
- Thermal mass (routinely achieved with a concrete floor slab and brick internal walls) sufficient to even out temperature fluctuations between day and night and to store winter heat for release on cloudy days.
- Landscaping for shade in summer and shelter in summer and winter.
- Air locks at entrances.

As an indication of the potential energy savings, houses are being built in Perth at present which require no energy for summer cooling and use only the sun's energy for winter heating. These houses maintain temperatures in the accepted comfort zone of 18°C to 28°C, except for one or two of the coldest mornings each year (G. Baverstock, 1985, personal communication). Performance is achieved using conventional materials and construction techniques. The Perth custom of building double brick houses on concrete floor slabs makes the achievement of a passive solar house quite easy once the foregoing design principles are put into practice.

As indicated above, the main source of winter heating is through north windows. Two of the biggest obstacles to collecting this free energy lie outside the actual design of the building. The first is that solar access, the provision of a clear path from the sun to the windows of the home, is not protected with any certainty by law. Hence a neighbour could construct a building or plant a tree that could seriously reduce solar access to an owner's passive solar house and it would be very difficult for the owner to prevent him by recourse to the common law.[5]

The second obstacle is that very few subdivisions of land in Perth to the present time have created blocks of land of an ideal shape or orientation for the construction of a passive solar home. To some extent, if they had done so, the problems of ensuring solar access by using the common law would be diminished. A subdivision to be released by the Urban Lands Council in the northern Perth suburb of Kingsley in December 1985 has been specifically designed with the aim of maximising the opportunity for solar access on each lot. Provision to maintain solar access in the future has been made with appropriate by-laws in the town planning scheme for the subdivision as provided for in the Town Planning and Development Act 1928-1983. This will be something of a test case for the establishment of solar access provisions in this State and if successful could well be a model for such provisions in residential subdivisions in all parts of the State in the future.

Subdivision of land offers many other opportunities for energy conservation in addition to the provision of blocks of suitable shape and orientation. Such matters include:

- narrower streets;
- trees in streets and on public open space sited deliberately for shade, windbreaks and channelling cooling breezes;
- natural drainage;
- encouragement to pedestrians such as proximity of homes to frequently-used facilities and suitable paths to get there;

- cycleways.

Solarch[6] discusses subdivision planning in depth, including extensive guidelines and a case study done for the Housing Commission of NSW in suburban Sydney.

Once a passive solar house has been constructed the operation of the house is important to reap the benefits of the design. The main considerations are as follows:

- installation of curtains (with pelmets to prevent undesirable thermosiphons being established) and then opening them to let heat in on winter days and closing them to keep it in at night. The reverse procedure is necessary in summer, when curtains need to be closed during the day to keep out unwanted heat;

- opening and closing of windows and doors to promote ventilation when required, and prevent it when not;

- operation of adjustable shading such as blinds, awnings or moveable shade cloth when required.

Where additional heating is required opportunities exist for using appliances which efficiently consume renewable sources of energy such as wood. Efficient electrical appliances and lights also afford opportunities for energy savings by reducing the unwanted heat load on a building in the summer.

WATER HEATING

A solar hot water service, installed during construction of the house or added to an existing house, is the best known example of the use of a renewable energy source for water heating. Solar hot water services have the potential to supply 80% of the requirements of an average Perth home in a cost-effective manner. Other opportunities for the use of renewable energy exist in coupling a wood fire installed primarily for heating purposes to the hot water service, something that was a matter of course when wood stoves were widely used for cooking. Nowadays new installations of slow combustion heating stoves often include a booster connection to a low pressure solar hot water service.

Wood fires, in the form of chip heaters, specifically for the heating of hot water are still used in the older suburbs of Perth and are a useful way of using renewable energy for water heating.

Conservation opportunities in water heating however it is heated, include reduction of the length of pipe between the storage tank and the outlets, insulation of the storage tank, and insulation of the pipes. This latter measure is not a matter of course in Perth construction.

The opportunities for saving energy in the use of hot water lie in reduced consumption. This can be achieved in a mains pressure system by the use of reduced flow shower heads without loss of consumer amenity. Otherwise the opportunities require a change in consumer attitudes towards the taking of shorter showers and fewer or shallower baths, or having them at a cooler temperature.

Methods of heating hot water which involve the use of non-renewable sources of energy followed by storage of the heated water are not the most efficient way to make use of the energy. Much of the energy is used to maintain the temperature of the store against losses to the atmosphere. This observation is equally applicable to the boosting of solar hot water storage. Opportunities exist, particularly with the advances in electronic control systems using microprocessors, to design and manufacture an instantaneous water heater which delivers hot water at a predetermined temperature, whatever the flow rate. This is in contrast to present gas instantaneous heaters which require a considerable flow rate before the gas will light. The proposed instantaneous heater could be used in conjunction with a solar storage system to boost the temperature to the desired level at the time of use, or could be used with cold input directly from the mains. The system would have to be small and cheap enough to install one at each of the main outlets except where they were in close proximity.

LIGHTING, COOKING AND APPLIANCES

At the design stage opportunities exist for energy savings in lighting through the maximising of daylighting. Although more relevant to commercial buildings where lighting is often used during the day, there is a particular problem with a passive solar house in the summer when curtains may be closed during the day to reduce the heat penetration through the windows. Most opportunities for energy savings here, as for water heating, lie in consumer attitudes towards such things as turning lights off when not required. Design can also make turning off lights a much easier task in rooms or areas which have more than one entrance if switches are located at all points of exit.

In lighting, improved efficiency in electric light globes is being achieved so that more light and less heat are produced. This usually means that lights of reduced power are installed. The reduced heat output of more efficient lights is of benefit in maintaining summer coolness, although in winter the heat previously available from the lighting has to be made up from other sources.

Opportunities exist for major improvements in the efficiency of appliances such as refrigerators. In Canada energy labelling of refrigerators has created a considerable improvement in efficiency since no manufacturer wishes to be known as the one who produces the product that is most costly to run. In Denmark research has indicated that a reduction to 25% of the annual energy consumption of the average 1983 refrigerator is possible. These improvements are achieved by increased insulation as well as modifications to the compressor and evaporator. Prototypes which achieve the calculated gains have been built. Other appliances for which the Danish work indicates improved efficiency are freezers, washing machines and ovens.[7]

Microwave ovens can use less energy than conventional ovens due to the absence of preheating and from reduced cooking times. The improved efficiency is particularly noticeable when cooking small amounts. An estimated 500 000 microwave ovens were installed in Australia by 1983, and an equal number were expected to be sold in each of the following two years.[8]

ENCOURAGING A CHANGE TO RENEWABLE ENERGY

For the long-term future of energy supplies, the opportunities which ought to be seized are those involving substitution of renewable energy sources for non-renewable. Hence changing to passive solar design for housing and to solar hot water services is to be encouraged.

Conservation measures such as changes to the efficiency of appliances are buying time while conversion of the electricity supply to renewable fuels takes place. However, such changes must still be encouraged because they make the ultimate capacity of the renewable fuelled electricity supply system that much less. One possibility (discussed in other review papers) is the provision of a home's electricity by its own photovoltaic system, with the ability to sell excess production to the interconnected grid. Having efficient individual appliances and managing the load amongst them will hasten the day on which such a system can work economically.

The ways in which these changes to renewable fuels and to conservation measures might be encouraged are discussed in the following paragraphs.

PASSIVE SOLAR DESIGN

If all homes in Perth were designed and built using passive solar principles, one-third of the domestic energy requirements would be provided directly from the energy of the sun. This is about the same amount of energy as is provided as electricity to domestic consumers. The State Strategy could recommend that all new homes from 1990 onwards be built to passive solar housing principles. Home owners who want to build a passive solar house should have the opportunity to buy a block of land of suitable dimensions and with guaranteed solar access. They would also need to have access to the advice necessary to help them make the decision that a passive solar home is a sensible and desirable method of housing.

To encourage a future trend towards passive solar housing the following points could be followed:

(a) encourage community awareness of attractive, functional, passive solar homes with a view of making ownership of one a desirable objective;

(b) development of consistent and factual advice from government agencies;

(c) implementation of a thermal performance standard for government housing;

(d) encouragement of project home builders to offer a range of designs, accompanied by sound advice from sales consultants to build the homes with the correct orientation;

(e) subdivision of land so that suitable blocks are created;

(f) include specifications of thermal performance in the building by-laws.

To date in Western Australia, only items (a) and (e) have been addressed, and only partially at that.

There are already a few upper middle-priced homes with passive solar orientation, and a steady trickle of new ones are being built. These are seen by about 50-100 potential home builders through the monthly excursion of the Solar Housing Interest Group (SHIG), which is one of the activities of the Appropriate Technologies Development Group Inc. (APACE).

There is an opportunity every year to reach a wider audience through the annual housing awards organised by the Housing Industry Association and The West Australian newspaper. The winning homes in the design for the climate section of this award for the last five years have been exemplary passive solar homes. It has been unusual for these homes to be open for public inspection because they have all been individual designs for a particular client. However the 1985 winner was an exception. It was an entirely passively heated home built for the Bristile/Whittakers Solar Ideas Display Centre at Kardinya. It has attracted a steady stream of visitors throughout the year, some of whom, in the winter months, were observed to be looking for the presumed hidden heating appliances.

Compared to the activities of the Energy Information Centre of the Energy Authority of NSW, or the Energy Information Centre of the Victorian Department of Minerals and Energy, this State's Energy Information Centre of the State Energy Commission (SECWA) is misnamed. A name more descriptive of its display and function would be a gas appliance showroom. On the positive side, SECWA does have a few useful publications about energy usage of typical appliances, hints for operating appliances and a basic booklet on passive solar design. These are widely distributed to schools and at shows and exhibitions. However SECWA does little to publicise the availability of off-peak power for domestic water heating. For instance an advertisement to announce the latest increase in tariffs (The West Australian 29 June, 1985, p26) missed the opportunity to mention Tariff B1 – Domestic "Off-peak" Water Heating.

An Energy Information Centre of the calibre and funding of the NSW and Victorian examples is a worthwhile objective of the State Conservation Strategy.

The State Housing Commission (now Homeswest) has built three passive solar homes on an experimental basis. At the 1981 census there were 15 190 Homeswest rental homes. All their homes until recently were built without ceiling insulation. Homeswest have begun to rectify this situation. They have sponsored a Community Employment Programme (CEP) project administered by APACE, which is retrofitting 220 Homeswest homes in the Fremantle area to improve their thermal performance.

Homeswest and the Building Management Authority (housing for government employees) should encourage passive solar housing by making every house they build an example.

Project home builders, responding to market pressures, will eventually be offering passive solar designs in all price ranges. However, initiatives such as the Glass Mass Insulation (GMI) Five Star Rating can be a useful way of creating an interest in building to these designs. GMI is a consortium of government and industry groups promoting better housing, including better energy efficiency. The Five Star Rating, to be used by the builder in promotional activities, is given provisionally to a design and finally to the completed house. It is to be hoped that this rating system will soon become established in Western Australia.

The desirable aim of ensuring that blocks of suitable dimensions and with solar access are created in subdivisions could be achieved through the powers of the State Planning Commission. The Town Planning and Development Act 1982-1985 enables the Board to make "such conditions as the Commission may think fit" on subdivision applications. Conditions at present include such things as widths of street, provision of drainage, lot size and frontages and proportions of public open space (see Bradbrook[5] for a full discussion of the powers of this Act).

Building by-laws have been used in various parts of California to specify a certain thermal performance for building. These by-laws even extend to preventing resale of the home without the performance being up to standard. In this State, building by-laws could certainly be used to specify the thermal performance of a building. Perhaps the first step would be to stipulate a minimum standard of ceiling insulation.

WATER HEATING

The sale of solar hot water services in this State would seem to need no further encouragement because of the success of industry marketing efforts. However the State Government could do much to make sure that solar hot water is used wherever possible in government houses and buildings. One area in which the Government could set the lead would be as landlord of Homeswest tenants. Often tenants are forced into using the expensive energy of electric water heating chosen for them by their landlords. Solar hot water cannot usually be installed by a tenant. The capital cost is significant and the system cannot be removed (easily) when the tenant leaves.

The Victorian Government's energy strategy sets out to encourage installation of solar hot water services with the intention of fostering a manufacturing industry in that State.[9] In Western Australia, where there are at least three established manufacturers, local industry would be given a boost by the adoption of a similar policy.

APPLIANCES

Although the microwave oven had to conquer some consumer apprehension about safety, its successful marketing sets an example to others who propose to market an energy efficient appliance. At an average cost of about $500, the microwave in most cases was sold into a kitchen which already had a conventional oven.

To keep the consumer well informed about the energy choices that are available, energy-use labelling of all products should be instituted. This procedure could encourage the manufacturers to compete in the area of energy efficiency to improve their products.

The State Government could also encourage energy efficiency in appliances with a policy of purchasing the most efficient appliances for government buildings such as schools and offices.

ENERGY TARIFFS

The consumer is given information about the costs of electricity for domestic consumption through the structure of the tariff. Except for the off-peak rate available for storage water heating, the tariff structure gives the domestic consumer no indication that there are peaks and troughs in electricity demand and that the system has to have the capacity to service the peaks. Opportunities exist for the tariff structure to be used to inform the consumer of the costs of the peak capacity, allowing him to make decisions about the use of appliances at particular times of the day or even by the minute. For instance, some energy utilities in the USA have begun giving domestic consumers the option of various time-of-use tariff schemes.

Another possibility, already used for some industrial tariffs in WA, is to charge for the maximum rate of power usage as well as the number of units used. For instance, at breakfast time (one of the domestic peaks) the consumer who turns on the electric fan heater, the toaster, the electric kettle and a hot plate to cook his porridge, all at the same time, would pay more for his consumption than one who had only one or two of these appliances running at a time. One of the difficulties in implementing these types of tariffs may be appropriate measuring of usage. These difficulties might be solved by advances in telemetering and telecommunications in the near future.

The present off-peak tariff for electricity in Perth gives no encouragement to the solar hot water user to make the change to off-peak power for boosting. With an additional supply charge of 8.43 cents per day and the consumption charge of 4.65 cents per kilowatt hour the break-even point is 740 kilowatt hours. That is, the consumer would have to use 740 kilowatt hours of boosting before he starts to make savings on the off-peak tariff. Furthermore the consumer has to find $100 to $200 for an electrician to rewire the meter board to take a second meter supplied (free) by SECWA. The average solar hot water service owner is probably expecting to need only 1000 kilowatt hours of boost (20% of the average 5000 kWh used in Perth for hot water). The extra 260 units above the break-even point would cost $11 more at the normal rather than the off-peak rate. It is hardly surprising that the consumer is not inclined to switch to off-peak power, and leaves himself with the flexibility to use the booster whenever required.

Finally, any declining block tariff (decreased unit prices above certain levels of consumption) provides no incentive for conservation. There is such a tariff for domestic gas but not domestic electricity in this State.

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HEALTH PERSPECTIVES

by COLIN BINNS

An Invited Review Paper as Background
for the Development of a
STATE CONSERVATION STRATEGY FOR WESTERN AUSTRALIA

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HEALTH PERSPECTIVES

It has proved difficult to define what we mean by "Health", in fact the average Australian gives little thought to what it means to be a healthy person until he becomes ill and loses his health. Hence, health has often been defined in a negative way, i.e. in terms of the load of illness which exists in the community, and is measured by morbidity or mortality rates.

Historically health has taken on a variety of meanings in different societies. The Greeks and Romans stressed physical well-being and hygiene. The ancients recognised the tension between health, as represented by Hygeia, and health care or healing as represented by Aesculapius. The Bible added the concept of spiritual well-being as important to health.

The broader notion of health was again emphasized in the seventeenth and eighteenth century when John Locke wrote about "A sound mind in a sound body". In the eighteen-fifties Shattuck in Massachusetts emphasized the need for preventive programmes and indicated that health was more than just the absence of disease. But it's really only in the last thirty or forty years that the notion of health has been extended to include optimum well-being. The modern view of health places emphasis on the whole individual and his or her inter-relationship and inter-dependency with society.

Modern definitions of health include:

> World Health Organisation (1947) – "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity". Subsequently this definition has been modified in the following way: "A state of physical, mental, emotional and social well-being which allows an individual to live in harmony with the environment".[1]
>
> Dunn described health in the following terms: "The goal of health now at mid-century calls for not only the cure of alleviation of disease. Rather it looks beyond to strive for maximum physical, mental and social efficiency for the individual, for his family and for the community".[2]
>
> The Holistic view of health considers man as an integrated whole and includes a spiritual dimension together with the physical and emotional aspects. The definition proposed by Ardell reads: "Holistic health refers quite simply to the integration of mind, body and spirit in the person, and emphasises the importance of treating the individual, regardless of physical symptoms, in the "whole" sense, as a being who requires balance and harmony in all three dimensions, in relationship with his health, the environment and the universe".[3] Rene Dubas quotes Katherine Mansfield as writing: "By health I mean the power to live a full, adult, living, breathing life, in close contact with what I love – the earth and the wonders thereof, the sea and the sun. I want to be all that I am capable of becoming".[4]

These definitions illustrate a changing perception of health, from an absence of disease to a more dynamic and complete state which is described as wellness.

The development of the concept of wellness has followed the shift in the importance in our society from infectious diseases, to those diseases attributable to lifestyle. Figure 1 shows the model of disease resulting from an infection. This was usually an acute episode of illness and either recovery or death closely followed the infection. The model is simple with a single causative agent acting on the host to produce disease, from which complete recovery is usually possible. The whole of the medical care system which developed in our state during this century is based on this simple model. When one becomes ill, and only then, the health system (e.g. Doctor) is contacted and a cure is sought.

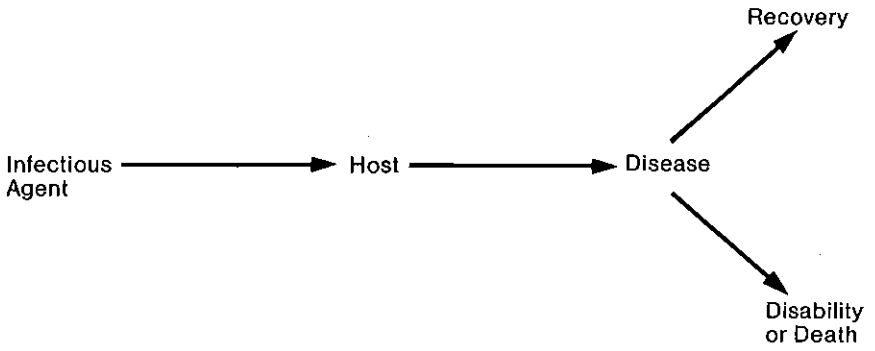


Figure 1. Model of a communicable disease.

Later in this paper the historical changes in the importance of different diseases in Western Australia is described. We now face the challenge of chronic diseases, which are often the result of our lifestyles over a prolonged period of time. Figure 2 is a model of a chronic disease which emphasises the multifactorial aetiology and the length of time between the action of the causative factors and the development of disease. The outcome may be death or recovery but a spectrum of degrees of disability are also possible. In this model the health system has a role in prevention, in the acute phase of the disease, and continuing with the process of rehabilitation and, if necessary, providing long-term care. But the health system has a less important role as prevention becomes far more important.

The conquest of infectious disease and the emerging importance of chronic disease, and hence of the individual's lifestyle, stimulated the interest in wellness as a positive aspect of health. Albert Dunn (1959) defined wellness, "As an integrated method of functioning which is oriented towards maximising the potential of which the individual is capable of within the environment where he is functioning". An

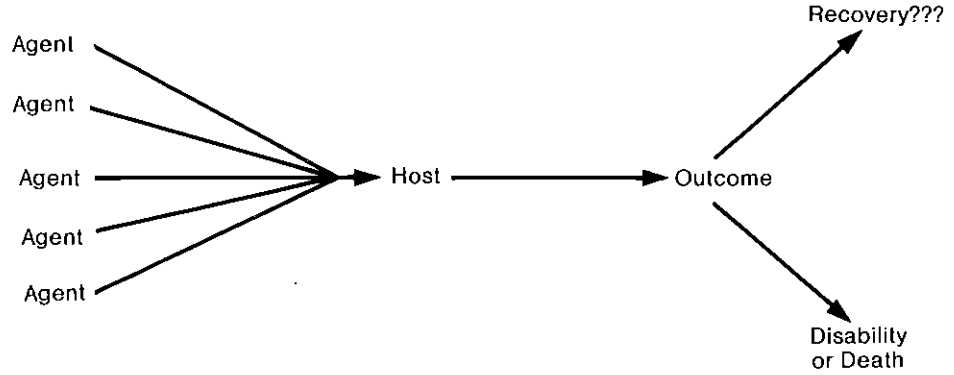


Figure 2. Model of a non-communicable (chronic) disease.

alternative definition is that : "Wellness is an active process through which the individual becomes aware of, and makes choices towards, a more successful existence. These choices are greatly influenced by one's self-concept, and the parameter of one's culture and environment. Each individual develops the unique lifestyle which changes daily as a reflection of the intellectual, emotional, physical, social, occupational and spiritual dimensions".[5]

Wellness is a positive approach to living, an approach that emphasises the whole person. Hettler[6] has drawn on the work of a number of authors to emphasise the following dimensions of wellness:

Intellectual – This measures the degree to which one engages his or her mind in creative, stimulating mental activities. An intellectually well person uses the resources available to expand his or her knowledge in improved skills, along with expanding potential for sharing with others.

Emotional – Measures the degree to which one has an awareness and acceptance of one's feelings. This includes the degree to which one feels positive and enthusiastic about one's self and life. Measures the capacity to appropriately control one's feelings and related behaviour, including the realistic assessment of one's limitations.

Physical – Measures the degree to which one maintains cardiovascular flexibility and strength. It represents the behaviours that help one to prevent illness, including the degree to which one chooses foods that are consistent with the dietary goals of Australia.[7]

Social – Measures the degree to which one contributes to the common welfare of one's community. This emphasises the dependence with others and with the social and physical environment.

Occupational – Measures the satisfaction gained from one's work and the degree to which one is enriched by that work.

Spiritual – Measures one's ongoing involvement in seeking meaning and purposes in human existence. It includes an appreciation for the depth and expanse of life and natural forces that exists in the universe.[8]

The foregoing may be summarised in a hexagon showing the six dimensions of wellness (Figure 3).[9] Wellness is part of a continuum, ranging from premature death at one end to total wellness at the other (Figure 4).[9]

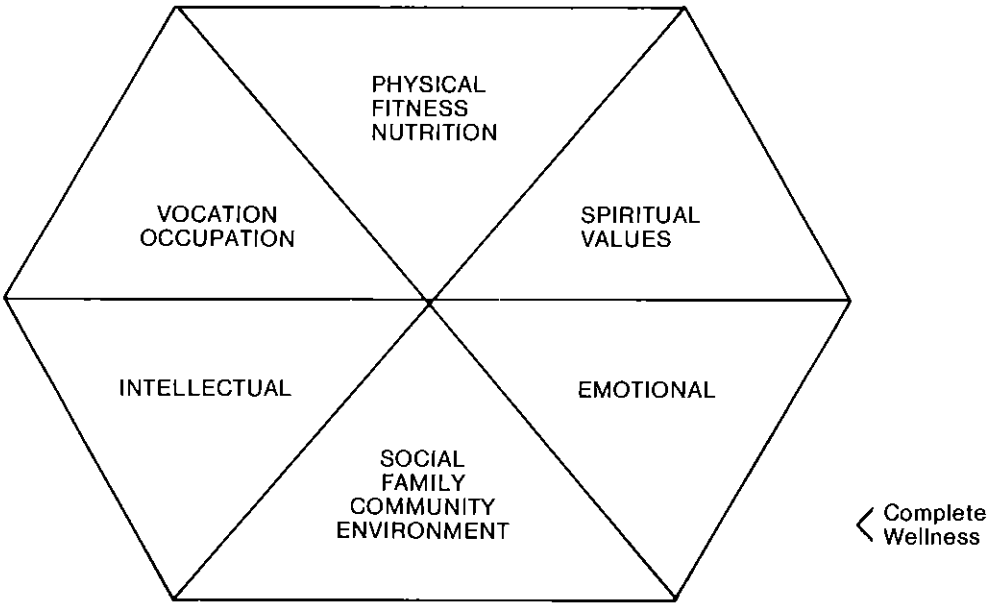


Figure 3. The dimensions of wellness.

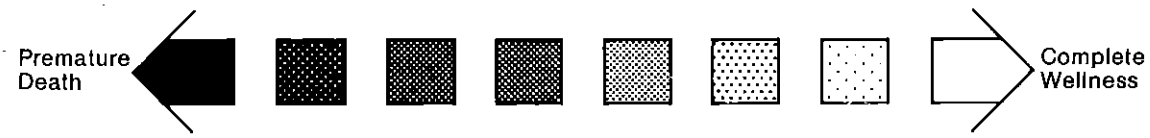


Figure 4. The continuum of wellness.

The concept of wellness is relatively new to Australia and has not been emphasised in planning. An increasing number of authors have accepted the emphasis on wellness, and with the change in the ratio of chronic to infectious disease are now emphasising that "health" results from an interaction with the total environment. These concepts were translated into a professional document by Marc Lalonde in 1974 when he discussed the health of Canadians and popularised the use of the concept of health fields.[10]

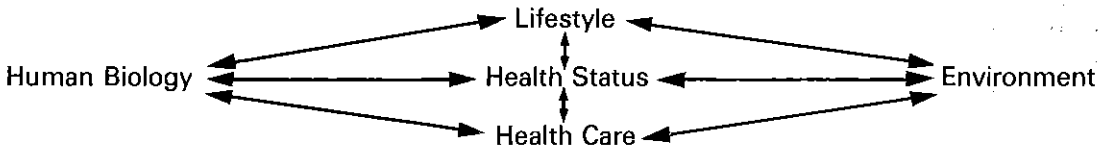
The four major fields or forces affecting health are:

Environment – The most important force. In it are included such elements as education, affluence, cultural, culture, government, adequacy and safety of food and water, etc.

Behaviour or lifestyle – There is increasing evidence of the influence of lifestyle and behaviour on morbidity and mortality.

Medical care – Some medical technologies, such as immunisation and a knowledge of nutrition, have proved remarkably effective in preventing disease. The modern medical care system undoubtedly reduces disability in the community. However, beyond a basic level of medical care, the medical system makes only a modest contribution to survival or longevity. It also adds its own disturbances of wellness, particularly as the more heroic methods are introduced and may result in morbidity itself (iatrogenesis).

Heredity (Human Biology) – The interactions in health field concept can be illustrated in this way:



The basic structure of the human body as a more complex model illustrating the interactions of these forces has been prepared by Blum.[11] In Figure 5 the size of the arrows represents the relative importance of each of the forces or fields. It is this model that provides an appropriate basis for considering the influences on health, or wellness, in Western Australia as we turn towards the 21 st Century. It illustrates how any change in any aspect of the environment will have an influence on health (or wellness).

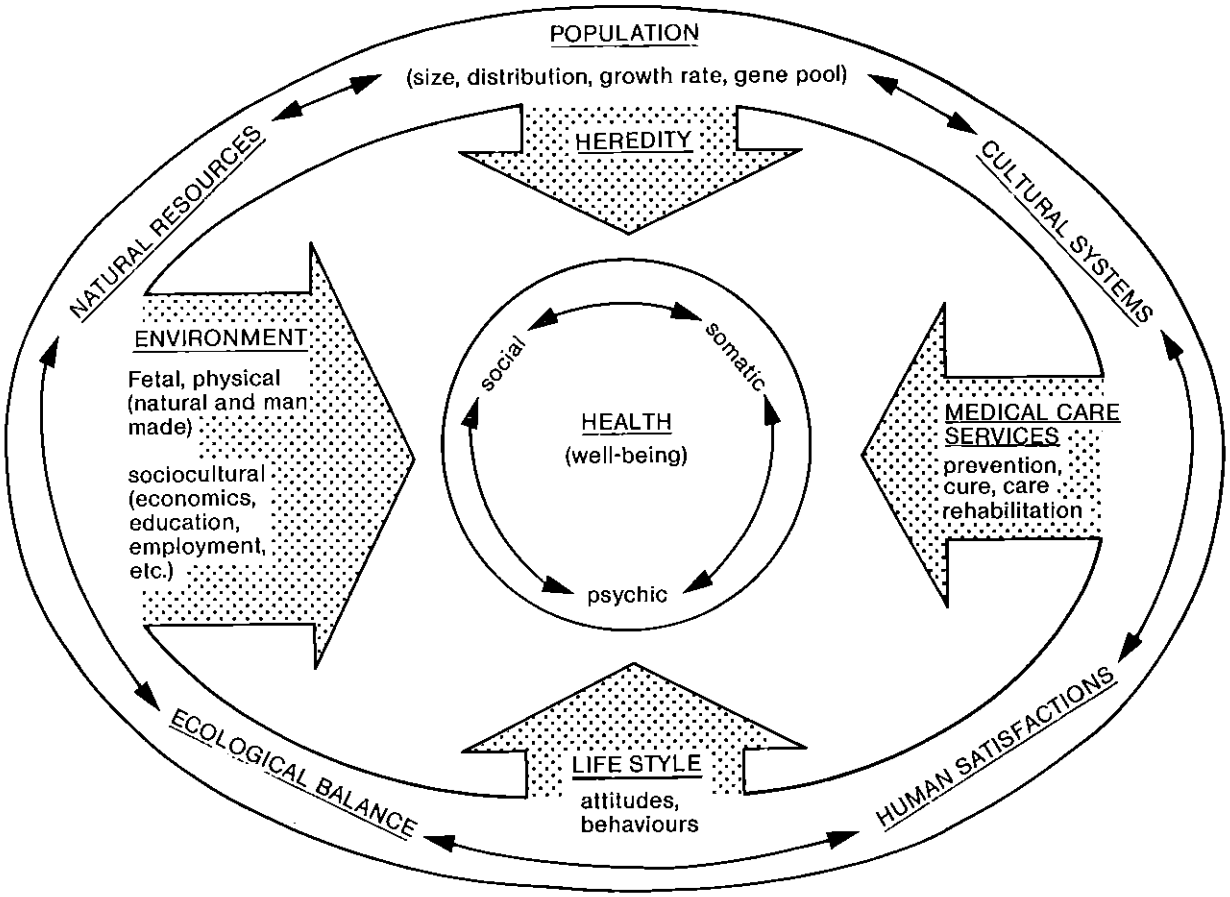


Figure 5. The relationship of health to the environment and other health fields.

Some examples of changes would include:

- Industrial development causing air pollution.
- Liberalising liquor laws increasing alcohol consumption.
- Unemployment rates.
- Poor sanitation services.
- Overcrowded housing.
- Lack of recreational opportunities.
- Poverty.

The relationship between the environment and lifestyle is thus illustrated. Lifestyle affects both our health (well-being) and the environment. The best results will be achieved when there is balance between these factors. That is when we are prepared to adjust our lifestyles to conserve the total environment while following a lifestyle which optimises wellness.

HISTORICAL CHANGES

There has been a dramatic improvement in the health of Western Australians in the past 150 years. This includes the immigrants who came mainly from European countries, and the original inhabitants of this land. The early years of colonisation were beset with difficulties, as efforts were made to make a living in a hostile environment. Malnutrition was rife, with many children dying in their infancy (Figure 6). Scurvy was so common that a ship lying off Fremantle was converted into a floating "hospital" to hold the many victims. Many of the colonists retreated from these frustrations with excessive consumption of alcohol and a common cause of death in these early years was drowning, as the drunken settlers fell from their boats.

Figure 6. Infant mortality rate in Western Australia.

In the early years, epidemics of infectious disease were relatively uncommon due to the colony's small size and its isolation. The discovery of gold brought about a rapid population explosion, and with it, a number of major epidemics. The first reported epidemic was of measles, in 1884, which resulted in more than one hundred deaths. Later typhoid epidemics swept the goldfields and in a ten-year period from 1895 it is estimated that there were at least ten thousand cases with more than a thousand deaths.[12] After World War One the influenza pandemic reached Perth and left at least five hundred dead. Since the turn of the century there has been a steady improvement in health, particularly as the various environmental factors have improved. The improvement accelerated between the world wars, as hygiene, nutrition and the general standard of living improved. However, the steady improvement in health was interrupted by the social upheavals of the Great Depression. During this period there was continued development of one of the health care system's important components: the network of infant welfare nurses stationed across our State. The emphasis was on preventive care which was a most important innovation.

The improvement of health this century is reflected in the dramatic decline in the infant mortality rate (Figure 6), and the improvement in life expectancy (Figure 7). After World War Two the continued improvement in living conditions, nutrition and hygiene and the availability of immunisations and antibiotics have further improved the health of the community. The proportion of deaths due to infectious causes as compared to those related to lifestyle causation, has been reversed during this century (Figure 8). While improvements in environment and medical care system have had a dramatic effect on infectious disease as a cause of death, these improvements have had only a modest impact on chronic diseases, the diseases of lifestyle. To reduce the impact of these diseases a more radical change in lifestyle is required.

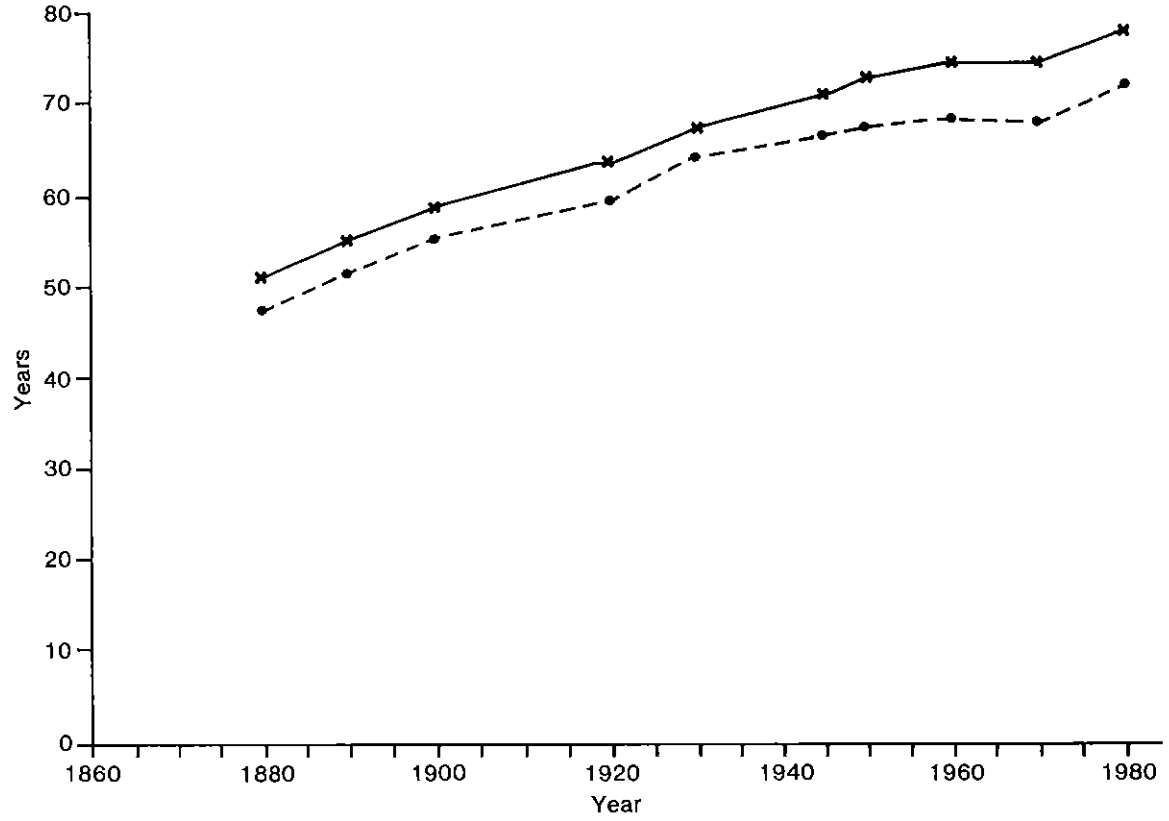


Figure 7. Life expectancy in Australia at birth.

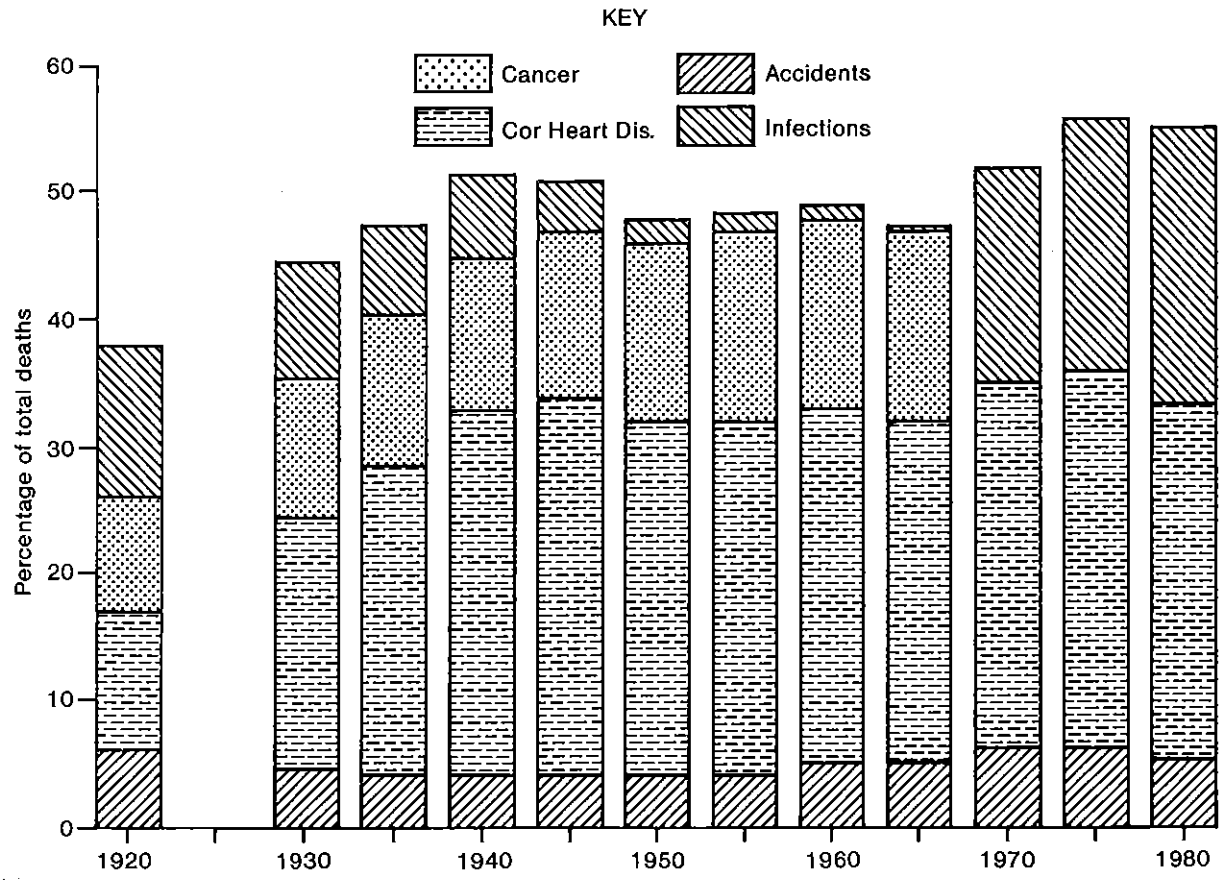


Figure 8. Major causes of death in Australia.

For the working person, occupation is an important determinant of health. Western Australia has had its share of occupational health problems. One of the disasters which is still bearing a toll of death and disease is the asbestos mining industry which was centred in Wittenoom. The dusty conditions in the mine and mill resulted in the exposure of thousands of workers to high levels of asbestos fibre. Twenty to thirty years later this has caused an epidemic of mesothelioma.

