Record of Meeting

Biodiversity Climate Change Science Planning Workshop

23 & 24 June 2008
Swan Yacht Club, East Fremantle, WA

Organized & Hosted by WA Department of Environment and Conservation

In collaboration with:

Agriculture Research WA (ARWA)
Australian Bureau of Meteorology
CSIRO
Curtin University of Technology
Edith Cowan University
Murdoch University
South African National Biodiversity Institute
University of Western Australia
WA Department of Environment and Conservation
WA Department of Water
WA Office of Climate Change

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Report prepared by Richard McKellar & Colin Yates, WA DEC Science Division
Draft 1: 3 August 2008

Introduction & Background

The need for good science to support sound decisions about important matters of public policy and investment is well accepted. This is particularly important where the matter has been primarily identified and defined by science, such as climate change. The development of basic scientific principles enabled the possibility of human induced climate change resulting from altered atmospheric composition to be suggested in the late 19th century, and scientific and technological development during the 20th century have enabled this possibility to be investigated using increasingly detailed and robust methods. Towards the end of the 20th century the first observed impacts of human induced climate change were asserted, and these have been confirmed at greater levels of certainty in the past 8 years.

Climate warming is now described authoritatively as unequivocal on a global scale, with most of the observed increase in global average temperatures since the 1950s very likely to have resulted from human induced climate change[1]. Similarly, effects of regional climate changes on natural systems have been observed[2]. However, projecting future climate conditions remains a developing art and projecting future climate change impacts is yet more problematic. There are many reasons for this, particularly that future climate conditions will be affected by future atmospheric concentrations of greenhouse gases, that climate is inherently variable over differing time and geographic scales, and that the role of climate in many other systems is only partly understood.

The IPCC report (IPCC AR4 Figure 11.4, p 529) identifies natural ecosystems as Australia's most vulnerable sector to climate change, even more vulnerable than the water security and coastal communities sectors. The responses of natural ecosystems to climate change is complex: climate plays a direct role in the location of species across a landscape or continent through temperature or water availability thresholds, and through favoring competitive interaction towards one taxa or life strategy over others; climate also plays an indirect role in ecosystem composition and structure through its influence on fire behaviour, disease, pest and other ecosystem stress vectors.

Thus sound advice about the potential impact of future climate change on species and ecosystems requires knowledge of future climate conditions at appropriate scales and pertaining to relevant climate parameters, and the direct and indirect roles climate has in defining species presence and health and ecosystem composition, structure and health. Advice about the effectiveness of alternative adaptation response actions requires further knowledge relating to how management actions might support the achievement of management goals in the face of the future climate change impacts.

A workshop was held on 23 & 24 June 2008 to discuss these critical science challenges and to further a process to define a research program which would generate the knowledge required for sound climate change adaptation response measures for biodiversity management in Western Australia, with reference to similar matters in South Africa. This report contains a summary and a record of that workshop.

From this report and further discussion with workshop participants and others, a biodiversity – climate change impact and response research plan for Western Australia is to be developed.

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[1] The IPCC 4th Assessment report, Summary for Policy Makers; http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf

[2] ibid

Summary of Workshop

The workshop brought together almost 50 of WA's leading biological, ecological and climate scientists from Government agencies, universities, the Australian Bureau of Meteorology and the CSIRO and three scientists from the South African Biodiversity Institute to discuss key research issues for the Mediterranean, arid/semi-arid and tropical ecosystems found in Western Australia with reference to South Africa. Many invited scientists were unable to attend but are to be included in later research program development processes and collaborations.

The morning of the first day commenced with several presentations by representatives of the organizations present, outlining the current biodiversity climate change research activities, capacity and interests of those organizations. A research framework was also presented and discussed. In the afternoon of the first day several groups were formed to develop research programs and activities for the three main biogeographic regions found in WA (Mediterranean, arid/semi-arid and wet tropics) and aquatic ecosystems. This process resulted in the development of several projects for each area, and the identification of some common important and urgent tasks:

- Identify, assemble, interpret and digitize if necessary data sets that would support sound bioclimate research programs and activities;
- Develop integrated research programs involving the use of existing data and clever assembly and use of new data, experimental manipulation, ongoing modeling and analysis and monitoring to test hypotheses;
- Identify key species, ecosystems and localities on which to build research programs.

