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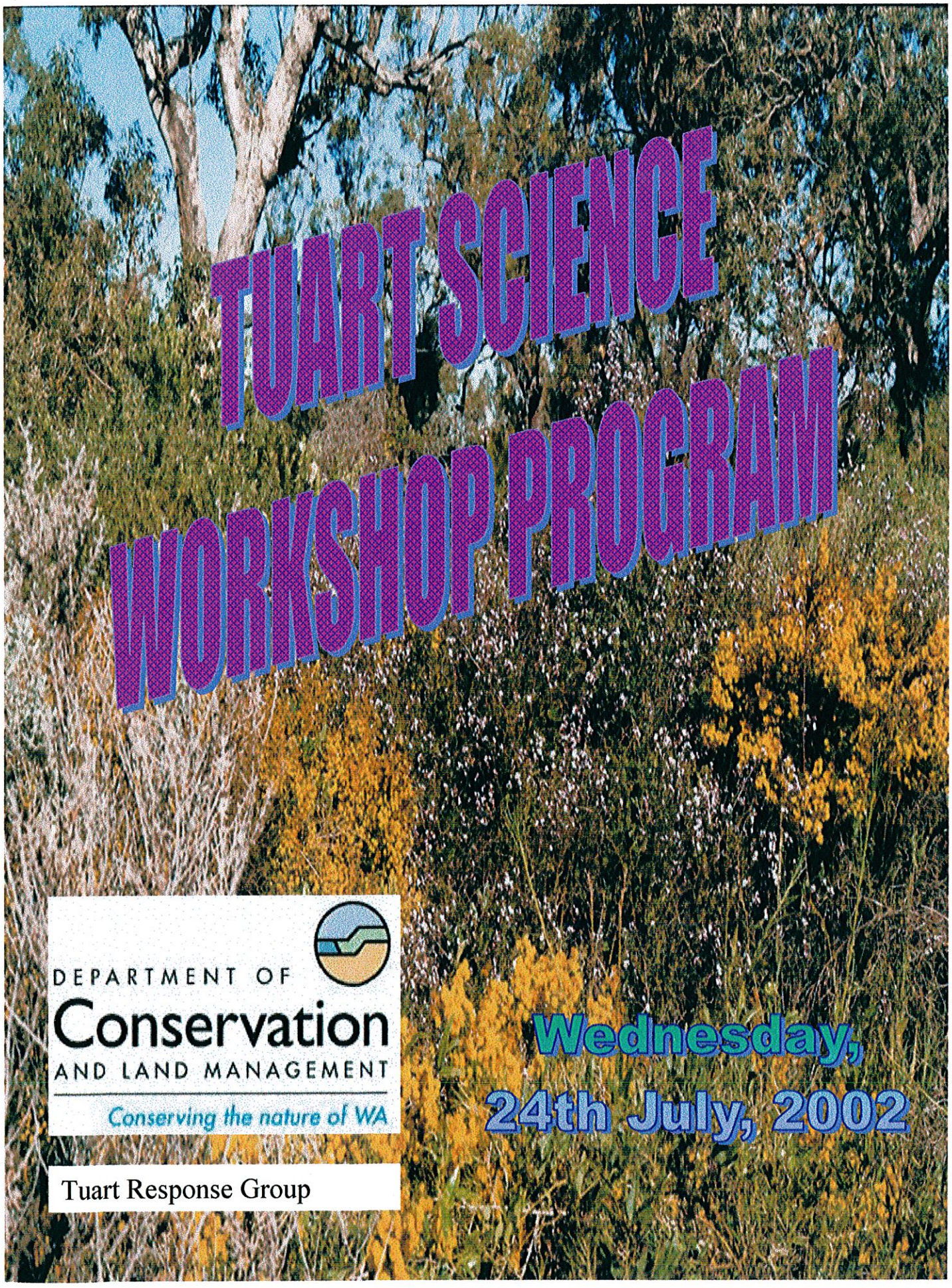

TUART SCIENCE WORKSHOP PROGRAM

DEPARTMENT OF
Conservation
AND LAND MANAGEMENT
Conserving the nature of WA

Wednesday, 24th July, 2002

Tuart Response Group

TUART SCIENCE WORKSHOP

MANAGING SUSTAINABLE TUART ECOSYSTEMS

Wednesday 24 July 2002
Technology Park Theatre, Bentley

PROGRAM AND SPEAKERS

Time	*Session*	*Presenter*
8:30 am	Registration, tea and coffee	
9:00 am	**Introduction and objectives**	Alan Walker
	Opening	Fran Logan, Parliamentary Secretary
9:30 am	**Session 1: Background** Chair: Tim Sparks	
	Tuart vegetation classification and conservation status	Angus Hopkins
	A model for vegetation health	Dr John McGrath
	Climate variability affecting woodlands	Brian Sadler
	The wandoo problem – introduction to a wider perspective in woodland conservation and protection	Roger Underwood
10:30 am	Morning tea	
11:00 am	**Session 2: Threats to tuart ecosystems - main candidates.** Chair: Professor Hans Lambers	
	Characterisation of tuart woodland hydrological support mechanisms and predisposition to decline.	Dr Ray Froend
	Groundwater, climate and human impacts	Philip Commander
	Altered fire regimes	Rick Sneeuwjagt; Dr Lachie McCaw
	Insects and fungi	Mike Stukely; Alan Wills
12:20 pm	Lunch	
13:20 pm	**Session 3: Future research directions – scientific research.** Chair: Alan Sands	
	Approaches in tree health research – water and nutrients	Dr Erik Veneklaas
	Future scientific research directions – pests and diseases	Dr Ian Abbott
	2003 Australian Research Council (tuart) Linkage Grants	Dr Giles Hardy
	Open forum	
14.40 pm	Afternoon tea	
15:00 pm	**Session 4: Future research directions – operational research** Chair: Dave Mitchell	
	Tuart regeneration and ecosystem maintenance	Bob Chandler
	Tuart rehabilitation after clearing	Assoc Professor David Jasper
	Tuart conservation and protection outside secured reserves	Charles Roche
	Open forum	
16:20 pm	**Key directions**	Dr John McGrath
16:45	**Close**	Alan Walker