An increased awareness of the importance of occupational health should prevent a recurrence of such disasters.

HEALTH TODAY

There are a variety of sources of information available about the health (or more realistically, the ill-health) of Western Australians. A recent series of papers by the Data Base Working Group of the Committee on the Review of Health Promotion and Health Education in WA reviews all of this data and the major points are highlighted here.

HOSPITAL ADMISSIONS

In 1983 the cost of keeping a person in hospital for one day was around $230.[13] On any one day just over 5500 persons are in short-stay hospitals in our State, or approximately 4% of our population. 72% of the bed-days used were accounted for by the fifteen conditions shown in Table 1.

Table 1 Annual Bed Days in W.A. Hospitals 1981

Condition	Bed Days
Musculo-Skeletal	167796
Digestive	141355
Ill-Defined Symptoms	125711
Obstetric	124032
Mental Disorders	123447
Other Reasons	120501
Other Accidents	113571
Respiratory	112393
Female Genito-Urinary	78206
Cerebrovascular	77276
Circulatory Diseases	61837
Normal Delivery	61579
Skin	58741
Nervous System	57412
Ischaemic Heart Disease	54243

The same rankings also applied to bed-days during working life (age 15-64 years), with the exception of cardiovascular disease, which was replaced by transport accidents. Despite being a major cause of hospital admission, transport accidents still accounted for only 3% of the total bed-days during working life.

In the ten years to 1981, the birth rate declined from 21.7 to 17/1000, reducing demand for obstetric beds. However, the overall discharge rates for hospitals in WA increased by 16% in males and 28% in females between 1971 and 1981. The largest absolute increases were observed in musculo-skeletal and connective tissue diseases, genito-urinary diseases, ill-defined signs and symptoms and miscellaneous reasons for contact with the health service. During the same period the number of beds in Mental Health Service hospitals and the proportion of the population being admitted to these hospitals had fallen by almost 50%.

MORTALITY

The most common causes of death in WA are circulatory disease, neoplasms, injury and poisoning, and diseases of the respiratory system, which together accounted for 86% of all deaths.[14] An important way of looking at deaths is to analyse the person-years of life lost (PYLL) by age 70 years (i.e. a person who dies at age 20 has lost 50 years of useful life, one who dies at 55 years of age has lost 15 years).

Table 2[14] shows the most prominent causes of PYLL to age 70 and Table 3[14] PYLL by age 50, conditional on having reached 20 years of age which is a useful means of identifying the causes of premature death.

It is interesting to note that PYLL from road deaths was 30% higher by age 70 than for ischaemic heart disease. Over the past 20 years the mortality rates for Western Australians fell by 25% in men and 34% in women, with the greatest contribution to the decline being made by reduced deaths from diseases of the circulatory system (Tables 2 and 3).

An alternate view of the contribution of each disease category to premature death is shown in Figure 9,[15] which shows how life expectancy would be extended by eliminating specific causes of death.

Table 2 Age Standardised Mortality Rates and Annual Person-Years of Life Lost Before Age 70 Years from Different Causes of Death in Western Australian Males and Females in 1979-1982 (ICD-9 Chapters)

Cause of Death (in descending order of annual person-years of life lost before age 70 years)		Age Standardised Mortality Rate (deaths per 100,000 person-years)				Annual Person-Years of life lost before age 70 years		
		Males		Females				
		Rate	S.E.	Rate	S.E.	Males	Females	Persons
XVII	Injury and Poisoning	67.78	1.63	25.61	0.99	14733	4465	19198
II	Neoplasms	162.30	2.51	98.85	1.86	6832	5635	12467
VII	Disease of the Circulatory System	318.85	3.54	182.16	2.23	8474	3098	11572
XV	Certain Conditions originating in the Perinatal period	12.87	0.84	9.35	0.74	3761	2669	6430
XIV	Congenital anomalies	9.36	0.71	8.16	0.67	2658	2206	4864
XVI	Symptoms, signs & ill-defined conditions	9.00	0.69	5.26	0.51	2358	1179	3537
VIII	Disease of the Respiratory System	67.23	1.68	24.40	0.86	1523	932	2455
IX	Diseases of the Digestive System	24.28	0.99	13.18	0.65	1335	677	2012
VI	Diseases of the Nervous System and Sense Organs	9.96	0.65	6.99	0.50	918	601	1519
III	Endocrine, Nutritional and Metabolic Diseases and Immunity Disorders	11.20	0.68	10.65	0.58	504	425	929
I	Infectious and Parasitic Diseases	4.40	0.43	3.35	0.36	523	387	910
X	Diseases of the Genitourinary System	9.09	0.63	7.51	0.47	183	239	422
V	Mental Disorders	6.20	0.50	3.43	0.31	291	94	385
XIII	Diseases of the Musculo-Skeletal System and Connective Tissue	1.42	0.24	2.20	0.26	84	91	175
IV	Diseases of Blood and Blood-Forming Organs	1.69	0.27	1.18	0.19	97	52	149
XI	Complications of Pregnancy Childbirth and the Puerperium	–	–	0.40	0.12	–	121	121
XII	Diseases of the Skin and Subcutaneous Tissue	0.10	0.06	0.28	0.09	11	13	24

Table 3 Annual Person-Years of Life Lost Before Age 50 Years from Different Causes of Death in Western Australian Males and Females Aged 20 or More Years at Death in 1979-82 (ICD-9 Chapters)

Cause of death (in descending order of annual person-years of life lost before age 50)		Annual person-years of life lost before age 50 years in persons aged 20 or more years at death		
		Males	Females	Persons
XVII	Injury & Poisoning	4616	912	5528
II	Neoplasms	832	722	1554
VII	Disease of the Circulatory System	745	292	1037
IX	Disease of the Digestive System	214	117	331
VIII	Disease of the Respiratory System	158	118	276
XVI	Symptoms, Signs & Ill-Defined Conditions	163	79	242
VI	Diseases of the Nervous System and Sense Organs	153	68	221
III	Endocrine, Nutritional Metabolic Diseases and Immunity Disorders	52	48	100
XIV	Congenital Anomalies	48	44	92
V	Mental Disorders	60	23	83
I	Infectious and Parasitic Diseases	52	22	74
X	Diseases of the Genitourinary System	30	39	69
XI	Complications of Pregnancy, Childbirth & the Puerperium	–	66	66
XIII	Diseases of the Musculo-Skeletal System & Connective Tissue	13	8.5	21
IV	Diseases of Blood and Blood-Forming Organs	7.2	1.8	9.0
XII	Diseases of the Skin & Subcutaneous Tissue	3.0	1.8	4.8
XV	Certain Conditions Originating in the Perinatal Period	–	–	–

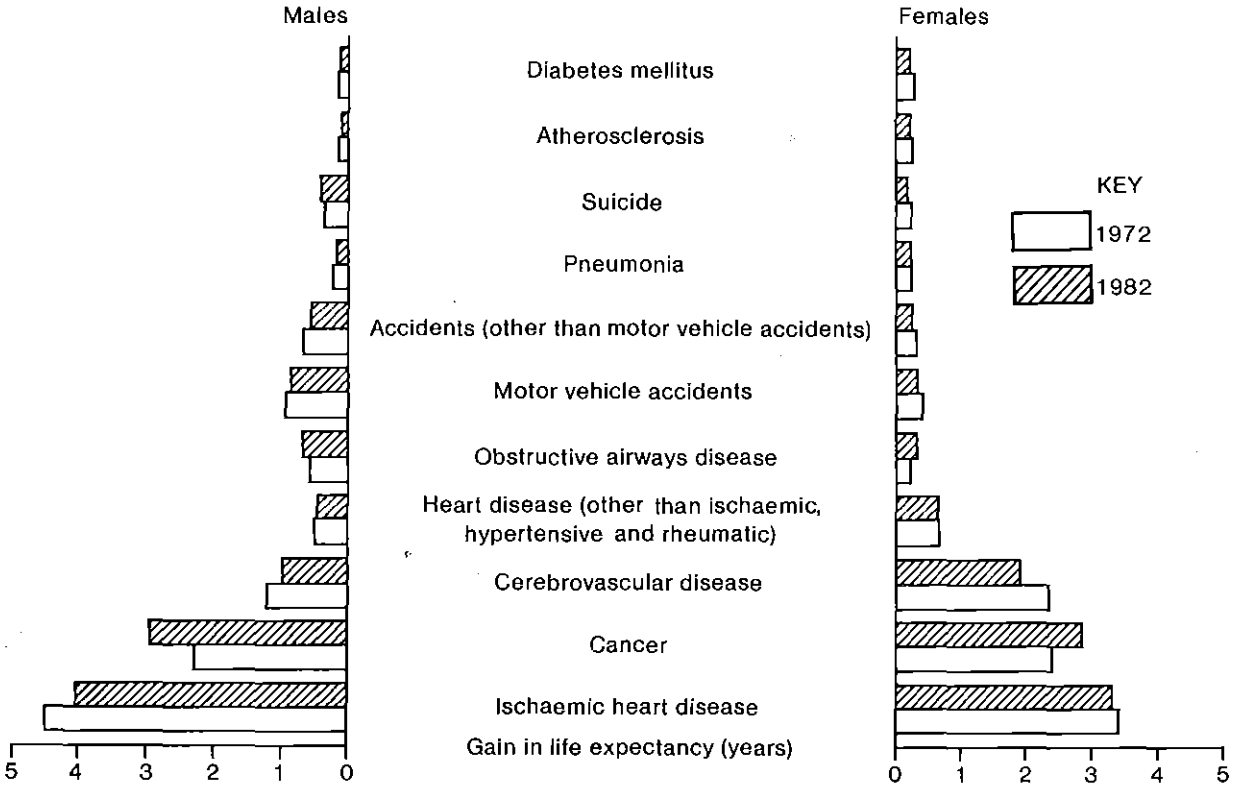


Figure 9. Gain in life expectancy at age one year if specific causes of death were to be eliminated.[15]

HEALTH IN THE COMMUNITY

It is impossible to assess wellness by only discussing deaths and hospital admissions. In 1977 and 1978 the Australian Bureau of Statistics interviewed a large sample of Australians to determine how healthy they were (Table 4). The Australian Health Survey (1977-78) found that 65.3% of the population had experienced one or more illnesses in the two weeks prior to the interview. More than half of these consulted their doctor.[16]

It is interesting to note the high proportion of the population (22%) who complain of mental disorders and high percentage of diseases such as arthritis in the older population – 44% over 65 years of age (Table 4).[18]

Australians spent an average annual equivalent of 19.7 days when they felt unwell and had to reduce their usual activitities, and 5.1 of these days were spent in bed.

Table 4 Incidence of Recent Illness (a), 1977-78
(Recent illness per 1000 population)

	Age Group (Years)					Total		
Type of Illness	Under 15	15-24	25-44	45-64	and over	Males	Females	Persons
Infective and parasitic diseases	44.4	41.8	36.5	25.0	18.4	31.8	39.5	35.6
Endocrine, nutritional and metabolic diseases	6.2	19.0	35.9	54.4	42.7	20.7	38.1	29.4
Mental disorders, nervous tension & depression	61.2	260.8	290.2	292.1	278.7	181.7	265.6	223.5
Diseases and symptoms of the nervous system & sense organs	54.4	113.6	116.9	174.6	234.7	110.1	133.2	121.6
Diseases and symptoms of the circulatory system	*	8.0	24.8	106.7	223.7	40.5	59.0	49.7
Diseases and symptoms of the respiratory system	344.3	326.7	298.0	261.9	245.4	315.9	290.9	303.4
Diseases and symptoms of the digestive system	76.1	58.1	53.6	58.5	73.4	61.5	64.7	63.1
Diseases and symptoms of the genito/urinary system	62.2	20.0	25.3	33.5	50.9	27.6	48.8	38.1
Diseases and symptons of the skin & subcutaneous tissue	58.9	53.7	45.7	46.1	46.4	51.1	50.3	50.7
Diseases and symptoms of the musculo-skeletal system and connective tissue	12.6	146.2	179.2	339.2	440.5	168.2	200.2	184.2
Neoplasms (cancer)		1.7	2.5	7.1	13.3	3.9	3.3	3.6
Diseases of the blood and blood-forming organs		2.2	2.4	–	–	–	3.5	2.2
Complications of pregnancy, childbirth etc. and certain causes of perinatal morbidity	2.7	20.5	16.9	–	–	–	16.4	8.2
Congenital anomalies		–	–	–	–		2.8	2.1
Illness due to absence of limbs or organs		–	–	–	–	1.4	–	1.3
Symptoms and ill-defined conditions not elsewhere included	6.1	25.6	31.5	34.3	55.3	21.5	31.3	26.4
Injuries or illness due to accidents, poisonings and violence	33.1	70.4	59.7	43.4	49.9	59.8	40.8	50.3
All recent illnesses	**763.6**	**1169.2**	**1224.3**	**1485.4**	**1782.5**	**1098.4**	**1289.4**	**1193.6**

(a) Provision was made to record up to five recent illnesses for each respondent.

The extent of long-term disability, that is a chronic condition which had lasted for more than six months, or which caused permanent disability, was also measured. Overall 45.1% of the population had one or more chronic conditions, rising from 24.5% under 15 years of age to 77.6% of persons aged 65 years or over.[17]

The proportion of persons who have sight and hearing problems is shown in Figures 10 and 11.[18]

Figure 10. Proportions of population having sight problems (Feb-May 1979).

	Age group (years)				
	15-24	*25-44*	*45-64*	*65 and over*	*Total*
Persons who have no hearing problem	98.3%	95.7%	89.3%	78.5%	92.6%
Persons who have a hearing problem –					
Males	0.9	2.7	7.2	10.9	4.5
Females	0.9	1.6	3.5	10.6	3.0
Currently possess a hearing aid	0.2	0.3	1.4	8.2	1.5
Do not currently possess a hearing aid	1.6	4.1	9.3	13.3	5.9
Total	*1.7*	*4.3*	*10.7*	*21.5*	*7.4*
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
			'000		
Males	1228.4	1968.7	1392.8	520.4	5 110.3
Females	1215.0	1927.8	1388.2	684.2	5 215.2
Persons	2443.3	3896.5	2781.0	1204.6	10 325.4

Figure 11. Hearing condition of persons aged 15 years and over, September 1978[18]

INFECTIOUS DISEASE

Improved nutrition, better living conditions and personal hygiene, immunisation and the availability of antibiotics, have all played a role in the decline of mortality and morbidity from infectious diseases. However, the rates of immunisation with rubella, measles and triple-antigen vaccines are slightly lower in WA, than in the rest of Australia.[19] Although most of these diseases are now uncommon, their continued control depends on continued immunisation programmes.

The most prevalent infectious diseases are viral, most of which are relatively minor, such as the common cold. One serious disease which appears to be increasing is Hepatitis B which can be spread by intravenous drug usage. The potential exists for the transmission of a number of viruses, such as dengue and Ross-River virus, by insect vectors in WA. This is likely to become more of a problem if closer settlements are established in the tropical north of our State.

The serious chronic infections of tuberculosis and leprosy still occur, but are much less common. Their continued control and decline will depend on the improvement of the quality of life of the at-risk groups in our community, particularly the Aborigines and recent Asian immigrants.

The reported rates of venereal disease have fallen by 26% in the past ten years. It is hoped that this trend will continue. However, the introduction of AIDS (HTLV3 virus infection) will present WA with its most serious public health challenge this century. There is at present no treatment or immunisation available and control will depend on behavioural changes. This will require a major change in attitudes by the community.

At the present it seems that most of the major infectious diseases are under control, but this situation depends on the continuation of our favourable environment, the high rates of immunisation and the widespread availability of treatment.

CANCER

Cancer caused 3526 new cases and 2135 deaths in 1982.[20] It is the second commonest cause of death, after circulatory diseases. In terms of person-years of life to age 70, all cancers combined rate second, behind injuries and accidents. Cancer is largely an avoidable disease. Australia is very similar to the USA where Doll and Peto[21] estimate that 75-80% of cancers are potentially avoidable. Thirty per cent of cancer deaths are due to tobacco; about 640 deaths in WA each year. Nutrition is also important in cancer causation; Doll and Peto estimate that it causes up to 35% of cancer deaths. Other environmental factors are alcohol 3%, reproductive and sexual behaviour 7%, occupation 4%, pollution 2%, geophysical factors 3% and infections 10%.

In WA the priorities for prevention of cancer should be:

- control of tobacco;
- moderation of alcohol consumption;
- changes to our diet.

CORONARY HEART DISEASE

Coronary heart disease is the major cause of death in WA.[22] However, the death rate has been steadily falling during the past two decades. Between 1967 and 1978, the death rate in the 30-64 year age group fell by 27% in men and 29% in women. This fall may well be due to changes in the prevalence of coronary risk factors, including cigarette smoking, hypertension, diabetes and diet. Improved health care involving coronary care units and coronary artery sugery, may also be a factor in the declining death rate. However, it seems that these encouraging statistics represent the adoption of healthier lifestyles by a substantial proportion of the population.

ALCOHOL

The per capita consumption of alcohol in WA has increased by 13% in the last ten years to 14.08 L of absolute alcohol in 1981-82.[23] This level is approximately 3% above the national average. If WA was a separate country it would rank seventh in the world for alcohol consumption. Alcohol is a causative factor in many diseases including liver cirrhosis, hypertension and cancer. The role of alcohol in motor vehicle accidents is well known and in 48% of traffic accident deaths, the blood alcohol level was above the legal limit of 0.08%. Alcohol is also involved in civil, divorce and other types of social disruption.

In the past, attempts to control the alcohol problem have emphasised the role of the individual. However, the alcohol problem is a complex social and political problem. Its solution lies in changing the total community system.[24] This will mean that any successful solution must involve the market environment as well as the social climate. This approach has been successfully implemented in the Scandanavian countries.[25]

In recent years the following changes in the social environment relating to alcohol have had adverse effects:

- Lowering the legal minimum drinking age from 21 to 18 in WA increased the number of casualties admitted to hospital from traffic accidents and other injuries.
- The introduction of Sunday alcohol sales increased the number of persons killed and the number of casualty traffic accidents on Sundays.

- Increase in the ease of availability of liquor leads to increased consumption.

Thus any further liberalisation of any licensing laws in WA will further increase the alcohol problem, at present described as a "problem of epidemic proportions".[26]

TOBACCO

Tobacco is the most preventable cause of death in Australia today.[27] Its role in the causation of cancer, especially lung cancer and heart disease has been well documented. In 1980, 35.9% of males and 25.5% of women were current smokers. Many of these have attempted to "quit", but the highly addictive nature of tobacco makes this difficult.

Increasingly the importance of sidestream smoke, smoke affecting the innocent bystander, is being recognised. While some progress has been made in eliminating smoking from some confined areas, e.g. buses, the majority of the population, who are non-smokers, are still subject to air contaminated with cigarette smoke.

Present government policy in WA is directed towards discouraging the availability of tobacco in the community.

SUMMARY

This section has documented the causes and extent of disease, disability and death in our community. By world standards we must be regarded as a healthy community. Yet many people die prematurely from causes preventible by environmental or lifestyle changes. In addition, a high proportion of our citizens suffer from long-term disabilities. For many of these persons the fulfilment of their lives is lessened by illness or disability.

Society should have as a priority measures to reduce disease and disability in the community. However, as many persons will continue to be disabled society must accommodate their special needs. Figure 5 shows the extent of environmental factors which may be involved; almost every aspect of society has some impact, for better or worse, on the health of the community.

HEALTH IN THE FUTURE

AREAS OF CONCERN

The health successes in Western Australia have been against infectious disease, and in improving nutrition and the environment.

We have been far less successful in combating the major health problems today, in particular cardiovascular disease, motor vehicle accidents, mental problems and malignant disease. All of these problems have lifestyle and the social environment as the major components of their causation. It is doubtful that early diagnosis or treatment will provide the answers. Significant progress will only be made with successful preventative programmes, involving lifestyle and environmental change.

The following diseases and causative factors will be the main area of concern during the next two decades:

Cardiovascular Disease – Studies since World War Two have established many of the causative factors cardiovascular disease. Major trials have demonstrated the effectiveness of dietary change, increasing exercise, less smoking, decreased level of obesity and control of hypertension in reducing the incidence of cardiovascular disease. Drug therapy has a role to play in the control of hypertension and hyperlipidaemia. While there has been a reduction in the death rates and incidence of acute myocardial infarction, the incidence remains relatively high. This will maintain the present high levels of demand for cardiac surgery and hospitalisation. However in the longer term, lifestyle changes are the answer.

Mental Illness – The incidence of minor mental illness has been increasing in developed countries in the past few decades. This rate of increase is likely to continue, as there is evidence that increasing urbanisation is associated with social disruption and mental illness. It seems that alienation in social life and family disruption are often the penalties for living in a modern, free, urbanised society. Unemployment and poverty are contributing factors to these socially caused problems. In Australia there is a lack of communication between levels of society, between ethnic groups, between original Australians and white Australians and between generations. It must be an aim of social planning to improve communi-

cations between each of these groups and between individual persons. The breakdown of the nuclear family structure in Western Australia is shown in Figure 12.[28] In 1982 there were 41 000 divorces in Australia, and 61% of these involved children, a total of 53 000 children. There is every indication that these changes in the historical family structure of society will continue. Perhaps some of the answers lie in part in continually restructuring the education systems to emphasise communication and life survival skills. Any social or political changes which encourage stable family life will probably lead to reduced mental illness.

With the social problems in our society, emotional disorders in children will continue to increase. Western Australia has a number of programmes devoted to the detection of early emotional disturbances and child/parent problems. There will be an increasing need for the extension and improvements of these programmes.

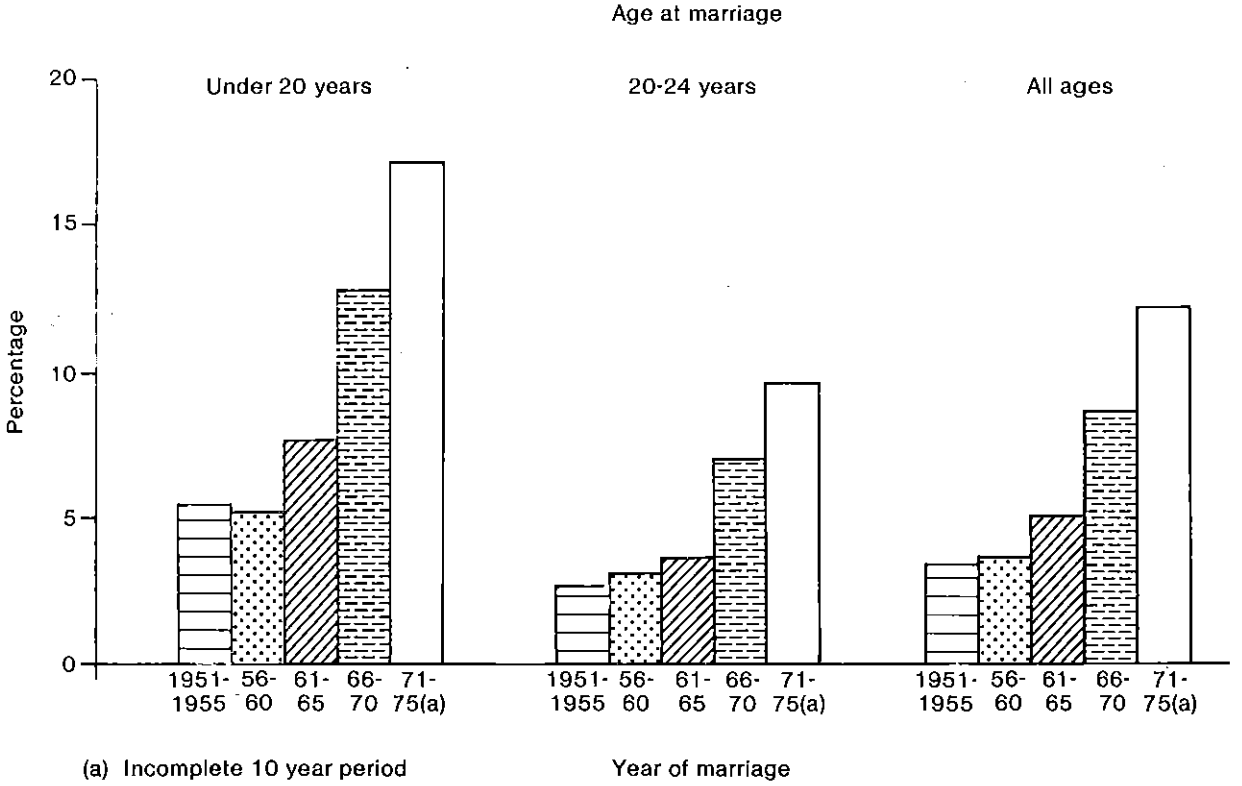


Figure 12. Proportion of first marriages ending in divorce before 10 years: year of marriage and age of wife at marriage.

Motor Vehicle Accidents – Motor vehicle accidents are a particular problem in modern society because of the age group of the people involved and the fact that in many cases innocent bystanders are killed or permanently disabled. The relationship between drink-driving and accidents has been well established. Since the introduction of Sunday trading in Western Australia the rate of accidents on the weekend has increased. It is entirely possible that extension of trading hours associated with the America's Cup will lead to increased number of deaths from motor vehicle accidents. What is most tragic is that many of these will involve innocent people. It seems likely that there will be further pressure for the liberalisation of liquor licensing laws and advertising and promotion, which will lead to an increasing number of MVAs and other alcohol-related diseases.

Cancer – With an aging population and the control of many deaths at a young age, cancer becomes increasingly important. This does not mean that age-adjusted mortality rates from cancer are increasing; in most cases they are not. The one major exception is lung cancer which is almost entirely due to cigarette smoking in Australia. The prospects of curing cancer in the immediate future are not good. However, knowledge of prevention has increased substantially over the past decades. The reduction in cigarette smoking and improvement in diet should contribute to a decline in the incidence of a number of cancers. However, as with cardiovascular disease, the success of this programme depends on the lifestyle of the individual and the community environment of Western Australia.

Infections – Most of the bacterial infectious diseases in Western Australia have been adequately controlled by immunisation or by treatment with antibiotics. However, the recent upsurge in cases of whooping cough demonstrates need for continuation of immunisation campaigns. The low incidence of

infectious disease makes it easy for society to relax its vigilence and expose a vulnerable population to risk. With viral diseases the situation is less satisfactory. While most viral diseases are relatively minor, there are a number of viral diseases which can occur in Western Australia which cause severe morbidity and even mortality. There is an increasing incidence of hepatitis B, which may be attributed to increased use of hard drugs and promiscuity. The recent availability of vaccine for this disease which can be given to at-risk groups, including health workers, may substantially reduce the prevalence of this disease. The north of Western Australia is prone to a number of arbor viruses. Building of large dams in the tropics, such as Lake Argyle, exposes residents in that area to these insect-borne viral diseases. People now have greater expectations of the health care system and while there will be pressure for control of diseases such as the common cold and influenza, there is no prospect for this in the near future.

Genetically Determined Disease – Much publicity has been given in the past few years to in vitro fertilisation and genetic engineering techniques. However, it is unlikely that these will provide any relief of the incidence of genetically determined diseases in the foreseeable future. What has happened in Western Australia is that programmes for the in-utero detection of certain disorders such as muscular dystrophy and mongolism have been developed.

Abortion – Abortion has become increasingly common in Western Australia in the past two years. The availability of safe, medically supervised abortion has almost eliminated maternal deaths from septic abortion. While the situation in WA has not reached the level in some states in the USA, where the number of abortions now exceeds the number of live births, the high incidence of abortion in WA cannot be regarded as satisfactory. It highlights the need for the continued provision of family planning advice for all couples who desire it and the elimination of unwanted pregnancies.

Venereal Disease – There is a likelihood that in the future vaccines may be developed for the common forms of venereal disease. Continuing health education, and the surveillance of high-risk groups should result in a continuing reduction in rates of venereal disease.

However, the advent of AIDS caused by the HTLV3 virus presents Western Australia with its most important public health challenge since the typhoid epidemics of the last century.

The severity of this disease and the demand on medical resources for its treatment will cause an increase in the demand for acute hospital care in Western Australia. Because the disease is incurable with present knowledge, the emphasis must be on prevention. Continuing surveillance of high-risk groups and the widespread use of condoms may partially control the disease. However, no comprehensive control strategies have proven to be entirely successful. So far transmission of the disease to professional staff such as hospital workers has only been reported in one or two cases in the United States.

Demographic Changes – It is important to make demographic projections in order to understand the pressures on and changes to the social and physical environment. Immigration is the demographic variable which is most difficult to predict. In WA the number and the proportion of the elderly will increase in the medium term, but there will be little change in birth and death rates. Studies at Busselton and Tasmania have demonstrated the increased utilization of health services by aged persons, is due to the fact that almost all chronic diseases increase in prevalence with age. Therefore the aging population will result in increasing numbers of persons with most of the chronic diseases which have been discussed above.

ENVIRONMENTAL CHANGE FOR IMPROVING HEALTH

As health in the community is directly linked with the condition of our environment, more attention should be given to the following environmental aspects:

The Social Environment – This is extremely complex, for many changes which by themselves may have only marginal changes, together, may cause disease. Important positive factors include those which promote stable family relationships and improve equity in the distribution of community resources. The availability of work is an important determinant of health and every effort should be made to keep unemployment to a minimum. For those who are unable to work, satisfying alternatives will have to be found.

Physical Environment – The provision of pure water, sewage, and basic home facilities such as a refrigerator and cooking stove are almost universal in Western Australia. Efforts must be made to ensure that each person in society has access to these basic rights. In planning the physical environment, adequate consideration must be given to the health implications. Crowding people together in high-rise apartments obviously has serious effects. Provisions

must be made for adequate and safe recreation facilities in order to increase the amount of exercise being undertaken by the community. Industrial and urban development should not be allowed to pollute the environment.

Health Education and Health Promotion – There is considerable scope for improving the health of the individual members of our society. Some health promotion initiatives have been most successful and have resulted in considerable improvements in health. A good example has been the fluoridation of water supplies which has considerably reduced the amount of dental disease in the community.

However, such activities involve some curtailment of individual rights. There is a delicate balance between rights and responsibilities. For example, each person should have the right to work in a pollution-free environment and hence smoking should not be permitted in the workplace. But smokers also have a right not to be harassed, when because of the nature of their addiction, they have some need to indulge in it.

The availability of "health" information to the community is also a "right" and should not be influenced by business or political considerations.

Occupational Health – there has been increased emphasis on Occupational Health in Western Australia in the past few years. More stringent noise regulations should result in reduction in the noise factor in work-induced deafness in the future. The increasing recognition of the dangers of substances such as asbestos, and the recognition of the need for safe handling of hazardous chemicals will result in a safer working environment for workers. Increasingly employers are recognising the benefits of the healthy workforce, in terms of reduced absenteeism and accidents and increased productivity. Many have now introduced Health Promotion Programmes and are encouraging employee health and fitness. However, the introduction of new technologies may increase the number of people undertaking unrewarding work or alternatively may release some people from repetitive activities. Obviously much thought and consultation is needed.

Treatment Facilities in Western Australia – There will be increasing demand for acute-stay hospital beds in Western Australia due to the aging population, the increasing expectations of the public, the availability of improved surgical techniques and the general level of increasing medical technology. The increasing levels of minor psychological disturbance may lead to pressure for increased consumption of psychotropic drugs. This would be an unfortunate development and education of the public and health professionals should be directed towards the use of alternate methods of treatment and prevention. Research in viro-technology and immunology may lead to the availability of new drugs for the treatment of cancer and other chronic diseases, but not in the medium term. Thoughtful planning of Health Services will be required to ensure that they meet community needs, but that they do not proliferate to the extent of encouraging dependency within the community or produce iatrogenic disease. Health resources could be diverted into monitoring environmental change and its relationship to the promotion of health.

Rehabilitation – There may be some reduction in the level of disabilities and the number of handicapped persons in the community as a result of the control of some infections and degenerative diseases. If the rate of motor vehicle and occupational accidents can be reduced a further source of disability will be controlled. The development of improved methods of rehabilitation including occupational therapy, physiotherapy, improved surgical techniques and the development of the prosthesis and artificial devices, including microprocessor controlled equipment, will improve the prospects for the handicapped in our community. However, this will only be achieved at considerable cost for each individual and problems of distribution and equity of access to the techniques will have to be addressed. Efforts will have to be made to improve the rehabilitation of persons with occupational diseases such as repetitive strain injury and those who have psychological illness.

CONCLUSION

Health, or the lack of it, is very important to the average citizen. Yet as individuals and as a community, we still do not put enough effort into planning to maintain and improve our health. The major causes of disease in W.A. at the present time relate to our lifestyles, including the social and physical environment. Yet we devote little time and even fewer resources to exploring this complex relationship. We need to

ensure that the physical and social environment in which we live is conducive to attaining a maximal level of health. If this effort is made we will no doubt benefit in seeking harmony with our environment. We should seek a lifestyle which maintains environmental quality and in return this will maximise our achievement of the goal of health for all members of our society.

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HAZARDOUS CHEMICALS AND THE ENVIRONMENT

by B.P. KENNEDY

An Invited Review Paper as Background
for the Development of a
STATE CONSERVATION STRATEGY FOR WESTERN AUSTRALIA

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INTRODUCTION

Chemicals are an important part of modern life. For example, chemicals have enabled the provision of modern materials(e.g. plastics), improved the efficiency of food production (by use of pesticides and fertilisers), and are central to the operation of industry and the mobility of people (petrol, and petroleum products).

There is, however, increasing concern that irretrievable harm may be done to the environment by the misuse or misapplication of chemicals, or by the indiscriminate dumping of chemical-based wastes. The misuse and overuse of pesticides has caused concern for non-target species (e.g. aquatic species in streams receiving run-off, and the predators of the aquatic species). Pesticides and fertilisers may also contaminate groundwater used for human consumption. Emissions from internal combustion engines include nitrogen oxides and hydrocarbons, which, under certain climatic conditions result in photochemical smog. The lead in petrol has also been of environmental and health concern. The use of chlorofluorocarbons as propellants in aerosols has led to speculation about their possible effects on the atmospheric ozone layer.

As a result of concerns in Australia about the effects of chemicals on the environment, and on human health, a number of reports have been commissioned, e.g.[1,2,] and seminars held, e.g.[3,4]

There has been a great deal of activity, at both State and National levels over the past several years, in attempting to rationalise and improve chemical controls, in order to minimise exposure of people and the environment to harmful chemicals, although much work remains to be done. A great deal of effort is also required to ensure that the majority of users of chemicals are properly trained. They need to be aware of their responsibilities, both legal and moral, to the environment and for the protection of their own health and that of others who may come into contact with the chemicals, or the produce or products which may contain those chemicals.

INTERACTION OF CHEMICALS WITH THE ENVIRONMENT

In the discussion which follows, the concept of the "life cycle" of a chemical will be used. The life cycle includes the stages of manufacture or importation, transport, storage, use and disposal. The concept is useful, because it allows identification of the stages at which a chemical is likely to interact with the environment. Different types of chemicals are likely to impact on the environment at different stages of their life cycle, depending on their intended function.

From the point of view of the environment, the air is most likely to be affected by industrial emissions (e.g. sulfur dioxide), vehicle emissions and aerosols. Marine environments are likely to be affected by industrial effluents and oil spills, as are estuarine environments. Soils and groundwater are likely to be affected by industrial effluents, leachates from improperly managed waste dumps (including dumps unknown to the authorities), and pesticides and fertilisers.

The actual impact of the chemical on the environment will depend on several factors, some of which relate to the chemical itself, and others which relate to the extent and pattern of use, the extent and pattern of misuse (eg overuse, or application to non-target species) and the nature of the ecosystem.

TYPES OF CHEMICALS CONSIDERED

The principal classes of chemicals used in Western Australia are related to the economic activity of the State. The classes of chemicals which may be considered are:

- explosives;
- dangerous goods;
- drugs – veterinary
  - pharmaceutical
- fertilisers;
- pesticides;
- industrial chemicals.

Explosives are used principally in the mining industry, and all aspects of their life cycle are closely controlled by regulation. Apart from the obvious effect explosives have on the environment in the normal course of their use, the major hazard is to human health, and not to the environment. By its nature, mining is disruptive to the affected environment, whether the minerals are won by machinery alone, or in combination with explosives.

The term "dangerous goods" is a legal one, and covers a wide range of different types of chemicals (e.g. fertilisers, pesticides and industrial chemicals). Apart from chemicals discussed below in terms of their use, dangerous goods are most likely to enter the environment through accident – e.g. a transport or storage emergency. There is, consequently, a need for appropriate information and emergency response systems, to help ensure that such situations do not arise, or if they do, to minimise risk and damage to people and the environment. In Western Australia, the transport situation is catered for.[5,6] The situation regarding storage, and placarding of storage areas is less advanced, and is the subject of a report which is now out for public comment.[7]

Drugs, although of concern in the public health and veterinary health arena, do not appear to be of concern in the environment.

Fertilisers are specifically designed to be applied to the environment to enhance the growth of economically desirable plants. This is particularly necessary in the light soils encountered in Western Australia, particularly in the wheat belt. Fertilisers can cause problems if they are applied at rates greater than those recommended, or needed, for a particular region. Over-application often results from the notion on the part of users that if a certain amount is good, more must be better. An example of where fertiliser over-use has caused problems is the Peel-Harvey Estuarine System.[8] Over the years (particularly since the Second World War) local farmers have been applying phosphate-based fertilisers to their land. In the 1970s, the run-off into the local rivers, and eventually into the Peel Harvey System, caused eutrophic conditions in the estuary, leading to the extensive formation of *nodularia* blooms, which had adverse effects on the aquatic life and recreational value of the estuary. Whilst the algal blooms can be harvested, the long-term solution to the problem remains the reduction of the phosphorus store in the soil and water, and the reduction of further input of phosphorus into the system. The first is being tackled by proposals to dredge the system so as to allow greater drainage to sea, and to build the Dawesville Channel, which will also enhance drainage to the sea. Input of phosphorus is being reduced by the introduction of a new "high-sulfur" fertiliser, and by monitoring fertiliser levels in soils, enabling recommendations to be made to farmers on quantities of further fertiliser to be added. In addition to its environmental benefits, this program has a distinct economic advantage to farmers, and has been very successful. Otherwise, there is little monitoring of the effects of fertilisers on the environment in WA.

Pesticides have the potential to have a great deal of impact on the environment, as they are specifically designed to be toxic to particular organisms. The extent of pesticide usage in Western Australia is increasing, as shown in the following table:[4]

Pesticides Sales (Western Australia)

	Sales ($000s)				
	1978	1979	1980	1981	1982
Herbicides	7 386	11 116	18 517	19 233	29 616
Insecticides	2 664	3 586	3 274	3 120	4 489
Fungicides	925	1 049	1 458	1 816	2 130

The rapid increase in herbicide sales has been due to the acceptance of "minimum tillage" methods of farming, which involves the use of a pesticide and direct drilling at seeding. This involves less work (and cost) for the farmer, and conserves the top soil.

Work done in 1985 for the Department of Conservation and Environment confirms the widespread use of pesticides throughout Western Australia, by government departments, farmers, other commercial users (e.g. market gardeners, floriculturalists, horticulturalists) and pesticide operators. It is not yet possible to quantify the use, but the geographical spread is considerable.[9]

Pesticides can cause problems with non-target organisms by direct contact, and through "biomagnification". This results when pesticides are concentrated up food chains. Rachel Carson, in her book *Silent Spring,* Penguin, 1965, brought this problem, among others, to public attention, particularly in relation to organochlorine pesticides (which are difficult to degrade). Thus fish can absorb organochlorines, and the birds which eat the fish may lay eggs with thin shells, which are easily cracked, affecting the viability of the predator species.