During the second day, differing groups developed research priorities and activities for two key issues (climate change and carbon cycles, refugia) and for fundamental ecological responses to climate change (persistence, contraction, dispersal and transformation). Several common issues were identified:

- Refugia could play a key role in protedcting the existence of many taxa;
- Monitoring and experimental manipulation will need to concentrate on carefully chosen taxa, communities, ecosystems and localities.
- However, climate change may require ecologists to review well-established concepts such as "keystone" species and refugia;
- Unavoidable uncertainties will result in the factor remaining a fundamental element in advice to policy and planning professionals and decision-makers;
- Evolutionary plasticity remains a significant unknown for climate change adaptation;
- Models provide the only way to integrate knowledge and to test the importance of factors about which relatively less is known;
- Interactions between existing stressors, particularly Phytophthora and fire, will be important in all parts of WA;
- However, it is important to seek to experimentally distinguish the effects of climate change from other impacts wherever possible.
- Given the temporal nature of climate change impacts and the likelihood that climate will continue to change for a very long time after greenhouse gas emission are stabilized, scientists need to determine the extent to which they can learn from the past to inform the future, or use spatial and temporal scales to inform the other.
- The emergence of indigenous invasives as species disperse and prosper in response to climate change; it was recognized that policy considerations are required to guide management responses, including translocation activities.

The workshop closed with broad agreement to continue the collaborative development of a research plan with a view to finalizing a draft plan by October 2008.

Appendix A: Workshop Program:

Biodiversity Climate Change Research Plan for Western Australia

Planning workshop: 25 – 26 June 2008

Swan Yacht Club
Riverside Road
East Fremantle
Western Australia
Ph 9339 3520

Objective of the Workshop:

Define key science directions, questions and projects to support effective biodiversity adaptation management initiatives, including

- opportunities and barriers
- opportunities to partner
- climate projection data
- funding options
- research collaboration opportunities
- existing data sets

Process for the Workshop:

1. Overview of situation and background.
2. Scope implications of climate change for WA's biodiversity and carbon fluxes.
3. Confirm a research framework.
4. Develop research projects.
5. Form regional research plans.
6. Consider next steps: WA biodiversity climate change research collaboration.

Program

Wednesday 25 June

9-11am	Background and context to WA Biodiversity Climate Change Research Plan Setting the scene - Climate change research and issues across sectors and research institutions Presentations and discussion (Whole group) – Chair: Richard McKellar
11 – 11:30am	Break
11:30 – 1:00pm	Initial scope: implications of projected climate change for WA's biodiversity and carbon fluxes Review Research framework (Whole group) – Facilitator: Colin Yates
1pm	Lunch
1:45 – 3:30pm	Resolve Research Questions and Research areas (Small group discussion) (Are these the correct research questions?)
3:30 – 3:45	Break
3:45 – 4:45	Scope research projects – Parts 1, 2 & 3 of Research Pro-forma (Small group discussion)
4:45 - 5:00	Share initial project statements; complaints; suggestions; highlights (Whole group) – Facilitator: Grant Wardell-Johnson
5:00	Close
6:30	Dinner (Fremantle) – Villa Roma Restaurant, 9-13 High Street, Fremantle

Thursday 26 June

9-11 noon	Refine projects; where possible nominate project sponsors and collaborators (Small groups)
11 – 11:30	Break
11:30 – 1:00	Define project cost, resource requirements (Project groups)
1pm	Lunch
1:45 – 3:30pm	Present projects, discuss synergies & regional focus areas (whole group) – Facilitator: Will Stock
3:30 – 3:45	Break
3:45 – 5:00	Review and improve Research Framework, Next steps: state, national & international science, collaboration & resource opportunities
5:00	Close – Neil Burrows

Appendix B: Record of Discussions:

Day One

Neil Burrows - Director, Science Division, DEC
Welcome and introduction to the workshop