Mr Alan Walker

Department of Conservation and Land Management

Introduction and Objectives

Mr Fran Logan

MLA

Opening

Session 1: Background

Chair: Mr Tim Sparks

Mr Angus Hopkins

Department of Premier and Cabinet

Tuart Vegetation Classification and Conservation Status

ANGUS HOPKINS

Angas Hopkins is a Principal Research Scientist with the Department of Conservation and Land Management. His major research interests are in the field of disturbance ecology (including fire and rehabilitation) and application of principles derived from these studies in the management of Western Australia's National Parks and Nature Reserves. Angas has recently compiled data on the vegetation of the State into a GIS database; this is now being used as a conservation planning tool, for example in identifying priority land for inclusion in the conservation reserves system. He has also mapped all the remnant vegetation of the State in collaboration with staff in the Department of Agriculture as part of a vegetation mapping project for the National Land and Water Resources Audit.

Angas is currently seconded to the Policy Office, Department of the Premier and Cabinet, where he has responsibility for overseeing implementation of the Governments Policy commitments on urban bushland conservation and an involvement in the preparation of the State Sustainability Strategy.

Tuart-dominated vegetation types in South Western Australia: existing mapping in the context of the national vegetation mapping program.

Angas Hopkins
CALM Science Division
WA Wildlife Research Centre
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Abstract

Tuart (*Eucalyptus gomphocephala*) is a structurally dominant component of vegetation types that extend from the Sabina River near Busselton northwards to near Jurien. At the scale of 1:250,000, six distinct vegetation associations have been mapped: their pre-European extent has been estimated and the present extent has been mapped from aerial photography. Each of these vegetation associations will be described structurally and floristically, and details of the extent and conservation status will be given. The map data have been compiled in accordance with a national protocol that will also be described.

More detailed mapping has defined a larger number of vegetation units associated with tuart, within specific areas. These projects will also be described. However, these large-scaled mapping projects do not cover the known extent of the tuart. Approaches to developing a complete and consistent map coverage will be suggested.

Dr John McGrath

Department of Conservation and Land Management

A Model for Vegetation Health

Profile - John McGrath

Currently I manage the Forests and Tree Crops Group within Science Division. The research carried out by scientists in this group covers the range from forest ecology through to work on plantation productivity

My own research (stretching back to 1977) has concentrated on understanding the nutrient and water requirements of tree crops and how these factors interact in determining the productivity and sustainability of commercial tree species in south-west W.A.

This work has involved investigations of the nutrient requirements of the trees growing on the inherently infertile soils of Western Australia. As well the interaction of nutrient uptake and nutrient cycling within trees with the annual cycle of water availability in the very seasonal Mediterranean climate of south-west W.A has been studied.

A Vegetation System Health Model

John McGrath

Department of Conservation and Land Management,
Technology Park-Western Precinct, 17 Dick Perry Avenue Kensington WA 6151

A decline in the health and vitality of the dominant tree species in two of the main Western Australian woodland ecosystems has been observed over the last two decades. The decline in Wandoo has been observed since the early 1980s while the severe decline in the Tuart woodland has occurred more recently. Tree decline is often the result of a number of interacting abiotic and biotic factors.

The multiplicity of factors which cause tree decline and death fall into three categories (Manion 1981)
Predisposing factors are defined as long term factors such as climate, soil and landscape factors (nutrient supply, soil depth, and position in the landscape). These factors weaken trees growing in inappropriate locations or in situations where there is a change in these factors, such as a long-term reduction in rainfall.
Inciting factors are short-term factors such as drought, frost and insect defoliation, which produce a sudden injury from which trees have difficulty recovering.
Contributing factors are long term factors such as bark beetles; canker and root rot fungi that are able to invade weakened host trees. They are often very conspicuous but are best regarded as indicators of severely stressed or dying trees.

The major abiotic factors that determine the distribution and vitality of trees in the Mediterranean ecosystems of southwest WA are water and nutrient supply. However, salinity, changed fire regimes, and biotic factors such as fungal pathogens and insects are also influential in determining the health of forests and woodlands. A simple model of the processes involved in tree growth has been modified to identify the factors that may influence the health and vigour of trees in woodland ecosystems

Manion, P.D. (1981) Tree Disease Concepts, Prentice-Hall Inc., New Jersey.

Mr Brian Sadler

Indian Ocean Climate Initiative

Climate Variability Affecting Woodlands

Vita: Brian Sadler PSM FTSE

An engineer by professional education, and a Fellow of the Academy of Technological Sciences and Engineering, Brian has 40 years of experience in water resources management and planning.

Most of his career has been in service of the State Government from which he was also very active nationally and internationally in water resources science, planning and public process.

Before leaving State service, Brian was Executive Director, Water Resources in the former Water Authority of WA where he was responsible for water resources assessment, management and planning, throughout Western Australia.

In semi-retirement Brian has continued to contribute professionally as a consultant in water policy.

He has been a very active Chairman of the Western Australian Government's Indian Ocean Climate Initiative Panel since it was formed in January 1998.

IOCI is about developing and communicating scientific knowledge to assist future decision-making affected by climate variability and change in our region.