Once pesticides are applied, their concentraton can be reduced by a number of factors, such as volatilisation, adsorption onto the soil (making some unavailable for further use), leaching into the groundwater, dissolution in surface run-off; photochemical breakdown, and chemical and microbial breakdown in the soil. Some of these processes (e.g. the breakdown processes) ensure no further effect on the environment. Some of the physical processes transport the pesticide to other areas, and can lead to non-target organisms suffering. This is particularly so if the pesticides are not easily degraded (e.g. organochlorines) and persist for long times in the environment. DDT has been implicated in eggshell thinning of peregrine falcons. Dieldrin (also an organochlorine) has a different use pattern than DDT, and thus causes a different set of problems. It has been used principally against potato weevils, and whiteants in soil and wood structures, such as sheds and houses. Dieldren residues have been detected in potatoes, cows milk for human consumption, pig and beef meat, and human breast milk. In some cases, the residue levels have been greater than the maximum residue limits (MRLs) for dieldren in the respective products. All agricultural uses of dieldren have now been disallowed. Heptachlor is another organochlorine, which has been used in the Argentine Ant program. Part of the reason for its use is its slow rate of degradation but this very property makes it that much more likely to interfere with non-target organisms.

Because of their persistence (and their over-use in the past), organochlorines are losing favour, and are slowly being replaced by substitutes, often organophosphate-based pesticides, which are much less persistent.

Direct contact of non-target organisms can occur through poor application (e.g. spraying too close), spraying in windy conditions, poor attention to switching on and off by aerial operators).

Selective herbicides may alter the ecological balance (usually to reduce genetic diversity) of weeds on farmlands. Up to forty years ago, the principal weed problems in Western Australian cereal crops were radish, turnip, capeweed, and broadleaved weeds. These species were controlled by 2,4-D, which then allowed annual grasses (e.g. annual rye-grass and wild oats) to become dominant. Herbicides which appeared in the late 1970s have almost eliminated these as problems, and Brome and Silvergrasses are now the dominant species.[4]

Monitoring of the effects of pesticides on the flora, fauna, soils, groundwater and people has not been very extensive in Western Australia. "Monitoring conducted by State authorities is not on an as-planned routine as occur with export produce. Monitoring occurs in relation to specific problems or specific areas."[4] (p13). After large amounts of organochlorine pesticides were used in the Ord River Irrigation Scheme an extensive monitoring scheme was established, to determine residue levels in produce. The monitoring has been kept going to establish the persistence of the residues. Specific surveys of south west rivers, metropolitan rain water, cows' milk, birds and fish, eggs, human breast milk, and other organisms or products have been undertaken, many on an on-going basis.[3]

The principal thrust of Western Australian regulations on pesticides is protection of human health and the economic well-being of the State. There is increasing recognition of the need for environmental protection in the clearance and registration procedures for pesticides.

Greater emphasis on correct application (and personal protection) procedures by operators will ensure less application to non-target species, and hopefully less cost in terms of pesticide used. The congruence of economics and environmental protection is a fortunate one. As mentioned above, minimum tillage methods have encouraged the use of herbicides, and in this case economics and environmental concerns appear to be opposed. Integrated pest management is a concept that may reduce pesticide consumption. It requires an adequate knowledge of the population ecology of the pest to be controlled, and other organisms, especially its natural enemies. By combining crop management, and biological and mechanical controls (and if necessary chemical controls), the intensity of pesticide use can be cut. The US Office of Technology Assessment has estimated that this approach could decrease US pesticide usage on some crops by 75%, and reduce pre-harvest losses by 50%. Thus both economic and environmental impacts are very positive.[10]

"Industrial" chemicals are usually taken to be those used in industry. They are usually defined by exclusion (not scheduled poisons, nor pesticides nor veterinary drugs nor food additives). Little is known

about the extent of use in Western Australia of industrial chemicals. The Commonwealth Government is in the process of introducing a mandatory notification scheme for new chemicals, which will require, *inter alia,* an assessment of their effects on the environment. As a preliminary to the introduction of the scheme, however, companies are being encouraged to notify the Commonwealth of the chemicals they are currently using. No details of environmental assessment or health effects are required. For this reason, it will be necessary to identify "priority existing chemicals" which need to be examined for their health and environmental effects.

Contamination of aquifers by industrial chemicals can be serious, as was shown in the Cockburn Sound study. For example:

- hydrocarbons beneath an oil refinery;
- caustic soda, ammonia, chromium beneath an alumina refinery;
- ammonium sulfate, chlorides and nickel from a nickel refinery;
- phenol, 2,4-D, and 2,4,5-T from a herbicide plant;
- ammonia, nitrate and nitrite under a fertiliser works;
- chromium beneath tanneries.[11]

Such contamination can be prevented, or drastically reduced, by plant design features (safety systems, bunding to retain escapes) and operational procedures.

LIFE CYCLE

Manufacture of chemicals in Western Australia is principally at Kwinana, with some formulators in the metropolitan area. The vast bulk of chemicals are imported into W.A. however. The existence of the Transport Emergency Assistance Scheme has already been mentioned. There is a need to extend this scheme to storage areas, including manufacturing and formulation sites, to prevent environmental damage and minimise risks to health in the event of an emergency.

Transport of dangerous goods by road is well regulated,[5] and recommendations for storage are in train.[7] The use of pesticides is covered by label directions, although the extent to which directions are followed is not known. Poisons are controlled through the sale and supply mechanism, with explicit statements on labels giving warnings, and where warranted, first aid messages. Apart from a restricted range of industrial chemicals, the use of most industrial chemicals is completely unregulated. Requirements for labelling, indicating safe methods of use, first aid and clean-up procedures are most necessary.

Disposal of hazardous chemicals occurs at a site at Orange Grove with an impervious clay lining, preventing entry of chemicals into the groundwater. Disposal in non-metropolitan areas is a problem of unknown magnitude. In agricultural and mining areas, pesticides containers and chemicals containers can be difficult. Residues in the containers can have long-term environmental effects, but good chemicals management should ensure nil residues.

The Government is currently investigating the possibility of establishing a national waste incinerator in Western Australia to incinerate intractable wastes. The intractables include chlorinated aromatic compounds, (e.g. polychlorinated biphenyls, and pentachlorophenol) which do not degrade in the environment. The facility would also be able to handle other types of hazardous waste.

FUTURE DIRECTIONS

In order to reduce the impact of chemicals on the environment and human health, several programs need to be implemented:

- monitoring of the environment to ascertain its current state;
- establishment of standards;
- provision of information systems (labelling, placarding of buildings, emergency response);

- training people to use information systems (e.g. read the label) in order to minimise environmental and health problems and to maximise economic return;

- investigation of non-chemical means of solving problems.

Given the limited resources of the State, it is neither feasible nor desirable to establish monitoring programs for the impact of all hazardous chemicals on all aspects of the environment. Foci of interest need to be recognised. Pesticide problems are the province of the Pesticides Advisory Committee, and the agencies represented on it have the expertise to assess the need for, and establish, monitoring programs, and assess the results thereof. Where pollution affects, say, waterways or wetlands, the appropriate agencies should be the ones to establish monitoring programs.

Another set of committees, with a more general focus, is the Community Consultative Committee on Chemicals and the W.A. Advisory Committee on Chemicals. The latter consists of representatives of government departments with an interest in chemicals, and the former consists of those government officers,plus a broadly-based range of community groups. These committees have identified a number of issues of concern to the community, and have made, or are making, reports on some of these. These include the storage of hazardous chemicals and the development of a survey to establish the extent of use and storage of all types of hazardous chemicals.

In a survey carried out for the Department of Conservation and Environment, pesticide use patterns throughout Western Australia were determined, and when the data are analysed, will form a useful basis for future work.[9]

Information systems are not generally well established, apart from labels for pesticides and poisons, and much further work needs to be done in this area, at both National and State levels.

Disposal of hazardous chemicals poses a problem in Perth with its sandy soils. Although the current arrangements are satisfactory, there is a need to identify possible future sites which are suitable geologically and environmentally. Their location must be such that transport of waste to them is economically viable in the context of alternative disposal methods.

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THE PRESENT STATUS OF INTRODUCED SPECIES IN WESTERN AUSTRALIA

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AGRICULTURE PROTECTION BOARD OF WESTERN AUSTRALIA

An Invited Review Paper as Background
for the Development of a
STATE CONSERVATION STRATEGY FOR WESTERN AUSTRALIA

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INTRODUCTION

The sole objective of the Agriculture Protection Board is to safeguard the agriculture and pastoral industries, related resources and the associated environment from the effects of certain problem plants and animals.

The Board has three functions: preventing the introduction and spread of declared plants and animals; eradicating and controlling plants and animals already present, and research into the status, management and control of declared plants and animals.

The prevention of introduction and spread of potentially damaging plants and animals into the State is a primary function of the Board.

Introduced weeds not only reduce crop and pasture yields, they may also invade bushland competing with native plants and changing the environment to the detriment of native animals. The impact of weeds on agriculture in Western Australia can be gauged by the value of the herbicide industry which is in excess of $100 million annually.

Introduced animals may cause damage directly to crops and compete with domestic animals for grazing. They may also prey on native animals, or compete with them for food, habitat or breeding sites. There is also the threat of exotic diseases for which the feral animal population would provide a reservoir.

Animals which are not indigenous to W.A. are assumed to be potentially harmful to our agriculture, environment and wildlife unless the contrary can be proved.

The powers of the Agriculture Protection Board are set out in the Agriculture & Related Resources Protection Act. The Board can 'declare' species of plant and animal and place restrictions on the entry, keeping, movement, control and management of each species. Declaration may be for the whole of the State or any part thereof.

Considerable effort is made to reduce the chance of a new pest plant or animal species from being introduced to the State. A major cause for concern is the interstate movement of livestock and machinery, and the accidental arrival of animals and/or plants by sea or air. Road and rail checkpoints are carried out on interstate traffic at Norseman and Parkeston respectively. Animals and goods arriving by air or sea are inspected on arrival. Premises, such as those of aquatic plant and fish dealers, are inspected regularly for *Lymnaea* snails, hosts of the liver-fluke parasite. Searches are made of likely infested areas for the presence of such weeds as Skeleton weed. A team stationed at Eucla constantly monitors and controls the entry of the would-be immigrant, the starling.

Declared species are placed in an appropriate category depending on the seriousness of the pest, the costs and practical limitations to control it, the area known to be infested, and the geographic and climatic range of the pest. The categories of declared animals and plants are detailed in Appendix 1, the declared animals in Appendix 2 and the declared plants in Appendix 3.

Not all of the crop and pasture weed species in W.A. are "declared" plants. Many, including traditional agricultural weeds such as doublegee, wild turnip, wild radish, thistles, sorrel, wild oats and annual ryegrass, are amongst the most troublesome weeds to farmers. It is estimated that annual ryegrass and wild oats would, if they were not controlled, reduce cereal crop yields by at least $100 million annually.

In addition to the agricultural plant pests a large number of introduced species have developed into significant weeds on roadsides, nature and recreational reserves, and in home gardens. Several of these species receive individual attention in this paper while Cape tulip, dock, castor oil plant, watsonia and many others have been omitted.

Introduced species of animals in Western Australia have undoubtedly had a considerable impact on the natural environment. This impact can be recognised by the degradation of rangelands (e.g. from donkey, goat, rabbit and pig), increased soil erosion (e.g. from donkey, goat and rabbit), and a diminishing flora and fauna (e.g. cat, fox, pig and potentially from sulphur-crested cockatoo and starling).

Collectively, the impact of introduced species poses a significant ecological threat to attempts to re-establish either individual species or whole habitats, or to prevent their further decline. The following accounts provide examples of the different types of environmental impact recognised for introduced (declared) animals.

Introduced animals which are not declared species include rats, mice, feral pigeons, two dove species, the

kookaburra and the mallard. Declared animals not included in the position paper include the feral camel, feral horse, feral cattle, palm squirrel, dingo and feral dog, rainbow lorikeet, and the many forms upon which the Board places restrictions on the importation and keeping in captivity.

FERAL GOAT *(Capra hircus)*

In Western Australia, feral goats are now found over all the central pastoral areas in varying numbers (Figure 1). These areas vary in vegetation from open mulga savannah woodland to densely vegetated woodland in the lower Murchison.

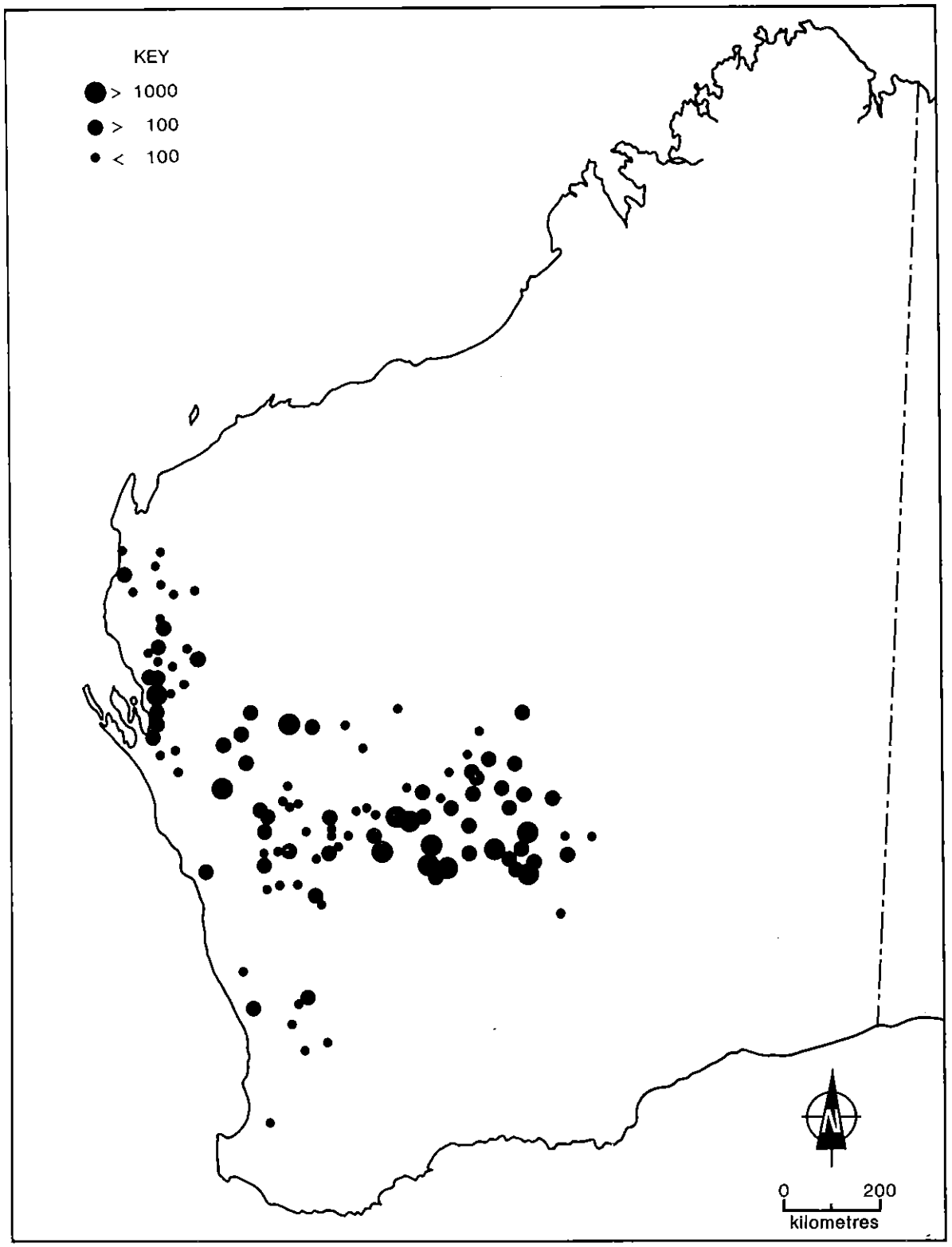


Figure 1. Population estimates of feral goats on pastoral stations, as given by APB District Officers, 1985.

In the early 1970s pastoralists estimated the total population of feral goats to be in the order of 450 000.[1] However, estimates of the Western Australian population vary from 300 000 to 700 000.[2,3]

Since 1973 over 1.5 million feral goats have been harvested in Western Australia and the present rate of harvest is approximately 100 000 per year (Table 1). These animals are either sent for slaughter or destroyed for bonus payment. Whilst the population may have been significantly reduced in some areas of W.A., it is unlikely that numbers are less than half of the original population.

The extent of the impact of feral goats is mainly the degradation of the rangelands and its consequences. Most of the area in which feral goats are found in large numbers is devoted primarily to sheep raising. The presence of the feral goats means less production from the sheep and greater pressure on the natural pastures.

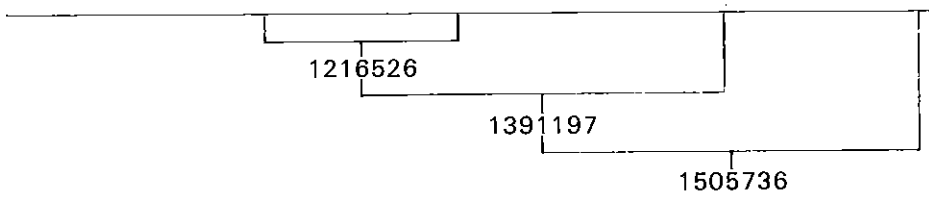
Goats eat most species of trees and shrubs which occur in their habitat and also eat the short lived plants (ephemerals) and grasses which grow after rain.[2] How serious this damage is will depend on the number of goats present and the way in which the land is used.

Relatively little is known of plant productivity in arid and semi-arid pastoral areas of Australia or Western Australia. The regeneration of some trees and shrubs has been prevented by the combined effects of sheep, feral goats and rabbits.[2]

Table 1 Goat Destruction Figures

Goats Destroyed

YEAR	SLAUGHTERED MARKETED	SLAUGHTERED PET MEAT	DESTROYED NON-BONUS	DESTROYED BONUS	TOTAL
1973	142772	13939	81637		238348
1974	114522	10802	63269		188593
1975	60669	8121	4368		69158
1976	87324	1356	15226		103906
1977	80339	2095	10171		92605
1978	50090	–	–	5107	55197
1979	113057	–	–	29232	142289
1980	100895	–	–	33310	134205
1981	86486	–	–	9869	96355
1982	66853	–	–	11567	78420
1983	91096	–	–	10967	102063
1984	81631	–	–	5709	87340
1985	99479	–	–	8778	108258
	1180213	36313	174671	114539	1505736



The APB incurs relatively few costs for feral goat control. Costs are primarily administrative and include the issuing of permits, property inspections, and until recently, payment of bonuses. The majority of the costs of feral goat control are met by landholders who pay the costs of mustering and transportation.

The dollar value of the feral goat infestation on the environment in Western Australia has not been estimated.

In 1982/83 the goat meat market was worth over $2.0 million to pastoralists in W.A.[4] Pastoralists have been receiving up to $18 per head and in some cases this has been the main source of station income.

At least 30 per cent of the feral goat population today could produce reasonable quantities of cashmere, as it stands, and with processors paying up to $110 a kilogram the returns could be very high.[3]

Feral goats are 'declared' (noxious) animals under the Agriculture Protection and Related Resources Act (1976). The objective of this declaration is to eradicate them from the State.

In 1972, the APB introduced a commercialization policy for feral goat control. This policy allows landholders to sell them to abattoirs for slaughter. A permit from the APB is required before they can be held on a property or transported. The APB requires that all feral goats be destroyed if they are not shipped for slaughter or held under a permit. To encourage this a bonus of up to $1.00 was paid on the ears of feral goats in some regions of the State. This bonus system was recently revoked as it was not achieving its objective.

The impact of effectiveness of the commercialization policy is unknown. After thirteen years of control, and the destruction of approximately 1.5 million feral goats, primarily through commercialization efforts, the population appears to be unchanged.

The economic incentive of commercialization has influenced, and likely reduced, the control programme's effectiveness. Landholders, transportation companies and meat processing and marketing organizations all obtain immediate economic rewards from feral goats. There appear to be strong incentives to manage feral goats to maximise returns, especially by those who are not affected by goats on their properties. Although the principles for the use of commercialization as a control method are sound, where the cost to the community is relatively low, as a control method it will never result in the eradication of goats. This is indicated by the estimated level of infestation still remaining after 13 years of control.

If eradication is the prime objective, the required input to achieve this would be extremely high. An estimate of this input is nearly impossible as the distribution and nature of feral goats make it extremely difficult to eradicate all of them. The cost of removing 37 goats from Bernier Island by shooting from helicopters amounted to $25 045[5] (Table 2).

It is unlikely that funds to undertake the level of activity to eradicate the feral goat from W.A. will become available in the immediate future. Therefore, the current policy using commercialization may be the only feasible and acceptable method of control currently available.

Table 2 Costing of Bernier Island Goat Eradication Programme (From Morris 1984)

1.	HELICOPTER	
	Ferry Flight Kununurrra-Carnarvon-Kununurra 27 hours = $300/hour	$ 8,100
	Charter Bernier Island 35.6 hours = $325/hour	11,570
	Fuel : 3,400 litres Jet A1	1,550
	Pilot's Expenses	160
2.	PRELIMINARY AERIAL SURVEY	
	1.9 hours = $165/hour	315
3.	EQUIPMENT PURCHASED	1,450
4.	WILDLIFE RESEARCH CENTRE PERSONNEL AIRFARES & ALLOWANCES	1,900
	TOTAL	$25,045

FERAL PIG *(Sus scrofa)*

In the south west feral pigs are known to be present on 191 properties in 20 shires. The degree of infestation is described as light on 137 properties, medium on 23 properties, and heavy on 31 properties (see Table 3). Numbers of feral pigs involved and the area covered on each property are not recorded. They also occur in many forestry areas away from agricultural lands. The present known range extends from just north of Perth south to Bridgetown and Boyup Brook. North of Perth concentrations of feral pigs exist in the Greenough and Chapman Valley areas, in the Pilbara and north west regions, and on a number of the river systems in the Kimberley.

It is estimated that there are probably 10 000 feral pigs in the south west of Western Australia.[6] A density of 2-4 pigs/km^2 has been recorded at South Dandalup dam and estimates over this part of their range indicate a density of c.1 pig/km^2. Estimates of the total number of feral pigs in W.A. range from 500 000[7] to 25 000-30 000 pigs. Figure 2 shows the distribution of pigs by infested properties.

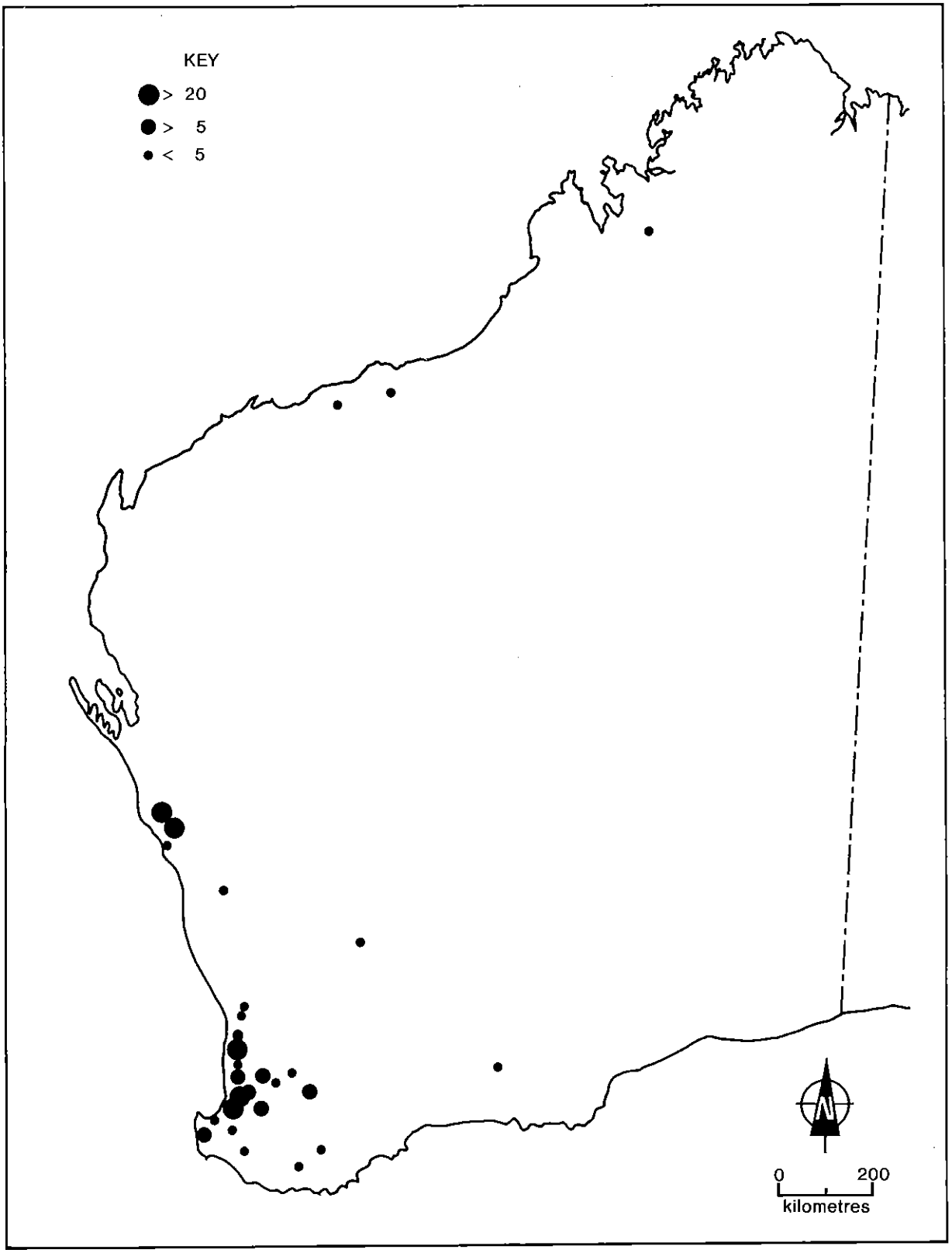


Figure 2. Feral pigs, numbers of infested properties, 1985.

Table 3 *Pig Infestations in Western Australia in 1985

*1 Density of Infestation

Shire	Light	Medium	Heavy	Total Properties
South West				
Augusta-Margaret River	11	3	–	14
Boddington	9	1	–	10
Boyup Brook	13	–	–	13
Collie	5	–	1	6
Cuballing	1	–	–	1
Cranbrook	1	–	–	1
Dardanup	16	4	–	20
Denmark	3	–	–	3
Donnybrook-Balingup	32	3	2	37
Esperance	–	–	1	1
Greenough	1	–	–	1
Harvey	10	5	26	41
Murray	20	3	–	23
Mundaring	1	–	–	1
Nannup	1	1	–	2
Serpentine-Jarrahdale	1	–	–	1
Swan	2	1	1	4
Waroona	3	1	–	4
Williams	2	–	–	2
West Arthur	5	1	–	6
Totals	137	23	31	191
North West Pilbara				
Port Hedland	1	–	–	1
East Pilbara	1	–	–	1
Totals	2	–	–	2

(*data from APB computer) (*1 estimated by APB District Officers)

In Australia, feral pigs cause damage to potatoes, sugar cane, oats, barley, wheat, rice, sorghum, sunflowers, millet, corn, soy beans, pastures, and cause damage to roads, tracks, fences and water supplies.[8,9,10,11,12] They have also been accused of causing damage in vineyards and preventing forest regrowth.[12] One authority[13] accuses them of being a predator of small animals and ground nesting birds. Predation on lambs has been recorded by many authorities.[7,8,11]

There are no qualitative assessments of the problems caused by pigs in the state forests of Western Australia.[14] The extent to which they may aid the spread of jarrah dieback *(Phytophthora cinnamomi)* or produce conditions which are favourable for spread is not known. Feral pigs have the potential to increase turbidity in water supplies but there have been few problems directly attributable to pigs in the south west forests.

The potential of feral pigs to harbour disease transmittable to man and other animals is considerable. Anthrax,[8,13] leptospirosis,[15] brucellosis, tuberculosis,[16] foot and mouth disease, rinderpest, swine fever (Hog cholera), African swine fever and trichinosis[17] could be or are carried by pigs. Feral pigs in New South Wales are frequently infected with Leptospira and Murray Valley Encephalitis.[18] Pigs are also host to a stage of *Spirometra erinacei* tapeworm of dogs, cats, foxes and dingo.[19]

There are no estimates of the value of feral pig infestations in W.A. The main technique used in their control is 1080 poisoning.[14] Trapping has been used in metropolitan water catchment areas but erecting and tending traps involves high labour costs. Hunting and fencing do not appear to have been used extensively in W.A. Information from other parts of Australia suggests that hunting and fencing are not cost-effective.[20] The reductions estimated from track counts before and after 1080 poisoning programmes[21] in 1981 (49%) and 1982 (38%) are below the level (70%) suggested in eastern Australia[22] as necessary to effectively reduce the population over a twelve month period.[14]

Total eradication is not possible with existing control techniques and knowledge of the ecology of this species. There is hope that they can be contained within the present range with improved control measures. Currently, research is in progress on methods of control.

FERAL DONKEY *(Equus asinus)*

Feral donkeys are found over a considerable portion of the interior and north of Australia. They are commonplace in the pastoral country of the northern two-thirds of Western Australia. The total number of feral donkeys in Australia is difficult to estimate. Based on a questionnaire in 1976 it was estimated[23] that the total population of donkeys "is probably as high as 75 000". This now appears to be a gross under-estimation as current APB estimates for Western Australia set the figure between 0.5 to 1.0 million.

In Western Australia, feral donkeys are widely distributed in the Kimberley, Pilbara, north west and Goldfields districts.[24] Although no accurate population assessment is available Figure 3 shows the population estimates of feral donkeys on pastoral stations as given by APB District Officers, 1985.

Competition is the major impact of the feral donkey infestation in W.A. Donkeys compete with cattle for food as they have extremely catholic tastes in their feeding habits, and seem to be able to eat almost any plant that grows.[23] This decreases the amount of vegetation available for cattle. An aerial survey in the East Kimberley in 1980 showed that there was approximately one donkey for every three cattle along the flight transects. This is indicative of a significant level of competitive interaction as it is believed that both species exploit similar environmental resources.[25]

It has been alleged that donkeys are in such concentrations as to cause pasture deterioration through overgrazing. Only limited studies have been made of the overgrazing issue, and these have usually exonerated the donkeys.

Donkeys are also adept at digging for water soaks in dry stream beds and apparently will drink saltier water than either horses or cattle.[23] This has led to competition for water and also fouling and erosion of water holes. Donkeys can negotiate very rough country, which enables them to range widely in search of food and water. This has resulted in degradation of the fragile rangeland environment.

The only documented cost of the feral donkey infestation in W.A. is in terms of the costs of control. Table 4 shows the expenditure of the APB for the control of donkeys. For the seven years since the helicopter shooting has begun over $700 000 has been spent. This translates to a cost per donkey killed of approximately $3.00.

Petmeat processing is one income-generating aspect of the donkey population. The return from such practices however has not been evaluated.

Feral donkeys are 'declared' (noxious) animals under the Agriculture and Related Resources Protection Act (1976). The objective of this declaration is to eradicate them from the State. Prior to 1978 there was no concerted control programme. Activity was usually limited to ground shooting by pastoralists. Since 1978 improved cattle prices have made it a matter of concern to pastoralists that the large numbers of donkeys are competing with cattle for valuable grazing land. The three methods of control presently being carried out are pet meat shooting, shooting by station personnel, and APB helicopter shooting.

Pet meat shooters have been estimated to take 20 000 annually prior to the last two years when numbers would have dropped to 10 000. Most of these animals have been shot and processed in the field from ground vehicles with associated freezing facilities. Some helicopter mustering, and mustering and transport to slaughter facilities has taken place. However, this method of control was not economical as donkeys were more difficult to muster with helicopters than cattle.[26]

In general, destruction of donkeys for pet meat has been restricted to the readily accessible areas of the Kimberley region. The rugged country, where most donkeys are found, causes extensive vehicle damage

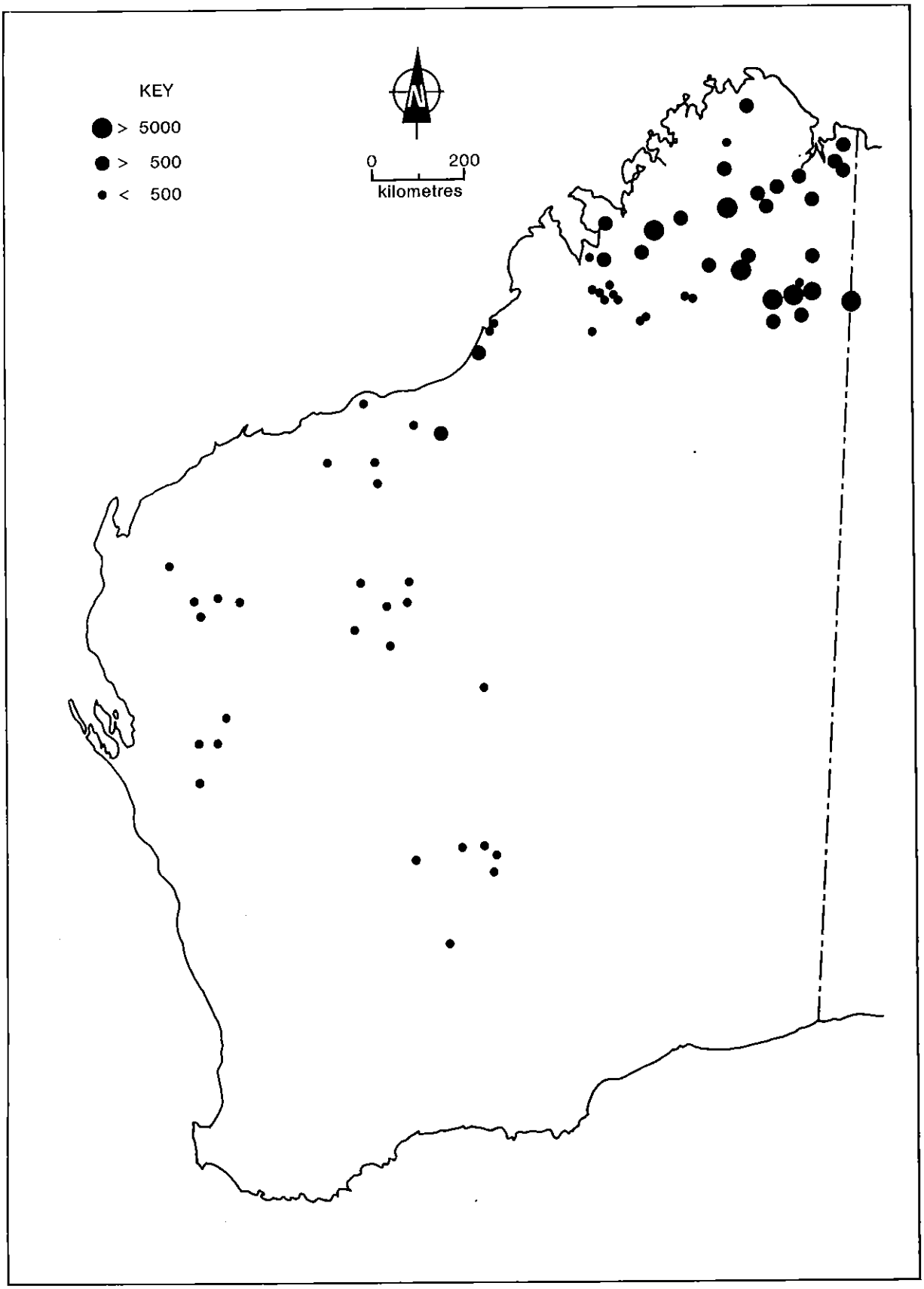


Figure 3. Population estimates of feral donkeys on pastoral stations, as given by APB District Officers, 1985.

Table 4 Donkey Control Expenditure ($) 1978/79 to 1984/85

YEAR	EAST KIMBERLEY	WEST KIMBERLEY
1978/79	35783	35783
1979/80	48494	50420
1980/81	69043	52160
1981/82	64208	56016
1982/83	66732	31729
1983/84	48450	65286
1984/85	62681	50784
TOTAL	$395391	$342178
	$737569	

and limits access to freezer facilities. Controlling donkeys on the accessible land and around waters merely leads to reinfestation from the rugged areas. It is doubtful in the light of these difficulties and the high reproductive potential of the donkey whether commercial harvesting, as it is now practised, will have a significant impact on population size.[26]

Most control by pastoralists has been from ground vehicles, although some contract shooting from helicopters has also been done. The number of donkeys shot by station staff is very difficult to determine but estimates in the East Kimberley put a figure of 70 000 from 1978 to 1981. This method of control, using casual shooting, seems to have had little effect on donkey numbers. The major effect of this shooting in the Victoria River-Kimberley area has apparently been to reduce the average age of the population rather than reduce overall numbers.[26]

In 1978 the APB initiated a donkey control programme which involved the use of helicopters for shooting in inaccessible areas. Since this time over 150 000 donkeys have been shot in the East Kimberley area (Table 5) and over 90 000 in the West Kimberley (Table 6). In the East Kimberley approximately 1500 helicopter flying hours have been flown and 300 000 rounds of ammunition used (Table 5). These figures indicate that this type of control can cover a vast area of land while at the same time achieve high kills efficiently (approximately two rounds per donkey) and humanely.

The effectiveness of this programme is being evaluated by aerial surveys. Results from these indicate that between 1980 and 1985, donkey numbers in the surveyed area have decreased by approximately 70%.[27]

To eradicate feral donkeys in Western Australia, both funding and level of control activity would need to be increased. To achieve this, more pastoralist involvement, both in funding and resources, may be necessary to offset the increased costs.

There may be merit in full commercialization as an eradication tool if it was technically feasible.[28] However, inaccessibility plus abundant natural waters would appear to rule out such a tactic.