- Climate change is the major emerging threat to WA's biodiversity. It holds both direct threats arising from the impacts on species and ecosystems from changed temperature and rainfall patterns and indirect threats from impacts of these changes on existing stressors such as fire intensity and patterns, disease spread and activity such as Pc, the activity of invasive pests and other organisms and salinity.
- DEC Science has been developing its conceptual approach to the most effective and important research required to unpin sound decisions on managing climate change impacts, and has integrated climate change in many programs. DEC Science has also established collaborative biodiversity climate change research programs with some WA and overseas scientists, including particularly with scientists of the South African Biodiversity Institute.
- There must be an increase in the research effort concerned with developing a better understanding of the vulnerability of WA's biodiversity to climate change impacts and this will result from both a redirection of resources and new resources.
- This workshop has been organized to initiate a process aimed at developing a fully collaborative WA research effort, focused on biodiversity but including other NRM sectors where relevant, particularly in this instance relating to agriculture and water resources. Social and economic research will also be very important, but are not specifically encompassed by the ambit of this workshop.
- Thank you to all who have been able and willing to make your time available to participate in this workshop.

Colin Yates – Science Division, DEC
Developing a Biodiversity and Climate Change Research Framework

- Biodiversity surveys in WA reveal that climate is a fundamental influence on where plants flourish, what communities and ecosystems develop in a location and what habitat is available there. Climate change thus has the potential to significantly impact on the State's natural biodiversity.
- Current and future climate change expected to effect biodiversity in WA directly though changes in temperature, rainfall and frequency of extreme events; indirectly though altering factors such as stream flow, groundwater levels, fire regimes and the nature and intensity of existing threats. Increases in CO2 concentrations will also effect species and ecosystems.
- Understanding species climate tolerances and interaction of climate change with threatening processes will be important for adaptation
- Vulnerability of biodiversity to climate change a function of exposure (regional climate change, micro-habitat buffering), sensitivity (species ecology, life-history, physiological tolerances, current stresses) and adaptive capacity (functional gene diversity, ecosystem resilience).
- Biologists will need to work with climate scientists to get access to better resolution climate projection data for the climate variables they think will have the most influence.
- There are many modeling, experimental and monitoring approaches that will assist with assessing the vulnerability of biodiversity to climate change. All methods have advantages and disadvantages.
- Presented a research framework that links ecological responses to climate change with research questions, projects and management (adaptation).

Nicki Allsopp – Global Change and Bio-adaptation, South African National Biodiversty Institute (SANBI)
Global Change Research on South Africa's Plant Biodiversity

- Components of climate change and bio-adaptation program at SANBI include monitoring and understanding and population change; carbon dynamics; assessing and predicting the impacts and vulnerability of biodiversity; synthesis policy and communication; and adaptation
- Impacts of increases in temperature and declines in rainfall on seed germination, plant physiological function and population dynamics are being investigated with mesocosm experiments and field manipulations in Succulent Karroo and Fynbos Biomes.
- Ecosystem level carbon dynamics are being investigated in South African savannah ecosystems and involve measurements of soil CO_2 efflux, photosysnthesis, and canopy flux measurements.
- The effects of increasing CO_2 concentrations growth of select species are also being investigated.
- Modelling species responses to climate change using bioclimatic modeling techniques has and continues to be used widely.
- The South African Environmental Observation Network (SAEON) aims to detect environmental change and identify the drivers of change including emissions, climate change, disturbance regimes, invasive alien species and land-use changes. There are 6 nodes one of which is monitoring Fynbos and which is based at SANBI in the Global Change and Bio-adaptation Program.
- The information being generated by SANBI is being incorporated into vulnerability assessment and adaptation policy documents.

Senthold Asseng - Climate Adaptation Program Science Coordinator, CSIRO
Agriculture Research Western Australia's Climate Adaptation Program CAP

- Agriculture Research Western Australia (ARWA) partners have developed a Climate Adaptation Program (CAP).
- The aim of the program is to create greater adaptive capacity and resilience to climate change in the agricultural sector using the Northern Agricultural Region as a test bed and a time-frame of between now and 2035.
- The focus is on adaptation at the enterprise and regional levels with the aim of delivering information, knowledge and tools that decision makers require manage the risks and capture the opportunities a changing climate will present for agriculture.
- Biodiversity is not a target in CAP, but it is recognized that agriculture affects biodiversity and that biodiversity on farms can affect their performance. There are therefore linkages with climate change and biodiversity impact and adaptation studies being done by DEC and others.
- Key characteristic of CAP are linkages with IOCI, CSIRO Climate Adaptation Flagship, Industry, State and Federal Government Agencies and industry
- There are four central themes in CAP: Climate information; Impacts and opportunities; Managing Risk and capturing opportunities; Education and training, capacity building and communications.
- A number of projects were identified from a workshop that relate to the themes.