In that position Brian stresses that his role is as a *user and interpreter* of climatology in decision-making - and not as a professional climatologist or research scientist.

Climate variability affecting woodlands

Brian Sadler FTSE
Chairman Indian Ocean Climate Initiative
brian.sadler@bigpond.com

Recent research of climate variability in the South-West region shows that non-stationary and non-linear variation of climate are likely to prove significant factors in the past evolution and the future sustainability of regional woodlands.

Internationally the evidence on climate change, assembled through the IPCC, has confirmed that the enhanced greenhouse effect has dominated natural trends in global temperatures of the last century. In the first nine centuries of the previous millennium, global temperatures were not stationary but exhibited a gradual and natural decline. However, over the last century, this trend abruptly reversed into a phase of comparatively rapid warming. These global trends are manifest in observed Australian climate variation.

IPCC investigation also predicts that future climate will not be stationary but will follow trends progressively dominated by the enhanced greenhouse effect. Associated warming is expected to continue throughout the present century, at rates unprecedented in recent millennia, regardless of how effectively greenhouse emissions are controlled. International and national modelling have also established a strong expectation for future rainfall decline in the South-West associated with the global warming.

In the last quarter century this region has experienced a significant decrease in winter rainfall. Research associated with the Indian Ocean Climate Initiative, shows the decrease to have been a step change to an alternative and drier climate regime which is associated with switching in large scale atmospheric circulation. This regime is characterised by reduced early winter rains, less rain days, less rain on extreme days and a virtual absence of the "wet" winters that were a characteristic of natural climate variability in the previous half century. This non-linear behaviour is significant. It makes sustained runs more probable than they would be under purely random variability although research suggests that the current sustained drought is, nevertheless, unusual in its severity. Such non-random "wet" and "dry" runs may have been a natural expectation in past climate and part of the evolutionary history of regional woodlands.

From current research it is judged as most likely that natural variability and the enhanced greenhouse effect have both contributed to the current "dry" run.

Although such "dry" runs may have occurred naturally in the evolution of the South-West woodlands, the future expectations of regional climate variability and change point to more frequent and sustained occurrence of such stress conditions. These will be associated with a dry rainfall regime and warmer conditions which exacerbate the stress caused by rainfall decline.

IOCI (2001): *Second Research Report - Towards Understanding Climate Variability in south western Australia.* Indian Ocean Climate Initiative Panel, c/- Dept Environment, Water and Catchment Protection, East Perth Western Australia.

Nicholls N et al (In Publication): *Climate variability and change in Southwestern Australia.* Indian Ocean Climate Initiative Panel, c/- Dept Environment, Water and Catchment Protection, East Perth Western Australia.

CSIRO (2001): *Climate Change Projections for Australia.* CSIRO Atmospheric Research, Aspendale Victoria

IPCC (2001b): *Climate Change 2001: The Scientific Basis - Summary for Policymakers and Technical Summary of the Working Group I Report.* Intergovernmental Panel on Climate Change. *www.unep.ch/ipcc*

Mr Roger Underwood

York LCDC

The Wandoo Problem – Introduction to a Wider Perspective in Woodland Conservation and Protection

"Roger Underwood is a West Australian forester with many years experience in
forest management and conservation. He has known and worked in the wandoo
forest since 1963. He is currently working as a consultant, focusing on dryland forestry and environmental management. At this workshop he is representing the York LCDC."

Abstract

The wandoo problem – a wider perspective on woodland decline in WA

Wandoo is currently experiencing tree decline and death similar to tuart. The syndrome is very widespread and completely unexplained. First noticed in the mid-to-late 1980s, it intensified in the mid-1990s, and now occurs almost throughout the distribution of the species. Wandoo and powderbark wandoo are both affected. Trees decline from apparently unaffected to dead over a period of 3-5 years, as the crown recedes and dying epicormic shoots are not replaced. Trees on crown land and on farms, on uplands and lowlands and on clay, lateritic or sandy soils are all equally affected.

The problem is well advanced in the Talbot State forest in the Helena Catchment and on farms west of York, Beverley and Brookton. A concerned local group, the York LCDC has convened a public field day and workshop and prepared an Action Plan, now endorsed by the Minister. CALM has initiated preliminary monitoring, survey and analysis, and research projects are being considered. Otherwise, there is no money being applied to the issue, and as yet there is no coordinated scientific/government/community response.

Uncontrolled observation suggests that the syndrome is extending eastwards. The first signs are being seen in other woodland species, notably salmon gum, York gum and flooded gum. If it develops in these species (but even if it doesn't), there will be a dramatic impact on salinity, biodiversity and landscape values over the eastern parts of metropolitan catchments and farmland and road reserves in the western wheatbelt during the next few years.

The tuart problem therefore needs to be seen as part of a much wider problem. Future research and the management response for tuart should be designed bearing this in mind.

By Roger Underwood
York Land Conservation District Committee, York WA 6302

Session 2: Threats to Tuart Ecosystems – main candidates

Chair: Professor Hans Lambers

Dr Ray Froend

Edith Cowan University – School of Natural Sciences

Characterisation of Tuart Woodland Hydrological Support Mechanisms and Predisposition to Decline

Biographical sketch of Ray Froend

Ray Froend is a Senior Lecturer in Environmental Management, Edith Cowan University, Western Australia, and Director of the University's Centre for Ecosystem Management. He has conducted research on impacts on terrestrial and wetland vegetation over the last 19 years and currently leads a research group at ECU which specialises in plant ecology and water requirements. He currently serves on several state and national technical advisory committees providing expertise in the field of ecological water requirements.

Characterisation of Tuart Woodland Hydrological Support Mechanisms and Predisposition to Decline.