Table 5 Station Statistics Since 1978 (Helicopter Programme) – East Kimberley

Numbers of Donkeys Killed

Station	1978	1979	1980	1981	1982	1983	1984	TOTAL
Mt Amhurst/Moola Bulla	4220	946	1817	3807	3736	1288	725	16,539
Elvira/Koonjie Pk	516	–	–	–	1756	437	518	3,227
Lamboo/Sansue	2348	897	1502	–	1154	824	1171	7,896
Margaret R	425	60	796	–	761	–	533	2,575
Behemia/Louisa	2664	404	–	–	3594	–	2888	9,550
Lansdowne	3613	–	3960	–	–	1182	–	8,755
Bedford	1548	2792	556	–	331	1088	–	6,315
Springvale	1108	459	1367	–	1457	1443	–	5,834
Ord Regen.	2151	4745	–	8242	4113	Conduct own shoot		19,251
Mornington/Tablelands	–	8026	3659	–	–	West Kimb. area		11,685
Marion Downs	–	1158	1011	–	–	West Kimb. area		2,169
Ruby Plains	–	143	–	217	435	321	1071	2,187
Sophie/Saunders Ck	–	302	–	1608	575	199	1294	3,978
Alice Downs	–	437	581	2644	886	560	–	5,108
Mabel Downs	–	1654	1007	2179	1857	441	–	7,138
Texas Downs	–	1448	–	4560	622	–	–	6,630
Bow River	–	1416	–	2851	1494	160	–	5,921
Spring Ck	–	441	–	2925	781	–	–	4,147
Lissadel	–	–	–	2980	627	–	–	3,607
Osmond Valley	–	–	–	317	224	–	–	541
Burks Park	–	–	–	199	53	55	–	307
Nicholson	–	–	–	2119	–	–	–	2,119
Doon Doon	–	–	–	–	–	2337	1961	4,298
Ivanhoe	–	–	–	–	–	–	388	388
El Questro	–	–	–	–	–	1528	1402	2,930
Ningbing/Carlton	–	–	–	–	–	–	3544	3,544
Home Valley	–	–	–	–	–	2088	–	2,088
Karungie	–	–	–	–	–	1690	–	1,690
Total Kill	18593	25328	16256	34648	24456	15641	15495	150,417
Helicopter Flying Time (Hrs)	150	232.6	162.5	298.1	238.0	197.6	202.8	1481.6
Donkeys Killed Per Hour	123.95	108.87	100.04	116.22	102.75	79.15	76.40	101.05
Number of Rounds Fired	29000	45132	33181	71691	45072	35198	35300	294,574
Rounds Per Donkey	1.56	1.78	2.04	2.07	1.84	2.25	2.27	1.97
APB Expenditure ($)	35783	48494	69043	64208	66732	48450	62681	395,391
Cost per Donkey Killed ($)	1.92	1.91	4.25	1.85	2.73	3.10	4.04	2.63

Table 6 Station Statistics Since 1978 (Helicopter Programme) – West Kimberley

	Number of Donkeys Killed							
STATION	1978	1979	1980	1981	1982	1983	1984	TOTAL
Oobagooma	–	–	1972	2000	–			
Napier Downs	5114	1826	476	2000	1000			
Beverley Springs	–	–	70	1000	–			
Mt. Hart	–	706	5356	2000	–			
Mt. House/Glenroy	–	–	–	4000	–			
Mt. Barnett	–	–	–	1500	–			
Tarraji River	–	–	–	3000	–			
Kimbolton	–	–	–	1500	–			
Leopold Downs	2630	2503	–	–	2000			
Brooking Springs	1760	637	–	–	–			
Fairfield	–	375	–	–	1000			
Fossil Downs	2700	2025	–	–	4500			
Gogo	–	1436	–	–	1000			
Kimberley Downs	171	–	–	–	–			
Christmas Creek	–	–	–	–	1000			
							No Breakdown	
Total Kill	12395	9508	7874	16890	10500	21000	10421	88588
Helicopter Flying Time (Hr)	143.75	134.25	96.5	193.0	135.0	243.5	150.0	1096
Donkeys Killed Per Hour	86.23	70.82	81.6	87.51	77.78	86.20	69.47	80.82
Number of Rounds Fired	31000	24500	27500	41647	23750	55460	29425	233282
Rounds Per Donkey	2.50	2.58	3.49	2.42	2.26	2.64	2.82	2.63
Cost/Donkey Killed ($)	N.A.	3.83	6.21	3.07	2.88	3.10	4.87	4.00

RABBIT *(Oryctolagus cuniculus)*

Rabbits occur throughout most of Western Australia except the far north.[24,29] The extent of infestation for 1983/84 and 1984/85 is shown in Table 7. These figures are predominantly from the south west of the State where major control work is undertaken.

Rabbits are not economically important further north than Shark Bay or in inland pastoral areas where their distribution is generally sparse.[24]

Rabbits can cause severe damage to crops, pasture and native flora, compete with domestic and native stock, and cause soil erosion. They eat a lot of pasture that would normally be available for livestock. It is frequently estimated that eight rabbits eat as much as one sheep. Work is underway to more accurately determine the actual relative rates of intake. Rabbits graze more closely to the ground than do other stock, killing germinating seedlings. During drought rabbits strip bark from shrubs and the increased grazing has helped degrade the vegetation cover leading to soil erosion.

Rabbits have a highly detrimental impact on the native flora and fauna. It is suggested that the impact may be most serious in the pastoral areas.[31] Successive years of above-average rainfall in arid regions can result in a build-up of very high rabbit numbers which can have a very severe effect on the vegetation.[30]

The cost of the infestation in terms of the indirect cost to the farmer or the environment has not been documented. Research is presently being undertaken to identify these costs and the cost-effectiveness of control methods.

The control of rabbits is also performed by the APB under contract. Table 7 shows the number of operational hours and cost of control carried out by the APB during 1983/84 and 1984/85.

Table 7 APB Computer Data on Rabbit Infestation

	1983/84	1984/85
Total Infestation (Ha)	114,955	146,182
Number of Properties Infested	3,285	4,255
Number of Programmes Done by Farmers	1,503	896
Area of Programmes Done by Farmers (Ha)	23,723	4,026
Number of Programmes Done by APB	186	2,168
Area of Programmes Done by APB (Ha)	17,013	89,012
Total Operational Hours by APB Staff (Hr)	1947.63	3272.38
Cost of Operational Hours by APB Staff ($)	70,114	117,805

The main control undertaken on rabbits is poisoning. The main poison used is 1080. This is produced in two forms, 'one-shot' and 'conventional'. Farmers can only use the 'conventional' form after an APB officer has mixed it, while APB officers are the only authorised personnel who can handle the 'one-shot' form. Another poison which is registered for use as a rabbit poison is an anticoagulant called pindone. This poison, again, can only be handled by APB officers.

Other control of rabbits is restricted to warren fumigation and ripping, and harbour destruction. These three methods are primarily used as follow-up treatments after poisoning. Control is carried out on islands off the coast, such as Carnac, Wooded and Morley islands (Abrolhos group), Mistaken and Dirk Hartog, to allow regeneration of the native flora.

The effectiveness of control in terms of population decline has not been accurately documented. Population size and distribution can vary considerably as a result of seasonal conditions.

The cost-effectiveness of control methods is presently being investigated in the south west of the State. Their cost to primary production in this area appears to be greater than the cost of control. Rabbit control measures in pastoral areas of Western Australia, however, are unlikely to be cost-effective in terms of their cost to primary production,[32] but could be worthwhile in areas which are of particular importance for the conservation of native flora and fauna.

The required input to achieve the result of eradication would far exceed the resources presently available. The logistics of such an effort and the cost to the farmer to achieve this would appear to be unwarranted in many areas of the State.

FERAL CAT *(Felis catus)* and FOX *(Vulpes vulpes)*

Since their introduction both of these predators have spread throughout the whole of the State, with the exception of the northern Kimberley. The fox is only absent from the Kimberley north and west of the King Leopold Ranges.[33] It appears to be less common in the midwest interior, in the interior desert areas, and in the south and east Kimberley.[33] Both animals are commonly recorded in all habitat forms throughout their range.

The fox and the cat are considered generalist feeders making the most of whatever prey is most abundant at any one time.[34,35,36] Only the fox is recorded as preying upon domestic livestock, in the form of lambs and poultry, although research indicates that foxes prefer rabbits, other small animals and carrion.[37] There are no records of feral cats attacking lambs, but many small birds and mammals have been recorded as prey items. The greatest impact of these two predators is upon the indigenous fauna either in the form of predator-prey relationships or predator-predator competitive interactions.[38,39,40,41,42]

It is often suggested that the fox and cat are major factors in the diminishing distributions of small ground living bird and mammal populations. Recent increases in fox numbers in the south west have coincided with drastic declines in the populations of medium-sized native animals.[41]

No economic value has been placed on the small lamb losses attributed to foxes and there is no way of estimating the damage caused to native fauna.

The potential loss to primary industry in the event of a disease outbreak, such as rabies, is enormous. Both the fox and cat are prominent vectors of rabies in Europe and they are of primary concern in the possible spread of rabies epizootics.[43]

At present there are no control measures currently in use, or proposed, for the feral cat.Coincidental poisoning of feral cats with 1080 rabbit and dingo baits, and opportunistic shooting (sporting or otherwise) are the only existing control forms. The use of biological control for cats using feline influenza virus has been advocated, but studies show that the disease is already common in the feral population.[44] For the year 1984/85 a total of 242 agricultural properties in W.A. reported infestations of foxes. Seventy seven fox control programmes covering an area of 1959 hectares were initiated. During that period a total of 14 648 wrapped strychnine baits were issued (1080 is prohibited in agricultural areas as a fox poison). Under special licence some 1080 poisoning was conducted on Crown land fauna reserves.

There are no measures of the effectiveness of fox control programmes. There is some evidence to suggest that fox numbers may have increased in the lower south west with the decline in use of 1080 poison for rabbit control.[45] In order to achieve control of foxes and cats in this State (total eradication is probably unrealistic) further information is required. In order to maximise the success of any control programmes the population densities, and types of bait acceptance and the optimal times of year for poisoning need to be determined.

STARLING *(Sturnus vulgaris)*

The present western limits of the starling range approach the border between Western Australia and South Australia on the south coast. Since 1970 numerous invasions of the species into Western Australia have occurred, particularly in the south coastal areas in the vicinity of Eucla and Esperance.

Starlings are potential pests in Western Australia. They are capable of causing considerable damage to various fruit crops such as grapes and cherries and will dig up germinating seedlings.[46] They may also be responsible for the dissemination of some diseases affecting both domestic stock and wildlife. Once established, starlings would compete with native bird species for food, habitat and nesting sites. Starlings are hole nesters and would utilize many hollows which are at present available to native species. In other areas of the world where they have been introduced, and are now present in huge flocks, starlings have displaced some native bird species.[46] In some areas of eastern Australia they are thought to have assisted in the decline of parrot numbers.[47]

There are no figures available for the damage that starlings may cause if they become established in Western Australia. Based on potential damage, it is thought that it would amount to considerably more than the present costs of control. Table 8 shows an estimate of the total costs incurred in starling control since 1981.[48] During 1981/82 the campaign was basic and total costs of $82 000 were incurred. This increased to $360 000 in 1983/84.

Almost half the starlings killed in the Esperance area campaigns were destroyed by shooting. The method involves long hours and considerable operator discomfort, many starlings are frightened off when shotguns are used. Legislation to allow the use of silencers on rifles has helped considerably in the campaigns.

The majority of Nullarbor starlings were obtained by trapping. The use of live birds as lures in cages has resulted in large numbers of young birds being captured. Traps are found to be invaluable in the catching of a few birds that remain once the main groups have been destroyed.

Explosive charges have been used successfully on some occasions but their use is limited to areas where starlings are regularly using the same trees for roosting.

Since 1970 the policy of the Agriculture Protection Board has been to destroy by whatever means possible any colonies of starlings which become established in W.A. or near the W.A. border in South Australia.

To date, the campaigns against starlings in W.A. have been successful. The species has not become established permanently in this State. At present it is probably cost-effective to keep them out of Western Australia. The present control efforts have prevented their establishment anywhere in Western Australia. However, if larger flocks more regularly invade the State it may become impossible, or no longer cost-effective, to attempt to eradicate them.

Table 8 Eradication Campagin Costs for Starlings

	1981/82	1982/83	1983/84
Eucla			
Salaries & Wages	45,988	55,316	89,148
Running Costs	24,834	57,301	102,376
Plant & Buildings (depreciation)	10,900	23,025	18,000
Additional Salaries		23,629	23,629
Additional Allowances		10,071	10,544
SWPA (Special Works Projects)		25,192	
Wage Pause			22,210
Totals	81,722	194,534	265,907
Esperance			
Salaries & Wages		11,149	8,362
Running Costs		15,985	15,985
Plant & Buildings (depreciation)		7,675	6,000
Additional Salaries		31,349	31,350
Additional Allowances		9,481	9,930
SWPA		25,192	
Wage Pause			22,210
Totals		100,831	93,837
Total Eucla and Esperance	$81,722	$295,365	$359,744

SULPHUR-CRESTED COCKATOO *(Cacatua galerita)*

In the early 1970s large flocks of sulphur-crested cockatoos *C. galerita* were noted in the Pinjarra and Guildford areas. Subsequent surveys revealed that the species could be established over an area from Harvey in the south to Bullsbrook in the north.[46] They appeared to be rapidly increasing their numbers and range.

It was estimated, on the basis of habitat and climate which they inhabited in their native range, that sulphur-crested cockatoos could potentially occupy much of the south west of the State. This area is already well populated with a range of five large cockatoos, at least one member occurring in any ecological niche that may be occupied by sulphur-crested cockatoos. Competition for breeding hollows would occur between this species and the five resident species.

There are no measures of the species impact in Western Australia. As with most exotic introductions, action to eradicate them before they become more widely established and a pest has been the Agriculture Protection Board's policy.

In the eastern States of Australia the sulphur-crested cockatoo is a pest of cereal crops.[49] They will damage haystacks, bagged grain, ripening maize and sweetcorn, peas, almonds, sorghum, wheat and grapes in vineyards.

Since 1979, shooting, trapping and poisoning with 1080 have been carried out to control flocks of sulphur-crested cockatoos. In the initial stages some were obtained by the use of cannon nets; however, this method was found to be slow, and many birds escaped before the net trapped them.

The main control method has been that of shooting. Shotguns have accounted for many birds, but generally .22 rifles are preferred because of their greater range. Trapping using decoy birds in traps has not been overly successful. Poison with 1080 on sunflower seeds has been partially successful.

Since 1979 nearly 300 sulphur-crested cockatoos have been destroyed in W.A. Two-thirds of these were taken by shooting and the remainder mainly by trapping. The numbers have been significantly reduced, but small flocks still remain. The per cent reduction in the total population to the present time is not reliably known because of the mobility of the flocks, but is thought to be in the vicinity of 60%. Some flocks do not appear to have bred young in the last two years and this may be related to the extent of the harassment from the control programmes. The complete eradication of the remaining small flock is thought to be possible, but will be time consuming, slow, and costly, because of the available control methods.

BLACKBERRY *(Rubus fruticosus)*

Western Australia's major blackberry infestations are south west of a line joining Bunbury to Albany and in the valleys of the Darling Range where average rainfall exceeds 750 mm (see Figure 4). Records based on the Agriculture Protection Board's field inspections show that some 8051 hectares on 1960 properties are affected. The density of these infestations recorded in 1984/85 was expressed as light 4818 ha; medium 1683 ha; heavy 1550 ha, a total of 8051 ha. Approximately half of this infestation is on private land and half on public land. A more detailed distribution and density summary of 24 local authority areas is shown in Tables 9 and 10. The extent of infestation on public land, particularly in State forests is probably understated by the current records.

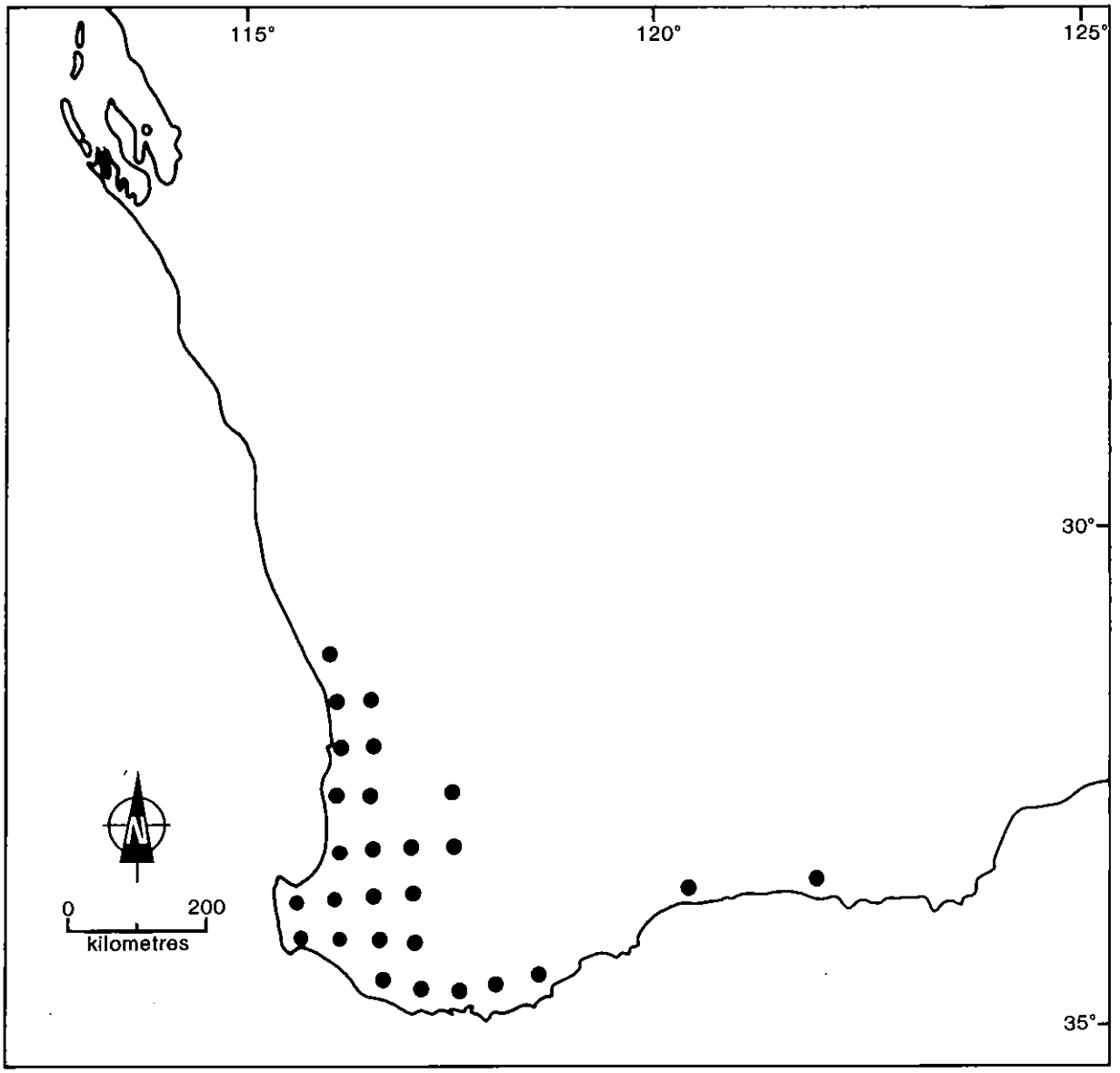


Figure 4. Distribution of the blackberry in Western Australia.

Table 9 Distribution and Density of Blackberry in W.A.

Shire:	Number Properties Infested	Area Infested Ha	Density of Infestation		
			Light	Medium	Heavy
Serpentine-Jarrahdale	10	118	24	25	69
Murray	80	212	142	62	8
Waroona	27	95	45	42	8
Harvey	75	129	72	32	25
Collie	96	105	101	3	1
Bunbury	5	5	4	1	–
Dardanup	63	119	86	23	10
Capel	4	8	8	–	–
Donnybrook-Balingup	158	3126	1845	643	638
Busselton	41	56	47	8	1
Augusta-Margaret River	108	272	143	96	35
Nannup	54	299	118	70	111
Bridgetown-Greenbushes	221	318	284	25	9
Boyup Brook	15	18	15	1	2
Manjimup	654	2311	1187	567	557
Denmark	76	196	126	34	36
Albany (Town)	2	13	5	3	5
Albany (Shire)	243	295	235	39	21
Plantagenet	13	320	319	1	–
Boddington	10	13	10	3	–
Mundaring	1	10	–	–	10
Kalamunda	1	1	–	–	1
Gosnells	1	1	1	–	–
Canning	2	11	1	5	5
TOTAL	1960	8051	4818	1683	1550

Source: APB Analysis of Infestation Report, 1-7-84 to 30-6-85.

Table 10 Blackberry Control Operations

Shire	Programmes		APB Work		
	Number	Area Ha	Contracts No.	Area Ha	Operation Hours
Serpentine-Jarrahdale	4	0	5	85	76
Murray	62	149	28	54	43
Waroona	26	23	6	24	12
Harvey	68	57	28	71	192
Collie	96	67	1	5	5
Bunbury	5	2	1	1	2
Dardanup	53	39	16	18	33
Capel	1	1	3	7	24
Donnybrook-Balingup	106	132	86	537	847
Busselton	20	8	14	21	22
Augusta-Margaret River	89	32	42	116	101
Nannup	45	51	9	18	72
Bridgetown-Greenbushes	204	181	29	82	194
Boyup Brook	12	12	3	5	6
Manjimup	526	381	202	1372	2312
Denmark	37	26	23	57	129
Albany (Town)	1	10	2	3	38
Albany (Shire)	203	205	44	75	143
Plantagenet	2	2	18	324	138
Boddington	10	12	2	2	13
Mundaring	–	–	1	1	4
Kalamunda	1	–	–	–	1
Canning	–	–	2	2	2
TOTAL	1960	1571	565	2880	4407

Source – APB Analysis of Infestation Report 1-7-84 to 30-6-85.

Blackberry most commonly grows in disturbed areas where exposed soil has allowed seedlings to become established. It is particularly common on eroded creek and river banks where land has been cleared for timber, agriculture or roads. On forestry land blackberry stands affect the productivity of pine plantations where thinning is foregone because of the infestations. In National Parks and other reserves, blackberries become the dominant vegetation along many drainage lines, and at the expense of the native species. There is also a high potential loss on forestry and National Park land due to restricted access for fire fighting purposes.

The blackberry plant successfully competes for soil, moisture and nutrients with other plants. It covers large areas with a dense canopy which excludes light from the soil surface, thus eliminating other plants, particularly pastures. It will completely and quickly dominate the vegetation of an area.

No studies have been made of the direct losses caused by blackberries in Western Australia. The main enterprise on infested farming land is beef cattle production, with some vegetable growing, dairying and

sheep. Infestations usually occur on the most potentially productive land. Blackberry has no economic benefits in W.A. It is not used for honey production and there is no commercial jam or fresh fruit industry utilisation for it. In central western New South Wales, the economic costs caused by blackberry have been identified;[50] the most important was the loss of potential livestock production.

The overall cost of the Agriculture Protection Board's involvement in blackberries was an estimated $950 000 in 1983/84. The Board's district officers negotiated control programmes for 980 properties in 1983/84. APB staff carried out 2916 hours of contract spraying on blackberries in 1983/84, at a cost to landholders of some $100 000 for the labour involved, plus approximately a further $100 000 for herbicides. In addition, control work was carried out by the Forests Department with their own labour or by private contractor, costing a further $50 000. Other control work was also carried out by private landholders. No accurate figures are available on the cost of this work, since it includes herbicides bought from commercial sources and the landholders' own costs in engaging private contractors or using their own machinery and time. The overall costs could amount to a further $100 000.

Summary of Costs – Western Australia (1983-84)

APB services to landholders	$ 950 000
Operational work by APB	$ 200 000
Other control work by Forests Department	$ 50 000
Other control work by private landholders	$ 100 000
	$1 300 000

The Agriculture Protection Board's strategy for blackberry is to prevent it spreading wherever this is possible; to eradicate the smaller isolated and accessible infestations, and to continue a planned, programmed control campaign of the larger, more inaccessible infestations. Inspection of land for blackberry, programming of landholders' control work and contract operational work on blackberry make up a significant part of the workload of the Agriculture Protection Board in the south west of W.A. The control methods employed for blackberry include: burning, herbicides, cultivation, slashing, grazing with goats and biological control with the rust fungus *Phragmiduim violaceum* at a number of sites in 1984.

Several chemicals have been used to successfully control blackberry since the 1950s. One of the most successful of these was 2,4,5-T formulated as an ester; however, the introduction of the Spraying Restriction Regulations has virtually stopped its use. In the late 1970s the Agriculture Protection Board and the Department of Agriculture commenced a programme to find more effective herbicides for blackberry control.

A number of herbicide treatments, if used in conjunction with timely burning, offer the best control alternative at the present time. Although the rust fungus has been released into the State's blackberry-infested areas and indications show that it will become established, it is still too early to predict its full impact. Cultivation, slashing and grazing by goats play a part in controlling small isolated infestations; however, their role is limited.

Although there is plenty of blackberry left in Western Australia, the situation since organised control began in the early 1950s has continued to improve. The development of new herbicides such as triclopyr, although more expensive, should enable further progress to be made. The limitations preventing eradication in the short-term include costs of controol, accessibility and landholder co-operation.

The major infestations of blackberry remaining in Western Australia occur in forest country, much of it inaccessible. Further spread of the rust fungus *Phragmiduim violaceum* may slow the rate of spread, enabling the on-going control programme to catch up. In 1984 it was estimated that $1 500 000 would be required to eradicate blackberry from State forests over a three-year period.[51] It is unlikely that funds to undertake this level of activity will become available. The level of operations existing now are considered to be adequate to handle the situation in the long term.

MESQUITE (*Prosopis* spp.)

In 1954, mesquite was spread over more than 77 square kilometres on Mardie Station (in the north west of Western Australia) alone and about 10 km^2 had reached thicket form. In 1975 it was estimated

that the infestation had increased to be approximately 100 000 hectares;[52] however, other estimates placed it in the order of 15 000-20 000 hectares[53] at most (see Figure 5). Probably 10 000 ha were characterised by defined thicket areas with the remainder being more open areas with single spaced plants with smaller thickets. The other major infestation in W.A. occurs at Onslow. This area includes a total of some 40 000 hectares.[52]

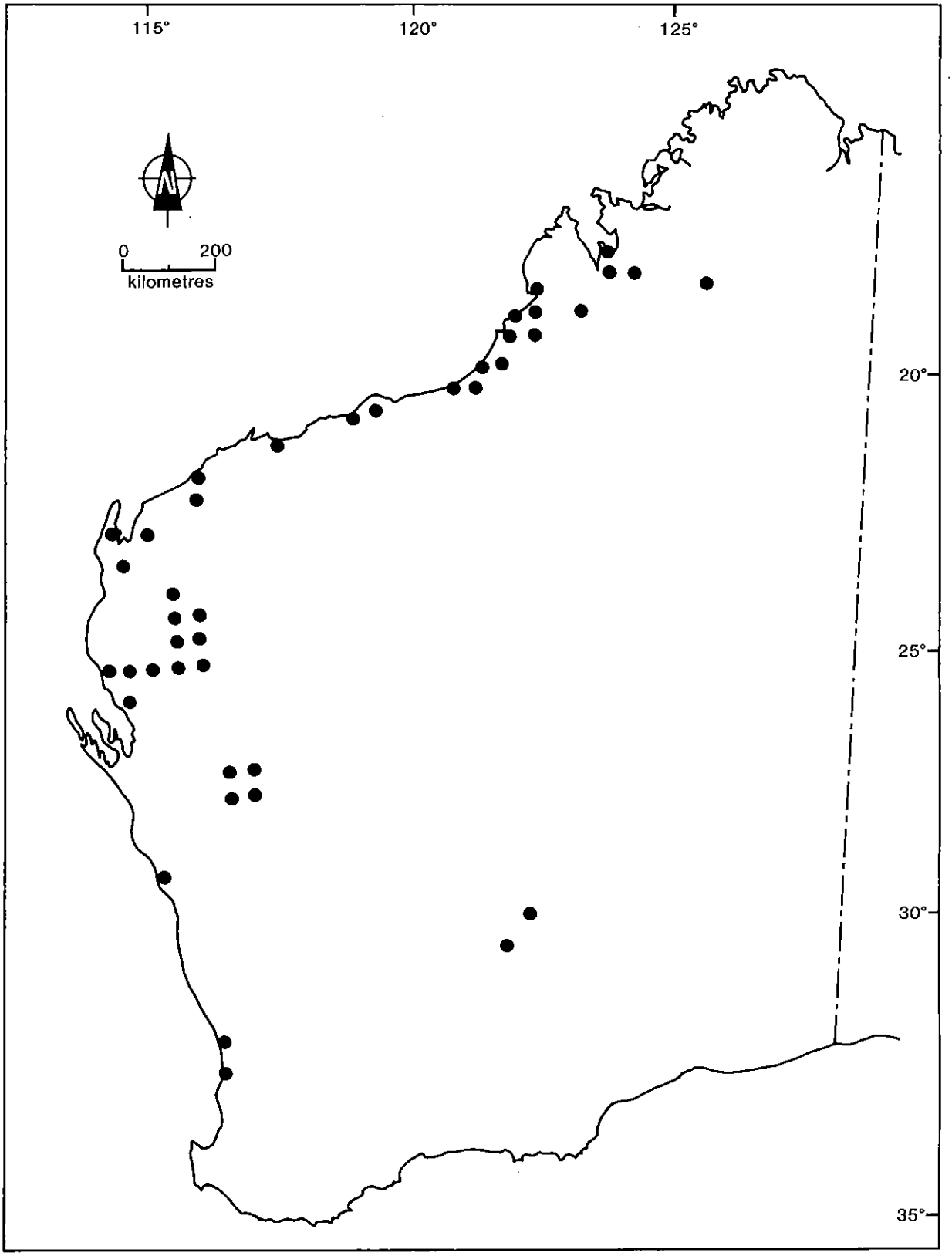


Figure 5. Distribution of mesquite in Western Australia.

Table 11 shows present recorded infestations of mesquite in W.A. from information reported by Agriculture Protection Board officers. Figure 5 shows the distribution of mesquite as determined from Western Australian Herbarium and APB field officers' records.

Table 11 Distribution and Density of Mesquite in W.A.

Shire	Number Properties Infested	Area Infested (Ha)	Density of Infestation (Ha)		
			Light	Medium	Heavy
Derby/West Kimberley	2	1900	1500	400	–
Port Hedland	2	501	–	500	1
Roebourne	2	15700	15700	–	–
West Pilbara	16	95350	93570	1000	780
East Pilbara	1	15	10	5	–
Carnarvon	8	1071	1067	4	–
Upper Gascoyne	2	1500	1000	500	–
Shark Bay	1	1	1	–	–
Murchison	1	1500	1000	500	–
Yalgoo	1	1	1	–	–
TOTAL	36	117539	113850	2909	781

Source – Analysis of Infestation Report 1-7-84 – 30-6-85

Once established, *Prosopis* spp. possess characteristics that make them aggressive invaders and persistent competitors. Infestations initially result in the reduction of available forage and ground cover which predisposes the soil to erosion. Other problems associated with mesquite include dense thickets interfering with mustering; prolific growth near windmills acting as a wind shield and preventing the pumping of water; thorns injuring the hooves of animals and puncturing vehicle tyres; and severe digestive troubles resulting from impaction where stock is forced to subsist chiefly on beans and leaves.

It has been claimed[57] that mesquite reduces the amount of light and moisture available to native grasses and shrubs.

There is no information known on the value of the infestations, either in lost production or damage to the environment. Mesquite has no economic benefits in Western Australia as it has in the U.S.A. where there is a conflict of interests. Although a major weed in the U.S.A. it is also a native plant, providing a food source and shelter for many animals. Recent scientific interest has focused on the cultivation of mesquite as a fuel crop or for the food value of the highly nutritious pods. The tree has not been used commercially by Western Australian bee-keepers, although mesquite is known to be a good producer of honey.

The main strategy employed against mesquite in the north and north west has been to prevent the plant from spreading. A number of control methods have been employed, including cultural, ecological, chemical and biological. A Western Australian entomologist is presently working in the U.S.A. investigating a number of possible biological control candidates and agents.

A system of entering into control work agreements with pastoralists has been developed. Under the agreements, pastoralists contract to the Agriculture Protection Board to undertake work on their leases with the costs being met from the special funds available for this purpose. The contracts usually cover the cost of supplying herbicides while spray units, if necessary, are supplied. Payment is subject to inspection and certification by field staff that the work is of a satisfactory standard.

Chemical control over the years (2,4,5-T at 1:60 in distillate applied as a basal bark spray) has proved very effective for mesquite control, provided plants have not been under stress at the time of spraying. Now that 2,4,5-T is no longer available, alternative herbicides have been under investigation.

Research Officers of the Agriculture Protection Board and Department of Agriculture are presently engaged in assessing a number of alternative control techniques: these include several newly-developed herbicides and the use of goats to browse control mesquite.

Control work on Mardie Station has been effective in areas outside the main infestation.[53] The most serious infestation in the lower reaches of the Fortescue River now poses a control problem. It is considered[54] that the present level of input can achieve acceptable control in the long term on all infested areas except Mardie Station. Here, control strategies on the main infestations of 15 000-20 000 ha is going to be an expensive undertaking and will require follow-up work. Chaining and burning would probably be the cheapest options. Aerial spraying would cost in the order of $1-$1.5 million, plus considerable follow-up work would be required. While eradication is a desirable objective, it is not thought to be possible within the present constraints, particularly on Mardie Station.[54]

ARUM LILY *(Zantedeschia aethiopica)*

The main infestations of arum lily in Western Australia are in the south west corner of the State within the area bounded by the 800 mm isohyet (see Figure 6). Other smaller infestations are known to occur north and east of Perth, but these have not caused any concern.

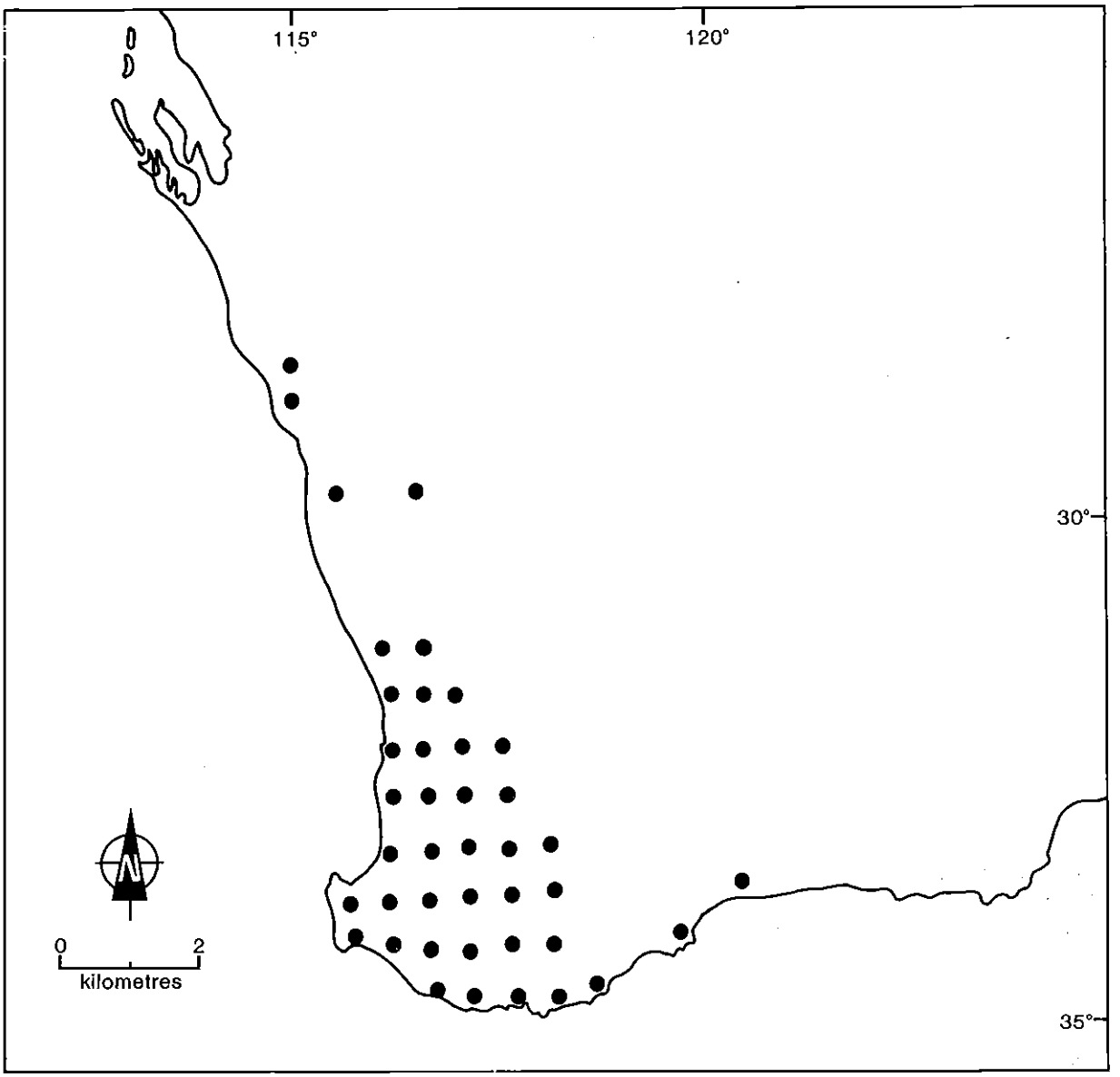


Figure 6. Distribution of arum lily in Western Australia.

Field inspections by officers of the Agriculture Protection Board show that some 6361 hectares on 754 properties are affected. The density of these infestations, as recorded in 1984/85, were: light 3099 ha; medium 1577 ha; heavy 1685 ha, making a total of 6361 ha. Approximately 73% of this area is on private land and 27% on public land. A more detailed distribution and density summary of the 17 local authority areas is shown in Table 12. It should be noted that the actual infestation level on public land is probably understated in current records.

Table 12 Arum Lily Distribution

Shire	No. of Properties	Light	Medium	Heavy	Total
Murray	2	–	1	4	5
Waroona	21	37	30	10	77
Harvey	57	67	27	5	99
Collie	19	19	–	–	19
Bunbury	4	4	–	–	4
Dardanup	11	11	1	–	12
Capel	21	92	44	20	156
Donnybrook/Balingup	36	35	3	1	39
Busselton	128	1666	1265	1469	4400
Augusta/Margaret River	49	275	103	46	424
Nannup	8	12	1	–	13
Bridgetown/Greenbushes	20	21	–	–	21
Manjimup	81	80	2	1	83
Denmark	26	341	51	6	398
Albany Town	1	4	–	–	4
Albany Shire	263	398	49	123	570
Plantagenet	7	37	–	–	37
TOTALS:	754	3099	1577	1685	6361

Arum lily grows primarily in low lying, swampy areas, but has extended its range to adjacent moist country. It is not restricted to farmed areas, many infestations being located in bush and forest habitats. Arum lily spreads vegetatively by bulbs, and by seed carried by birds and animals.[55] The plant competes with valuable perennial pasture plants on moist summer land. Stock deaths have been attributed to the grazing of arum lilies. The white and yellow flowers are attractive to children and fatal poisoning has occurred from eating them.[56] On forest reserves and in National Parks arum lily can dominate the understorey at the expense of native flora. It is common to see infestations under trees in undisturbed forest.

No studies have been carried out to ascertain the direct losses caused by arum lily. Productivity of farming land is substantially lowered by infestations of the plant. Arum lily has no economic benefits in Western Australia. The Primary Industry Association of W.A. says that it is avoided by honey producers because of the poor quality of the pollen produced. In 1983/84 an attempt was made to develop an export market for the flowers, but this has not yet been successful.

The estimated cost to the Agriculture Protection Board in 1984/85 for control work was $180 000. Herbicides used in these operations would add a further $5 500 (approximately) making the total cost to landholders of $19 300. This figure covers 131 contracts in excess of the 630 programmes arranged for landholder control.

Summary of Costs – Western Australia (1984/85)

APB Service to Landholders		$ 180 000
Operational work by APB		$ 19 300
Control work by Private Landholders		$ 23 600
	Total:	$ 222 900

The Agriculture Protection Board's strategy towards arum lily is to prevent its spread wherever this is possible; to eradicate the smaller isolated and accessible infestations and to continue a planned, programmed control campaign on the larger and more inaccessible infestations. Control methods recommended for use on arum lily include – spraying with chlorsulfuron, 2,4-D and glysphosate. Recent work with chlorsulfuron shows it to be an effective, cost-effective herbicide for arum lily control.

Before the recent release of chlorsulfuron there was little satisfactory control of arum lily. Trials with this material show it to be an effective herbicide for the control of the plant. However, control with herbicides is time consuming and expensive. Poor responses to herbicide treatment have meant that little progress has been made in the plant's control. Chlorsulfuron has enhanced the prospects of effective control and opinion at present is that within five years the plant will no longer be a major problem in Western Australia.

AFRICAN LOVEGRASS *(Eragrostis curcula)*

The size of the problem in Western Australia is at present being assessed by the Agriculture Protection Board in a state-wide survey. It has certainly spread widely along major roadsides throughout the south west land division and some encroachment into arable and non-arable land has occurred.