Lynda Chambers - Centre for Australian Weather and Climate Research, Bureau of Meteorology
National Ecological Meta Database

- Compared to the northern hemisphere Australia and WA in particular have little information on the impacts that recent climate change has had on species and ecosystems.
- One of the main reasons for this is knowledge of and access to good quality and long time series datasets. For some regions these data exist, but obtaining access and knowing who to contact can be difficult.
- BoM with partners (University of Melbourne, Macquarie University, Australian Greenhouse Office) is developing a National Ecological Meta Database which aims to

document all long term ecological datasets – eg. phenology, range shifts, migration and breeding dates.
- The database only collects information about datasets. The custodians of the datasets retain the rights on who can use the data and for what purpose.

Grant Wardell-Johnson – Centre for Ecosystem Diversity and Dynamics, Curtin University
Biodiversity and Climate Change: Research, Directions and Issues in High Rainfall South-Western Australia

- Mediterranean climate areas of the world occupy less than 5% of the Earth's surface, but provide habitat to at least 20% of the world's vascular plant species.
- All Mediterranean climate regions are global biodiversity hotspots and all are predicted to be effected by climate change.
- High rainfall Mediterranean climate region of SWWA may be particularly vulnerable because it is isolated with no high latitude connections, summer drought stress will intensify and rainfall will decline; it is a fire-prone environment with increasing human pressures and introduced organisms; there is little scope for altitudinal migration; biota has limited capacity for overland movement and there are localized patterns of lineage persistence and endemism (many relictual taxa).
- There is a comprehensive network of permanently marked monitoring quadrats in the High Rainfall Zone which provides many opportunities for understanding the environmental determinants of biodiversity patterns and the impacts that climate change may have on species and ecosystems.
- The potential impacts of climate change on locally endemic forest eucalypts is being investigated with UWA.
- Curtin University with contributions from DEC, all WA Universities and others have bid for the Terrestrial Biodiversity Climate Adaptation Research Network as part of the National Climate Change Adaptation Research Facility.
- A proposal has been put forward to TERN to monitor the impact of regional environmental change on the SW forests/ ecosystems.
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Will Stock – Centre for Ecosystem Management, Edith Cowan University
Climate Change Related Research at ECU

- Wide range of research interests in the Centre for Ecosystem Managemnt at ECU. Many projects are not specifically about climate change but are related and include climate change as an important component that will affect the dynamics of the systems being studied.
- ECU have a number of studies investigating water requirements and ecohydrology of wetland and groundwater dependent vegetation on the Swan Coastal Plain and the vulnerability of these systems to climate variability and altered water and groundwater availability (Ray Froend, Will Stock and colleagues)
- Also a number of studies investigating effects of declining rainfall, groundwater abstraction and land-use on aquatic systems (Pierre Horwitz and colleagues).
- Two studies pending ARC funding "Significance of atmospheric CO_2 in mitigating impact of climate change on biodiversity in SW Australia" and "Predicting the impacts of climate change on biodiversity and ecosystem function in biodiverse shrublands" (with Murdoch, Curtin and DEC)
- Climate change is but one aspect of global change (land clearing, habitat fragmentation, invasive species, changed fire regimes etc) and all need to be considered when thinking about the fate of biodiversity.

Giles Hardy – School of Biology, Murdoch University
WA Centre of Excellence for Climate Change, Woodland and Forest Health

- Centre has links with other WA Universities and State Government agencies including DEC.