Dr Ray Froend
Centre for Ecosystem Management
Edith Cowan University, Joondalup WA 6027
r.froend@ecu.edu.au

The decline in rainfall in the southwest of Western Australia during the last 20 years and site-specific changes to hydrological conditions due to neighbouring land uses, may be the most significant (widespread) abiotic causes of (precursor to) Tuart decline. Emphasis needs to be placed on determining whether the onset of water stress in Tuart is the sole (major) stress agent and/or a precursor to biotic causes of decline. Previous studies on the water stress related decline of Banksia woodlands in the southwest of WA (Zencich *et. al.* 2002) have shown alteration of the hydrologic supply mechanism through separation from the water table and increased dependence on meteoric water as the major alteration to Banksia habitat. Hydrologic supply mechanisms are also spatially and temporally variable due to differences in soil stratigraphy and seasonal change in water availability. Differences and changes in water supply mechanisms are a possible cause of variability in Tuart vigour and predisposition to pests and diseases.

Contrasts between the plant water status and hydrologic supply mechanisms of healthy and declining populations of Tuart will allow the identification (quantification) of their water requirements. These requirements can then be considered in water allocation planning of catchments (both surface and groundwater) that contain Tuart to minimise (where possible) hydrologic conditions that induce water stress and predisposition to tree decline.

Zencich SJ, Froend RH , Turner JV, Gailitis V (2002) Influence of groundwater depth on the seasonal sources of water accessed by Banksia tree species on a shallow, sandy coastal aquifer. Oecologia 131: 8-19.

Mr Philip Commander

Water and Rivers Commission

Groundwater, Climate and Human Impacts

Philip Commander is currently Supervising Hydrogeologist with the Water and Rivers Commission, now amalamating into the Department of Environment, Water and Catchment Protection. Philip has spent the better part of his thirty-odd years as a hydrogeologist with the State Government working on aspects of groundwater in the Perth Basin. In the late 1970s he carried out the groundwater investigation of the Yalgorup coastal lakes which found that the lakes were underlain by hypersaline groundwater. Recently, he has become involved in the definition of groundwater dependent ecosystems in the Perth Basin, and is currently rolling up the results of forty years hydrogeological work in the Perth Basin into one publication.

Groundwater, climate and human impacts in areas of Tuart decline

Philip Commander
Supervising Hydrogeologist,
Department of Environment, Water and Catchment Protection

Tuart distribution on the Swan Coastal Plain coincides with the soils of the Spearwood Dune system, developed on Tamala Limestone. Groundwater flow on the coastal plain is westward, with the watertable sloping westward below the Tamala Limestone, in places 60m below the surface.

The core area of Tuart decline in the Yalgorup area, west of Lake Clifton, lies within the Yalgorup Lakes groundwater flow system, which is a groundwater sink. Rainfall on the groundwater catchment of the lakes eventually discharges into the lakes and is evaporated, leaving behind the contained salts. Over the last few thousand years the salts have concentrated, resulting in the groundwater below the lakes having a salinity twice that of sea water. In this area, there is a layer of fresh groundwater overlying the hypersaline groundwater.

The last thirty years has been a period of below average rainfall, and in the absence of other factors, water tables have fallen as a result. In the Yalgorup area, these changes are likely to be comparatively small, as water levels in the Tamala Limestone do not fluctuate as much as in the Bassendean Sand, and the water table is also regulated by sea level and lake level.

Particularly low rainfall in 1993/4 seems to have resulted in the water level in Lake Clifton dropping below sea level, and for the salinity to jump from around 15 g/L to around 25 g/L, presumably due to ingress of the underlying hypersaline groundwater. Since this is the time that Tuart decline was first noticed, the question arises as to whether the trees were merely responding to lower soil moisture, or whether changes in the groundwater system could also have played a part. Subsequent spread of tuart decline to areas where the water table is deep suggest groundwater conditions not to be a factor. The initial area of decline is also hydraulically separate from groundwater abstraction, which is located east of the lakes.

Mr Rick Sneeuwjagt
And
Dr Lachie McCaw

Department of Conservation and Land Management

Altered Fire Regimes

RICK SNEEUWJAGT

Rick Sneeuwjagt is the Manager of Fire Management Services for the Department. He has been leading the fire section since 1989. Rick began his career in 1969 with the Forests Department. He studied fire behaviour in karri forests and pine plantations in his capacity as Fire Research Scientist, and is responsible for the development of the forest fire behaviour prediction system in 1976 which is still in use today.

Rick Sneeuwjagt has 36 years experience in a broad range of fire management and land management roles, and his expertise is recognized at national and international levels through the involvement in National fire authorities, and with FAO and United Nations Environmental Program (UNEP). He has strongly supported research studies undertaken by CALM scientist David Ward on the fire history reconstruction of tuart forests and other southwest ecosystem using fire scars on Grasstrees (Xanthorrhoea spp.).

LACHLAN McCAW

Academic Record

1979 Bachelor of Forest Science (Hons.), University of Melbourne
1997 PhD, Department of Mathematics, University of New South Wales

Professional achievements

Dr Lachlan McCaw has 21 years experience as a Research Scientist working on applied land management issues in Western Australia, and has acknowledged expertise in bushfire science and the implementation of ecologically sustainable forest management. This expertise is recognized at the national level through publication of scientific papers and review articles in national and international journals, chairmanship of a national working group, presentation of invited papers at workshops and seminars, and by representing the Department at national forums held to review research priorities and decide on future directions. He also regularly reviews scientific manuscripts for national and international journals.

