Plants and the Environment

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Preface

This thesis includes an account of my research, cross referenced to the list of publications which follows. A portfolio of publications selected from refereed papers and book chapters is provided.

I am pleased to acknowledge the postgraduate students and other co-authors of my publications. I especially acknowledge my wife Jen McComb for her support and collaboration. Granting bodies have been acknowledged in individual papers and listed in the curriculum vitae, presented as a separate document.

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A.J. McComb
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1. Account of Research

My research has been in two areas of Plant Physiology, the first concerned with the control of plant growth by internal factors, the second with control of plant growth by the aquatic environment. To understand how my research has evolved it is necessary to first describe discoveries published in papers derived from MSC and PhD research. These papers are clearly marked in the list of publications and are not included in the Portfolio.

At first I worked on the plant growth-regulating chemicals known as gibberellins. When I began my Masters degree in Melbourne the gibberellins had only just attracted attention in the western world, despite their discovery in 1927 by Japanese plant pathologists working in Taiwan. Because of their spectacular effects on intact plants, where they interact with plant genotype and environmental factors such as photoperiod, their occurrence and mechanism of action were of particular interest, and at the time poorly known. My work was among the first in Australia involving these compounds, and my first publication was in ‘Die Naturwissenschaften’, (the German equivalent of ‘Nature’), with my supervisor Denis Carr, and one of his other former students, Lynette Osborne. Our paper described how treatment of a rosette plant with gibberellic acid led to stem elongation, and subsequently (under long-day conditions), to flowering. Soon after that I published with Denis my first letter to ‘Nature’, providing evidence that gibberellin-like compounds occur naturally in higher plants.

Following the award of an Overseas Scholarship by the Royal Commission for the Exhibition of 1851, I continued research in the Botany School of the University of Cambridge, where I was able to synthesize C_{14}-labelled gibberellic acid by feeding the fungus which produces it with labelled acetate. I used the labelled gibberellic acid to examine its translocation and stability in higher plants. I also published on the possibility that gibberellin might become bound on protein as legume seeds mature, and that gibberellin has an effect on plant growth movement.

Work continued in this general area after my appointment to a lectureship in the Botany Department of the University of Western Australia, where with research students I explored the biochemical changes which follow arrival of the hormone in a target organ, the expanding pea internode; I found gibberellic acid to stimulate cell wall synthesis, then, with research students, that it stimulates protein synthesis, with an altered pattern of enzyme activity, then that it enhances RNA synthesis. Following this up at the Atomic Energy Commission Plant Research Laboratories of Michigan State University, my wife (Jen McComb) and I, together with American colleagues, found that the increased RNA was associated with an increase in RNA polymerase, without an increase in the amount of DNA template available for transcription. Also at Michigan we explored the possibility that the phenotypic control of growth rate in tall and dwarf strains of pea seedlings is graft transmissible. It is not.

Much of my work on the metabolic control of growth in pea seedlings was summarized in an invited review on growth regulation for a book on the physiology of the pea plant.
I also examined with students the occurrence of growth regulators in algae\(^{19,27}\), and the structural changes consequent upon treatment of the aquatic plant *Callitriche*\(^{22}\), which I had previously found to respond dramatically to gibberellin treatment\(^{16,30}\). (This was followed up by colleagues in the States, who found that ethylene mediates in the response.)

As an extension of my work on plant hormones, I became involved in plant tissue culture, introduced the relevant techniques to our Department, and spent a sabbatical in the laboratories of the late Professor Street at the University of Leicester, again working with my wife. We looked at the induction of haploidy in tobacco anthers\(^{45,49}\), and callus induction using phenoxy butyric acid analogues of the auxin indole acetic acid\(^{53}\). Another direction of my physiological interests was the design and use of growth cabinets to investigate the control of plant growth by environmental factors. The commercially-available cabinets were prohibitively expensive in the funding climate of the day, and so with a local refrigeration company, Arcus, I set about the design of a cheap but efficient cabinet which I described in a conference presentation\(^{168}\) and illustrated in a book chapter\(^{29}\). A number of such cabinets were constructed, and proved reliable in work at the University of Western Australia and Murdoch University.