- Centre will focus predominantly on causes of decline in trees *Eucalyptus gomphocephala*, and *Eucalyptus wandoo* but also *Eucalyptus rudis*, *Agonis flexuosa* and *Corymbia calophylla*.
- Woodland and forest health affected by a complex set of interacting processes.
- There are four research programs 1. Climate change, woodland and forest decline. 2. Decline ecology. 3. Restoring biodiversity values. 4. Education, training and communication.
- Program 1 will develop knowledge on how climate change will impact on the health of woodlands, forests and their ecosystems; remote sensing technologies to predict the impact of climate change on tree and woodland and forest health; models to predict impacts of climate change on tree health based on data collected from permanent monitoring plots.

Pieter Poot and Dale Roberts - Schools of Plant and Animal Biology, University of Western Australia
Climate Change and Biodiversity – Research at UWA

- Wide range of research interests in the Schools of Plant and Animal Biology many of which are studying the ecology and physiology of species in relation to stresses (eg. fire drought etc) and therefore relevant to understanding how climate change will impact on biodiversity.
- Ecophysiological studies of drought tolerance in wandoo and shifts in species composition in Banksia woodlands (Pieter Poot and Erik Veneklaas).
- Dendroecological studies using the tree ring record in *Callitris* to look at past responses in growth to historical climate variation (Pauline Griersen, Louies Cullen).
- Bioclimatic and physiological species distribution modelling approaches being used to predict impacts of climate change for a range of taxa in WA, rare frog species (Dale Roberts, Kimberly van Niel), reptiles (Nicki Mitchell), high rainfall forest trees (Kimberly van Niel, Joselyn Fissioli).
- Detecting changes in ecosystems and understanding adaptive capacity and physiological tolerances of species are seen as important research directions.
- UWA has started this year a new degree in Climate Change Studies.

Tea Break

John Ruphrecht

- Rainfall has stabilised over the past 10 years but stream flow is still declining. While DoW is watching climate change, also seeing climate variability – how do you superimpose a 6-7 year dry period over a drying trend associated with climate change.
- DoW is modeling climate change and variability impacts on water resources in specific catchments for both water supply planning and aquatic ecology purposes. This is being done with the Australian DCC.
- DoW is developing downscaled climate change projections for one scenario (A2) to provide a spatial context for planning.
- Brian Sadler has been contracted to provide a report on regional water resource impacts for WA, providing baseline information about rainfall and hydrology impact projections.
- Regional allocation plans and the Gnangara sustainability study are including climate change as one factor. In the Perth –Peel Region water plan is taking account of the interaction between a long term drying trend (2030 year and 6-7 year drying periods. CSIRO is preparing a sustainable yield (hydrological water availability) report for SW WA that will include some of this information.
- DoW has been given the role of preparing a Water and Science Innovation Plan for WA involving universities and other state agencies. One of the themes will be trying to understand the implications of climate change and variability for aquatic ecosystems.

John Scott – CSIRO Climate Adaptation Flagship

- CSIRO Flagship has over 100FTE's, lead by Andrew Ash, 4 research projects:
- Pathways to Adaptation – Bryson Bates, based in WA, lots of opportunities for collaboration particularly with downscaling.
- Sustainable cities and coasts – no leader yet identified, based in SE Oz with no projects defined at this time for WA.
- Adaptive primary industries and enterprises and communities – leader is Mark Howden, most WA activities will be through ARWA.
- Managing species and natural ecosystems – leader Trevor Booth – understanding species and ecosystems responses to climate change, managing marine ecosystems under climate change, managing the impacts of fire, invasives both introduced and indigenous, protecting and restoring ecosystems under climate change.
- Best way for WA scientists to interact with CSIRO flagship biodiversity theme is through Trevor Booth or for invasives speak to John Scott.

James Duggie – Role o f WA Office of Climate Change

- OCC is the new and expanded Greenhouse Policy Unit which was formerly in the Dept of Premier and Cabinet.
- OCC has four key roles
    - Lead climate change policy development and implementation on whole-of-government basis;
    - Coordinate across government climate change response both mitigation and adaptation;
    - Intergovernmental relationships
    - Specific projects: IOCI and LEED projects
- 12 FTEs in OCC
- Adaptation and climate science are key areas for OCC; Considering establishing a WA climate change science alliance, discussions with Lynne Beazley and others and investigations of possible governance arrangements.
- James is developing an adaptation policy framework which will become part of a future climate
- Future funding opportunities include state government funding processes which OCC coordinates, Commonwealth Government funding processes some of which will emerge from the COAG processes in which OCC has a role, the National Climate Change Research Facility and associated research plans and planning processes. OCC is eager
- Where common data set needs are common to differing sectors OCC has a role to seek delivery, such as digital elevation data, rainfall and runoff projections and so on. Inform OCC of such common data requirements.