IMPACTS OF ALTERED FIRE REGIME ON HEALTH AND MANAGEMENT OF TUART FORESTS

Abstract

Dr Lachlan McCaw, Science Division CALM and Rick Sneeuwjagt, Fire Management Services, CALM

Fire histories reconstructed from Grasstree fire scars for Tuart forests have confirmed historical and anecdotal evidence that aboriginal burning practices maintained the open grassy tuart savannahs prior to European Settlement in the 1800's. The fire regimes were characterised by very frequent, patchy fires that were short enough to kill emerging woody seedlings, and mild enough not to stimulate germination of deeply buried seed, whilst encouraging regeneration of grasses. The frequent burning was maintained to a variable degree by European grazing leases until upto 1960's when the Yalgorup National Park was declared.

The change in fire regimes has resulted in the replacement of the Tuart savannahs to one that is dominated by more or less dense understorey of peppermint and/or banksias, and a lack of tuart regeneration. This change appears to have begun to occur since the 1850's, which coincided with the demise of the Aboriginal traditional burning. Since 1960, substantial parts of Yalgorup National Park have not been burnt for 20 to 40 years.

The increase in density of peppermint understorey may have resulted either as a reduction in frequent, low intensity fires, leading to a period of irregular and severe fires in some areas. These wildfires would have promoted woody understorey thickets. The exclusion of fire will also result in establishment and further development of peppermint seedlings and rootstock.

The dense woody understorey impacts on tuart overstorey through increased competition for moisture and nutrient, thereby affecting the vigour and health of the standing trees, and preventing establishment of tuart seedlings.

Fire Management and understorey treatment options for the maintenance of tuart are discussed. These include the mechanical removal of peppermint and the regeneration of tuart seedlings without significant disturbance of standing tuart trees. Future fire management options may depend on whether to maintain a tuart savannah or to allow the woody understorey to re-establish to present condition.

There is a need for urgent decision-making and action because recent severe insect attack is seriously limiting the opportunities for successful re-establishment and maintenance of a healthy tuart ecosystem.

Mr Mike Stukely
And
Mr Allan Wills

Department of Conservation and Land Management

Insects and Fungi

Mike Stukely holds a Bachelor of Science (Agriculture) degree with Honours, from The University of Western Australia. He has worked in forest research since 1977 with the Forests Department of WA and then with the Department of Conservation and Land Management. Major pathology-related projects have included an investigation of mortalities of *Pinus radiata* (caused by *Phytophthora cinnamomi*); the demonstration of genetic resistance of *P.radiata* to *P.cinnamomi* and selection for this trait (with Mr T.Butcher, now of FPC); the demonstration of genetic resistance of jarrah to *P.cinnamomi*, and then a selection program, leading to the current establishment of seed orchards for the production of dieback-resistant jarrah for use in rehabilitation plantings.

Mike has been monitoring Mundulla Yellows disease in eucalypts in the south-west since 2000, and has been Manager of CALM's Vegetation Health Service at Kensington since July 2001.

The role of pathogens in the decline of tuart

Mike Stukely

Abstract

Plant pathogens can belong to any of a range of diverse and large groups – fungi, bacteria, nematodes, viruses, viroids, or phytoplasmas. There is a limited amount of information available on the pathology of tuart, and only fungi have received much attention. Fungi may directly attack either tree roots, stems, branches and twigs, foliage or reproductive organs.

Canker fungi are known to be present in tuart, and can significantly affect some trees. But cankers in trees are very common – these fungi are normally present in healthy forests and do not often cause great or lasting damage. Similarly, wood rot fungi are present in tuart, and these can significantly weaken some trees; these, too, are common in healthy forest. *Phytophthora cinnamomi* is not considered to be a problem, as tuart has a relatively high resistance to it; moreover, tuart grows on low-impact sites for *Phytophthora* (Spearwood sands and related systems). Some amenity plantings of tuart have shown damage from *Armillaria*, but tuart is generally more resistant to this pathogen than jarrah or wandoo. It is unlikely that some "new" pathogen alone is responsible for the decline – but the potential for the newly-described Mundulla Yellows disease to affect tuart needs to be examined further.

A large amount of time could be spent on well-meaning studies of populations of the countless species of micro-organisms that inhabit tuart trees, and examining the damage that they might cause under various conditions. But this in itself probably would not bring us much closer to solving the tuart decline problem.

Where trees are showing a Decline syndrome, as in the case of tuart, it is unlikely that a primary pathogen or pest is the sole cause (although one or more pathogens may be involved). In these situations generally, tree vigour is reduced over time by some external stress; trees' defences are consequently lowered and they become predisposed to attack by various opportunistic organisms that will quickly exploit any advantage. In some cases, the underlying problem may abate naturally, and trees can then recover without the need for management intervention. Cycles of decline and recovery may thus occur over time.

Complex interactions of environmental and biotic factors result in tree declines. The "Disease Triangle" illustrates this dynamic interdependence of factors. Perturbations in the balance of this triangle may lead to predisposition of trees to attack, and to increased disease. There is a need for investigation into the effects on tree vigour and health that result from interactions between frequently encountered pathogens and pests, environmental factors such as water availability and nutrition, and the application of different management treatments. It is necessary first to determine which factors are relevant and are contributing to decline, and which of these, if any, can be manipulated. If the underlying cause(s) of tree stress can be identified and addressed early enough, affected trees may be helped to recover and possibly others can avoid exposure to these factors following management treatments.

The need for this work is especially pressing in the case of tuart, as it is a relict species now surviving generally on marginal sites. With increasing urban development and land-use changes in its environment, tuart is likely to become increasingly vulnerable. Predicted climate changes in coming decades will superimpose additional stresses that may favour disease development. Furthermore, with regeneration from seed now often low or non-existent, the remaining tuart stands will become increasingly senescent, less able to adapt to imposed stresses, and more susceptible to attack by pathogens and pests.