Another program concerned the occurrence and function of plant resins. My interest in this area came about because colleagues in the Department of Organic Chemistry at the University of Western Australia had found that the resins of certain arid-zone plants contain chemicals so closely related to gibberellic acid that certain test plants respond to the resin compounds just as if they had been treated with gibberellin, to which they are converted by a simple biochemical process. It seemed logical to use resin synthesis in these plants to follow the synthetic pathways\(^{32}\). Bernie Dell and I worked on this, and the possible ecological significance of resins; after publishing in this area\(^{35,43,50}\) we were invited to review plant resins for an international journal\(^{51}\).

As my interests in plants and the environment expanded I became increasingly involved in ecological aspects of plant physiology. This was partly because of the intellectual challenges inherent in such work, partly because research students needed supervision in the increasingly important and well-funded ‘environmental’ area, and especially because the projects were logical extensions of my previous work. One program concerned the autecology of annual plants in semi-arid regions of Western Australia, my interest in these plants deriving from my earlier work on photoperiod and temperature control of flowering in rosette species. This program culminated in papers on the ecology of everlasting and other annuals in semi arid regions\(^{34,39,40,41}\), and my interest in rangelands was recently resurrected through supervision of a Professional Doctorate in Natural Resource Management (Tony Brandis) at Notre Dame University.

I became involved in two projects concerned with root growth. The first concerned the discovery by a research student, Byron Lamont, of the widespread occurrence of small root clusters by plants in the family Proteaceae, which he named "proteoid roots", the growth of which it turned out was stimulated by microbial activity in the soil\(^{53}\). Another project involved a PhD by Nick Malajcuk (with other supervisors) on the possible effects
of root microorganisms in helping protect against the disease "dieback" of *Eucalyptus*, caused by the fungus *Phytophthora cinnamomi*\(^{36,37,46,47,55}\).

This shift in my interest towards projects involving the environment coincided with the realisation that I did not have the facilities or staff necessary to sustain a major program on plant growth regulation, an area which, at an international level, was increasingly dominated by advanced organic chemistry on the one hand, and biochemical studies of gene action on the other. Besides, these were not areas into which I could attract senior undergraduate students in Botany to work with me; they wanted to work on the environment, and several excellent students asked me to supervise their work in this area, which came to dominate my interests. So even though I felt my contributions had helped lay the foundation for much that was going on in the field of hormonal control of plant development, and had led me to publish three notes in Nature and a suite of other publications, I made a conscious decision to discontinue my work on plant hormone research, and concentrate wholly on environment aspects of plant physiology.

An honours student, Bob Congdon, wished to work with me on wetlands, an area in which I had a long-standing interest. In Melbourne I did an undergraduate project on the Juncaceae (rushes), had taken an interest in the fenlands of Cambridge, and had published, with my wife, the first account of fen vegetation in Western Australia\(^{20}\), and as noted above I had used the aquatic *Callitriche* in work on plant hormones.

Bob Congdon and I examined eutrophication in an urban lake\(^{42}\), introducing a number of techniques to our laboratory for the analysis of nutrients in water. Bob proceeded to a PhD, working with me on the ecology of the Blackwood River Estuary, a project supported by the Department of Conservation and Environment (DCE). There had been a proposal to dredge for mineral sands in what was a relatively pristine area of considerable aesthetic and conservation interest. Our role in a wide-ranging study (coordinated by Dr Ernest Hodgkin of DCE, and including hydrology, fisheries, geology, and public attitudes), was to provide insight into the functioning of the main primary producers in the system. After preliminary survey, we concentrated on salt marsh and seagrass\(^{54,57,58,64}\). The work was of considerable scientific and management significance, and was important to me because it brought me into close contact with a number of persons who would become long-term collaborators, notably Jorg Imberger, Ernest Hodgkin and Bernard Bowen. It was also my introduction to working with teams of collaborators. In the event, the application for sand mining was withdrawn.