African lovegrass is a summer growing perennial grass which establishes from seed and forms persistent tussocks. It is native to southern Africa and was introduced into Australia as a potential pasture plant; however, its fodder value is poor. African lovegrass has adapted well and persists under low and variable rainfall, soil infertility and on light sandy soils. These attributes make it a valuable soil conservation plant.

The potential impact of African lovegrass was brought to our attention by visiting weed biologists from both Victoria and New South Wales. A survey of African lovegrass in New South Wales in 1983 indicated a distribution in 56 Shires, on 644 properties and occupied 45 000 hectares of land. It was present on roadsides, railway land, river banks and spread to adjacent agricultural land. African lovegrass has been declared a noxious plant in Victoria and New South Wales.

The natural attributes of the plant, copious seed production, seedling vigour and low palatability suggests a potential for invasiveness. This has been confirmed by field studies and observations, its ability to spread is increased by low pasture and plant groundcover during the period of active growth (spring to late summer). Its ability to invade and encroach into disturbed areas is particularly noticeable on roadsides where it interferes with road shoulder maintenance, reduces visibility and increases the fire hazard. It is possible that African lovegrass may invade native bushland following burning or other disturbance and dominate some native flora.

On the agricultural scene, there is still conjecture as to whether African lovegrass should be classified as a valuable pasture plant or an unpalatable weed. The dollar value of infestations is unknown. The only control action known is undertaken by the Main Roads Department on major roads. Both mechanical and herbicidal techniques are used; results appear to be variable. There is no information available as yet on the effectiveness of control activities.

VELDTGRASS *(Ehrharta* spp.)

Both annual *(Ehrharta longiflora)* and perennial veldtgrass *(E. calycina)* have invaded much of the coastal strip, particularly around Perth, where deep sands seem to suit its propagation. The recorded invasion of King's Park by both species, especially the perennial, dates from the 1930s. It is now established in varying degrees throughout King's Park and is regarded as a weed displacing and suppressing native species from the bushland. Five species of *Ehrharta* introduced into Western Australia have now become naturalised.

Perennial veldtgrass is an erect, tufted warm season perennial grass native to South Africa. Nicholas[58] claims that it can be utilised as an alternative pasture plant for deep sands as once established stands can thicken if natural re-seeding is allowed.

Veldtgrass contributes to the well-known fire hazard existing in parts of King's Park as it does on much of the coastal strip. The unsightliness of veldtgrass invasions along tracks, roads and other disturbed areas of the park detract from its natural beauty.

No information as to the dollar value of the infestations is known.

The King's Park Board's policy on veldtgrass is to ultimately eradicate it or at least reduce its vigour so that it is eliminated in competition with native species without undue damage to the native flora and to reduce the risk of wild fires. Field experiments and extensive control work on veldtgrass have been practised within the park for many years. A control management strategy using the herbicide Fusilade(R) (fluazifop) is showing promise as selective elimination of the veldtgrass is possible allowing the vacant niche left to be filled by native species before further invasions of other weed species.

ONION WEED *(Aspholedus fistulosus* L.) and *(Trachyandra divaricata)*

Onion weed is now considered to be naturalised in Western Australia. It does not appear to be restricted by rainfall or soil type, being recorded as well established in such diverse ranges as eroded coastal sand-hills in the 1100 mm rainfall area to red loam in the 200 mm rainfall area. Onion weed is, however, particularly well suited to conditions of low soil fertility.

In Western Australia it commonly infests unused, disturbed land such as road verges and railway reserves. The National Parks Authority, having expressed concern about the weed, carried out a survey on its incidence and effect on native flora in the Yalgorup National Park (south of Mandurah) in 1984. This survey concluded that while onion weed is at present restricted to firebreaks and road verges in the park, it is possible that it will slowly spread into undisturbed areas and may compete with native species of flora.

Onion weed is not generally an agricultural problem in Western Australia as cultivation or perennial pasture satisfactorily control it. It is a major agricultural pest in South Australia where it competes vigorously with pasture, but the reason for the differing habits of the weed in the two States is not known. The plant is not a declared plant, nor has it been gazetted as a pest plant by any local authority in this State.

No estimate of the "dollar value" of the weed has been made, and no action, as far as is known, is being taken to control it.

No selective herbicide is known to control onion weed, but in areas where selectivity is not required, herbicides such as paraquat, diquat or picloram can be used.

Acknowledgements

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APPENDIX 1

CATEGORIES OF DECLARED PLANTS & ANIMALS

P1 Plants which cannot be introduced (prevention). All declared plants are in this category. Declared plants are also in one of the following categories.

P2 Plants which will be eradicated (eradication) e.g. skeleton weed.

P3 Plants whose population will be reduced (control) e.g. saffron thistle in northern wheatbelt areas.

P4 Plants which will be prevented from spreading (containment) e.g. Paterson's Curse in northern agricultural areas.

P5 Plants which will be treated only on roads or reserves.

A1 Animals which cannot be introduced, e.g. the starling.

A2 Introduced animals which will be eradicated, e.g. the rabbit.

A3 Animals which cannot be kept in Western Australia, e.g. the hare.

A4 Animals which can only be introduced under conditions and restrictions, e.g. some exotic aviary birds.

A5 Animals whose numbers will be reduced, e.g. the dingo.

A6 Animals which can only be kept under restrictions and conditions, e.g. deer.

A7 Native animals for which there is a management programme to regulate numbers without endangering the species, e.g. red kangaroo.

Each introduced declared animal may be included in three categories, relating to –

— introducing the animal (Categories A1 or A4)
— controlling the animal (Categories A2 or A5)
— keeping the animal (Categories A3 or A6)

For example, the rabbit is declared in Categories A1, A2 and A3, meaning it can't be introduced to Western Australia, those within the State will be eradicated and it cannot be kept in captivity.

The APB publishes a list in the Government Gazette each year of declared plants and animals with their categories.

APPENDIX 2

DECLARED ANIMALS IN WESTERN AUSTRALIA

MAMMALS

Common Name	Scientific Name
Native pest mammals – Category A7	
Wombats	*Vombatus and Lasiorhinus spp.*
Agile Wallaby	*Macropus agilis*
Red Kangaroo	*Macropus rufus*
Euro	*Macropus robustus*
Western Grey Kangaroo	*Macropus fuliginosus*
Mammals which under special circumstances may be introduced and kept subject to permits – Category A4, A6.	
Blackbuck	*Antelope cervicapra*
Deer	*Family Cervidae*
Cattle (feral and straying)	*Bos taurus and B. indicus*
Pigs feral	*Sus scrofa*
Domestic mammals which are feral or running wild	
Buffalo feral	*Bubalus bubalis*
Camels feral	*Camelus spp.*
Donkeys feral	*Equus asinus*
Goats feral	*Capra hircus*
Mammals which may be introduced and kept in approved zoos, circuses and wildlife parks, subject to permit. Categories A4 and A6.	
Bantan Cattle	*Bibos sondaicus*
Barbary Sheep	*Ammotragus lervia*
Chital Deer	*Axis axis*
Dingo	*Canis familiaris*
Fallow Deer	*Dama dama*
Lion	*Panthera leo*
Macaque monkeys	*Macaca spp.*
Tiger	*Panthera tigris.*
Mammals which may not be introduced or kept and which must be eradicated. Categories A1, A2, A3.	
Fox	*Vulpes vulpes*
Hares	*Lepus spp.*
Rabbits	*Oryctolagus cuniculus*
Squirrels, Indian Palm	*Funambulus pennanti*

BIRDS

Native pest birds – Category A7	
Emu	*Dromaius novaehollandiae*
White-tailed Black Cockatoo	*Calyptorhynchus baudinii and C. funereus latirostris.*
Parrots, Port Lincoln	*Barnardius zonarius*
Parrots, Red-capped or WA King	*Purpureicephalus spurius*
Parrots, Rosella, Western	*Platycercus icterotis*

Birds which may be introduced and kept subject to permit. Categories A2, A4, A6.

Alexandrine Parakeet	*Psittacula eupatria*
Brown Parrot	*Poicephalus meyeri*
Crimson Rosella	*Platycercus elegans*
Cutthroat Finch	*Amadina fasciata*
Eastern Rosella	*Platycercus eximius*
Hooded Siskin	*Carduelis cucullata*
King Parrot	*Alisterus scapularis*
Little Lorikeet	*Glossopsitta pusilla*
Moustached Parakeet	*Psittacula alexandri*
Musk Lorikeet	*Glossopsitta concinna*
Namaqua Dove	*Oena capensis*
Orange-cheeked Waxbill	*Estrilda melpoda*
Ostrich	*Struthio camelus*
Rainbow Lorikeet	*Trichoglossus haematodus*
Pheasants, Ring-necked	*Phasianus colchicus*
Scaly-breasted Lorikeet	*Trichoglossus chlorolepidotus*
Silver Pheasant	*Lophura nycthemera*
Siskin	*Carduelis cucullata*
Sulphur-crested Cockatoo	*Cacatua galerita*
White-breasted Ground Dove	*Gallicolumba jobiensis*

Birds which may not be introduced but may continue to be kept subject to permit. Categories A1, A2, A6.

Lovebird hybrids	*Agapornis spp.*
Blossom-headed Parakeet	*Psittacula cyanocephala*
Bronze Mannikin	*Lonchura cucullata*
Chukor Partridge	*Alectoris graeca*
Fischers Lovebird	*Agapornis fischeri*
Madagascar Weaver	*Foudia madagascariensis*
Magpie Mannikin	*Lonchura fringilloides*
Masked Lovebird	*Agapornis personata*
Nyasa Lovebird	*Agapornis lilianae*
Peach-faced Lovebird	*Agapornis roseicollis*
Red-fronted Parakeet	*Cyanoramphus novaezelandiae*
Red-headed Finch	*Amadina erythrocephela*
Rose-ringed Parakeet	*Psittacula krameri*
Ruddy Ground Dove	*Columbigallina talpacoti*
Strawberry Finch	*Amandava amandava*
Waxbill, St Helena	*Estrilda astrild*
White-backed Munia	*Lonchura striata*
White-headed Munia	*Lonchura maja*
White-throated Munia	*Lonchura malabarica*

Birds which may not be introduced but may continue to be kept by original owners subject to permit. Categories A1, A2, A6.

Black-headed Munia	*Lonchura malacca*
Collared Turtle Dove	*Streptopelia decaocto*
Greenfinch	*Carduelis chloris*
Java Sparrow	*Padda oryzivora*
Spicefinch	*Lonchura punctulata*

Birds which may not be introduced or kept. Categories A1, A2, A3.

Blackbird	*Turdus merula*
Californian Quail	*Lophyrtyx californicus*
House Sparrow	*Passa domesticus*
House Crow (Indian or Ceylon)	*Corvus splendens*
Indian Myna	*Acridotheres tristis*

Red-billed Quelea	*Quelea quelea*
Red-whiskered Bulbul	*Pycnonotus jocosus*
Songthrush	*Turdus ericetorum*
Starling	*Sturnus vulgaris*
Tree Sparrows	*Passer montanus*
Weavers	*Euplectes and Foudia spp.*

Birds whose numbers must be reduced – Category A5

Corella, Little	*Cacatua sanguinea*
Eagle, Wedge-tailed	*Aquila audax*
Galahs	*Cacatua roseicapilla*

INSECTS

European Wasp	*Vespula germanica*
Argentine Ant	*Iridomyrmex humilis*
Grasshopper, Small plague	*Austroicetes cruciata*
Locusts, Australian plague	*Chortoicetes terminifera*
Grain weevils (eleven spp.)	*Various*

AMPHIBIANS

African Toad	*Xenopus laevis*
Giant Toad	*Bufo marinus*

MOLLUSCS

Liver-fluke snails	*Lymnaea spp.*

APPENDIX 3

DECLARED PLANTS IN WESTERN AUSTRALIA

Common Name	Botanical Name
African Thistle	*Berkheya rigida*
Apple of Sodom	*Solanum sodomaeum L.*
Artichoke Thistle	*Cynara cardunculus l.*
Arum Lily	*Zantedeschia aethiopica*
Bathurst Burr	*Xanthium spinosum L.*
Blackberry	*Rubus fruticosus L. (agg)*
Calotropis	*Calotropis procera*
Camelthorn	*Alhagi camelorum Fisch.*
Cape Tulip (one-leaf)	*Homeria breyniana (L) G.J. Lewis*
Cape Tulip (two-leaf)	*Homeria miniata (Andr.) Sweet*
Common Heliotrope	*Heliotropium europaeum L.*
Cotton Bush (narrow leaf)	*Gomphocarpus fruticosa L.*
Docks	*Rumex pulcher; R. crispus, R. conglomeratus; R. brownii, R. obtusifolius*
Doublegee	*Emex australis Steinh.*
Doveweed	*Eremocarpus setigerus*
Elodea	*Elodea canadensis*
Field Bindweed	*Convolvulus arvensis L.*
Geraldton Carnation Weed	*Euphorbia terracina L.*
Glaucous Star Thistle	*Carthamus leucocaulos*
Gorse	*Ulex europaeus L.*
Gorteria	*Gorteria calendulaceae*
Harrisia Cactus	*Eriocereus martinii*
Hoary Cress	*Cardaria draba (L) Desv.*
Horehound	*Marrubium vulgare L.*
Leafy Elodea	*Egeria densa*
Mesquite	*Prosopis spp. D.C.*
Mexican Poppy	*Argemone mexicana L.*
Mintweed	*Salvia reflexa*
Noogoora Burr	*Xanthium spp. Wallr.*
Parkinsonia	*Parkinsonia aculeata L.*
Parrot's Feather	*Myriophyllum aquaticum*
Paterson's Curse	*Echium plantagineum L.*
Pennyroyal	*Mentha pulegium L.*
Perennial (Canada) Thistle	*Cirsium arvense (L) scop.*
Prickly Pear	*Opuntia spp.*
Ragwort	*Senecio jacobaea*
Saffron Thistle	*Carthamus lanatus L.*
Salvinia	*Salvinia molesta D.S. Mitchell*
Silverleaf Nightshade	*Solanum elaegnifolium Cav.*
Skeleton Weed	*Chondrilla juncea L.*
Soursob	*Oxalis pes-caprae L.*
Stemless Thistle	*Onopordum acaulon L.*
St. John's Wort	*Hypericum perforatum L.*

Thornapple	*Datura spp.*
Variegated Thistle	*Silybum marianum (L) J.Guertn.*
Water Hyacinth	*Eichhornia crassipes (Mart.) Solms-Laub*
Water Lettuce	*Pistia stratiotes*
Yellow Burr Weed	*Amscinckia spp.L.*

The following weeds have also been declared to prevent their entry into this state

Common Name	Botanical Name
Alligator Weed	*Alternanthera philoxeroides*
Arrowhead	*Sagittaria graminea; S. montevidensis*
Lagarosiphon	*Lagarosiphon major*
Spinyhead Sida	*Sida acuta Burm. F.*
Flannel Weed	*Sida cordifolia L.*
Parthenium Weed	*Parthenium hysterophorus L.*
Giant Sensitive Plant	*Mimosa pigra L.*
Common Sensitive Plant	*Mimosa pudica*

In addition, the following weed has been declared for the whole of the state because of its potential threat to native flora. It is not a weed of agricultural significance.

Boneseed	*Chrysanthemoides monilifera L. (Norlindh.)*

THE ABORIGINAL HERITAGE AND ENVIRONMENTAL MANAGEMENT

by MICHAEL V. ROBINSON

An Invited Review Paper as Background
for the Development of a
STATE CONSERVATION STRATEGY FOR WESTERN AUSTRALIA

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INTRODUCTION

The Western Australian Government's decision to endorse the National Conservation Strategy for Australia is a welcome one as it sets the stage for the establishment of a State strategy to guide policy for sustainable development. A review of Western Australia's natural resources and the impact of development on them has already been undertaken[1] and a consultative committee has been established with broad terms of reference to draft a definitive long-term strategy for explanation, discussion and refinement.

This paper is offered as a short statement relevant to a proposed section on Aboriginal heritage and environmental management in the draft State Strategy. It is confined in the main to comments from a social anthropological perspective on the need to include cultural heritage matters within the broader strategy. A consideration of such matters is noticeably absent in both the World[2] and National[3] Strategies and, in my view, should be included. The paper does not seek to explicate the position of Aborigines in Western Australian society, nor does it examine the inter-relationship between Aboriginal people, development and conservation. Such an examination will be necessary, however, if Aboriginal people and their cultural heritage are to be given proper recognition in the State strategy.

NATURE AND THE CULTURAL HERITAGE

Citing "respect for nature" as one of the causes of resistance to development by non-industrialised societies, the anthropologist Claude Levi-Strauss observed that there were fundamental differences between industrialised and non-industrialised societies' perceptions of the natural world and the relationship between it and the need for development. The former, he noted, tended to give development an unconditional priority over a positivistically defined nature, whereas the latter tend to view nature more sympathetically and ambiguously.

> 'Nature is preculture and it is also sub-culture. But it is by and large the means through which man may hope to enter into contact with ancestors, spirits, and Gods. Thus, there is in the notion of nature a "supernatural" component, and this "supernature" is as undeniably above culture as nature itself is below it.'[4]

Moves to protect and preserve the State's Aboriginal heritage are in part a recognition of the special view of the natural environment held by Australian Aborigines. In Aboriginal terms the natural world is more than a resource for the material benefit of humans. It is a world endowed with meaning. It is "preculture" in the sense that Aboriginal people attribute the origins of their cultural systems to fantastic feats of creation during the epoch known universally in Australia as the Dreaming. This creative period, which continues through to the present and has been characterised by Stanner as the "Everywhen", saw not only the creation of landforms and geological features, but the beginnings of living resources through the exploits of proto-beings who dwelt in, moved through and brought order to an originally unordered primordial landscape. These proto-beings, some of whom were to be the precursors of men themselves, were believed by Aboriginal people to have established the foundations for present day culture. They not only ordered the physical world and its resources, but they brought social order as well in establishing codes for conduct, marriage and exchange laws and rules for interpersonal relations. The Aboriginal "pre-cultural" view of nature, then, involves a committed belief in the simultaneous creation of all things physical, material and social by extraordinary transformations which occurred before the emergence of Aboriginal culture as it now exists.

Nature is also "sub-cultural" in the sense that Aboriginal people live in and utilize the living world and its resources. Although the spiritual significance of the natural world is continuously remembered and celebrated, Aboriginal societies like those elsewhere exploit the natural environment for their sustenance, for their food, water, building materials and material resources. In this sense nature is "acted upon" and modified to meet biological and cultural needs.

In Aboriginal terms, however, the pre-cultural and sub-cultural aspects of nature are not distant from each other. They are held together by what Levi-Strauss calls the "supernatural" component, by the belief that the natural environment evidences man's cultural past and his spiritual continuity and that its resources must only be used within a framework of spiritual acknowledgement and respect. Species and natural resources are not only that, they are also the embodiment of the spiritual past and present and must be used with care, respect and deference. Aboriginal man's use of the environment is not, in the sense of spiritually distanced industrialised societies, a detached exploitation but one which is surrounded by rules, prohibitions and observances which are culturally transmitted from one generation to the next.

The environmental features which we characterise as Aboriginal "sites" represent the broad spectrum of these views of, and interactions with, nature. At one level there are those places in the landscape which Aboriginal societies see as evidence of the "pre-cultural" element, places which commemorate the deeds of the mythological beings who transformed the original landforms. Such sites may be hills, watercourses, trees, boulders or other physical features which are identified in Aboriginal mythology as being the legacy of the Dreaming. The natural environment also contains physical evidence of Aboriginal man's utilization of the land and its resources. Throughout the State there is archaeological testimony to Aboriginal use of a variety of habitats, testimony in the form of campsites, middens, quarries, fish traps and other places with material evidence of past use. In varying degrees, both sorts of sites continue to be of direct significance to Aboriginal people who maintain their traditional lifestyles. They also form an important aspect of the cultural heritage of the State and of man's use of its resources which, contrary to the impressions given by the National Conservation Strategy, did not begin 200 years ago but extends back 40 000 years or more. An adequate conservation strategy should not only recognise the importance of the Aboriginal cultural legacy, but should seek to draw upon the richness of Aboriginal beliefs about the environment in developing a sensitive and complementary approach towards its protection.

HERITAGE LEGISLATION

The **Aboriginal Heritage Act 1972-80** remains the only Western Australian legislation designed to extend protection to Aboriginal sites. Recommendations for new heritage legislation made by the Seaman Inquiry into Aboriginal Land Rights[5] have not been acted upon by the State Government.

The Act takes a broad view of Aboriginal sites (unlike legislation in some other States which is restricted to the protection of archaeological sites and relics). The definition of sites in section 5 extends to all of the places described above.

"This Act applies to:

(a) any place of importance and significance where persons of Aboriginal descent have, or appear to have, left any object, natural or artificial, used for, or made or adapted for use for, any purpose connected with the traditional cultural life of the Aboriginal people, past or present;

(b) any sacred, ritual or ceremonial site, which is of importance and special significance to persons of Aboriginal descent;

(c) any place which, in the opinion of the Trustees, is or was associated with the Aboriginal people and which is of historical, anthropological, archaeological, or ethnographical interest and should be preserved because of its importance and significance to the cultural heritage of the State;

(d) any place where objects to which this Act applies are traditionally stored, or to which, under the provisions of this Act, such objects have been taken or removed."

The effect of section 5 is to bring all sites, whether recorded or not, within the ambit of the Act. To this extent the legislation is an improvement over other statutes which require registration or declaration before protection is extended.[6]

The Act also provides for "outstanding" sites under threat to be declared Protected Areas and to afford greater powers of protection and preservation over these (see sections 19 and 20 and Regulations).

Protection may also be accomplished through the creation of covenants with landowners (section 27) or through conditions applying to notices concerning land use (section 18).

As at 1 January 1986, 63 sites had been declared Protected Areas under the Act. The covenant provisions have not yet been utilized.

Section 17 makes it an offence to destroy, damage or otherwise interfere with a site without the permission of the Trustees of the Western Australian Museum or the Minister. Archaeologists must obtain a permit from the Trustees before excavating an Aboriginal site (section 16). Other offence provisions are contained in the Act's Regulations. A history of the legislation and an explanation of its provisions is given in Dix,[7] Wright[8] and Robinson.[9]

Two Federal Acts also apply to Aboriginal sites in Western Australia. Under the **Australian Heritage Commission Act 1975**, Aboriginal sites on the Register of the National Estate may be protected against

the actions of Commonwealth agencies or those carrying out work on their behalf. The most important contribution of the Commission, however, is in the provision of resources for site recording and conservation. It has funded several site protection programmes in the State through the Western Australian Museum and has supported the employment of a Site Documentation Officer in the Museum for several years.

The **Aboriginal and Torres Strait Islander Heritage (Interim Protection) Act 1984** also provides potential protection for Aboriginal sites. Following an application by, or on behalf of, an Aboriginal group, the Federal Minister for Aboriginal Affairs may make a declaration protecting a "significant Aboriginal area" which is under threat. The Act extends to significant objects and skeletal material but not to archaeological sites unless they can be shown to be of significance to Aboriginal people. The Act is administered by the Department of Aboriginal Affairs and has a life of two years (the Federal Government is at present examining proposals for its continuation, abandonment or replacement). To date the Minister has received 15 applications for declarations under the legislation. No declarations have yet been made in relation to sites, while one only has been made for the protection of Aboriginal objects.

ADMINISTRATION

The Department of Aboriginal Sites at the Western Australian Museum is responsible for the administration of the **Aboriginal Heritage Act.** Ultimate responsibility for the legislation rests with the Minister with special responsibility for Aboriginal Affairs who is advised by the Museum Trustees and the Aboriginal Cultural Material Committee.

The Department has a staff of 13 including three research officers and a resident ranger at the Woodstock/Abydos Reserves which are vested in the Museum. The Department's functional budget for 1985/86 is $201 000.

Although the Department has initiated a number of specific site conservation projects over the past 12 years (including a rock art conservation programme and several site specific projects such as those at Walga Rock and Upper Swan), no long-term site conservation strategy has been adopted. There are several reasons for this, including a lack of staff and financial resources, but most importantly because day-to-day priorities have been governed by the need to respond to particular development proposals. Over the past decade the Department has been under increasing pressure to commit its resources to examining development plans (including mining and exploration, road building, townsite development and planning, and infrastructure programmes) and their potential for impact on sites.

From 1975 to 1980 this work was done almost exclusively by departmental staff, usually under contract to the relevant developers, but more recently the work has been taken over in part by independent consultant anthropologists and archaeologists. The absence of suitably qualified and available consultants and accelerated development has meant that some responsibility for survey work has been retained by the Department, however, and the task of assessment of reports and evaluation of impacts on sites has remained its responsibility.[10]

TOWARDS AN INTEGRATED CONSERVATION STRATEGY

With the **Aboriginal Heritage Act** now some 13 years old, and with the endorsement of the National Conservation Strategy by the Western Australian Government and moves to establish a strategy tailored to State needs, it is timely to consider a review of Aboriginal heritage protection and its possible integration with a broader programme for living resource conservation. The details of such an integration are beyond the scope of this paper and I would argue that they should only be established after careful consultation with all interest groups. Direct Aboriginal participation in shaping the form of such a strategy is an essential pre-requisite.

Several matters may be suggested for consideration however, and may form the basis for further consultation and negotiation.

CULTURAL PERCEPTIONS OF THE ENVIRONMENT

Running through the documents produced for the World Conservation Strategy,[2] the National Strategy,[3] and early drafts of the State Strategy, there is a decidedly Western and industrialised view of what constitutes the natural environment. For Aboriginal (and other non-industrialised societies) it is difficult, if not impossible, to make a clear distinction between the natural and cultural worlds. If conservation strategies are to be relevant for Aboriginal society they must address Aboriginal

perceptions of the natural world and its relationship with Aboriginal cultural systems. In the Aboriginal scheme of things,culture and nature may be seen as one in certain contexts and it will not be meaningful to Aboriginal people to address the conservation requirements of one without the other.

In my view, the conservation of the Aboriginal cultural heritage should be included within a broader conservation strategy and Aboriginal people themselves should be closely involved in shaping its priorities and consequent programmes.

IMPROVING LEGISLATION

Although it has features which are an improvement on comparable State, Territory and Federal legislation, the Aboriginal Heritage Act is in need of amendment to tune it to present requirements. The pace and impact of development on Aboriginal sites were underestimated when the legislation was first introduced and there should now be a realistic reassessment of its provisions, including its administration and legislative powers. It will be particularly important to conduct such an assessment within the context of related changes to land-use and conservation legislation.
The Trustees of the Western Australian Museum, the Aboriginal Cultural Material Committee and parties appearing before the Seaman Inquiry made detailed submissions concerning possible improvements, and these could form the basis for legislative review. Of special importance, however, is the need to strengthen the Act's offence provisions and to extend the time within which prosecution may be made. The appropriateness of the Museum's responsibility for the legislation should also be examined. These points have already been made by the Trustees and the Aboriginal Cultural Material Committee.

COORDINATION AND RATIONALIZATION OF EFFORT

Greater attention needs to be paid to an integration of legislative and administrative approaches to heritage and living resource conservation. Although the respective agencies (the Museum, Department of Conservation and Environment and Department of Conservation and Land Management) have a sound working relationship on matters of mutual interest, they would benefit from a closer association at the level of policy making and field action. Two specific examples may illustrate the potential benefits. The maintenance of the Abydos/Woodstock Reserves in the Pilbara by the Museum to preserve the area's rich rock art has had the side effect of protecting the region from the pressures of development and pastoral activities and has led to the regeneration of native flora and fauna, including rare and endangered species. Current Aboriginal interest in participation in the management of the Reserves could provide an opportunity to integrate heritage, conservaton and contemporary Aboriginal needs. As a further example, the plan to train and employ Aboriginal people in the management of the Chichester, Millstream and Hamersley Range National Parks has important potential benefits not only for the natural resources of those areas but for the protection of their cultural heritage features. An integrated approach in both cases could establish valuable precedents for other regions of the State.

PUBLIC EDUCATION

At a time when public opinion about the aspirations and needs of Aboriginal people is largely influenced by misinformation, much could be gained by a careful and objective presentation of the nature of the Aboriginal cultural heritage and its relevance for all members of the community. American Indian critics of heritage legislation in the USA have long maintained that legislation alone is an inadequate means for the protection of their cultural sites and objects and have called on policy makers to place greater emphasis on encouraging a moral commitment by developers and the public at large towards conservation. The same argument could be advanced in Western Australia, and the inclusion of the Aboriginal heritage in a State Conservation Strategy might be an important first step towards promoting such a commitment.

THE NEED FOR RESOURCES

The resources available at present for cultural heritage conservation are totally inadequate. There is also a need to rationalize efforts at State and Federal levels. Each State has separate legislation dealing with the protection of Aboriginal sites and, with the involvement of the Federal Government through the Australian Heritage Commission and the Department of Aboriginal Affairs, there is not only inconsistency in the application of laws but an unnecessary competition for scarce resources. The development of a State Conservation Strategy should be accompanied by a critical appraisal of legislation, administration, financial resources and training. The role of the Commonwealth needs special attention to ensure that competing and overlapping structures are avoided and that legislative and administrative uniformity is promoted.

CONCLUSIONS

This paper argues a need to include strategies for the preservation of Western Australia's Aboriginal cultural heritage within an overall State Conservation Strategy. It is submitted that a clear separation between the cultural and natural worlds is in part a product of Western European and industrialised societies and is not shared by non-industrialised societies including Australian Aborigines. Failure to recognise these differing perceptions will not only impede the involvement of Aboriginal people in any conservation strategy but will also risk the omission of an important aspect of the State's heritage. Deficiencies in legislative and administrative measures have also been briefly examined and it is argued that a State strategy should encourage a detailed examination of these, along with the promotion of a greater public awareness of, and commitment to, the need to preserve the Aboriginal heritage.

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ABORIGINAL LAND MANAGEMENT

by ANN MOLLOY

An Invited Review Paper as Background
for the Development of a
STATE CONSERVATION STRATEGY FOR WESTERN AUSTRALIA

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INTRODUCTION

In traditional Aboriginal society the right to use or occupy land carried with it duties and responsibilities for the care of that land and its resources. These responsibilities included the protection and sustentation of the country and waterways. In order to survive from the land, detailed knowledge of it was essential and this knowledge was passed on to each generation. Involved were practices such as regular burning off as a means of crop, stock, and land management: this ensured that seeds and root plants were not totally depleted and that sufficient game survived for future seasons. These management principles tie in reasonably comfortably with the three major objectives of living resource conservation identified in the World Conservation Strategy and adopted by the National Conservation Strategy for Australia. However, European settlement has led to considerable changes, not only to the face of most of the land in Western Australia as it was in 1829, but also to the structure of Aboriginal society and the lifestyles and expectations of Aboriginal people.

Following European settlement, Aborigines not only lost access to many parts of the State, but their views on management of the land which had been developed during their thousands of years of occupation, were largely ignored. Thus a large body of expert knowledge of the land was either completely lost or was diminished.

In submissions to the Aboriginal Land Inquiry in 1984/85, Aborigines indicated their concern for the proper management of the land and their wish to be able to assume responsibility for it. By proper management, Aborigines mean management in accordance with their own life goals. These may not necessarily accord with the goals towards which either the wider community or other special interest groups wish to head.

At present most of the land which Aborigines use and occupy in Western Australia is vested in or controlled by a statutory body, the Aboriginal Lands Trust (ALT). Management of this land is therefore greatly influenced by the structure of the ALT, the resources available to it, the purposes for which the land is used and the type of title under which the land is held. This paper will look only at land vested or controlled by the ALT. However, it will not include reference to management of land protected under the terms of the Aboriginal Heritage Act.

As a general statement it can be argued that Aboriginal land in Western Australia is only being marginally managed in any sense of conservation. The resources that are available through various Government agencies are directed towards a different set of priorities. These include the provision of housing and associated essential services or towards the management of enterprise activities such as pastoral leases. Conservation of the land is generally left to the communities resident on it, or associated with it. They have a very limited level of resources to use for conservation purposes. These are outlined later in this paper. Aboriginal community groups continue practices such as burning off in many areas. However, because for a variety of reasons the groups have moved into a smaller number of larger, relatively stationary communities rather than the traditional configuration of many small family units dispersed throughout the land, large areas are no longer included in the burn-offs. The trend towards an outstation or homeland movement, which is discussed in the section on "Changes in Community Structure", may have the effect of widening the areas included in regular burn-offs.

ABORIGINAL LANDS TRUST

STRUCTURE

The Aboriginal Affairs Planning Authority (AAPA Act 1972-1984) provides for the establishment of the Aboriginal Lands Trust. The ALT's membership consists of a chairman and six other members, all of whom must be Aboriginal and appointed by the responsible Minister. Additional members may be appointed by the Minister on the recommendation of the ALT. Appointments are generally made in such a way as to ensure that each region of the State is represented.

FUNCTIONS

Subject to the AAPA Act 1972-1984 the functions of the ALT are as follows:

(a) to carry out such of the functions of the Authority as may be delegated to the Trust under section 24 of this Act, or as the Minister may direct;

(b) to acquire and hold land, whether in fee simple or otherwise, and to use and manage that land for the benefit of persons of Aboriginal descent;

(c) to ensure that the use and management of the land held by the Trust, or for which the Trust is in any manner responsible, shall accord with the wish of the Aboriginal inhabitants of the area so far as that can be ascertained and is practicable;

(d) to consult, negotiate, enter into financial arrangements, contract, and to undertake or administer projects, either directly or in association with other persons or bodies, as may be necessary or desirable for the development of the land for which the Trust is responsible;

(e) generally, on behalf of and as the corporate entity representing the interests of the Aboriginal inhabitants of the area to which the matter relates, to take, instigate or support any action that may be required to ensure the most beneficial use of the land.

LAND HOLDINGS

As at 30 June 1985, land vested in or under the control of the ALT totalled 20 611 945 hectares.

The major type of holding was reserve land which amounted to 18 981 809 hectares or approximately 7.5% of the State. Four contiguous reserves make up 75% of this reserved land. They are located adjacent to the Northern Territory and South Australian borders, stretching from the 20th to the 28th parallels. This is all arid land. Other major reserves are located in the Kimberleys, Pilbara and Eastern Goldfields. In addition, there are a large number of small reserves, some located within town boundaries, and others in agricultural regions. A map showing the major reserves is attached (Appendix 1).

In addition, the ALT is responsible for 18 freehold properties (3 640 hectares); six leasehold properties (57 512 hectares), and seven pastoral leases (1 564 700 hectares). Details of individual vestings are given in the Aboriginal Lands Trust Annual Report 1984/85.

LAND USE

Most of the reserve land vested in the ALT is classified "for the use and benefit of Aborigines". Other reserves are listed for special purposes such as Aboriginal Art, Aboriginal Burial Ground, Ceremonial Ground and so on.

Most of the reserves, pastoral leases and freehold areas are leased to or occupied by Aboriginal communities although a smaller number, mainly in towns, are leased to individuals or family units.

The land may be used for residential purposes, enterprise activities or a wide variety of social, cultural or recreational purposes.

When leasing land to a community or individual, the ALT expects that the lessee will assume responsibility for its management. However, the ability to manage the land is affected or inhibited by a number of factors. These include lack of resources, difficulties linked with the remoteness of much of the land, the nature of the land, and the need to comply with a wide variety of State and Local Government requirements.

RESOURCES

The Aboriginal Lands Trust is serviced by the Aboriginal Affairs Planning Authority, a relatively small (establishment of 17 as at 30 June 1985), Perth-based agency which has two other major statutory responsibilities in addition to its ALT responsibilities. The Authority provides the Trust with a secretary, and its three-person field section consults with Aboriginal communities throughout the State and liaises with State and Federal Government agencies, Local Government and any other relevant agencies or individuals. Both budget and time constraints limit the frequency with which field officers can visit any one part of the State. At present the ALT has very limited capacity to research land management matters.

The ALT meets quarterly, usually in Perth, to consider applications from Aboriginal communities on land and management matters and to advise and make recommendations to Government on matters connected with its land holdings.

However, the members of the Trust are not salaried and they do not receive funds to enable them to travel, other than to attend Trust meetings. The amount of direct contact that Aboriginal communities have with either ALT members or AAPA field officers is therefore very limited.

ENTRY PERMITS

Visitors to Aboriginal Reserves or non-Aboriginal transients passing through Aboriginal Reserves are required to apply for entry permits. The permits are approved after consultation with relevant

communities except for permits for travel through the Central Reserves region. These are approved by the AAPA without reference to the communities, although the Central Reserves communities do have some control over which routes are used. The permits provide for conservation of the land in that a number of conditions are laid down. Copies of these conditions are attached at Appendices 2 and 3. By controlling the lighting of fires and the use of firearms and by not permitting transients to leave the main roads and enter the reserve proper, some control over the land is possible. However, it is estimated that at least half the people travelling through the Central Reserves do not apply for permits.

LAND MANAGEMENT BY ABORIGINAL COMMUNITIES

RESOURCES

Aboriginal communities in Western Australia have limited access to a range of resources necessary not only for day-to-day living, but also for management of land.

The 1981 Census showed the median family income of Aborigines in Western Australia to be slightly more than half of the median income for all persons. Aboriginal communities are therefore very reliant on government funding for a wide range of functions.

As stated earlier, funding for land management is generally limited to management, either for essential services such as housing, water supplies and sewerage or for enterprise activities such as pastoral leases. Little if any funding is available for conservation management.

The large areas and frequently rugged terrain covered by some Aboriginal Reserves make it essential for communities to be equipped with reliable transport. Although most communities do have vehicles, these are often fully utilised in maintaining contact with towns or larger communities for the purposes of acquiring food, medical aid, education and other services.

Very little education and training in land management techniques is available, particularly to remote Aboriginal communities. Although knowledge of traditional management techniques survive in many areas, it is essential that education in modern land management techniques be available if the large area of land involved is to be preserved. This is especially important in the arid parts of the State.

The rapidly increasing tourist industry is also placing extra pressures on reserve land. Although the entry permit system allows a measure of control over the activities of tourists, it is important that Aboriginal communities be resourced both to enable them to benefit from the tourist industry where appropriate, and to protect the land from damage. One way of doing this could be to train and employ Aboriginal rangers whose duties would include conservation matters, including control of feral animals, the provision of information to visitors and the control of tourist behaviour and illegal prospecting which may damage the land.

CHANGES IN COMMUNITY STRUCTURE

Prior to European contact, Aborigines usually lived in small family units, deriving a living through hunting and gathering. The size of the unit was to an extent determined by the available food and water resources.

Following European settlement and the utilization of enormous areas of the State for the pastoral and agricultural industries, these small family units amalgamated into larger generally stationary communities. Although a certain amount of food was still gained from the land, the major part of the Aboriginal diet was made up of introduced and processed foods. This lessening of the need to acquire food through traditional means and the concomitant breakdown of many of the social and cultural structures of Aboriginal society led to a reduction in the land management practices that had previously been pursued on a regular basis.

Over the last decade there has been a marked increase in the outstation or homeland movement. This has seen a movement of relatively small (5-50 members) family groups away from town or the larger "artificial" communities created earlier in the century. The greatest development of homeland groups has occurred in the Kimberley, Pilbara and Western Desert areas. There had earlier been some fragmentation of groups within the Central Reserves area with the formation of a number of smaller communities.

With the establishment of this network of small, widely spread groups, management of Aboriginal land is entering a new phase. It is important that land management authorities consult with Aboriginal people in each area as to the resources needed to manage the land effectively.