Allan Wills: Technical Officer Department of Conservation and Land Management

Graduate of the University of Western Australia with Honors in Botany in 1985. Worked 1987-1992 as a Technical Office with CALM on silviculture of *Pinus radiata*. Worked 1992 to present as technical officer on forest entomology. Have published papers on interaction between fire and Jarrah leafminer insect as well as, canopy arthropods of Tasmanian bluegums, jarrah and marri. Am currently working on ground invertebrate faunas of the Jarrah forest.

Insects and Tuart health.

Abstract

A convenient method of defining Tuart ecosystem health is to use the health of Tuart as an indicator of ecosystem health. While this is perhaps a narrow indicator, it allows discussion of insects as threats to Tuart health in the context of broader models of ecosystem functioning.

While many species inflict damage on Tuart, few insect species could be considered as direct threats to Tuart health. These species include: Tuart Bud Weevil *Haplonyx tibialis*, which damages flower buds and poses a potential threat to canopy seed pools; pasture derived leaf feeders which damage young Tuart in early regeneration or afforestation plantings; and stem girdling wood and cambium feeders.

Tuart leaf area can be considered as an equilibrium between leaf area production and leaf area loss. During Tuart decline new leaf production diminishes and defoliating processes become important. The characteristics of Cerambycid stem borers can result in a contribution by this group of insects to defoliation.

The difficulties of separating damaging insects from those which threaten Tuart health is explored by detailing the principle wood/cambium feeders found at Yalgorup during the Tuart decline event.

P. acanthocerus. Borer of large stems and tree trunks. Rarely cases defoliation. Symptoms of stem boring more visible in stressed trees?
Bimia bicolor. A rarely collected branch borer common at Yalgorup. Characteristic species of mature tuarts?
P impavida. Borer of saplings and branches. Probably contributes to net leaf area loss in when new leaf production rate is slow.
P. semipunctata. Stress opportunist: preferentially attacks stressed and felled Eucalyptus spp. Variation in both susceptibility and attractiveness of stressed hosts. Little evidence of mass attack by *P. semipunctata* at Yalgorup.

The abundance or absence of symptoms of some of these species may provide indications of the state of Tuart health at in other Tuart stands.

Session 3: Future Research Directions – Scientific Research

Chair: Mr Alan Sands

Dr Erik Veneklaas

University of Western Australia

Approaches in Tree Health Research

Erik Veneklaas

PhD Utrecht University, the Netherlands, 1990, tropical ecology (water and
nutrients in tropical forest)

Projects since 1990 include:
Plant water relations
Woody plant growth
Diversity and functioning of tropical ecosystems
Banksia woodland ecophysiology
Root exudates and phosphorus uptake

Worked in the Netherlands, Mexico, Colombia, Ecuador, Peru, Syria and Australia

Arrived in WA 3.5 years ago
Research Fellow in Hans Lambers' group

Developing research on identifying causes for Banksia sudden autumn death
and wandoo crown

Approaches in tree health research – water and nutrients

Erik Veneklaas & Hans Lambers
Plant Biology, Faculty of Natural and Agricultural Sciences, UWA

Abiotic stresses are often the primary cause of poor tree health, even if diseases or pests are ultimately responsible for increased mortality. The climate and soils of southwestern WA impose multiple stresses upon plants, in particular summer drought and scarcity of nutrients. Many plant species tolerate these stresses, as evidenced by their continued presence in the region, but the size and health of their populations may fluctuate substantially due to variations in climate, fire frequency etc. Health problems seem to be particularly severe in those trees that dominate forests or woodlands in the region (e.g., tuart, wandoo, banksias), perhaps indicating that the species with the largest resource requirements experience the highest stress levels.

Both the understanding and the management of water or nutrient-related health problems require the simultaneous study of environmental and physiological factors, e.g., soil moisture availability – plant water status – evaporative demand. Comparative ecophysiological research is needed to reveal why tuart suffers more at some locations than others; why tuart is more susceptible than other species; and why some trees seem to experience more severe stress than others. Valuable information is obtained by traditional monitoring of plant water status and water use across the seasons. More advanced analysis of water fluxes, hydraulic architecture and failure and repair of conducting vessels will provide insight into the consequences of drought within the plant. Experimental approaches are important for hypothesis testing and identification of management options. They may include irrigation/rainfall exclusion, and removal of canopy foliage or understorey vegetation.

Similar principles apply to the assessment of the importance of changes in nutrient availability or ion toxicity. As a first step, concentrations of elements should be measured in leaves and other plant parts of tuart and accompanying species. Variation in leaf age, leaf structure and biomass partitioning may occlude important differences in nutritional status of plants, and therefore need to be considered. Plant internal remobilisation and tight cycling are very important pathways for nutrients in the ecosystems under study, and possible alterations in leaf shedding, decomposition/mineralisation and root functioning may therefore need to be addressed.

Dr Ian Abbott

Department of Conservation and Land Management

Future Scientific Research Directions

Ian Abbott

Ian Abbott is Science Adviser to the Director of Science Division and a Senior Principal Research Scientist in the Department of Conservation and Land Management. He holds degrees from 3 universities – Sydney (B Sc), Monash (Ph D) and UWA (D Sc) – and has conducted field research in New South Wales, Victoria, Tasmania, Galápagos (Ecuador) and Western Australia. Ian has developed expertise in island, forest, fire and historical ecology, biogeography, and with trees, birds and invertebrates.

In 1984 he commenced research in forest entomology in jarrah forest, particularly the pest Gondwanan insect species known as jarrah leafminer. Currently he leads a team of three officers active in studying the ecology of invertebrates in relation to logging, fire and environmental gradients. Ian has published more than 20 papers about earthworms and arthropods in jarrah and karri forests and bluegum plantations.