Because of developing collaboration with DCE, my laboratory was invited to support work on two major environmental problems, both involving aquatic systems. These included funding to carry out analyses of the different forms of phosphorus and nitrogen in water, and I was involved in planning and supervising major aspects of the two programs, in both of which we had research officers, students and technical staff working in our department, in close collaboration with staff of DCE.

The first of the two programs concerned Cockburn Sound, a marine embayment to the south of Perth, adjoining a recently-industrialized stretch of coastline. Seagrasses had
died back in the Sound\textsuperscript{69}, and subsequently phytoplankton blooms had become more prominent. My PhD student Marion Cambridge, and honours student Katie Silberstein, traced the demise of seagrass to enhanced growth of algal epiphytes on leaf surfaces\textsuperscript{72,80,85,110}. Another PhD student, Tony Chifffings, studied the distribution of nutrients and phytoplankton in the water of the Sound, establishing that the primary cause of nutrient enrichment was a fertilizer works, with a sewage outfall destined to become more important as the population of Perth increased\textsuperscript{63}.

These studies, which were part of a broader program of investigations coordinated by Dr Graham Chittleborough of DCE, were instrumental in the State Government deciding to expend some $M40 in re-routing treated sewage effluent to a more appropriate discharge site to the south, while industry responded by reducing levels of nutrient discharge into the Sound. These measures have led to improved water quality. Scientifically the work was significant in demonstrating a clear link between epiphyte growth and the suppression of seagrass photosynthesis, and is often quoted in the literature for this reason. For me, this work brought ongoing collaboration with a number of other scientists working on seagrasses, notably Tony Larkum and John Kuo, and led to a number of key publications in this area\textsuperscript{97}, including a major treatise on the biology of seagrass\textsuperscript{3}, and a recent significant review on patterns and stability in seagrass communities\textsuperscript{159}.

As the seagrass work on Cockburn sound was getting underway, Marion Cambridge found that the most prominent species of seagrass was undescribed. We enlisted the aid of John Kuo, at the time a post-doctoral fellow working in our department on plant anatomy and fine structure, a key anatomical feature of the undescribed taxon was found to be sinuous cell walls in the leaf epidermis, a feature readily discerned at low magnification. The new species was named in consequence \textit{Posidonia sinuosa} Cambridge et Kuo\textsuperscript{96}. This study laid the foundation for John’s subsequent career as an internationally-acclaimed expert in the taxonomy and anatomy of seagrasses, and I have continued my interaction with him in this area\textsuperscript{68,75,132,133,134}.

My interest in the Cockburn Sound area has continued through the company Cockburn Cement, which has been required to report on the impacts on seagrass of dredging for shellsand, (necessary for lime production), from banks to the north of the Sound. I became a member of the company’s Environmental Management Advisory Board. I have continued a significant interaction in this area with another staff member at Murdoch, former PhD student Dr Eric Paling\textsuperscript{116,117,139}, who works with his students on seagrass transplantation in the Cockburn Cement programs.

The second major program, which overlapped with the Cockburn Sound Study, addressed the Peel-Harvey estuarine system, which consists of two linked, shallow estuarine basins near the coastal resort of Mandurah, 70 km south of Perth. These basins showed evidence of intense eutrophication, with accumulations of macroalgae (especially in Peel Inlet) and extensive summer blooms of the blue-green ‘alga’ \textit{Nodularia} (especially in Harvey estuary)\textsuperscript{123,170}.
My role in this program was to supervise research students working on key projects helping to underpin the overall program, and to oversee the laboratory supporting field work and undertaking nutrient analyses. David Gordon worked on nutrients and macroalgae\textsuperscript{59,61,65,77,93}, Rod Lukatelic on nutrients, sediments and phytoplankton growth\textsuperscript{62,82,83,101}, and Paul Lavery on macroalgal decomposition and nutrient cycling\textsuperscript{105,106,107}. A Masters student, Tim McAuliffe, looked at the effect of nitrate addition in suppressing phosphate release from sediments\textsuperscript{135,137}.