SUMMARY

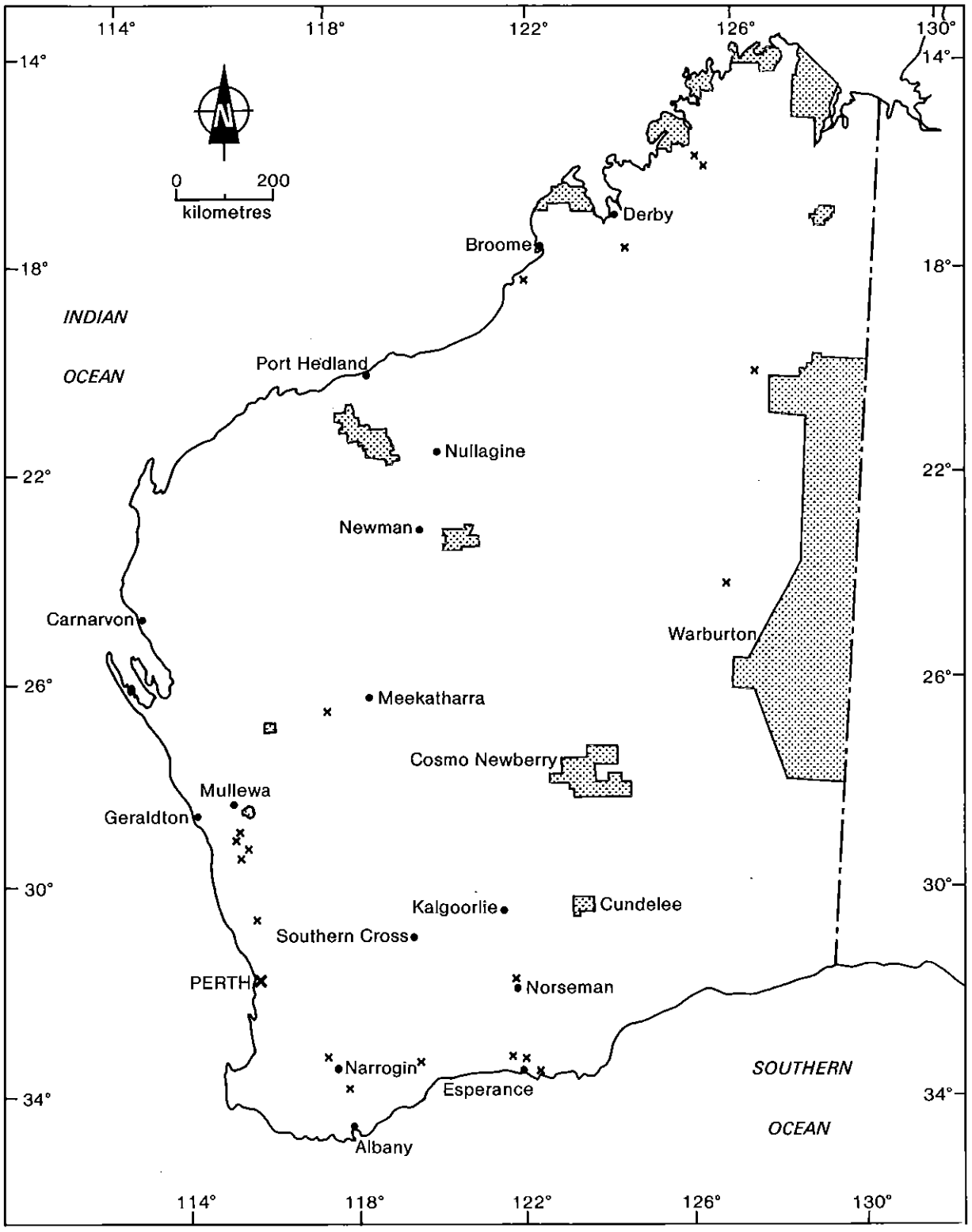
Issues relevant to the management of Aboriginal lands include:

- consultation with Aboriginal people resident on the land or associated with it;
- training in conservation and land management techniques;
- employment of Aboriginal rangers;
- control over visitors to Aboriginal land;
- control of feral animals;
- restocking of native flora and fauna where these have become depleted;
- review of existing structures by which Aboriginal land is managed;
- provision of resources for land management.

APPENDIX NO. 1

MAJOR ABORIGINAL RESERVES

Reserves of less than 1000 ha and Reserves in towns are not shown. (After Lands and Surveys Dept WA 1982, Div National Mapping, 1982).



APPENDIX NO. 2

ABORIGINAL AFFAIRS PLANNING AUTHORITY

RESERVE ENTRY PERMIT

TO ENTER CENTRAL RESERVES

In pursuance of the provisions of SECTION 31 of the Aboriginal Affairs Planning Authority Act, 1972, and of the regulations made under the Act, I HEREBY GRANT

permission to enter and remain on Aboriginal Reserve Numbers 22032, 25051, 21471 & 17614 in the State of Western Australia, subject to the person(s) names herein shall at all times abide by the conditions listed on the reverse.

Any three consecutive days between:-

This permit is valid from the day of 19 and expires on the day of 19

FOR AND ON BEHALF OF THE MINISTER

SPECIAL CONDITION

The holders of this permit must travel direct from Warburton to Giles. Any deviation from this main route may result in prosecution.

CONDITIONS:

1. Follow the Warburton-Giles-Docker River road, and not depart from it whilst in the Reserve by more than thirty metres on either side and spend as short a time as practicable in the Aboriginal Reserve.

2. Refrain from photographic activities of any kind whilst within the boundaries of the Reserve listed on the reverse.

3. Have neither contact nor dealings with Aborigines, nor interfere in any way with Aboriginal art, artifacts, sacred areas or water sources. Do not acquire or seek to acquire any Aboriginal artifacts other than from an approved agency.

4. Use a vehicle which is preferably a four-wheel-drive and in good condition.

5. Observe all laws having application to Aborigines in Western Australia.

6. Refrain from capturing, acquiring, maiming or killing any animal, bird or reptile or wantonly destroying or damaging any flora within the Reserves.

7. Refrain from undertaking prospecting or mining activities within the Reserves.

8. All litter such as tins, bottles, cartons, etc., shall be burnt, and/or buried so as to leave campsites in a clean and tidy condition. All campfires shall be effectively extinguished.

9. Carry out directions given by members of the Warburton Community Council or Department of Aboriginal Affairs Officers, within their spheres of Authority.

10. Refrain from the use of any firearms within the meaning of the Western Australian Firearms and Guns Act whilst within the Reserves boundaries.

11. Refrain from having possession of any explosives within the meaning of the Western Australian Explosives and Dangerous Goods Act whilst within the Reserves boundaries.

12. It is accepted that no assistance will be expected from either Giles Meteorological Station or the Western Australian Government in the event of mechanical or other trouble.

APPENDIX NO. 3

Aboriginal Affairs Planning Authority Act, 1972
(Section 31)

PERMIT TO ENTER A RESERVE

In pursuance of the provisions of Section 31 of the Aboriginal Affairs Planning Authority Act 1972, and of the regulations made under the Act, I hereby grant

permission to enter and remain on Aboriginal Reserve No. ..... in the State of Western Australia, subject to the conditions that the person(s) named herein shall at all times:

1. Observe all laws having application in Western Australia, and carry out lawful directions given by the resident Aboriginal Community, the Aboriginal Lands Trust, the Aboriginal Affairs Planning Authority, the Department of Aboriginal Affairs, and the Western Australian Museum or any person acting on their behalf.

2. Refrain from undertaking mining or prospecting within the Reserve(s).

3. Not acquire or seek to acquire any Aboriginal art, sacred object or artifact other than from an approved agency.

4. Refrain from photographic activities of any kind whilst within the Reserve(s).

5. Refrain from having possession of any firearms within the meaning of the Western Australian Firearms and Guns Act whilst within the Reserve(s).

6. Refrain from any unnecessary interference with the activities of the Aboriginal people or any actions which are detriment to their welfare; nor interference with water sources or Aboriginal culture sites.

7. Refrain from capturing, acquiring, maiming or killing any animal, bird, fish or reptile, or wantonly destroying or damaging any flora within the Reserve(s).

8. Burn and/or bury all litter such as tins, bottles, cartons, etc., so as to leave campsites in a clean and tidy condition, and make sure all fires shall be effectively extinguished.

9. Obey any lawful instructions issued by the residing Community Chairman.

THIS PERMIT IS VALID FROM THE DAY OF 19

AND EXPIRES ON THE DAY OF 19
UNLESS SOONER REVOKED BY THE MINISTER.

.....
FOR AND ON BEHALF OF THE MINISTER

ECOLOGICAL REGIONS OF WESTERN AUSTRALIA: THE BASIS FOR COORDINATED PLANNING AND MANAGEMENT OF CONSERVATION AND DEVELOPMENT

by K.L. TINLEY

An Invited Review Paper as Background
for the Development of a
STATE CONSERVATION STRATEGY FOR WESTERN AUSTRALIA

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'In the great chain of causes and effects nothing and no activity should be regarded in isolation.' Alexander von Humboldt 1807.

INTRODUCTION

There are as many kinds of regions delineated on maps as there are subjects and interests. Except for those identifying the natural regions of the Earth, in which human cultures and activities have been moulded since their origins, most used are convenient straightline-bounded compartments quite unrelated to the functional ecological unity of natural regions and their subunits. Ignoring natural processes, artificial regions are constructed by superimposing grids of development activities which disrupt the landscape unity. This misfit initiates and then compounds the disharmony of man with land such that environmental degradation and damage, and hence poor economy, is entrained in a cumulative way.

It is still not clearly realised by many that the quality of life is dependent on the quality of our effective environment. Although today this is increasingly influenced by global happenings the core remains the regional ambient. The environmental predicament is not something happening far away in Third World countries, it has been a long standing problem here in Western Australia. The close interdependence between quality of the environment and the viability of economy, employment, and developments is well illustrated close to home.

As a direct result of vast landscape clearing of deep-rooted native woodlands in the Southwest winter region of the State, wheatbelt soils have become increasingly saline and almost all the rivers are already too saline for domestic, urban, irrigation or industrial use – inhibiting present and future development options for the region. The people who live in Carnarvon and use the Gascoyne delta for large-scale food production are increasingly under threat from massive flash floods due to large-scale overgrazing and soil denudation by stock in the river's catchment. Flood reach is progressively exacerbated by heavy silt loads building up the river beds.

As the chain reactions in these two examples involve all aspects including farmers' responses to market compulsions, community viability, economic, and political issues – it is essential to take in the whole field of vision and not concentrate on one point or object in isolation. The complexity of problems is aggravated if the field of vision is limited by preconceived boundaries unrelated to the area of actual interaction. This area is the process unit through which chain reactions are transmitted and multiplied throughout the system, affecting many other components.

To avoid the pitfall of studying or trying to resolve environmental problems in a piecemeal unrelated way it is vital that they are assessed within the contextural setting of their ecological area (arena) of influence and not in isolation. Only by integrating all the disparate parts into a whole interactive unitary system is it possible to see how it functions, and where and how corrective measures can be best applied. The problems have to be dealt with in the context of a minimum natural functional area, such as a river catchment, whose bounds are practically identifiable by most anyone on the ground, on maps and photographs.

Such measures are needed to restore the integrity of the functional processes operating in life support systems as well as enhancing those of dependent human communities.

We live in an age of specialisation where everyone's interests and activities pull in different directions. Disciplines and agencies of administration of many kinds have their own preconceived regional divisions to which they work and relate. In real earth terms however a river, for example, drains across all the straightline boundaries drawn on maps affecting all biophysical components and human activities from its source to its mouth and thence into coastal seas. Real earth unit areas must be identified on which to base organised and effective use of a region in a balanced way. This balance must be reached by working in collaboration with natural determinants and processes and not against them. An attainable ideal is a single frame of reference based on common unit areas as the basis for all planning and management.

People live in a place, a region or its subunit, and affect changes in the landscape by their activities. These linkages between people and the place they live in become part of the interacting complex of processes that makes up the functioning of the regional ecosystem. Only by combining conservation and development planning and management will it be possible to minimise conflicts and ensure that development proceeds on a permanent ecologically sustainable basis protecting its own viability as well as that of life support systems. The healthy functioning of both are interdependent.[9,60]

To escape the narrow short-term view of the environment as a convenient bottomless pit either for stripping out resources or for dumping rubbish we need to develop an active symbiotic relationship – a

mutual advantage between people and their habitats. The use of ecological processes and key environmental determinants in planning and management should become as routine as including the economic and employment factors (which in turn depend on the healthy functioning of a landscape as illustrated by the local examples above).

There needs to be a collective responsibility and accountability for each unit area so that problems in a catchment affecting the sea life and in turn fishermen's purses will be treated as one issue related to the functioning of the whole system, and not dealt with merely by juggling catch quotas or doubling up of the take-off of other communities' resources. Such conflicts are directly related to development processes which are too inflexible and needlessly destructive where inadequate environmental planning and lack of rational allocation of land and water uses cause growing antagonism. The habit of dealing with problems singly has to be replaced with a systems analysis approach which considers people as part of the environment, and which develops a framework of salient information from which it is possible to anticipate crises, to recognise new opportunities for creative thinking, and to ensure cooperation between urban and rural functions bound together by their regional setting.[9,15,17,37]

THE INFORMATION PREDICAMENT

The objectives of environmental conservation are firstly to protect organisms, including people, and their total effective surroundings from misuse or damage by human activities. Secondly, to ensure that life support systems and renewable resources are used in a permanent ecologically sustainable manner whilst supplying the conditions for a satisfactory human existence.

There is increasing concern with the growing reactionary role of human activities with the environment. This is jeopardizing the ecological viability of life support systems, and in turn the quality of the environment and of life. People are increasingly living above the carrying capacity of the ecosystems that support them due to overpopulation and/or excessive demands. What are the implications of these pressures under present and proposed uses, where our responses in practice remain prevailingly reactive? Day-to-day environmental problems, urgent in the view of immediate development pressure or political expediency, overshadow those issues which are really critical.

Worse still, due to time constraints imposed by the demand for immediate solutions, excessive emphasis is put on dealing with symptoms on a one-off basis, each considered in isolation from its causative arena. This often results in the entrainment of further, often unanticipated, environmental problems where new reactions or processes become superimposed over the original linkages which have not been adequately understood in the first instance. The store of knowledge acquired since historical times to the present is largely ignored, such that many environmental problems which can be avoided or prevented by applying first principles as guidelines remain unrealized. We are not supplying what is already known. Perception based on hindsight and foresight has been atrophied by reliance on massive, unfiltered, data gathering to vindicate decisions already made.

On the other hand, critics, who regard ecology as inapplicable to economics and development, look upon it as "the study of the incomprehensible by the incompetent". A belief unfortunately upheld by the massive tomes of biological inventories of unrefined data produced as "ecological evidence". This has assured the critics that environmental problems are so complex and obscure (the incomprehensible) that they cannot be analysed (the incompetent) to provide a meaningful framework for devising real solutions to the human predicament. Hence technological solutions keep being applied to environmental problems. The credo of this approach is that no matter how much technology damages the environment, further technological innovation can always fix it.

However, totally the converse is true of ecology if properly applied. Ecology (geography = human ecology) is the only integrative science[21,53] which permits both diagnosis and prescription if salient factor analysis is applied. Because of the lack of time and high cost of delay it is impossible for everything in an ecosystem to be taken into account. Not only is it impossible to study all the details and complexities of an ecosystem in a given time, it is also unnecessary. Determination and understanding of the key (salient) factors holding a system together ensures survival of its components and processes.

It is not generally realised that the complexities of ecosystems are bound by relatively simple key or salient factors. Survival of an entire wetland for example may depend solely on the persistence of the sill blocking the drainage exit – cut through this and an entire system is lost. No detailed volumes of data gathering could help if this single factor was overlooked. Emphasis in ecology should thus be on a holistic approach[53] in which the ecosystem is treated as a unit whose functional linkages and prime mover components are determined by salient factor analysis.

The systems approach provides a method for indicating the future consequences of present policy decisions, for anticipating future problems and for designing alternate solutions.

THE MANY KINDS OF REGIONS AND ECOSYSTEMS: WHICH TO USE?

A region is a larger scale unit area of the earth's surface differentiated by specific characteristics. Regions are of various kinds depending on the criteria used to identify them. An ecosystem is the basic functional unit of interaction and interdependence between organisms, including man, and the environment in a given area. Ecosystems are of various kinds and sizes from the macroscale at the level of the world system or biosphere[35] down through continental and oceanic-sized systems to regional dimensions and the microscale in all geographic zones. Each ecosystem is the energy processing unit[47] functioning in accordance with four principles which are the basic components of ecosystem organisation; these are (1) conservation of matter, e.g. recycling; (2) conservation of production; (3) conservation of structure; and (4) the principle of ecological equilibrium or ecosystem homeostasis.[57] Both regions and ecosystems are thus made up of hierarchy of units of decreasing magnitude.

A diversity of regional classifications of the same area result from using different criteria, as well as by changing the objectives or purpose of landscape demarcation. Thus no scheme of division would at first glance be expected to satisfy all subjects or objectives as the distributional characteristics of each may be expressed in different ways. This is well exemplified by the variety of physical regions alone identified for WA using different criteria (e.g. Figures 1.2 to 1.6 in[25]; Figure 2.3 in [42]). The land systems mapping approach used by CSIRO for land evaluation across large areas of Australia where little environmental data was previously available, is based on physiographic units which are frequently independent of, and cut across, hydrologic systems.[51]

A further array of regions within WA have been outlined for human interest purposes including administrative, agricultural croplands and rangelands, demographic, land management, planning and political (e.g. Figures 1.9 to 1.13 in Gentilli[25]; in CALM[10]). It is in the realm of biogeography however that the greatest variety of regional combinations and permutations occur.[31] A number of natural regions, regional vegetation formations and floristic provinces have been demarcated for WA[13,22,23] culminating in the most recent refinement by Beard[4] as interpreted from his epic vegetation mapping traverses of the State. The variety and validity of the biogeographic regionalisation used for the continent and WA in particular is reviewed by Jenkins.[30]

Which ecological unit area in the landscape best identifies the minimum arena encompassing all the process and response relationships of an ecosystem in terms of the combined interactions between physical, biotic and human activities? It should simultaneously allow the recognition of its larger economic role as a multidimensional system whose characteristics most easily identify the constraints and opportunities for determining multiple human uses.[37] The ecological unit area has to be practically identifiable in the field, on maps and airphotographs, and recognizable as the single unifying system common to the greatest number of interests and objectives.

Because of man's total dependence on the water resource and his manipulation of it both within and between catchment basins, hydrologic units are the only kind of ecosystem which most closely meet the above requirements as the principal organisational template for coordinating conservation and development. The boundaries of the ecological regions used here (Figure 1) are aligned primarily along the divides separating large or grouped hydrological ecosystem units which share the same physiographic and/or climatic features. Physiographic is meant here in its original wider connotation as an 'integration of geomorphology, plant geography and pedology'.[39]

The ecological regional boundaries therefore most closely resemble those of the drainage divisions identified for the continent (Australian Water Resources Council standard classification[63]). They differ significantly however wherever the unifying physiographic and/or climatic features combine the hydrologic ecosystem units into a regional whole. Such differences are most marked in two situations: (1) where the hydrologic unity of drainage off isolated, upland blocks of plateaux and ranges identify the ecological region (e.g. Pilbara, Kimberley, Victoria Basin, Arnhem Land); (2) in plainsland areas where the drainage is extremely diffuse or absent, the boundary to the ecological region or its subdivisions may be (a) better approximated on the ground by the change in vegetation across a climatic gradient (e.g. landward limits of the SW winter rain region), or (b) by the surface features, e.g. clay, sand, gibber, limestone, (see Figure 1).

Hydrology has to do with the properties, distribution and effects of water on the earth's surface, on the soil and underlying rocks, and in the atmosphere. Of the three hydrologic types, drainless (areic), internal

(endoreic) and external (exoreic) drainage, the first covers the greater area of the State across the Central Deserts, a distance of 2500 km between 80 Mile Beach on the north west coast to the Great Australian Bight in the south east. The second is associated with the many saltlake systems of the interior, and the third is confined to the periphery of the subcontinent. Each endoreic basin should be treated as a unit. The term hydrologic thus best defines the type of ecosystem units which make up the ecological regions and subregions.

Keeping in mind the above crucial differences, the hierarchical structure of hydrologic ecosystems and their terminological equivalence with drainage divisions are (1) the **region** – comprising a single or group of units covering a large area (based on catchments and/or a group of surface feature types); (2) the **subregion** – subgroups of units or types; (3) the **hydrologic unit** is the individual drainage basin or surface type (system or unit); (4) the **subsystems** or **subunits** of decreasing size order (e.g. individual tributary catchments or surface pattern and texture). Respectively these are partially equivalent to the drainage division, subdivision, basin, and subcatchment.

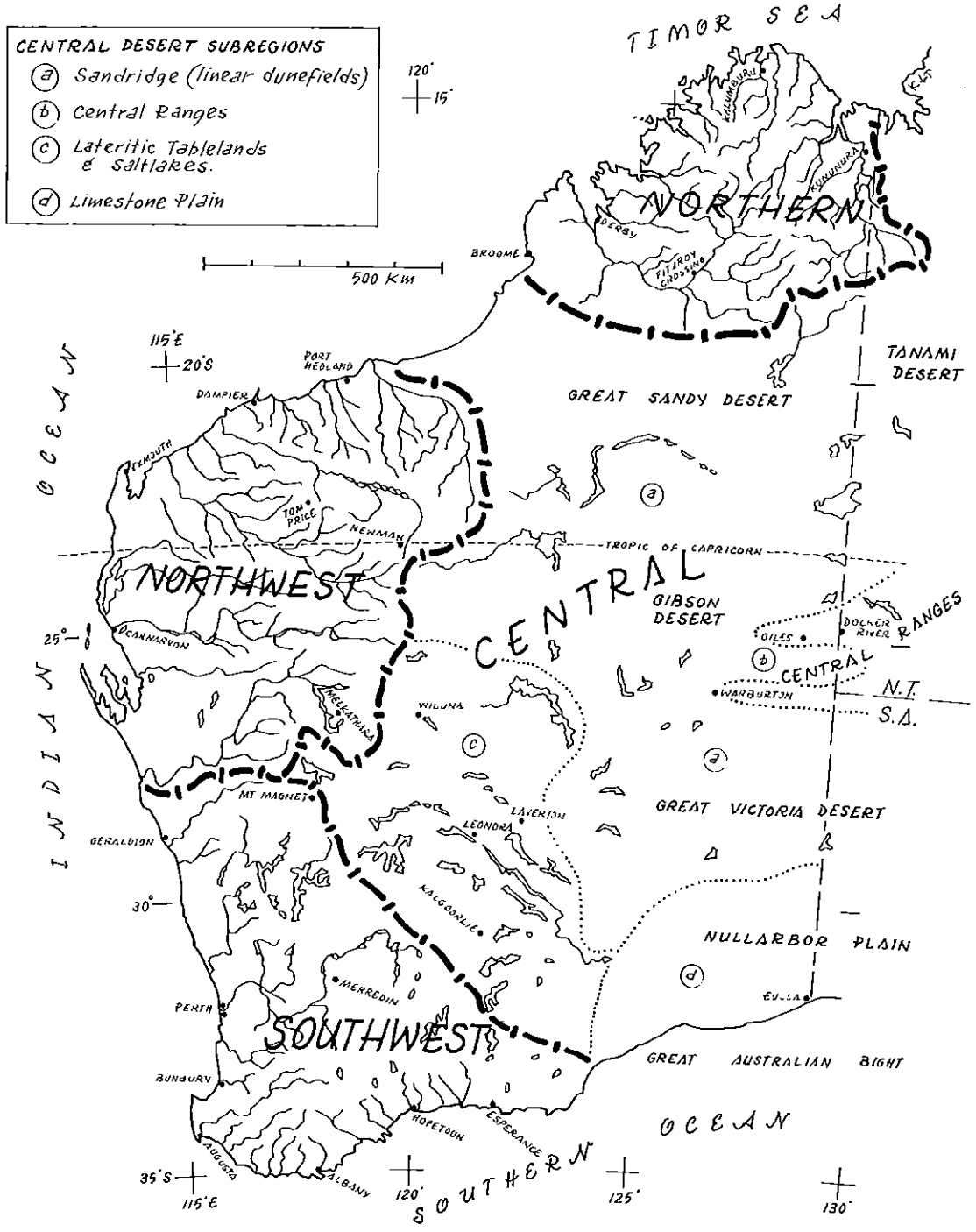

Fig 1. THE MAJOR ECOLOGICAL REGIONS OF WESTERN AUSTRALIA.
(AS IDENTIFIED BY THE CLOSEST FIT OF CLIMATE, PHYSIOGRAPHY & VEGETATION TO HYDROLOGIC DIVIDES).

THE ECOLOGICAL REGIONS

THE SETTING

In contrast to the Southern Hemisphere west coast of Africa and South America, the west coast of Australia does not have a north flowing cold current nor the associated extreme arid coastal deserts and dank fogs.

The Australian Continent is broader than long and reaches only to near 10° S of the equator allowing west flowing equatorial current waters from the Pacific Ocean to move between the islands of the Indonesian Archipelago into the Indian Ocean and pile up off the north west coast. This results in the development of a warm gradient current to flow intermittently southwards off the west coast along the shelf edge to curve around the south west peninsula into the Southern Ocean reaching eastwards to the Great Australian Bight.[45,46]

The presence of this current has climatic, ecological and biogeographic implications as well exemplified by the presence of mangroves *(Avicennia marina)* at 34°S on a west coast compared to 9°3'S in Africa and 3°4'S in South America.[5] Sea-grasses reach all the way to the Bight where they form extensive meadows in the shallow shelf seas.

The greater part of the central and western Australian Continent is under the predominant influence of the subtropical anticyclonic high pressure Trade Winds with their easterly dry descending (stable) air masses blowing seaward, resulting in prevailing hot arid conditions. Due to a vast relatively low interior continental plateau with no orographic highs to block or deflect the major anticyclonic and cyclonic weather-forming circulations, each have a far reach and overlap (Figure 2).

Hence monsoonal NW tropical air from the equatorial zone can affect weather in summer to far south of the Tropic of Capricorn particularly when hurricanes (tropical cyclones) from the NW coast move on a land trajectory and cross the continent to the Bight and South Australia. Temperate cyclones (cold fronts) from the circumpolar westerlies bringing winter rains reach to past the tropic particularly on the west coast (Figure 2).

These factors in combination result in broad interzones of transition between summer and winter rain regimes as exhibited in the field by the broad overlap of subtropical arid savannas with warm temperate arid woodlands and heaths. Despite the overwhelming flatness of the continent there is however an important local orographic control of higher rainfall to escarpments and the isolated massifs in the Kimberley, Pilbara, Central Ranges and the Southwest (see Figure 2). The climatic information is derived from Gentilli[24] and the Australian Year Book.[2]

The traditional use of the terms steppe, probably influenced by the Koppen world classification of climates, and desert for the Central Deserts of the Australian continent has unfortunately masked its real observable identity as an Arid Savanna Biome. Savannas are wooded grasslands between the equator and the true deserts, and Miller[38] and Stocker[52] have long pointed out that steppes are **cold** semi-desert shrubland regions, identified by having one or more months with mean temperatures of 6°C and less, which lie **polewards** of the tropical-subtropical deserts. In Western Australia the vegetation which most closely resembles the Patagonian and Asian steppes **in appearance** is the saltshrub vegetation of the Nullarbor and Carnarvon Plains. Typically the savanna belt in Australia is interpreted as lying north of the tropic except in the east, its boundary drawn close to or between the 500 and 700 mm isohyets,[40] but is given slightly wider application by others who accept mulga as savanna.[61]

Due to the prevailing flatness, isohyets are chiefly zonal and these serve as a rapid approximate means of identifying the biome-types (major world ecosystems) occurring in Western Australia. The isohyetal boundary intervals used here in Figure 2 are those that most closely correspond to the recent world aridity index classification used by UNESCO.[58] With the proviso in mind however, that edaphic properties may make an area more mesic or more arid than the long-term rainfall indicates.

As parallel homologues of the biomes occurring in the other southern continents[14,29] those occurring in Western Australia, with their ecotonal formations, comprise:

(1) the Moist Savanna type containing outlier patches of monsoon forest from eastern Northern Australia confined to the Kimberleys mostly above the 800 mm isohyet;

(2) the Mesic Savanna ecotone between the 400 and 800 mm isohyets where the properties and elements of the first and next biome overlap;

(3) the Arid Savanna Biome covering the largest area of Western Australia and of the whole continent between the 150 and 400 mm isohyets. This biome is both tropical and subtropical and in the west covers both the Northwest and Central Regions overlapping on a broad front along the transition zone between effective winter and summer rainfall regimes;

(4) the Arid Warm Temperate winter rain low woodland, scrub and heath zones between the 150 and 300 mm isohyets;

(5) the Mesic Woodland ecotone between the 300 and 700 mm isohyets;

(6) moist tall woodlands, high open forest and low heaths above the 700 mm isohyet in the south west corner;

(7) the perarid saltbush and subdesert biome-type.

The perhumid rainforest biome (more than 2000 mm) and true desert (less than 50 mm) does not occur in WA.

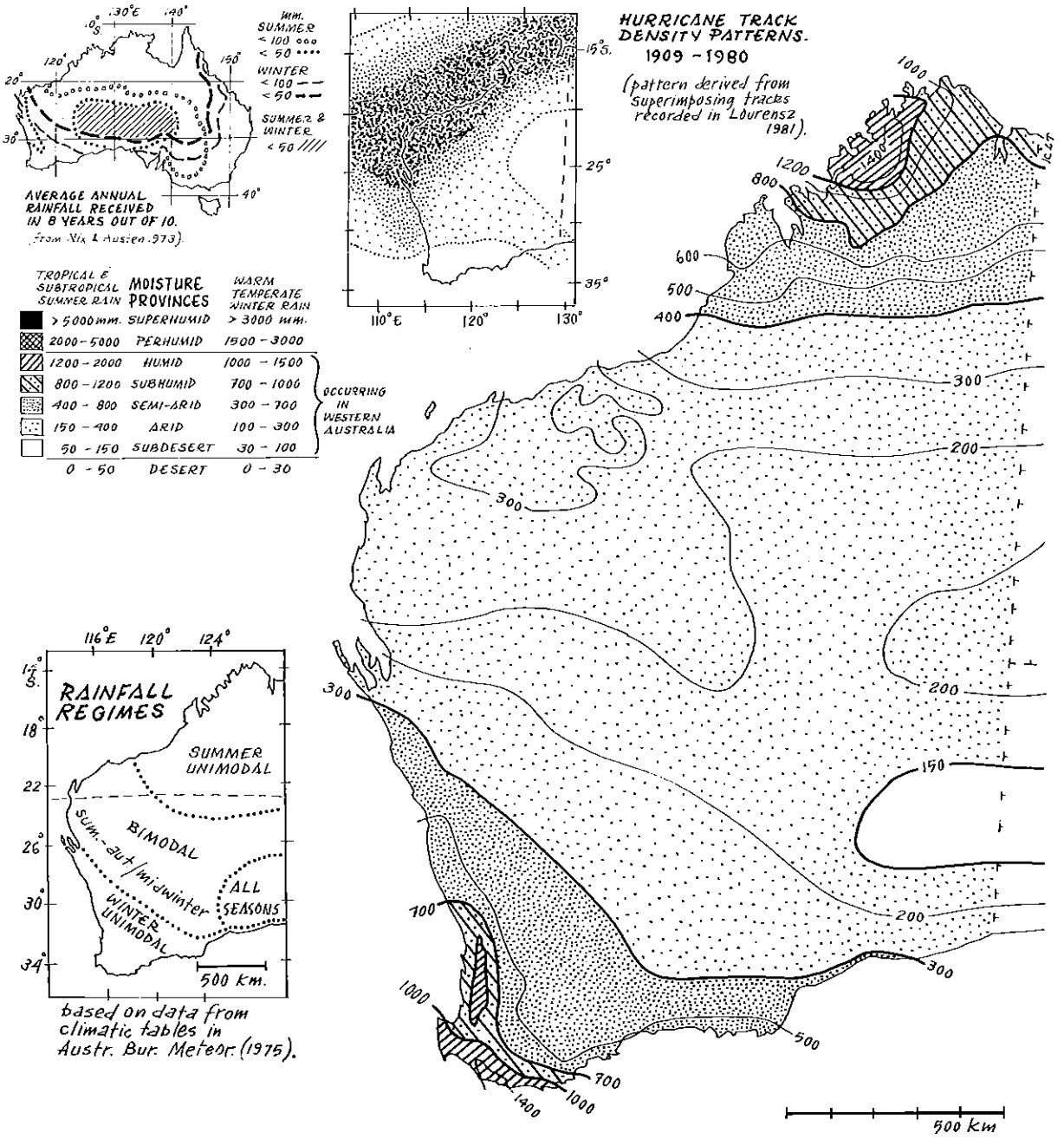

Fig 2. **MOISTURE PROVINCES OF WESTERN AUSTRALIA.**
[as delimited by isohyets which most closely correspond to Aridity Class boundaries (UNESCO 1979). Isohyets modified from Western Australian Yearbook 1983.]

OUTLINE OF THE REGIONS

There are four ecological regions in Western Australia as identified by the closest fit of climatic, physiographic and vegetation formations to catchment divides (Figure 1). These are (1) the Northern (Kimberley), (2) the Northwest (Pilbara), (3) the Central (Deserts), and (4) the Southwest (Swan).

The Northern Region: This is bounded by the Timor Sea coast to the north and landwards by the drainage basin divide of the rivers related to the isolated block of plateaux and ranges of the Kimberley. These attain 983 m at their highest point (Mt Wells). The greater part of the region is covered in tropical tall-tree/tall-grass savanna woodland. The southern drier zone of mesic savannas which grades into the arid savannas of the Central Deserts has a wider spacement of shorter trees and grasses. Treeless tracts of grassland are associated with floodplain alluvia. Tall, bare, conical or tower shaped termite hills are a feature of this region and parts of the Northwest Region. A characteristic feature of these savannas are the large number of tree, shrub and grass genera typical of the pan-tropical and African-Indo-Malayan savannas and their associated thicket and dry forest formations.[27,32,36] The region experiences a monsoon climate with a sweltering summer rainy season and torrid winter dry season.

Cutting across and linking the plateau, fold range, and plainsland physiographic units are three groups of hydrologic systems which identify the subregions:

(a) the northern ria-coast drainage off the Kimberley Plateau;

(b) the western drainage received by King Sound (Fitzroy and Lennard Rivers and lesser systems);

(c) the eastern drainage subregion entering Cambridge gulf (Durack and Ord Rivers and lesser systems).

The Northwest Region: This is a landscape composed of rocky plateaux, fold ridges and inselbergs with broad pediments (outwash plains) and flat floored valleys which support tropical arid tree and shrub savannas and hummock-grassland. The ranges and drainage basins are generally aligned on an east-west trend at right angles to the coast. Mt Meharry on the Hamersley Range is the highest point in Western Australia at 1251 m. The broad Carnarvon coastal plain, up to 150 km wide in parts, fronts the isolated assemblage of rugged ranges and breakaways. The saline soils and linear dune ridges of the plain is the second major area of saltbush country in the west after the Nullarbor Plain.

Connecting the various physiographic units are four major hydrologic subregions identified by one or more drainage systems:

(a) the De Grey and lesser rivers off the northern divide of the Chichester Range;

(b) the Fortescue and Ashburton systems;

(c) the Gascoyne, Macleod Saltlake, Wooramel systems; and

(d) the Murchison River.

The Central Region: This has a mainly areic hydrology on sands and limestone, with local endoreism of saltlakes, and covers the greater part of Western Australia. Most of the Region is vegetated by tropical and subtropical arid savannas and grasslands merging in the south with the saltbush and calcareous grassland of the Nullarbor Plain. The greater part of the region is the old planation surface of the interior continental plateau which lies between 200 and 500 m altitude. A feature of the arid savannas is the abundance of perch-based thicket bush clumps and branch mistletoes dispersed by birds. This and the Northwest Region have a year-round torrid climate.

A broad interzone, between Shark Bay in the north west across to the Great Australian Bight in the south east, is formed by the overlap of the south west warm temperate winter rain zone and its woodland and heaths with the subtropical summer rain zone and its savannas and grasslands. Superimposed lengthwise over the overlap and interdigitation of these two biomes is a third, the saltbush formation which extends in a band from the Nullarbor Plain to the Carnarvon Coastal Plain. The interzone is characterised by having an extremely high species richness of the genus acacia and eucalyptus.[8]

Four large-scale ecological subregions are identified by their surface features and associated hydrology (see Figure 1).

(a) The Sandridge Subregion covering the greater area between the north west coast SSE to the edge

of the Nullarbor Plain. The Sandridge Subregion is composed predominantly of linear dunefields of red sands with an east-west trend, each ridge separated by broad interdune sand flats which may contain bare clay or saltpans. The sand mantle is relatively thin and is underlain by rock which outcrops as isolated ridges, torfields and small inselbergs. Five major saltlake systems occur within this subregion. This landscape is remarkably similar in appearance to the Central Kalahari Desert in southern Africa.

(b) The Central Ranges is the smallest subregion and comprises two separate east-west trending ranges. These ranges are the western ends of the main Central Ranges region isolated in the centre of the continent (MacDonnell and Musgrave blocks). The northern range which extends 150 km into the State from the border is a mountain chain of spectacular scenery rising to nearly 1000 m, each section named separately as the Rawlinson-Schwerin Mural Crescent-Dean-Petermann-Blood (the greater part of the two latter massifs occur on the Northern Territory side of the State boundary). Eighty kilometres south of the Rawlinson Range are the Blackstone Ranges of low rocky ridges which reach 230 km into Western Australia and terminate near Warburton. The highest peak here is Mt Aloysius at 1085 m. The stony and sandy creeks and washes that run off these ranges are lost in the surrounding sandridge and calcrete plains or reach salt and claypan endpoints.

(c) The stony laterite tableland – saltlake and sandplain subregion to the south west is the second largest area. The saltlakes are linear systems occupying fossil drainage[59] and each has its own endoreic catchment, but in flood rain years some may actually flow and interconnect temporarily.

(d) The Nullarbor Plain is a low limestone coastal plateau between 100 and 250 m altitude, with internal karst drainage.

The Southwest Region: This has an arid to moist warm temperate winter rain climate. Its landward boundary is identified by the closest fit of the climatic and vegetation interzone, noted above, to the catchment divide of the south west drainage. Seawards it is outlined by the SE Indian Ocean and Southern Ocean coasts.

The western margin of the region is stepped with the low Swan Coastal Plain, of 30 to 40 km width, separated from the interior continental plateau by the Darling faultline escarpment and its incised hill zone. The hills of this scarp zone rise to between 300 and 574 m. The margin against the Southern Ocean is usually steep, cliffed in parts with rocky headlands and peaks which form the highest points in the south west landscape. The peaks and the highest mountain in the region, the Stirling Range (1096 m), are all isolated massifs. From behind the rugged coastline the land rises gradually inland as a broad low plain across faintly discernible steps to a gently undulating landscape with saltlakes along drainage lines.

High open forest occurs in the extreme south west of the region where the highest rainfall is concentrated. Tall woodlands occur in the adjacent mesic rainfall zone, a mosaic of tall to short woodlands, mallee scrub and heaths originally extended across the lower arid rainfall zones inland to the interzone, but most of the interior of the region has been cleared for wheat farming. The southern part of the region is the great mallee scrub country in which heaths often form the fieldlayer. Low and dense heath scrublands occur along most of the coast, but form a broader band along the northern west coast and the central south coast. The region is characterised by an extraordinarily high plant endemism.[8,26]

Three ecological subregions are identified by groups of hydrologic systems:

(a) a northern subregion composed of the Greenough, Irwin and Moore Rivers, and the endoreic Mongers Saltlake system;

(b) a middle subregion centred on the Avon-Swan drainage and its associated drainage-line saltlakes in the interior, as well as the smaller rivers entering the Swan Coastal Plain; and

(c) the Southern Coast catchment subregion extending from Cape Naturaliste in the west eastwards to the Great Australian Bight. Many large and small saltlake systems are contained in this subregion particularly at its northern and eastern margins.