Future scientific research directions – pests and diseases

Ian Abbott

Department of Conservation and Land Management, Locked Bag 104, Bentley Delivery Centre, Bentley WA 6983

The sustainable management of tuart forest and woodland should rely on a cross-disciplinary, co-ordinated, and integrated approach. *Ad hoc* surveys and general collecting of fungi, bacteria, viruses and invertebrates in the existing forest and woodland are unlikely to contribute to the resolution of how to care for the tuart community on a long-term basis.

A more pro-active focus on establishing a variety of relevant treatments, including thinning of tuart, thinning of wonil, and more frequent low intensity burning, should provide a useful arena for study. In determining knowledge goals, clear thinking is essential in order to avoid producing knowledge that is intellectually gratifying but tangential to understanding mechanisms and patterns of decline. We need to be mindful of causation chains and attempt to distinguish factors that are not relevant from those that are indirect/secondary/contributing or direct/primary/inciting. Cross-linkages have to be worked out. An appropriate first hypothesis is that pest insects and diseases are secondary, not primary, factors in the current decline of tuart.

Major research gaps include the apparent unavailability of basic information on groundwater levels (both current and before the decline became evident) and soil fertility gradients, together with uncertainty about the appropriate scale at which to apply the treatments listed previously (perhaps several hundreds of hectares). Highest priority research should investigate the effect of these treatments on activity/population size of potential insect pests and disease-causing organisms. Tuart should be included in a more comprehensive sampling program for the Mundulla Yellows virus/viroid.

Dr Giles Hardy

Murdoch University

2003 Australian Research Council (tuart) Linkage Grants

Dr. Giles Hardy
Senior Lecturer Forest Pathology, School of Biological Sciences and Biotechnology, Murdoch University.
I obtained my PhD at UWA.
I am interested in beneficial and detrimental fungal-plant interactions with particular interest in natural ecosystems, forestry and the rehabilitation of mine sites. I have worked extensively on *Phytophthora cinnamomi* for the last 10 years and have a large group of postgraduate and Research Fellows working on the pathology, genetics and control of this pathogen funded largely by Industry and the ARC. I am also involved in industry and ARC funded projects on *Armillaria, Botryosphaeria, Puccinia, Mycosphaerella, Endothia* and other fungal pathogens in forests/woodlands and eucalypt plantations. I am particularly interested in how predisposing stresses, in particular water stress and nutritional deficiencies influence disease development. I am also interested in biochemical and cellular mechanisms of plant defense. Lastly, I have just started some research on insects as vectors of fungal pathogens in woody plants.

Open Forum

Session 4: Future Research Directions

Chair: Mr Dave Mitchell

Mr Bob Chandler

Department of Conservation and Land Management

Tuart Regeneration and Ecosystem Maintenance

Biography Robert (Bob) Chandler

Born and resident in Western Australia, and on completion of secondary schooling joined the Forest Department as a Cadet to complete tertiary education at the Australian National University in Canberra. Awarded a Bachelor of Science (For.) in 1973. Career postings have been Manjimup, Jarrahdale and Bunbury.

Career experience includes several years field work in forest inventory followed by approximately seven years developing a mapping system for Phytophthora caused infestation in the forest. Concurrently with mapping, a dieback interpretation team was trained and standards established for dieback disease recognition. Several years were spent as a District Manager in the northern Jarrah forest involving all aspects of forest management, particularly bauxite mining rehabilitation. Ten years in estate planning followed, particularly developing the inter relationship of national parks with statutory land use planning and general regional development. The last five years were spent as manager of the South West Region based in Bunbury. The South West Region covers a wide range of interacting land use issues and conservation management with the prospect of marine reserves in the future.

TUART SCIENCE WORKSHOP

Tuart regeneration and ecosystem maintenance

Bob Chandler Regional Manager Department of Conservation and Land Management
South West Region – Bunbury Regional Office

The Department of Conservation and Land Management, and its predecessor, the Forests Department, have experimented with the regeneration of Eucalyptus gomphocephala at Ludlow over several decades and have developed a successful procedure for reforestation with tuart in that environment.

Since its declaration as the first gazetted state forest in 1919, a succession of foresters have observed the changes to the structure and composition of this forest as it underwent a range of productive land uses and was subject to a variety of management regimes.

The dominating influences are considered to be the cessation of the pre European aboriginal burning practice, clearing for farming, grazing of leases by domestic stock, the utilization of tuart timber, the incorporation of a pine plantation within and amongst the tuart, the exclusion of fire and protection from wildfire. This was accompanied by the presumed simplification of the natural ecosystem, an invasion by weed species and a probable change in the balance of tuart and peppermint in the forest. Despite these impacts on the natural system, the Ludlow tuart forest is still regarded as a conservation and scenic icon and boasts one of the most significant populations of two species of possums and other native fauna. There are also areas of wetland vegetation within and adjoining the tuart forest that preserve significant natural values.

The Ludlow forest provides a case study of environmental management that exemplifies the evolution of techniques such as the management of fuels, weeds, feral animals, fauna, timber products, utilities, neighbours, visitors and the regeneration of the dominant native tree species. However, the reconstruction of the 'natural' ecosystem and its ongoing maintenance is still a challenging ambition.

The extension of these 'tuart forest' management techniques to other places has only recently been considered; stimulated by the disturbing decline of tuart around Lake Clifton. Whilst it is a reasonable expectation that tuart at Yalgorup would respond to regeneration intervention there are some significant issues that must be resolved before it could be attempted on a trial basis.