The cause of eutrophication was established to be nutrients derived from the river systems draining sandy catchments used for agriculture\textsuperscript{70,73,74,75}. Collaborative work with staff from DCE, the Centre for Resource and Environmental Studies in Canberra (CRES), the WA Department of Agriculture, the Department of Soil Science and Plant Nutrition at the University of Western Australia, together with a follow-up study of management options by Bob Humphries and Chris Croft, which I directed jointly with Jorg Imberger, supported the conclusion that altered procedures for applying fertilizer to the land surface of the catchment would improve the estuary\textsuperscript{111,123,124}, but that a dramatic improvement in the short term could only be achieved by dredging a new opening to the ocean. The proposed opening, the Dawesville Channel, was constructed for some $M38 in 1994 after extensive environmental scrutiny, and led to an immediate improvement in water quality, in that there have been no further \textit{Nodularia} blooms in the Harvey, and a reduction in macroalgal biomass.

With the considerable activity involved in these programmes, my collaborators and I became involved in a number of other marine, estuarine and wetland projects\textsuperscript{81,86,88,91,100,103,113,139,163} - for example, on the productivity of seagrasses in the Swan/Canning Estuary\textsuperscript{125}, nutrient cycling, seagrass productivity and dugong grazing at Shark Bay\textsuperscript{79,89,90,94,102,146}, anchor damage of seagrass meadows near Rottnest Island\textsuperscript{59}, mangrove and coral ecology at the Dampier Archipelago\textsuperscript{98}, the water quality of Wilson Inlet\textsuperscript{87}, and the productivity of microphytobenthos\textsuperscript{145}.

Work in estuarine and nearshore marine areas inevitably involves extensive collaboration with research students, technical staff and persons in other disciplines, and I have been careful to direct work so that the contributions of individual research students can be disentangled from the complexities of a major study. I have seen my role as in planning and executing the work in such a way that fundamental processes are clearly conceptualised and critically investigated.

I have emphasised to my students and collaborators the way in which scientific validity is established by presentations at conferences, and especially by publishing results in the refereed scientific literature. The Cockburn Sound study provides a useful example. When loss of seagrass was becoming apparent, controversy surrounded the possibility that the loss might have been some sort of ‘natural phenomenon’ such as a change in plant succession, or even a disease such as that which wasted large areas of seagrass in Europe. Such interpretation was favoured by those who did not wish to see the loss attributed to industrial development and its consequence of eutrophication. As the work
became discussed at conferences, and (especially) published in the refereed literature, the role of eutrophication came to be accepted.

I wrote, with Rod Lukatetich, an invited chapter on estuaries in a book on Australian limnology, and was invited by a United States publisher (CRC Press), to edit a book on eutrophic estuaries and lagoons. My work on seagrasses has also had international recognition, for example by my becoming joint editor of a book on the biology of seagrasses, with particular reference to Australia, published in the Netherlands by Elsevier.

My interest in wetlands lead to the organization (with Professor W.D. Williams of Adelaide and Dr (now Professor) P.S. (Sam) Lake from Monash University) of a workshop in Sydney, sponsored by World Wildlife Fund (Australia), on the conservation of Australian wetlands. Sam and I edited and published the proceedings of the conference, and then published a general book on Australian wetlands. With A. Prof. Jenny Davis I also organised a major international conference on wetlands and published the Proceedings.

Since 1987 I have been involved in the establishment and management of the Capel Wetlands Centre. This lies in an area which has been subjected to mining for mineral sands, which left an undulating landscape in sandy soil, which intersected the water table. The company, then RGC Mineral Sands, (now Iluka Resources), was attracted by the concept of establishing a centre to carry out relevant research, and eventually establish a self-sustaining ecosystem which would support water bird populations and require little on-going financial input from the company. I became part of the company’s Capel wetlands management advisory committee, an honorary committee which recommends on the allocation funds for research projects and landscape modification. My relevant research activities have involved, with several collaborators, work on water quality, food webs, and establishment of wetland plants. I have again emphasised the importance of publication of management-orientated work as books, in the refereed scientific literature, as well as in technical reports.