THE HYDROLOGIC UNIT AS THE MINIMUM ECOSYSTEM AREA

Ecological regions should be the main areas for broad-scale planning and management in conservation and development, but what is the minimum area to which attention should be given for appreciating the

possible implications of local environmental problems to other parts of a system and its dependent life? Human activities are related to, or are influenced by, the nature of the hydrologic unit in which they operate.[49] Hence "Man's minimum ecosystem unit is the drainage basin that includes terrestrial and aquatic systems together with man and his artifacts all functioning as a system".[43]

There are many advantages in using the hydrologic unit area as the focus for understanding and measuring the dynamic interrelationships between the biophysical components and human actions. The 'eco' embodies the total surroundings (house), the environmental matrix or habitat, and the 'system' as an aggregation or assemblage of objects linked by regular interaction or interdependence, involving homeostatic feedback loops.[43,57]

All life is dependent on water in one form or another and is intimately connected to the hydrological cycle. In turn many physical, chemical and biological cycles[6,12,43] as well as landscape and ecosystem evolution are in response to the action of water or to changes in water balance.[54] Except in areic areas which are a special kind of hydrologic unit, drainage basins provide a clear basis for identifying an ecosystem unit area circumscribed by its catchment divides (interfluves). The hydrologic unit is a process-response system in which process interactions and feedback cause changes of response in form (shape, appearance and arrangement) and content (biotic make-up) of the system.[11,15,18,47,53]

The hydrologic ecosystem develops a dynamic equilibrium which is balanced by constant adjustment through a process of self-regulation maintained by feedback. Each disturbance alters the system so that it develops a new steady state (a moving or shifting equilibrium). This shifting equilibrium is composed of a large number of subsystems and elements, each adjusting on a different time, space and velocity scale.[18,19,33,48,57] This time lag between imposed change and adjustment is the reason why many changes are subtly cumulative requiring, at least, the establishment of a time series of fixed point photographs from the air and the ground as a monitoring record.

Geomorphic, hydrologic (water balance) and ecological change is multi-directional with reciprocal effects transmitted upwards and downwards to the confines of the hydrological unit. Some changes may be transferred across system boundaries along interfluves at the one end, and at the drainage confluence with estuaries, coastal seas or endoreic endpoints on the other.

The materials and chemicals transported downstream include rainfall runoff, sediments, minerals, nutrients, and pollutants including agrochemicals and other effluent wastes introduced to the system by human activities. The dynamics of soft coasts and its sand exchanging compartments is closely tied to fluctuating sediment supplies from rivers.[55,56]

The cycle of interaction within and between systems is well illustrated by the biomagnification up the food chain of certain toxic chemicals originating from inland catchments and transmitted into coastal fisheries thence back to man at the top of the food chain, affecting his health and well-being.[7,20]

The effects of environmental impacts such as drought, flood, fire, erosion, and deposition, increasingly accelerated in frequency and intensity by human action, are also transmitted to beyond the confines of each unit where water manipulation and degradation of interfluves occur." Any interference by man with the form, materials and processes . . . can set in motion a sequence of events that may extend throughout the whole system."[15] The most significant geomorphic process is the development of gully nickpoints which incise secondary and local base levels by headward erosion. This process affects the form of the land and its related ecosystems through changes in substrate and soil moisture balance.[54] Such changes reach to the confines of the drainage basin both upstream and downstream. Differential rate and intensity of erosion in each basin results in the asymmetric shift of divides. In this way the area of the more active system is enlarged and that of the less erosive is truncated.

Dams have multiple impacts on drainage basins both in an upstream and downstream direction. For example, a new secondary base level and sediment trap is established resulting in deposition and a change in grade upstream, and the scour of below-dam reaches by sediment deficient flood waters. These and out-of-season floods from drawdowns result in massive damage to river banks, floodplains and deltas and the wretchedness of human communities dependent on them.[1,33,44,50,62]

These examples illustrate the multivariate character of phenomena and the relationships between form, content, process and the reciprocity with human interference – all tied together by water and slope (gravity). As functional processes and interactive linkages are dynamic it is vital not only to discern those operating under present condition, but also to identify the trends or tendency to change and their direction and implications. Status and trends of systems can be identified by using indicator factors in the field which in combination with remote sensing are the most effective means of monitoring environmental change.

The hydrologic unit area as an identifiable ecosystem, has a corresponding value as the fundamental basis for planning and management of human activities, particularly in regard to use of the environment as a place in which to live, and for resource and economic development. By economic is meant not only the financial aspect, but the full value of resources in a multi-dimensional sense and their judicious deployment for which authoritative management and regulation are essential for their successful maintenance and distribution. The alternative to planned utilization is to be trapped into the "Tragedy of the Commons".[16,28,60]

As the hydrologic system or group of systems identify and delimit a region, it provides a natural unifying basis for organizing resource data from biophysical, social and economic sources into the same systems matrix. In this way it is possible to develop an analytical and predictive framework, from which to generate principles and policies as guidelines for right action in regard to environmental usage. The hydrologic unit forms the integrative basis for relating, assessing and anticipating change from natural and man-induced influences from the immediate to the long term. By cutting through to the nub of problems it is possible to intervene at key sites or areas to apply preventive or remedial measures.

The hydrologic ecosystem should also form the minimum context for field research and assessment of all kinds as the unit or its subdivisions provide a natural boundary for relating the six stages of applied research viz, (1) synopsis – salient factor analysis at the reconnaissance and survey level; (2) detailed studies; (3) synthesis; (4) application; (5) monitoring; and (6) review of re-assessment. The whole system approach is particularly relevant where remnant or patchy community distribution lies within a matrix of contrasting or modified systems where edge effect is high.

This coincidence of interests and activities emphasises the singular role of the hydrologic unit area as the key determinant underpinning all planning and development programmes in conservation and development. The hydrologic unit provides a unifying model the present lack of which has resulted in organisational problems of coordination where the programmes and activities of groups are defined by contrived unit areas convenient to their particular interests.

"The objective is to use ... drainage basins on a multi-purpose basis, so that there is complete integration and coordination of all the various uses of water, including the demands arising from needs beyond the basin's limits... in this way neither the (bio) physical nor the economic systems are studied in isolation, and the dynamic element of the drainage basin concept is explicitly involved."[15] Finally, the hydrologic ecosystem unit provides a relatively simple means of relaying information in an easily accessible and assimilable form from the field worker to planners, managers, administrators and policy makers.

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ENVIRONMENTAL MANAGEMENT IN WESTERN AUSTRALIA

by C.R. WHITAKER

An Invited Review Paper as Background
for the Development of a
STATE CONSERVATION STRATEGY FOR WESTERN AUSTRALIA

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"The fundamental prerequisite to good land management is an understanding of the processes involved in the ecosystems that are being managed."[1]

"We see a need for substantial improvement in procedures for the allocation of land to use."[2]

"... reservation alone [of conservation reserves] is insufficient, the land must be properly managed if the responsibility is to be met."[3]

"... when I prepare a planning study, I direct that scientists of the environment study the region in terms of the processes which produce the phenomena constituting the region. They describe the phenomena of the region as an interacting biophysical model. Such a model can then be seen to have intrinsic opportunities and constraints to all existing and prospective users."[4]

"... we are dealing with a complex and probabilistic system in which changes in activities, the spaces which accommodate them, or in communications or their channels, result in repercussions which modify the system."[5]

"... inappropriate development policies – involving for example the misuse of land or water resources – risk undermining the basis for sustainable development."[6]

"The EPA has continually emphasised the importance of public attitudes as prerequisites to satisfactory environmental management."[7]

INTRODUCTION

This account of environmental management in Western Australia is made by a relative newcomer to the State. Accordingly, the assessment of environmental management in the past and its legacy for the present is necessarily derived from the work of others. In contrast, the ideal framework proposed for the future is a personal view of a major challenge to the present generation.

THE SCOPE OF ENVIRONMENTAL MANAGEMENT

DEFINITION

The World Conservation Strategy focusses on the pivotal role of environmental **management** in its very definition of conservation, which is:

> "the management of human use of the biosphere so that it may yield the greatest benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations."[8]

The World Conservation Strategy and A National Conservation Strategy for Australia[9] both make it abundantly clear that such management should be designed:

- to maintain essential ecological processes and life-support systems;
- to preserve genetic diversity; and
- to ensure the sustainable utilisation of species and ecosystems.

The Australian strategy adds a fourth objective: to maintain and enhance environmental qualities.

TEMPORAL CONTEXTS

Environmental management should be considered in three distinct temporal contexts:

- the past, from which we must learn;

- the present, in which our sustainable use of the environment must be accompanied by monitoring and management to ensure that the needs of current and future generations are balanced. In addition we should seek to ameliorate, wherever possible, deleterious effects of past mismanagement;

- the future, in that we should anticipate and plan for changes to ecosystems, both those that are man-induced (e.g. constructing the Dawesville Channel which will increase the salinity of the Peel-Harvey Estuarine System), and those which will occur naturally (e.g. climatic and sea-level changes which appear certain to affect Western Australia[10]).

FORMAL CONTEXTS

In addition, it is instructive to identify three mutually-supporting **formal** contexts in which environmental management should be addressed:

- the broad-scale policy level, which may include a Conservation Strategy itself, or may be a policy for management of certain types of land (e.g. the Government Position Paper on Coastal Planning and Management in Western Australia[11]), or a resource allocation policy (e.g. an energy policy): such policies should include environmental management objectives;

- the planning level, including: land use plans (wherein appropriate tenures and uses are designated); regional plans (giving directions and objectives for future development and decision-making); management plans for a specific area (be it a multiple-use National Park, or a single purpose Wildlife Sanctuary); management plans for specific issues or problems (e.g. bushfire management plans, dieback management plans); and management plans for specific resources (e.g. for a water reserve);

- the project level, in which the onus is on the proponent to ensure that any adverse impacts on the environment are minimised, but where such impacts are unavoidable, that these are managed and ameliorated (e.g. by rehabilitation) to a level acceptable to the community.

It is often useful to view the formal mechanisms of policy/plan/project as a framework in which the policy sets the context for the plan, which in turn sets the context for the project. For example, the Government Position Paper on Coastal Planning and Management in Western Australia has set the policy context in which Coastal Management Plans can be developed; these in turn are an appropriate context in which to assess the environmental acceptability and appropriate management for a coastal marina.

INFORMAL CONTEXTS

Environmental management pursued through policies, plans, and projects may be regarded by some as a rather remote and mysterious field of endeavour, practised by the few cognoscenti (who advise decision-makers) – those environmental boffins who communicate with each other by way of impressive Latin names for organisms, and who speak of ecology and ecosystems and other words of Greek derivation.

The present generation must not delude itself that environmental management is the province and responsibility of the Government, developers, and the few "experts" who advise them. We **all** have a role to play regarding the land we hold in trust for future generations, and on the land or water we use or travel through. Every person has a responsibility to manage their own activities in an environmentally sensitive and sensible manner, e.g. use of water (from the mains or private bore); use of off-road vehicles; recreational fishing (adherence to bag limits and minimum sizes); wildflower tours (avoiding the temptation of illegal picking). Such activities may not be subject to any legal control (e.g. use of a private bore in many areas of metropolitan Perth), but even in cases where they are (e.g. fishing bag limits and minimum sizes, and wildflower picking), there is a limited enforcement presence and capability.

Furthermore, the potential **cumulative impact** resulting from many individuals putting pressure on the same resource may be considerable, and may require environmental management by government (to avoid potentially severe erosion problems) and responsible behaviour by individuals (e.g. the potential impact of America's Cup spectators on the fragile coastal environment overlooking the course).

OUR INHERITANCE

The present generation has inherited a number of environmental problems arising from inappropriate environmental management by previous generations. The damage has been done, and in many instances

it will tax our financial resources and scientific ingenuity to ameliorate the situation. In some instances it is likely that nothing can or will be done. However, it is not the purpose of the brief review in this section to apportion the environmental mismanagement of the past to varying degrees and combinations of ignorance, of inadequate enforcement by government agencies, or of callous indifference by a minority: rather, this brief review should prompt us to ask ourselves the kind of legacy we wish to leave to the next generations.

The following observations are mainly derived from a recent report by the Conservation and Environment Council, to which the reader is referred for further details.[12]

PASTORAL LANDS

Surveys commissioned by the Pastoral Board have been completed for five pastoral regions, and included a classification of land condition ("good-fair-bad"). Lands in "bad" condition (i.e. degraded and eroded due to overgrazing and poor management) comprise 40% of the Nullarbor Plain, 30% of the West Kimberley, 15% of the Gascoyne Catchment, 10% of the Exmouth-Shark Bay region, and 9% of the Ashburton region, giving a total of 20% of the five areas surveyed to date.[13] These lands now require special management measures, and it may take a long time to restore them to a sustainable condition.

Indeed, some degraded pastoral areas were identified by the Conservation and Environment Council, on which pastoral activities are "incompatible with conservation objectives". These include the Nullarbor Plain, the Ord River Catchment Regeneration Area, and the margins of the Great Sandy, Gibson, and Victoria Deserts.[14]

AGRICULTURAL LANDS

Erosion by wind and water is a major problem in many agricultural areas. Indeed, only about one third of cleared agricultural land may be considered to be stable at present: the remaining two thirds need "special care and improved management practices", and some limited areas are considered to be "beyond economic reclamation".[15]

Soil salinity has developed in many agricultural lands following clearing of natural vegetation. Approximately 2% of formerly productive land can be no longer used, but (due to lag factors) the percentage is likely to increase significantly.[16] Furthermore:

> "It is estimated that 99% of the freshwater swamps, lakes and streams in the agricultural zone are now saline. This has severely affected the ecology and amenity of these systems."[17]

The total costs of salinity include: an annual capital loss of land value of $10 million (in addition to an estimated land value of over $100 million for land lost up to 1979); a loss of water supply capital of $12 million; annual loss in farm output of $26 million; and annual costs incurred by salinity in the provision of urban water supplies of $15 million.[18]

The effects of inappropriate agricultural land management may also be transmitted downstream in the catchments, where they may be expressed in stream salinity (rendering the water unsuitable for use) or, in the case of excessive applications of fertilisers, in eutrophication (e.g. in the Peel-Harvey Estuarine System).

MINING

> "Exploration in Western Australia has had a long history and, as a consequence, some of the actions of mineral explorers of the past are still evident and form part of the State's backlog of ground that remains to be rehabilitated."[19]

Exploitation has disturbed a smaller area than exploration. However, there is also a backlog of former quarries, mined ground and associated processing areas (e.g. tailings dams) needing rehabilitation.

FISHERIES

> ". . . advances in the technology of catching have outstripped progress in husbandry . . . the objective of sustainable utilisation . . . is threatened."[20]

FORESTS

> "The State Forest consists of hardwoods with two main sawlog species, jarrah . . . and karri . . . . The slow growth of these hardwoods means that the rotation time is a minimum of 100

years for karri and longer for jarrah. Large scale forest exploitation only started about 100 years ago, and dedication of the State Forest only started in 1928. The present cutting rotation for karri was established less than 20 years ago and at present no similar sylvicultural rotation is available for jarrah. Because the forest has been under deliberate management for only a short time it is not surprising that the question of management for sustained yield is still a difficult one. The State Forest is not yet in a managed equilibrium system . . .[21]

GROUNDWATER

By way of example, a groundwater survey of the coastal zone between Kwinana and Cockburn[22] revealed a legacy of pollution caused by a variety of industries including: hydrocarbons from an oil refinery; caustic soda and sodium carbonate from an alumina refinery; ammonium sulphate, chlorides and nickel from a nickel refinery; phenol, 2,4-D and 2,4,5-T from a herbicide plant; ammonia, nitrate and nitrite from a fertiliser works; chromium from tanneries; and faecal bacteria from abattoirs and wool scourers.

So much for some of the negative aspects of our inheritance – but what will our legacy be? Before proposing an ideal framework for environmental management in Western Australia, it is necessary to summarise the existing formal framework in which it occurs.

THE EXISTING FORMAL FRAMEWORK FOR ENVIRONMENTAL MANAGEMENT IN WESTERN AUSTRALIA

CONSTITUTIONAL POWERS

The respective constitutional powers of the Commonwealth and State Governments continue to evolve. Both have the power to enact legislation for environmental protection and management. For example, legislation with respect to the following matters lies within the Commonwealth constitutional powers:

- all land owned by the Commonwealth for public purposes;
- the territorial sea;
- decision-making and activities of the Commonwealth, and Commonwealth authorities (many of which may require environmental management: e.g. railways, airports, defence facilities);
- overseas trade and commerce*; and
- certain fiscal powers*.

On the other hand, considerable powers reside with the State, including the power to:

- undertake land use planning;
- control mining and other development;
- control pollution (except in the territorial sea); and
- create and manage National Parks, Fauna Reserves, etc.

LEGISLATIVE AND OTHER PROVISIONS

Environmental management in Western Australia is required, implemented, enforced, or encouraged under a wide variety of Acts of Parliament, Regulations, standards, criteria, administrative procedures, guidelines and informal arrangements. It is beyond the scope of this paper to codify all of these, although a codification is overdue and would be of considerable assistance to planners and developers. The summary which follows gives examples under the headings of policy, land use allocation and planning, projects, and hazardous chemicals.

ENVIRONMENTAL MANAGEMENT AT THE POLICY LEVEL

The Western Australian Government endorsed the National Conservation Strategy for Australia in February 1985. In so doing, it adopted in a very broad sense the objectives, strategic principles, and

(*It will be shown later, in the discussion of the environmental management of projects, how the federal powers in these matters may be used to achieve environmental objectives.)

major goals of that strategy. The State Conservation Strategy for Western Australia is being developed within that framework, and when adopted will provide a major policy framework for environmental management. However, until that occurs, there will be no formal policy for overall environmental management which is specifically tailored to the State's environments, needs and aspirations.

It should be noted that the policy-making provisions of the Environmental Protection Act (Sections 28 to 53) have never been used explicitly. However, the Environmental Protection Authority (EPA) has made a number of statements of philosophy on key aspects of environmental management: they are to be found in successive Annual Reports of the Authority, in the "Red Books" containing the Authority's recommendations for Conservation Reserves, and in Assessment Reports on individual projects. For example, in its assessment of the proposed Mindarie Keys development, the EPA detailed the principles of environmental management against which it had assessed the project.[23]

In addition, a number of specific policies which have an environmental management component have been developed by other Government agencies. It is of course for the government of the day to determine policy, and in so doing it is advised by the relevant State agency; for example, the Department of Resources Development advises government on resource development policy, and the Department of Agriculture on agricultural policy. The administrative convenience of single-purpose government agencies inevitably leads to a compartmentalisation of policy-making and implementation, and is poorly suited to resolve conflicting uses for the same area, or to ensure consistency of approach to environmental management.

In this context, it is relevant to note recent government initiatives which have the potential to facilitate integrated policy development: these initiatives are to be commended. Four are of note.

First, the Western Australian Water Resources Council (WAWRC) is a statutory body, reconstituted in 1982 under the provisions of its own Act. It has a broad brief to provide advice on the development, conservation, management and protection of the State's water resources. The breadth of its responsibilities requires that it resolves important policy issues, and among the matters which it is to consider, the following are specified in the Act: the quality of any waters; the equitable distribution or use of any waters; the loss or wastage of any waters; the preservation and conservation of any waters; the health and welfare of the people; the conservation of flora and fauna; and the preservation of the amenity, nature, features and general character of a locality. Key government agencies are represented on this Council, together with community representatives.

Second, the Land Resource Policy Council (LRPC) was established by Cabinet following a major recommendation of the Task Force on Land Resource Management.[24] The LRPC reports to the Premier, and has the following functions:

- to evaluate and make recommendations to Government on major land use questions;
- to initiate land use policy for consideration by the Government and to evaluate new proposals for land use referred to it by the Government;
- to evaluate and make recommendations for the Government on the consequences of land resource management plans developed by individual agencies and their impact on other State resources;
- to co-ordinate land management research; and
- to review the regional plans by regional planning authorities.

It is the second term of reference which is of special note in this section. The Council comprises the permanent heads of key government agencies, together with representatives of outside interests.

Third, the Coastal Management Co-ordinating Committee co-ordinates State departments and local authorities: it prepared the Government Position Paper on Coastal Planning and Management in Western Australia. This is essentially a policy-level statement advocating sound environmental management.

Fourth, the Department of Conservation and Land Management has responsibilities for co-ordinating policy for the management and protection of designated public lands, waters, flora and fauna of Western Australia.

It is also encouraging to note a recent policy-level initiative from the private sector: the Environmental Policy of the Chamber of Mines of Western Australia. The policy, adopted and issued by the Chamber in

1984, has sections in its policy concerning land use planning, environmental management (of specific projects), environmental administration, and research and education. In addition, a number of resource companies have an "in-house" environmental policy.

ENVIRONMENTAL MANAGEMENT THROUGH LAND USE ALLOCATION AND PLANNING

There is a variety of provisions and practices for environmental management through the allocation of land for specific purposes and through planning. Until recently, these have evolved with little overall co-ordination. The following are of note:

- the Environmental Protection Authority has made recommendations on Conservation Reserves throughout Western Australia. The last region to be completed ("The Darling System – System 6") covers Perth and its hinterland:[25] State Cabinet has approved the progressive implementation, as far as possible, of the recommendations and has adopted procedures for dealing with conflicts. The Government has endorsed the recommendations made for the remainder of the State, and implementation is proceeding;

- following advice from The Agricultural Land Release Review Committee, the government now requires that future releases of agricultural land be subject to an environmental impact assessment, involving public participation. The objective is to ensure that land release for agriculture is appropriate in the long-term. Land suitability and land capability (discussed later) are key considerations, and monitoring of new releases is recognised as essential;

- provisions for environmental management can be attached to the granting of mining or petroleum tenements (e.g. by the Mining Warden, by the Minister for Mines, or by other Ministers or agencies whose approval is needed (e.g. the Minister for Water Resources)).

- maps of Environmentally Sensitive Locations and Special Protection Localities have been prepared[26] which guide developers and decision-makers concerning offshore petroleum tenements;

- proposed pastoral use of vacant Crown land adjacent to National Parks, Nature Reserves or recommended as Conservation Reserves is referred to the Department of Conservation and Environment for its advice by the Under Secretary for Lands.[28]

Regional planning is at an early stage in its evolution in Western Australia. Apart from the Perth Metropolitan Region, and the Bunbury Region, the "remainder of Western Australia" is subject to incremental and *ad hoc* planning,[29] principally because there has often been little perceived need to do otherwise. This planning vacuum (in particular the lack of planning policies and objectives for much of the State) has presented difficulties, particularly since there has often been no context in which to evaluate projects or to develop management plans for particular areas or projects. For example, an appropriate rehabilitation programme for the coal-mining areas of the Collie Basin has, as a vital pre-requisite, a clearly-enunciated regional plan:[30] such does not exist at present. Similarly, it is difficult to develop a management plan for a particular National Park without the context of a regional plan for the surrounding area.

Notwithstanding such obstacles, a number of planning mechanisms are in place. These can be used to achieve environmental objectives, and include:

- local government planning schemes prepared in accordance with the Town Planning and Development Act. These may state environmental objectives, within the context of which decision-making should occur. In addition, by-laws (e.g. for extractive industries) may have explicit provisions for environmental management;

- a General Working Plan for the State Forest, and the setting aside of Management Priority Areas (MPAs) for the conservation of flora, fauna and landscape. (However, it should be noted that while such MPAs have adequate security of tenure, there is insufficient long-term security of purpose.)[31] MPAs are also established for other priority uses (e.g. wood production, mining, water production, recreation, scientific study and education);

- single topic management plans (e.g. bushfire management, dieback management);

- the Conservation and Land Management Act 1984 has provisions for the development of management plans for areas such as National Parks, Nature Reserves, Marine Parks, and Marine Nature Reserves. It has also enshrined the concepts of multiple use and sustained yield in the case of State Forest or timber reserves (section 56(a)), and has requirements for public participation during their formulation;

- Working Groups have been established in accordance with EPA recommendations for Conservation Reserves to advise on the future control and management of certain Crown lands (e.g. Working Groups were established to report on Crown lands along the south coast of the State): a principal objective has been to ensure co-ordinated and integrated management at the State and local level;

- thirteen coastal management plans have been completed. These non-statutory documents were prepared in consultation with local authorities, and are "to guide local and State authorities in the long-term use and management of coastal areas".[32] Public comment on drafts is also sought.

In addition, controls on land management are enforceable through a variety of legislation (e.g. controlling weeds and vermin, and protecting Aboriginal sites).

Finally, as noted above, it is encouraging to note the roles of the W.A. Water Resources Council, the Land Resource Policy Council, and the Coastal Management Co-ordinating Committee: in addition to their respective roles at the policy level, all have major responsibilities to promote and ensure co-ordination of land use allocation and planning. In addition, it is expected that recently-announced changes to the planning system will lead to a greater emphasis on regional planning in Western Australia.

ENVIRONMENTAL MANAGEMENT AT THE PROJECT LEVEL

There is a sound framework for environmental management at the project level, particularly in the context of environmental impact assessment (EIA). The Environmental Protection Authority (EPA) undertakes this activity under the general headpowers of the Environmental Protection Act, 1971-1980. The objectives of the Act are to enhance the quality of the environment, and to control and wherever practicable to prevent any act or omission which causes, or is capable of causing, pollution.

The EPA undertakes environmental impact assessment of environmentally significant projects. The objectives of EIA may be stated as follows:

- to ensure that environmental considerations are afforded an appropriate place in decision-making;

- to frame its input in such a way as to maximise the attainment of a realistic balance between conservation and development; and

- to facilitate appropriate development by assisting the proponent, the government, and the public, to be sensitive to environmental issues in project decision-making and management at the planning, construction, operational and post-operational phases of a project.

Note that EIA **serves** the decision-making process – it is not the decision-making process itself. The EPA gives advice before decisions are made on projects, and wherever relevant maintains an involvement in environmental monitoring and management at the operational and post-operational stages.

In Western Australia, a strong emphasis has developed on the environmental management component of project evaluation. Indeed, this is reflected in the name of the document prepared by proponents for the evaluation of major proposals: the Environmental Review and Management Programme (ERMP). Impact assessment consists of the following stages:

- collection and interpretation of baseline information;

- prediction and evaluation of potential impacts;

- formulation of environmental management strategies;

- monitoring of impacts and efficacy of management strategies; and

- revision of management strategies where appropriate.

In its evaluation of proposals, the EPA takes a particular interest in proposed management strategies, and for major projects may require that the proponent submits monitoring reports on actual impacts and the performance of the management strategies.

Proponents of major projects subject to State Agreement Acts may be statutorily required to prepare and submit Environmental Management Plans (EMPs) to the Minister administering the Act. As the project

proceeds they may be required to submit annual and triennial monitoring reports, and to report immediately any unforeseen environmental occurrence. The environmental provisions of Agreement Acts have developed over time: some old Agreement Acts (still in force) place no environmental monitoring and management requirements on the proponent. More recent Agreement Acts (e.g. for Woodside, Alcoa, and the Argyle Diamond Project) have substantive requirements.

As noted earlier, the Commonwealth has the power to legislate in a number of areas. Of particular relevance here is The Environment Protection (Impact of Proposals) Act, 1974-1975. This Act applies to all **actions** within the power of the Federal government. Action is a broad term, covering not only a **physical act** (e.g. building a railway), but also a **decision.**

Therefore, for example, the Federal Minister for Trade is bound by the Act when he makes a decision on whether to permit the export of goods. For practical purposes, he is only concerned with certain goods (e.g. the export of uranium and woodchips requires export approval, whereas the export of gold does not). Accordingly, when he makes a decision to approve the export of woodchips, the Act requires that he must be satisfied that environmental matters pertaining to their protection have been properly considered. Indeed, he has the power to attach conditions to any export permit specifically requiring that proper environmental protection and management are adopted.

Similarly, the Federal Treasurer's approval is required to import significant amounts of foreign capital into Australia. If such capital is for the purposes of a major project (e.g. mining or industrial), the Treasurer's "action" (e.g. to approve) is subject to the Act, and he must consider the environmental implications of his action. Accordingly, he must be satisfied that the relevant provisions of the Act have been complied with. Furthermore, he may (and often does) attach environmental conditions to an approval to import foreign capital.

A common requirement is for the proponent to submit monitoring reports on actual impacts and the performance of environmental management measures.

The provisions of the Act also apply to Commonwealth developments, e.g. building a national highway or a defence facility.

In order to facilitate environmental evaluation, to avoid duplication, and to minimise conflicting or uncoordinated requirements on the proponent, Memoranda of Understanding on co-operation in EIA have been drawn up between the State and Federal governments.

In addition to the Western Australian emphasis on environmental management in EIA, numerous State Acts, standards, criteria, guidelines, and codes of practice may control or influence the way a project is managed: e.g. controls on air and noise emissions, controls on use and disposal of water, controls on soil and land conservation, and various provisions of the Health Act (e.g. in licensing a refuse disposal facility). Another example is the statutory role of the Waterways Commission which is responsible for the management of three declared areas: the Swan River and its tributaries; the Peel Inlet and the Harvey Estuary; and the Leschenault Inlet. The Commission has a number of powers (e.g. to control pollution), and must license dredging, reclamation, and structural works in these declared areas.

It should also be recalled that the Chamber of Mines has developed its own environmental policy on how projects should be managed. Furthermore, some proponents have developed "in-house" environmental awareness programmes – after all, it may be of little consequence what the company's environmental consultant has recommended on environmental management, or indeed what the decision-maker has required, if the bulldozer driver neither knows nor understands what it is all about!

In addition, the restoration of mined land may require the establishment of co-ordinating committees: e.g. The Mineral Sands Rehabilitation Co-ordinating Committee, and the Collie Coal Mines Rehabilitation Committee.

MANAGEMENT OF HAZARDOUS CHEMICALS

Environmental management also requires specific measures to protect the environment from the unwise or careless use and disposal of hazardous chemicals. Two committees (the Community Consultative Committee on Chemicals, and the WA Advisory Committee on Chemicals) have responsibilities for considering and advising on the effects of hazardous chemicals on the environment, and on occupational and human health. A number of important initiatives are summarised in the Annual Report of The Environmental Protection Authority for 1984-1985.

A FEW OBSERVATIONS

The brief statements which follow are a personal view, and set the context for the next section:

- a comprehensive State Conservation Strategy is needed, to define the overall context and purpose of environmental management;
- better co-ordination at the policy level between agencies is overdue, but there are encouraging developments – notably the WA Water Resources Council, the Land Resource Policy Council, and the Coastal Management Co-ordinating Committee;
- sufficient experience has now been acquired (concerning some components of the environment) for the EPA to develop formal environmental protection policies under its Act (although it is noted that certain procedural aspects of the Act require amendment to make this practical);
- policies developed by industry (with few exceptions) are poorly developed;
- a higher priority needs to be given to baseline studies (particularly on the functioning of ecosystems), and to land suitability and land capability assessment: these are the very foundations of wise land allocation;
- some existing land allocations and management practices require rethinking (notably in certain agricultural and pastoral areas);
- a "planning vacuum" (i.e. no policies, objectives, or strategies) exists for much of the State, creating uncertainty in the evaluation of proposals and in the development of appropriate management plans and strategies;
- management plans are urgently required for a number of fragile environments which are under great pressure;
- environmental management at the project level is developing well, but follow-up work by government agencies merits a higher priority if environmental management requirements are to be credible, and if we are to learn from experience;
- although provisions exist for public participation in the development of environmental management practices and plans, the scope and effectiveness thereof leave much to be desired;
- environmental management has often been reactive: this has diverted resources from anticipatory work. In part, this reflects environmental problems inherited from past decisions and practices. Getting ahead of the action may seem to be a rare luxury, whereas it is a prime necessity!;
- environmental management has often focussed on the highly visible major impact area (e.g. an open-cut mine), whereas greater environmental damage may result from chronic but widespread activity (e.g. poorly managed pastoralism, resulting in land degradation).

AN IDEAL FRAMEWORK FOR ENVIRONMENTAL MANAGEMENT IN WESTERN AUSTRALIA

If we wish to perform better than our forebears in environmental management, the following ten components would constitute an ideal framework:

THE ENVIRONMENTAL DATABANK

Environmental management requires an understanding of the functioning of ecosystems and their components. In particular, we need to know answers to questions such as:

- How resilient is the system?
- How well can it recover from extreme events?
- What are the weak but important links in the system?
- What are the magnitudes and frequencies of the natural perturbations to the system, including any natural hazards?

Establishing an adequate databank will be a huge task, and should be designed to facilitate **environmental management** rather than mere **environmental description.** Remote sensing techniques are rapid methods of data acquisition, and will prove invaluable.[33] Nevertheless, an adequate databank will take time to acquire, and meanwhile demands will continue for land resources to be allocated to specific uses: these pressures highlight the need for a high priority to be allocated to establishing the necessary databank.

The databank should be updated by monitoring of the effectiveness of environmental management strategies.

THE POLICY CONTEXT

The State should begin with a commitment to environmental management in its own State Conservation Strategy, which should be compatible with the National Conservation Strategy for Australia. All political parties, industry groups, and conservation groups should be in agreement with the Strategy.

The corporate plans of government agencies should also be explicitly conformable with the Strategy.

Environmental protection policies for specific components of the environment should be prepared. One priority would be wetland management. The World Wildlife Fund's **Year of the Wetland** in 1986 would be an excellent opportunity to adopt this: the EPA, the Land Resource Policy Council, and the WA Water Resources Council may all have a role to play in its development.

Policies should be developed and implemented for the use of renewable resources (based on sustainable use), and for non-renewable resources (based on maximising the benefit to present and future generations, and retaining as many options as possible for the future).

Co-ordination of policy development (where these have implications for environmental management) across Government agencies through the LRPC and the WAWRC should continue.

On occasions, it may even be appropriate to conduct environmental impact assessment of proposed policies: such is not uncommon elsewhere, and indeed this is specifically mentioned in A National Conservation Strategy for Australia (item 28d). A recent study by the Department of Arts, Heritage and Environment[34] amply illustrates how fiscal policy can have significant environmental ramifications. Moreover, the study also concludes that fiscal policy offers considerable potential in **solving** many environmental problems.

Finally, as a matter of policy, following the adoption of a State Conservation Strategy, the Government could require that each Cabinet submission includes a statement of the compatability of its recommendations with the Strategy. This would serve as a constant reminder to decision-makers of the provisions and significance of the Strategy.[35]

MATCHING LAND USE TO SUITABILITY AND CAPABILITY

We will promote sustainable use of the environment and minimise the cost of environmental management if our allocation of land to specific uses is environmentally sound in the first place. Land suitability analysis follows the pioneering work of McHarg,[36] and concerns the evaluation of particular or alternative locations for a particular use (e.g. land for pastoral purposes). Land capability analysis is a related technique which is used to determine the "carrying capacity" of an area for a particular use: e.g. to determine animal stocking rates. We are often confronted with multiple demands for use of the same piece of land: land suitability analysis and land capability analysis must be used in the resolution of these conflicts and the ultimate allocation of land, which may be to a mosaic of compatible multiple uses with integrated management. A recent example of this approach is the Rottnest Island Draft Management Plan[37] which used land capability work undertaken by Hesp and others.[38]

Furthermore, we must rethink (and if necessary reverse) some previous decisions on land use allocation. For example, it may indeed be necessary to ban pastoralism from some areas, or perhaps, as Ellyard[39] suggested, to use them for other purposes such as kangaroo husbandry for meat (for human consumption) and skins – with appropriate management, such use may be environmentally sustainable, whereas sheep or cattle husbandry may not. (This suggestion, by a committed environmentalist, sparked a lively debate at the Public forum on Kangaroo Management!)

THE PLANNING CONTEXT

Planning has an important role to play in environmental management. In its broadest sense, planning seeks to facilitate and encourage appropriate development, to prevent inappropriate development, to

conserve valued components, and to reduce conflicts between amenity and development.

Land use planning determines "what, where, and how much" and should be firmly based on land suitability analysis and land capability analysis.

Management planning seeks to designate how favoured uses will be controlled and facilitated, and how undesirable uses or potentially undesirable events (such as fires) will be controlled. Land use plans are an essential precursor to management plans since we must define **what, where,** and **how much,** before we define **how** by means of agreed objectives, strategies, and controls. For example, having decided that a particular part of a National Park is to be preserved for its wilderness value (a land use decision), we can then adopt appropriate **objectives** (e.g. to keep most people out) and **strategies** (e.g. to provide no access and no facilities) and **controls** (e.g. to require and ration permits before people enter, as a safety precaution).

In summary, Western Australia needs a comprehensive planning system which achieves the following objectives at the State, regional, and local levels:

- defines use or uses to which land can (or should) be put in terms of what, where, and how much, which is soundly based on land suitability analysis and land capability analysis;
- considers interactions and compatibilities (and reduces conflicts) between multiple uses of the same piece of land (both at one point in time, and in a sequential sense),and the **cumulative interaction** of these with the environment;
- considers the juxtaposition and spatial interaction with land use(s) on adjacent and nearby pieces of land (both at one point in time, and in a sequential sense);
- states objectives (including environmental objectives), in the context of which future decision-making on land allocation and proposed developments should occur;
- states management objectives and strategies in the context of which operations (e.g. by National Parks staff) should occur;
- defines proposals and tasks to be performed in the long and short term;
- facilitates appropriate development while simultaneously conserving social and physical environmental attributes of a community or locality that have been identified as being of value;
- prevents inappropriate development;
- provides for monitoring and review of all the above;
- provides for public input into all the above; and
- balances all the above to ensure that man's use of the environment is not abused to the overall detriment of the environment, specific groups of people, or future generations.

For the specific purposes of environmental management, planning will be most effective if a systems approach based on natural environmental units is used.[40] Examples are the Peel-Harvey coastal plain catchment, the Leschenault Peninsula, and Rottnest Island. However, it is recognised (for example) that the boundaries of many National Parks and individual pastoral leases do not conform to natural environmental units.

Systems planning places emphasis on:

- inputs to the system (including deliberate interventionist planning);
- dynamic functioning of the system and the inter-relationships and interactions of the component parts;
- analysis of the functioning of sub-systems and the relationships between them;
- outputs from the system (e.g pollution);
- monitoring of the system, the results of which may lead to modifications to inputs; and

- analysis of temporal trends in the system (with particular attention to irreversible trends).

The principal advantages of a systems approach to planning are:

- it provides a scientific basis to **guide** development and its management in an adaptive sense, rather than to **prescribe** development;

- it provides a sound basis to evaluate the cumulative impacts of multiple uses;

- in view of its dynamic component, it provides a logical basis on which to evaluate sequential land uses (e.g. land used for mining, and then for agriculture), thereby ensuring, as Zen averred:

  > "that decisions regarding short-term land use will take into account the long-term consequences of each decision . . ."[41]

- it provides a basis on which direct intervention by the planner and manager can be monitored.

Finally, in some instances, it may be appropriate to undertake EIA of draft resource management plans (e.g. the ERMP now in preparation for the Western Australian Water Authority's overall plan for the abstraction of water from the Gnangara Mound: this will set the context for the subsequent evaluation of individual proposals).

ENVIRONMENTAL MANAGEMENT OF PROJECTS

The present system, described above, should continue. However, higher priority should be given by government agencies to follow up on monitoring and management requirements, and consideration of the results. In addition, generic EIA of new technologies with the potential to affect the environment (e.g. new agricultural technology), should also occur.

AN INFORMED PUBLIC

A high priority should be given to ensuring that all who own or use parts of the environment, or who make decisions on its use, are informed about how the environment functions, the need for environmental management and their responsibilities and means of doing so. This should form part of the basic education received by all children. In addition: extension services of several government agencies merit upgrading and some warrant a greater regional presence; more interpretation centres are needed in National Parks; environmental orientation courses should be conducted for workers on major projects, and guidelines and handbooks prepared; and adequate provision should be made for regular development of skills by all those with specific responsibilities for environmental planning and management.