The efforts of a previous generation of foresters managing the tuart forest at Ludlow have given us the technique for successfully regenerating tuart in that environment and offers the expectation that similar treatments would regrow tuart elsewhere. This is an important tool to have in any consideration of tuart conservation and management because sustaining the dominant tree species in tuart plant associations is fundamental to their character.

However, even the successful regeneration of tuart at Yalgorup would still be a long way from a comprehensive sustainable tuart ecosystem maintenance formula. To achieve that, a holistic approach is needed through the auspices of a Tuart Conservation Strategy.

Associate Professor David Jasper

Centre for Land Rehabilitation

Tuart Rehabilitation after Clearing

David Jasper

B Sc in Agriculture from UWA (1977);
PhD in Soil Science (UWA) (1989).

Associate Professor in the Soil Science and Plant Nutrition Group at UWA, and Director (Teaching & Training) of the UWA Centre for Land Rehabilitation. Currently, David is also working with Outback Ecology, an environmental consultancy, as Principal Scientist.

David has worked in the area of land and mine rehabilitation for more than 15 years. He has been involved in a broad diversity of research in that area, including: restoring soil biology and soil fertility; reconstruction of mined soils; tailings rehabilitation; ecophysiology of native halophytes; and developing measures of rehabilitation success. David has active research programs in both the agricultural and mining industries.

As a result of his substantial collaborative research with the mining industry, David has excellent knowledge and experience of mine rehabilitation practices across Australia.

Rebuilding a Tuart ecosystem

Associate Professor David Jasper
Director (Teaching & Training)
Centre for Land Rehabilitation
The University of Western Australia

There are two scenarios in which rebuilding a Tuart ecosystem is most likely to be required. The first is on land that previously supported a Tuart ecosystem, and that is now under another land use, but has relatively unchanged soil characteristics. The second is after mining, in which substantial impact on the soil profile can be expected.

In the first of these scenarios, the primary tasks will be related to ensuring appropriate chemical fertility of the soil (pH, nutrients) and establishing vegetation with appropriate plant densities and species diversity. Outcomes will be enhanced by understanding nutrient requirements for growth and ensuring nutrient uptake strategies are re-established. Successful establishment will depend on thorough understanding of seed biology and germination requirements for the range of species that are representative of the ecosystem. A particularly challenging aspect is likely be weed control, with topsoils likely to contain substantial numbers of weed seeds. Adding to this complexity, the weed species may vary substantially from site to site, requiring locally- specific strategies to be developed.

Re-establishing a Tuart ecosystem after mining involves the additional challenge of reconstructing an appropriate soil profile, that will allow root exploration and that will hold and supply water. The severity of this challenge will depend on the nature of the mining operation. Soil disturbance may involve removal of surface layers in sequence and their subsequent replacement. At the other extreme, much of this profile may be processed and need to be reconstructed from sand and clay fractions. There are currently several research programs focused on soil profile reconstruction after mining, and a common objective is to optimise the soil physical fertility. This aspect is crucial for root exploration, and thus nutrient and water uptake. Implicit in this research is an understanding of the characteristics of natural soil profiles on which Tuart communities occur. The range is likely to be relatively broad, but is not well defined. Equally, the adaptability of Tuart, and its associated species, to soils outside this range is not well known. Both aspects require further research.

Re-establishment of a Tuart ecosystem will be enhanced if the biological fertility of topsoil is conserved. Populations of beneficial micro-organisms are most likely to be retained in topsoils, if a plant cover is maintained, and if stripped soil is respread promptly without stockpiling. There has been some research on the symbiotic associations of Tuart, but little for other plant species in the ecosystem. Recovery of microbial populations and processes will occur in re-established vegetation and is positively related to plant productivity, which in turn reflects the physical and chemical fertility of the soil profile.

Mr Charles Roche

Tuart Conservation and Protection Outside Secured Reserves

Bio- Charles Roche

Charles is a representative of the Tuart Coalition, formed in 2001 as an advocate for Tuart Conservation. In this capacity Charles is one of three community representatives on the Tuart Response Group. Other Tuart involvement includes being the Chairperson/Spokesperson for the Ludlow based *Friends of the Tuart Forest* and as the Project Officer for the *Busselton-Dunsborough Environment Centre.* Charles also works for the *Conservation Council of WA* who have assisted and supported his Tuart activities since becoming their Rural Liaison Officer in April 2002.

Charles has a BA from UWA, a Grad Dip in Environmental Science from Murdoch University and is currently working towards a Masters in Policy Studies (Ecologically Sustainable Development) at Murdoch. Charles credits his interest in the Tuart as an important indicator species and the many walks through the Tuart forest he has enjoyed whilst living in Ludlow and Busselton.

Protection and Conservation of Tuart outside Secure Reserves

Charles Roche
Tuart Coalition

The Tuart forests of Western Australia have a long history of exploitation and neglect. Over 65% of the total Tuart extent has been permanently lost with varying degrees of degradation in remaining areas. Although Tuart is no longer logged, other threats to Tuart remain. In recent years Western Australians have seen the loss of considerable Tuart woodlands due to agricultural and urban expansion. Whilst secure reservation offers protection from these threats, it offers no protection to the Tuart decline that has severely affected the Yalgorup National Park.

The protection of Tuart is a complex problem from both a scientific and community perspective. In seeking greater protection we must first understand the threats to Tuart and the effectiveness of our conservation system. Given the high level of community interest and ownership of Tuart lands, any conservation of Tuart outside secure reserves must be built upon a well managed conservation program for existing public lands.

Open Forum

Dr John McGrath

Department of Conservation and Land Management

Key Directions

Mr Alan Walker

Department of Conservation and Land Management

Close