More recently, I have supervised PhD projects on wetland modelling, the management of urban lakes, the effectiveness ecological impacts of mosquito control methods, and root mats in caves. And immediately before and after my retirement I have been involved, with former research student and now post-doctoral fellow Song Qiu, in studying effects of drying and re-wetting of wetland sediments, the role of microbial biomass in controlling transfer of nutrients from decomposing leaf litter to groundwater, and on to wetlands, and improving methods for disentangling the microbial contribution to soil nitrogen and phosphorus compartments.

Since my retirement I have been heavily involved in the additional area of organic waste management. I had helped draw up a successful proposal for a research centre in organic waste management, under the State Government’s ‘Centres of Research Excellence’ Scheme. I agreed to chair the Board of Management of the new Centre, and to be interim
director for the first year. Following the appointment of Dr Pratap Pullamannapallil as director I continued to chair board meetings. Pratap recently resigned to take up a more senior academic position at the University of Florida, and I resumed the directorship, a role I continue to fill.

Staff associated with the Centre are involved in research and consulting in areas such as municipal waste composting, land application of organic waste, anaerobic and aerobic digestion, and conflict resolution in the siting of waste facilities. I have inevitably become involved in the research and reporting, publishing with Pratap the proceedings of an international symposium on organic waste management we convened in Perth"'89, helping write reports"'29 and encouraging the publication of results in the scientific literature. As I see it, decomposition of organic matter follows underlying principles, whether it be algal or seagrass biomass, beach wrack, the sediment surface of a wetland or estuary, the gut of a cow or dugong, leaf litter in catchments, silage for agriculture, compost and garden mulch. There is much to be investigated and synthesised, and I look forward to an ongoing role.

Overview

My research has shifted from essentially academic research in plant physiology to much more applied research. This shift has been driven by a changing funding environment, the shifting interests of research students, my perceptions of areas which might offer employment opportunities for graduates, and the needs of providers of research funding. My career has throughout it has been driven by the scientific principles of carefully defining tasks, framing and testing hypotheses, and publishing results in the refereed scientific literature. It is a privilege to have enjoyed the excitement of making scientific discoveries, and of participating in work which has had practical outcomes and equipped students for their future careers.
2. Publications of Professor Arthur J. McComb

2-1 Books: 1-9

1. Pate, J.S. and McComb, A.J. (Eds.) *The Biology of Australian Plants*, The University of Western Australia Press, pp. 412, 1981.


2-2 Journal Papers, Book Chapters and invited book reviews: 10-164

*publications from MSc and PhD research


80. Cambridge, M.L., Chiffings, A.W., Brittan, C., Moore, L. and McComb, A.J. The loss of seagrass in Cockburn Sound, Western


91. Wrigley, T.J., Chambers, J.M. and McComb, A.J. Nutrient and
gilvin levels in waters of coastal-plain wetlands in an agricultural
area of Western Australia. *Aust. J. Mar. Freshw. Res.* **39**: 685-

Productivity and nutrient limitation. In: Larkum, A.W.D.,
McComb, A.J. and Shepherd, S.A. (Eds.) *Biology of Seagrasses*

93. Gordon, D.M. and McComb, A.J. Growth and production of the
green alga *Cladophora montagneana* in a eutrophic Australian
estuary and its interpretation using a computer program. *Water

distribution of macro-algal epiphytes on stems of the seagrass
*Ampelis antarctica* along a salinity gradient in Shark Bay,

95. McComb, A.J. Presidential Address 1988. After the first 200
years: The future of ecology and ecologists in Australia. *Aust. J.

96. Kuo, J. and McComb, A.J. Seagrass taxonomy, structure and
development. In: Larkum, A.W.D., McComb, A.J. and Shepherd,
S.A. (Eds.) *Biology of Seagrasses*. Elsevier/North Holland, pp. 6-

97. Shepherd, S.A., McComb, A.J., Bulthuis, D.A., Neverauskas, V.,
Steffensen, D.A. and West, R. In: Larkum, A.W.D., McComb,

98. Paling, E.I., McComb, A.J. and Pate, J.S. Nitrogen fixation
(acetylene reduction) in cyanobacterial mats from the Dampier

Effect of boat moorings on seagrass beds near Perth, Western

100. Zedler, J.B., Paling, E. and McComb, A.J. Differential responses
to salinity help explain the replacement of native *Juncus kraussii*
by *Typha orientalis* in Western Australian salt marshes. *Aust. J.