It is most unfortunate that in times of financial stringency, public information and extension services are the first to be cut: a good case can be made for these to be the very last to be cut!

Radio stations feature regular talk-back programmes on financial management, health management, pet management, etc. – why not environmental management, too?

An informed public, which believes in the desirability and possibility of a sustainable future, is essential if we are to ensure that environmental management features prominently on the political agenda, and is thereby translated "into workable and widely acceptable programmes of action".[42] Furthermore, an informed public is more likely to be environmentally responsible at the individual level.

AN INVOLVED PUBLIC

For environmental management to be effective, members of the public need to be involved, not only in the way they personally discharge their responsibilities, but also by their involvement in policy development, planning, and environmental management itself (e.g. assisting in the management of National Parks). There is considerable scope and need for members of the public to be involved: they usually have much more to offer in terms of local and regional knowledge about the environment than Perth-based bureaucrats. Furthermore, there is a lot of scope for volunteer participation (e.g. in the establishment of walking trails in National Parks). Provisions already exist for public involvement in some matters: e.g. in EIA, in the preparation of management plans under Part V of the Conservation & Land Management Act; in soil conservation districts; in integrated management planning for proposed Conservation Reserves (e.g. South Coast Working Groups). However, public involvement needs to be extended (e.g. in the policy area, and in actual management), and strategies developed to make it more effective.

ADEQUATE LEGISLATION

Legislative amendments may be necessary to facilitate this ideal framework for environmental management (e.g. to make the development of environmental policies by the EPA more practical, to **require** provisions for public involvement in various aspects of environmental management planning for which there is currently no provision).

In addition, standards, guidelines (such as those already developed for wetlands,[43] and codes of practice for the protection and management of the environment need to be developed. In the case of pollution management, thought should be given to standards based on the **assimilative capacity** of the environment (which varies from place to place), rather than rigid standards to be applied irrespective of local conditions. Furthermore, it should be recognised that a particular standard is the "lowest common denominator" which society is prepared to accept; however, proponents should always **aim above** such levels! Such an attitude is part of the environmental ethos which we should be nurturing.

CO-ORDINATION

With a multitude of decision-making authorities, a variety of vestings and tenure of land, and potential conflicts between these (at worst) or unintentional inconsistencies (at best), there is a clear need for co-ordination in environmental management at the policy,plan, and project levels. For example "at least twenty-five State Government organisations and forty-three coastal local authorities are directly or indirectly involved" in coastal planning and management in this State.[44] Clearly, bodies such as the Coastal Management Co-ordinating Committee, the WA Water Resources Council, and the Land Resource Policy Council have a major role to play. At a local level, committees or working groups are needed to co-ordinate "hands-on" environmental management.

While such co-ordination of environmental management responsibilities is essential, it is equally important that we do not develop "tunnel-vision" and focus solely on environmental management. We should also keep attuned to, and co-ordinated with, developments in other areas such as economic development policy[45] and fiscal policy:[46] these have considerable potential to impede or assist our efforts! For example, it has been argued that financial pressures (such as escalation of costs, and long-term debt) virtually compel pastoralists to exceed prudent stocking rates and thereby cause environmental degradation. Perhaps reduction of the financial pressures is the first priority: if this could be achieved there is a much greater possibility that management standards will be adopted which are compatible with long-term stability of the environment.

RESOURCES

All of these components of an ideal framework for environmental management in Western Australia will need resources additional to those already involved: for research; for design and implementation of environmental management at policy, plan, and project levels; for enforcement (where necessary); and for monitoring. Recognising that re-allocation of resources and the provision of additional resources cannot occur instantaneously, it may be appropriate to initiate, for example, a five (or ten) year plan to do so.

CONCLUSION

When Australia celebrates the bicentenary of European occupation in 1988, there will be a blend of recalling our past and anticipating our future. There could be no better context in which to consider environmental management in Western Australia for the benefit of present and future generations, and for the benefit of the environment itself. It would be a major achievement if we could achieve the following by the end of 1988: the adoption of a State Conservation Strategy for Western Australia; the design and preliminary implementation of a comprehensive and integrated framework for environmental management; and the adoption and implementation of a five (or ten) year plan to allocate the necessary resources to environmental management. How close we come to achieving these will be a measure of the priority which the present generation accords to sound environmental management.

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URBAN AND REGIONAL PLANNING IN RELATION TO A STATE CONSERVATION STRATEGY

by RORY J. O'BRIEN

An Invited Review Paper as Background
for the Development of a
STATE CONSERVATION STRATEGY FOR WESTERN AUSTRALIA

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INTRODUCTION

In essence, this review paper asks the question: how can urban and regional planning assist in achieving the aims of the State Conservation Strategy? Before this can be answered, another important question needs to be answered. Why is it necessary to prepare a State Conservation Strategy in the first place? McHarg[1] provides the answer, "he [man] has emerged as potentially the most destructive force in nature and [is] its greatest exploiter".

McHarg traces the reason for this back to man's adoption of monotheistic religion through which he became preoccupied with the uniqueness of man and man's "dominion over and subjugation of nature". The prevailing values of mankind have become anthropocentric, seeking not unity with nature but its conquest. McHarg maintains that man has achieved the conquest but **unity** with nature is needed in order to ensure man's survival.

In order to correct the anthropocentric imbalance that exists, **conservationists** need to promote a strongly ecocentric bias. Man has forgotten that he is **part** of the ecosystem which he so thoughtlessly uses. Primitive man could abuse his environment with impunity because he was relatively insignificant. Today, with millions of human beings and machines, man's impact on his environment is very high. It is therefore essential that at least a balance is established between man and the environment.

By formally endorsing the National Conservation Strategy (February 1985) the State Government of Western Australia adopted the objectives, strategic principles and goals of the National Conservation Strategy for Australia (NCSA).[2] These then become the framework within which the State Conservation Strategy will be shaped. The main objectives of these are:

- to maintain essential ecological processes and life support systems;
- to preserve genetic diversity;
- to ensure the sustainable utilisation of species and ecosystems;
- to maintain and enhance environmental qualities.

The purpose of this paper is to examine the role which urban and regional planning could play in supporting the aims of the State Conservation Strategy. Urban and Regional Planning, Land Resource Management, Environmental Planning and Regional Land Use will be discussed with particular reference to Western Australia. It is important to note at the outset that several land-related disciplines need to work in harmony to solve real world problems. It is not intended to present planning as a "panacea" for all land problems.

URBAN AND REGIONAL PLANNING

Planning has been defined and re-defined many times. Hall[3] defines planning (as a general activity) as the "making of an orderly sequence of action that will lead to the achievement of a stated goal or goals". Urban and regional planning, however, refers to planning with a spatial, or geographical component, in which the general objective is to provide for a spatial structure of activities (or land uses) which in some way is more desirable than the pattern existing without planning. The common elements of the above definitions are that planning is a goal-oriented process which is concerned firstly with the spatial structuring of human activities and secondly with the impact of those activities on the environment.

Originally, planning focussed on urban areas owing to the severity of the problems, poor housing conditions and pollution which occurred during the industrial revolution. Early this century Howard,[4] Geddes[5] and Abercrombie[6] saw the need to extend planning into the surrounding hinterland to provide a balance to the urban planning of the day. The economic depression of the 1930s added the concept of economic planning to assist the development of economically stagnating areas and to deal with their social problems. The analysis and distribution of land use as a basis for master plans was an approach used until the 1960s when **structure planning** (being flexible shorter-term plans) and use of policies began to supplant it. In the 1970s planning became more involved with social and political aspects.

Urban and regional planning is therefore practised at different scales; the local scale being the most detailed and of smallest areal extent, state and national being the greatest areal extent, and regional planning being intermediate between the two. Metropolitan planning would therefore fall into the last category as it focusses on the metropolitan region.

Urban and regional planning is not an exact science. Owing to the multiplicity of factors, value judgements and objectives involved in urban and regional decision making, planning attempts to achieve consensus and to provide for the amenity, equity and efficiency of the people. Planning by its nature encompasses several disciplines, for example; economics, sociology, environment, law, transportation, engineering, architecture, landscape design and surveying. Planning is also closely interwoven with the political system and is sensitive to it. The planner needs to have a broad appreciation of these disciplines and probably needs to be a specialist in at least one of them. The planner needs to be a co-ordinator of a broad range of individual elements.

When asked the question "What is the purpose of planning?", the average planner will probably answer, "Planning is for people". Planning is therefore essentially anthropocentric. This should not, however, be seen by ecologists as anti-environment. Planners should take cognizance of environmental factors as part of their concern for people. However, they should not be expected to support any one of the components of a planning issue to the exclusion of others.

Planners generally adopt a systematic methodology in undertaking a planning study: (Figure 1).

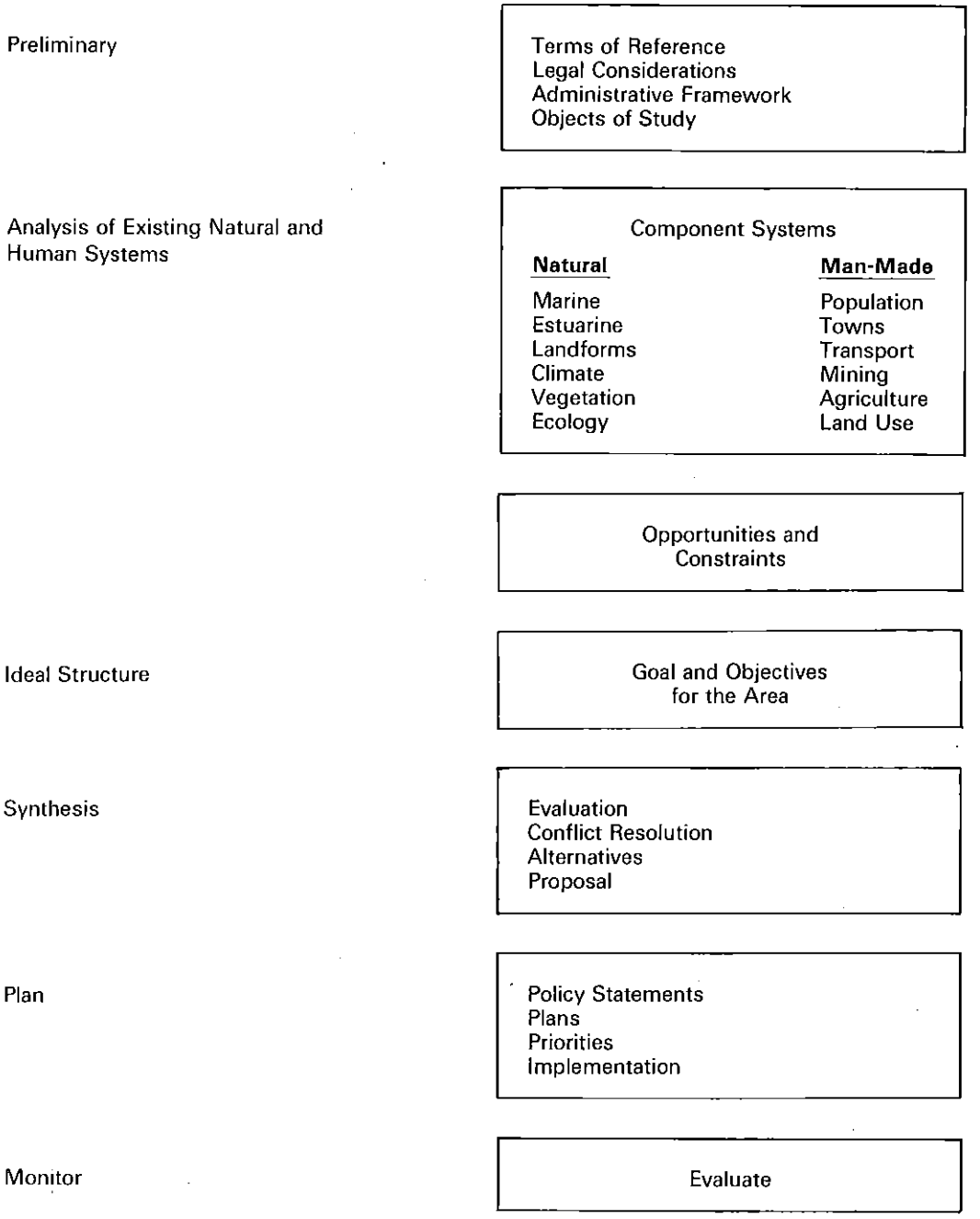

Figure 1 A Systematic Approach to Planning and Management

This methodology may vary according to the scale and scope of the plan but these elements are generally present.

To summarise therefore: urban and regional planning is concerned with the spatial structuring of human activities. Planning is anthropocentric in the broadest sense and should be seen as a means of balancing and integrating various elements rather than supporting any one element. Planners should not be seen as environmental advocates but as allies in advancing the environmental cause as an essential element in man's well-being.

LAND RESOURCE MANAGEMENT

As has been seen above, planning is oriented more towards "people" and providing for the social and economic needs of people. With the high growth in the numbers of people and the damage which people have done to land and resources, a new discipline of Land Resource Management has emerged. Land Resource Management has, as its focus, the good of the land and, as such, provides both a balance to the 'people' focus of planning and a complementary ally in the implementation of planning proposals.

Land resource management focusses in detail on individual environmental elements within an area. Management may be defined as, "the process of controlling an activity or system in order to maintain a desirable state or direction".[7] Hollick summarised the relationship between planning and management as follows:

> "Planning provides the objectives and control rules for management; while management provides the means by which plans can be implemented. Management processes also provide the information needed to form an image of the current situation in order to update the plan. Hence, planning without management is unlikely to be effective because of poor implementation; and management without planning would lack direction in a changing world".

It is for this reason that the Department of Conservation and Environment has adopted the joint planning and management approach to coastal management planning.

URBAN AND REGIONAL PLANNING IN WESTERN AUSTRALIA

Urban and regional planning in Western Australia started at the local scale and grew with development to the regional scale. Owing to the fact that the majority of the people in the State live in the Perth metropolitan region, it is understandable that a large proportion of time and resources have been concentrated in this region. Other plans have been prepared for developing areas as demand has required, for example, Bunbury, Geraldton and the Mandurah District. These may, however, be seen as plans for expanding urban areas rather than for a large region such as the Pilbara or the Kimberleys.

There is a need to produce an overall framework for regional planning in Western Australia and it is anticipated that this element will be expanded with the advent of the new State Planning Commission. The Report of the Committee of Inquiry into Statutory Planning in Western Australia[8] has proposed the formulation of a State Planning Strategy. This is an important step in the future development of the State as a whole. The Strategy would identify key issues of a State-wide concern, provide the basis for regionalisation of the State and examine issues such as population distribution and projection, economic factors and environmental characteristics. A State Planning Strategy should ideally be non-political but this, as with most activities, is difficult to achieve. A State Planning Strategy would provide planners with a synoptic approach which would assist in assigning priorities to regional planning rather than merely reacting to demands.

A world-wide problem which continually causes concern is the expansion of urban areas into productive agricultural land. This is occurring on a large scale in the Perth metropolitan region where residential subdivision has encroached into market gardening land, the valuable agricultural land in the Swan Valley and coastal wetlands. To a lesser extent this also occurs in the Avon Valley and at Margaret River. A recent policy has been prepared to direct urban development away from the Swan Valley but a comprehensive policy to induce development into land with less productive capacity has yet to be prepared.

Population data indicate that the Perth metropolitan area has continued to attract the majority of the population increase of the State. This may have both positive and negative effects on the physical environment. With initial growth, economies of scale offer many advantages. For example, infra-

structure and services are provided at one point and do not have to be duplicated at another. With continued growth, however, economic, environmental and many other thresholds are reached which require larger and larger financial inputs, resulting in diseconomies of scale. For example, with continued growth an existing dam may become insufficient to provide the new inhabitants with water, heavy costs are incurred in providing an additional dam. Similarly with roads, the existing system becomes inadequate at a certain level of use and freeways are suggested to remedy the problem, often at enormous environmental cost. Apart from the economic considerations there are also social costs to be considered. With continued growth of the metropolitan area the general quality of life for some people is bound to decrease.

In other parts of the world planners have in some cases added up all the pros and cons and decided that decentralization of population to smaller towns is a good alternative. This might be achieved by offering industrial incentives to entice development to locate in smaller cities or towns. The public cost of such incentives is high but can be justified if they reduce the high costs in the core city. This has not been done in Western Australia. The promotion of Bunbury might be seen as a political rather than a regional planning decision.

To summarise, urban and regional planning in Western Australia has tended to concentrate on local scale urban planning and metropolitan region planning. No State-wide planning has been attempted and a few broad-scale plans have been prepared for country areas. An examination of existing planning reports indicates that the level of environmental input into the planning system has been small.

ENVIRONMENTAL PLANNING

The World Conservation Strategy[9] proposed the integration of conservation and development through environmental planning. The WCS recommends a system of regional Ecosystem Evaluation (EE) as a means of ensuring that land use matches land suitability. Several different levels of evaluation are possible from broad synoptic ecological assessment through to detailed soil capability assessment. It is proposed that EE includes marine and freshwater areas.

Ecosystem evaluation contains the following elements:

- ecosystem suitability is assessed and classified with respect to specific kinds of use;
- a comparison of the outputs obtained and the inputs needed for each different use;
- an interdisciplinary approach is required, e.g., ecology, agriculture, forestry and fisheries;
- suitability refers to use on a sustained basis;
- comparison between existing and potential use.

The above, proactive approach requires complementary assessment of regional environmental effects. Environmental assessments are a means of ensuring that ecological and social information is included with physical and economic information as a basis for making decisions. Environmental assessments should be an integral part of the planning of all major actions and should examine alternatives to the proposed action.

One of the most significant contributions to closing the gap between planning and ecology has been provided by Ian McHarg, a planner and landscape architect who pioneered the ecological planning method. He criticised the planning of the day which imposed development on the landscape, regardless of consequences. He showed that man-made structures can be accommodated within the existing natural order.

McHarg's method was to utilize a series of suitability overlays, which, when superimposed, would provide the most suitable method for development.

At present, in Western Australia, an environmental impact assessment system is operative. The system is mainly 'reactive' to particular proposals. Regional environmental planning and environmental evaluation is almost non-existent in that alternatives are not considered. The recently established Terrestrial Ecology Branch in the Department of Conservation and Environment has approached the ecology of the State synoptically. A preliminary division of the State (at a macro scale) into major ecological regions, based on the closest fit of climatic, physiographic and floristic units to catchment divides has been completed[10] (Figure 2). It is worth noting that the ecological regions differ markedly

from the usual planning and statistical regions. It is intended to produce more detailed ecological studies at lesser scales which would fit in with the McHarg approach.

Regional and environmental planning is the key to linking environmental conservation with the planning process. By using sound environmental base-studies, urban and regional planners will have additional information on which to base decisions relating to the structural ordering of human activities. The present system of environmental impact assessment in Western Australia will help to keep up with developments but can never get ahead of the development process. Only through regional environmental planning based on ecosystem evaluation can this be achieved.

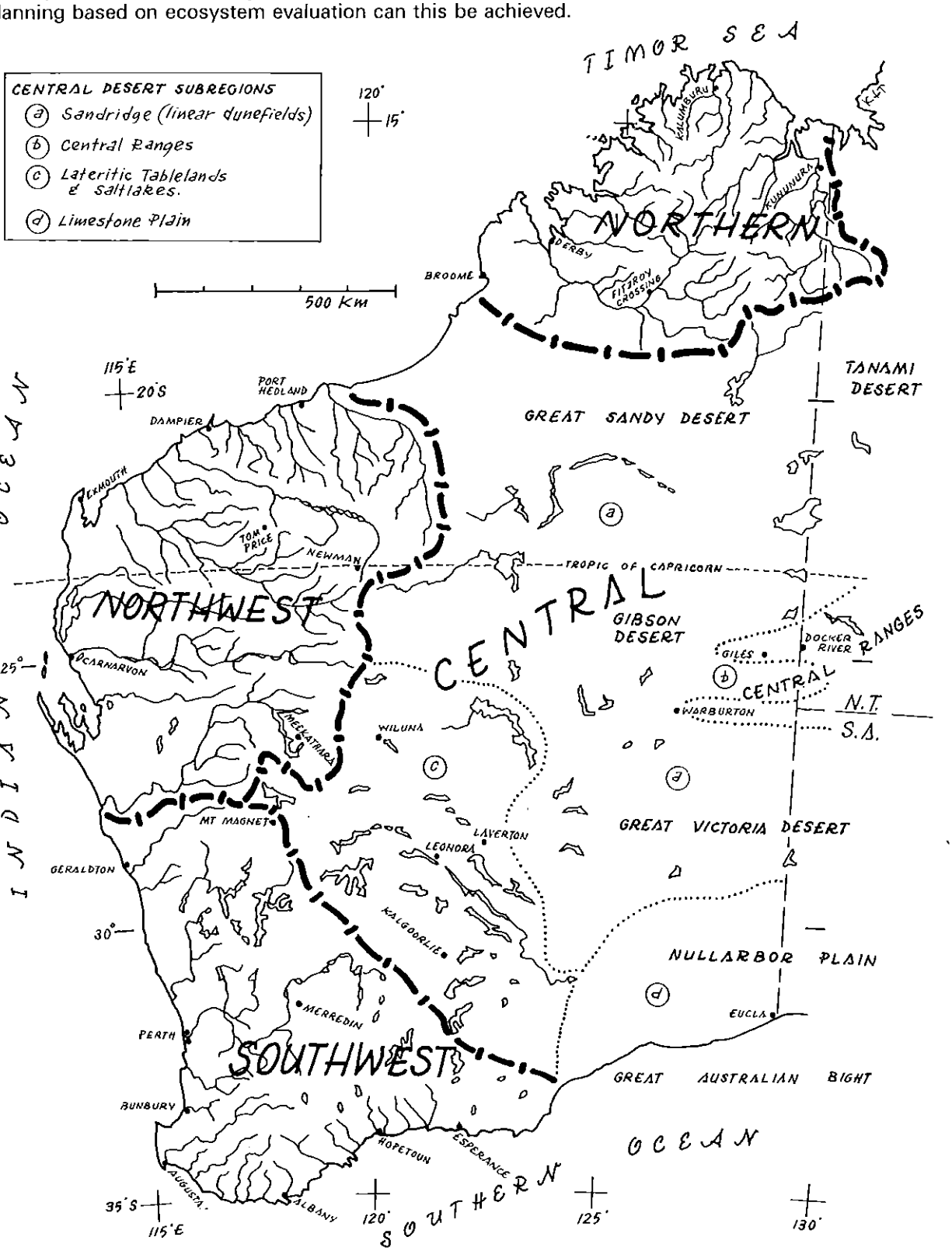

Figure 2 The major ecological regions of Western Australia (as identified by the closest fit of climate, physiography and vegetation to hydrologic divides). Source: K. Tinley.

RURAL LAND USE PROBLEMS

Western Australia has severe rural land use problems. The meeting held at Yanchep, Towards a Conservation Strategy for Western Australia,[11] considered a range of problems. The following were discussed:

- land becoming derelict through increasing soil salinity;
- soil degradation and erosion;
- eradication of noxious and alien plant species;
- the use and misuse of agricultural chemicals;
- overgrazing of pastoral land;
- the release of marginally productive agricultural land;
- vegetation degradation and deforestation.

At the Yanchep meeting, mechanisms were considered for dealing with the above problems. What is surprising is that the Environmental Protection Authority, Mining, Management and Planning organisations were cited as possible mechanisms for resolving the problems. With the exception of vegetation degradation and deforestation, which the Department of Conservation and Land Management should be dealing with, the remainder would seem to be agricultural issues. Should the Department of Agriculture not be taking a lead in these, which are essentially rangeland management and agricultural issues? Detailed land management issues such as those discussed above are not generally the concern of planning organisations.

The release of land for agriculture in marginal areas is another land use problem that needs attention. Banks and large business organisations tend to press agriculture into marginal areas, as a means of expanding business. As a result agriculture is spread into areas which are not ecologically suitable. This is an aspect which planners, environmental scientists and agricultural scientists could join forces on to solve problems.

Planning should be seen as a means of integrating the various environmental elements in rural areas. It can play a useful role in deciding on the priorities for land use in rural areas and in avoiding the develop-at-will approach.

URBAN LAND USE PROBLEMS

Urban land use problems in Western Australia have in the past focussed on the provision of housing and services to a rapidly growing population. When one considers that the entire built fabric of the State has been constructed in the past 156 years, it is obvious that a great number of urban land use problems have been solved over a relatively short space of time.

The impact of all the development on the environment has been enormous. The provision of building materials (clay for bricks and tiles, timber and limestone for cement) has resulted in forests being cleared, quarries being dug and radical changes being made to the landscape. Road construction, harbour building, draining of marshes and provision of a variety of services have all led to changes to the environment with the growth of the urban fabric.

With most of the urban development which has taken place, the wants of people have generally been put ahead of environmental considerations except when they might have adverse effects on people. Such a process is, once again, reactive and a system of regional environmental planning would ensure that urban development decision making is based on good environmental information.

STATUTORY PLANNING AND LAND CONSERVATION

Much of the discussion so far has been theoretical and general. It would be worthwhile, therefore, to examine some of the practical means by which planning can assist in achieving some of the aims of a conservation strategy.

Town Planning operates mainly through Statutory town Planning Schemes or zoning Schemes. These Schemes provide a framework which specifies those land uses which may or may not occur in any particular zone. Their limitation is that they are mainly a regulatory mechanism and do not go a step further and suggest how areas may develop.

A recent improvement to the Town PLanning Scheme process has been the incorporation of policy statements into a Scheme. Such policy statements provide the flexibility to include conservation and land resource management requirements but like all flexible mechanisms are open to varying interpretation and the vagaries of changing local government.

Town Planning Schemes are only compulsory for local government in the Perth metropolitan area. Many country shires have Schemes for their townsites but not for the remainder of the shire. In the non-zoned areas a system of Interim Development Orders (IDOs) operates which is often preferred by the local government as it provides them with more decision-making power. The main problem with IDOs, however, is that they lead to *ad hoc* decision making and planning without adequate base information.

Ideally, the whole State should be covered by a Town Planning Scheme or Zoning Scheme based on accurate land suitability studies of the natural environment. Clearly this would be an enormous task and economically unjustifiable. Resources could, however, be put into dealing with high priority areas and aiming for good coverage in the long term.

An alternative approach might be to prepare Statements of Planning Policy under Section 5AA of the Town Planning and Development Act (or its equivalent under the new Act).

By using such an approach particular problems might be tackled uniformly but this would still not obviate the need for an enormous volume of work.

Statutory backing of land management and conservation through a Town Planning Scheme is still not simple. Landowners consider that they have a right to subdivide and develop land as they want. A scheme that restricts a landowner or is seen to remove rights is likely to result in claims for compensation, and planning agencies generally try and steer clear of battling landowners. A scheme, however, that would assess potentials and provide a balance between restrictions and opportunities could solve many of the problems by providing incentives.

The present Western Australian statutory planning system does not readily lend itself to assisting the aims of land managers and conservationists. By modifying the system to place a greater emphasis on environmental base-line studies and by utilising land suitability studies and further refining the system of policy statements, Town Planning Schemes may become far more useful in the future.

CONCLUSION

At the beginning we asked how urban and regional planning can assist in achieving the aims of the State Conservation Strategy. In order to be able to answer this satisfactorily it was necessary to examine what urban and regional planning is and how it operates in Western Australia. Planning was seen to be essentially anthropocentric rather than ecocentric, but not to such an extent that the environment is cast aside. Man cannot afford to allow the ecosystems of which he is a small but influential part to run down.

Planning in Western Australia has tended to concentrate on urban planning. This is understandable in that the rate of development in the State has been rapid. The State is on the threshold of expanding its horizons by means of a State Planning Strategy and integrated regional planning. An examination of a range of planning reports, however, indicates that regional environmental issues have not been given a high priority in the past.

Land resource management, with its strong land conservation focus provides a balance to the "people" focus of planning and is a complementary ally in the implementation of planning proposals.

Environmental planning is seen to be the key to linking the planning process with environmental conservation.

Environmental impact assessment can assist in achieving the aims of the strategy for particular developments in a reactive manner, but it is always a few paces behind the process. Sound environmental base studies using both synoptic and detailed ecological evaluation of marine and terrestrial systems are essential in order to facilitate good quality planning which can ensure sustainable utilisation of species

and natural systems. Through this approach conservation and development can be integrated. Once this is achieved urban and regional planning will be able to make an important contribution to the aims of the State Conservation Strategy.

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CONSERVATION, DEVELOPMENT AND EMPLOYMENT

by ERNESTO SIROLLI

An Invited Review Paper as Background
for the Development of a
STATE CONSERVATION STRATEGY FOR WESTERN AUSTRALIA

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QUALITY PRODUCTS SATISFYING EMPLOYMENT AND CONSERVATION

Is there a way to conserve (natural resources), develop (an industry based upon them) and employ (lots of people) in the process? The answer is yes – but to do it we have to stop thinking exclusively of quantity productions and start thinking also of quality ones.

Quality productions are those in which human intervention adds so much value to the raw material that less (quantity) can reap more (profit).

We are surrounded by examples of such productions. Nearly every object or machinery or food item we use has some value added to it through a transformation of some sort. But has that value been added in Australia?

Are we transforming, i.e. adding enough value to our primary productions to guarantee that we are not, in fact, throwing them away?

As mentioned earlier, the best ice hockey boots in the world are made in Canada from Australian kangaroo hide.

The small southern blue-fin tuna taken off our south coast fetch 82c per kilo at local canneries. With good presentation for local sashimi consumption, the same fish could fetch four times this price. Well presented on the Tokyo market they could sell at $10-$15 per kilo, but there would, of course, be additional transport and handling costs. Larger prime southern blue-fin tuna are eagerly sought in Japan at prices reaching $45 per kilo.

Australia is now **importing** eucalyptus oil and Karri seed. The biggest international exporter of Kangaroo Paws (one of the hundreds of beautiful native plants of Western Australia) is Israel.

How many things could we produce here that are not produced now?

We could make much more money and better protect our environment by scientifically farming kangaroos and transforming their leather than by selling the two million untreated hides culled from the bush each year at present. Not only could we make more money, we could create hundreds of small factories and workshops specialising in products uniquely Australian.

We should discourage the export of raw materials uniquely Australian until our own workmanship has transformed them into quality productions. In doing so, we can conserve our resources if we increase their value.

The environment would not need to be depleted in an obsessive search for more and more to be sold at less to keep the country running. If a fraction of the gold, the iron ore, the wool, the timber of this country were transformed into processed products for export, we would not need to sell so much of our raw natural resources.

If we were to rely more on our own brains and our hands rather than on imported machinery and imported capital to create our wealth, we could create a sustainable economy where the conservation of the environment goes hand-in-hand with economic development and employment.

A LOW RESOURCE-CONSUMING ECONOMY

Why is an economy based on small-scale industries so much more sustainable?

First, it uses less resources and therefore has less impact on the environment, i.e. it is sustainable in a resource and conservation sense.

Second, it makes sustainable use of our manpower – which on present policies is becoming increasingly redundant.

Third, it is humanly sustainable as it builds on the greatest resource of all – human satisfaction.

What is the raw material of a writer? Of a musician? What natural resources are consumed by properly guided tourism? What is the raw material of education, communication, welfare, health?

INTRODUCTION

For those who, like me, come from countries with few natural resources the Australian economy seems very wasteful. Large quantities of food, wool, mineral ores, etc., are produced and exported in crude form, leaving many unemployed. There is massive over-use of natural resources, with insufficient return to the community.

Fantastic leather, wool and timber are sold untreated, as bulk products, often at prices which are determined by international agencies and set as low as possible.

Agricultural and mining products are fed into the waiting ships as quickly as possible with the least number of workers involved. The natural wealth of Australia is shipped out at the quickest and cheapest rate possible.

Little of our natural resource base seems to be treasured and utilised to its full potential.

The impacts of such development are obvious to those alert to soil erosion, salinisation, shrinking forests, degraded landscapes, etc. The lost employment opportunities are not so easily recognised by the average Australian, grown accustomed to this type of bulk export economy.

How many tens of thousands of people throughout the world are employed in transforming Australian wool into fabrics, garments, carpets, etc., of far greater value than our wool clip?

Few Australians know that the exclusive soft leather shoes purchased by them in Florence are in fact made of kangaroo hide bought untreated in bulk by Italian companies and in such quantities that make it very difficult to find any left in Australia.

Even fewer Australians know that kangaroo hide is the **best** leather for orthopaedic shoes and other quality goods such as riding, football and ice hockey boots. But Italians, Americans and Canadians know it and they employ large numbers of people in producing such items from Australian raw materials.

If we could research the wealth produced throughout the world by the manufacturing of Australian raw materials we would realise that we are holding the very short end of the stick. In fact in many university text books the Australian economy is equated often to developing countries' economy, i.e. to those countries like Zambia or Surinam which, even willing, would not have the know-how necessary to transform their raw materials, and instead have to export them.

RE-DISCOVERY OF CRAFTSMANSHIP

I do not believe that there is any necessity for 600 000 unemployed people in Australia. With the natural resources and the educational facilities available in this country, employment of all those wishing to work is not only possible but is within reach.

Many products now imported at inflated prices (and often made out of Australian materials) can be made here.

Prices, wages, unions are often blamed as causes for the inability of Australian products to compete on the national and international markets. The real cause, as I see it, is the lack of an understanding of the potential and intrinsic qualities of manufacturing and transforming industries *vis-a-vis* the more traditional primary productions. Nothing stops an individual in Australia to set up his or her manufacturing business. Nothing stops that person deciding how much he or she will take from the weekly earnings towards his or her wage. Nothing stops 100 000 or 600 000 people working for themselves using the natural riches and the training resources available in this country. In Italy 5 million people (9% of the population) are registered as holding an artisan licence. They work, in other words, in their own small, manufacturing and transforming business. How many do the same here? Education and encouragement for self-employment are urgently needed; these plus a new look at what we have here (which could be made into high value products) could transform Australia.

I'm not against mining or the export of wheat, I'm against the ingrained assumption that only mining and bulk agriculture are real economic and social cornerstones. I'm against bigness for bigness sake when the economic and social return of megaplants are absolutely disproportionate to their establishment costs. I'm against the huge exports of cheap, untreated products which leave the country bare, employing few workers, using foreign-built machinery, for limited returns which are often to be shared with foreign investors.

How many jobs do not consume any raw resources at all?

When the up-grading of raw materials occurs, the added value generated by human intervention is such that often low-cost materials are transformed into the most sophisticated and exquisite objects, ranging from violins to silicon chips. If the transformation of our natural resources is carried out in small-scale industries close to the supply of raw materials, this would foster decentralised, self-supporting communities, thereby improving the quality of life.

Time after time human ingenuity comes up with the useful, the sophisticated, the vital, the dangerous and the beautiful object. It is true that we change the environment around us, but it is also true that the changed environment changes us and this continuous dynamic interaction provides the ideas and the resources for the survival of the human species and our planet. These resources requirements are minimal from the earth.

A HUMANLY SUSTAINABLE ECONOMY

Our modern society, having developed from a needy one, seems unable to break away from an insatiable desire for more. Yet our physical **needs** can be met easily. Gandhi said that there is enough to feed everybody's hunger but not enough to feed everybody's greed!

The real problem is not **physical** but **psychological** hunger. A frustrated, unhappy, insecure individual can never be satiated. A nation of such individuals can use all of its natural wealth in a generation and still be looking for more.

The fact is that the majority of us are trying to solve an impossible mathematical equation. Do you remember your first class arithmetic? One apple plus one apple equals two apples? What we usually try to do is one apple plus one apple equals HAPPINESS! Of course we get frustrated – one house plus one house still equals two houses, not happiness. **Quality** of life has nothing to do with **quantity**.

To satisfy psychological hunger we need something which is psychologically nutritious. We need self-respect, security, self-esteem, companionship, freedom, belongingness and other such nutrients which **any** well done job can provide. To bake (well) a cake can be as psychologically nutritious as to perform (well) a cardiac by-pass.

If we could do what we really enjoyed doing, what would we do?

My guess is that we would take care of all the things that are there to be taken care of and that we would do it beautifully.

There is little empirical evidence to back me, but maybe you can help me by contributing your experience.

Have you ever met a happy person doing an awful job? I have. In fact, I have met happy garbage collectors, happy bank managers, happy fishermen and happy sky-diving instructors. To me all these jobs are awful: they are smelly, boring, wet and stomach turning. Yet for the happy people doing them they are just their "cup of tea".

Once I met two ladies who were folding, by hand, one million leaflets in the back room of their printing shop. I expressed my horror at their task and they said to me, "We love it – only our hands work, we chat, listen to the radio, invite friends to visit and we don't have to sell our brain for money," and then they asked, "What about you?".

The limit to what we want to do is our wildest dream. When I encourage people to start their small enterprises I often get criticised by people who call those enterprises Mickey Mouse projects. I love it because I can point out that in fact Mickey Mouse is a multi-million dollar business born out of an idea and made of the same stuff dreams are made of!

MAKING A START

Accountants will tell you that a small business, to be successful, has to follow the same rules as big business. They will mention cash flow, advertising, budgeting, etc., etc., and they will pinpoint the pitfalls of ill-founded ventures. What accountants don't usually say to you is that no matter how well prepared your business plan is, if you don't **passionately** feel for what you do then you will fail.

They usually also neglect to say to you that, if you passionately feel for what you do, no matter how ill prepared you may be at first, you are likely to succeed. You will succeed because you will work like a possessed person, never give up, learn quickly from your mistakes, and go, go, go for it.

The passionate person applies different rules from those mentioned by the accountant. Rules such as the following:

1. If you passionately want it and work for it, it will happen.

2. It will never happen exactly as you predicted because when you predicted it you were inexperienced and to work at it will change both you and your expectations.

3. Your enthusiasm will be contagious and other people will be attracted to you to share the excitement.

4. You will discover that your released energy is much higher than you ever thought possible.

5. You will work long hours for usually little money and love every minute of it.

In my experience other "strange" things happen to passionate people. Old aunties give them money, the town council gives them buildings to use free of charge, the news media makes a programme about them and friends lend them their cars and furniture without even being asked.

If you are in business for love you can even find yourself paid in love. How embarrassing then to tell your accountant, "No. I'm not making masses of money but I don't give a damn!".

CONCLUSION

To conserve the environment and develop a sustainable economy which provides abundant and meaningful jobs we have to make a quantum leap from quantity to quality productions. Australia's primary productions have to be complemented by an array of small manufacturing businesses based on the vision and ingenuity of its people in utilising local resources more fully. Such an approach based on quality products will lead to greater sustainability, greater employment, and greater satisfaction.

In my opinion many Australians understand this and many more would stop seeking a scarce and often ungratifying employment and would start doing their own things if encouraged to do so.

The natural resources of this country represent a unique and nearly untapped source of possible exciting productions.

In my job I constantly come across individuals who have the vision and often the skill to create a new product or to add value to an existing one.

In only the last year I have been associated with:

- Fishermen, willing to diversify their markets and develop sashimi techniques, fishing and marketing.

- A fish processor who has created a completely new product by smoking tuna fillets with Banksia cones.

- Farmers willing to try alternative agriculture on their marginal land by using native species.

- A number of individuals developing entirely new markets for Australian cut flowers, particularly wildflowers, that have not previously been grown productively.

- Manufacturers making outstanding products out of kangaroo and emu leather.

- Botanists creating a new perception of the Australian bush by analysing the chemical potential of native plants for commercial usage.

- A housewife who has perfected the technique of growing bonsai miniature Australian native trees.

The list could go on and include all those individuals who are slowly finding the courage to leave behind them the job they hate, to set up their own businesses.

If encouraged to take the first step, people can produce quality, rather than quantity, and create the basis for a sustainable economy in ecological terms and most importantly in human terms.