144. McComb, A. J., Qiu, S., Paling, E. I. and Hill, N. A. Sediment in Leschenault Inlet: a comparison with other estuaries in south-western


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**2-3 Reports, Theses and Published Conference Contributions: 165-231**


22.


183. McComb, A.J. Chairman's Introduction and Concluding Remarks. Benthic Microbes in Wetland Management. Proceedings of a seminar conducted by the Departments of Zoology and Microbiology of the University of Western Australia, June 25, 1986, Neville Stanley Field Station.


187. Walker, D.I., Lukatelich, R.J. and McComb, A.J. Impacts of Proposed Developments on the Benthic Marine Communities of


2-4 Statement on the contribution of the applicant to joint publications

Wherever possible I have published with others, to maximise the benefits accruing to more junior authors and, especially in work involving collaborative projects, to ensure all contributions to the work are acknowledged. It has been a pleasure to publish with a succession of research students with whom, if a publication draws on their work, they are of course first author. Taking up an opportunity to publish I regard as a key aspect of student research training, and I help in formulating what should be included in a paper, selecting the appropriate journal, correcting the draft manuscript, helping write the letter of transmittal, and addressing how to handle referee and editorial comments. When a student has left the university before a paper has been written, I have resorted to drafting the paper and seeing it through to publication. I have been flexible in publishing with my students or not according to circumstances relating to each individual and project. For example students coming into their PhD with considerable professional expertise have often published alone with my encouragement.

I am a joint author of 6 publications with my wife. Our first joint publication was an account of wetland vegetation, to which we contributed equally, and as explained in my cv, we carried out joint projects during periods of study leave in Michigan and Leicester, and these resulted in a number of joint publications, to which our contributions were equal.

Several of my books are co-authored: (as follows and referring to the numbers in the list of publications)-

1. The book I edited with John Pate was the proceedings of a conference, in which having run the conference, we collaborated equally in the tasks of chasing up the contributions from the authors, having them refereed, editing the final manuscripts, and interacting with the publisher.

2. This is the first of two books involving Professor PAS (Sam) Lake of Monash University. We ran a workshop in Sydney for WWF during their ‘Year of the Wetland’ with the aim of obtaining review statements from wetland scientists in each Australian State. This volume presents the edited results of the workshop. We both dealt with the manuscripts, with the final synthesis of the volume taking place in Perth, including most interaction with the publisher.

3. At the WWF Sydney conference, there was discussion about writing a general book on wetlands, drawing indirectly on the outcomes of the workshop. After the workshop proceedings were in press, Sam and I agreed to pursue this, and I was able to set this in train while on leave at what is now the University of Canberra, but most of the planning and drafting of the book took place in Perth. I drafted much of the general chapters and those on plants; Sam concentrated on things to do with animals and general limnology, and played a key role in sourcing archival photographs. Sam suggested I should be first author. I should add that writing this book collaboratively was a real pleasure, and especially creative away from the constraints of an edited, multi-authored volume.
4. The volume on the biology of seagrasses arose from a suggestion floated by Tony Larkum of the University of Sydney at a workshop on seagrasses, where he pointed out that there had been sufficient work on carried out in Australia for us to put together a book about these plants which would have international impact. Tony established contact with Elsevier, and the project went ahead, to be edited by Tony, me and Scoresby Shepherd from South Australia. We drew up a list of potential contributors, and each editor approached chosen authors, and edited and reviewed a suite of contributions. The editorial office was in Perth, where we did the detailed editing and brought the book into 'camera-ready' form and sent it to Elsevier. We agreed that Tony, who had set the book in train, be listed as first author.

5. The edited volume on eutrophication in estuaries arose directly from my work on eutrophication in the Peel/HarveySystem, and I edited this volume alone.

6. The work which led to this small practical guide to wetland plants was funded by MERIWA, and was put together by Jane Chambers and her assistant Natalie Fletcher. I played a minor role, attracting the grant and editing.

7. 8 9. These were all conference proceedings, and the order of the editors reflects their relative contributions