Richard McKellar – Climate Projections for WA

- Global GHG emissions are tracking above the highest SRES scenario. The most realistic temperature and rainfall projections should now be taken as the high emissions scenario outcomes for WA:
    - Temperature increases of at least 2oC are certain for WA by 2070 on an average annual basis;
    - There is a 50-80% chance of 3oC increase in WA by 2070.
    - There is a 10-40% chance of 4oC increase in WA by 2070.
    - Rainfall is less certain, but there is a 50-70% chance of 10% less rainfall and 30-60% chance of 20% less rainfall; but conversely the same models indicate 1-30% chance of 10% greater rainfall and 0-10% chance of 20% greater rainfall in WA in 2070.
- At 2.7oC warmer, the heat stress currently found in Carnarvon and regions east of the Pilbara would apply throughout most of SW WA and the deepest SW corner would experience the heat stress currently found in the Geraldton-Merridin corridor.
- The IPCC AR4 projects a 20-50% reduction in annual runoff for WA from the Pilbara south in 2081-2100 as compared with 1981 – 2000.

- At current emission rates and atmospheric changes, CSIRO notes that fundamental changes to systems on which humans depend are only a little more than a decade from now.

The Implications of Latest Climate Projections – A First Cut

A twenty minute discussion about the possible implications of the projected climate changes for WA's ecosystems, based on current knowledge.

- Grant Wardell-Johnson: Wet south coast forests – significant risk, but microclimate effects may mitigate
- Giles Hardy: SW WA woodlands – significant risks,
- Giles Hardy: Phytophthora – along the South Coast could be exacerbated, especially if there were wetter summer rainfall conditions; anything that will put systems under greater stress
- Pieter Poot: If certain species could survive 28 days at above 35oC per year, perhaps they could survive 45 days above 35oC per year.
- Grant Wardell-Johnson: While images of changing average conditions are dramatic, it is important to know when the heat happens, when the dry periods occur, what extreme events occur, and so on.
- Colin Yates: This highlights the need to define the climate data required to support effective analysis of bioclimatic interactions and the potential impacts of climate change on species and ecosystems. An th eGCMs deliver the kinds of climate data required?
- Tom Lyons: In SW WA the biggest challenge will be the variability to seasons such as for vineyards. Changes to average conditions and to variability can impact on plant (and eg fruit) growth but also how associated industries can manage their crops, etc. Need also variability information which is available from dowscaled models and regional models. It would be useful to define the sort of data needed to answer the key questions about the capacity of species and ecosystems to future climate variability and change, particularly combinations such as long hot and dry conditions. Look for surrogate data sources such as WA's extended remote sensing data.
- Pieter Poot?: Look at specific instances where significant biological changes appear to have
- Giles Hardy: In light of the frost event that impacted on many ecosystems including tuart and jarrah forests a couple of years ago, should also look at changed likelihood of other types of extreme events, such as unusual cold that could result from clear skies. Observations of death and other impacts could yield insights into thresholds.
- Pierre Horowitz: Changed seasonal patterns of rainfall in differing parts of WA and population responses to changed water availability could affect aquatic ecosystems. Changed winter water availability will affect certain species and ecosystems while changed summer water availability will affect other species and ecosystems in the same locality. The degree to which water is extracted from landscapes will be affected by policy decisions.
- Adrian Pinder?: For water availability issues also need to consider changes to temperature and
- Kevin Thiele: It would be useful to get information about future climate variability and well as about means and seasonal changes.
- Tom Lyons: Vignerons in Margaret River are now seeking advice about the variability of key climate parameters and indices which are critical to their industries.
- Dale Roberts: There have been climate extremes historically, even just during the 20th century, so there must be some capacity for species to cope with significant variations in climate. We need to determine the time horizon over which data becomes useful and climate change becomes a significant threat to species.
- John Scott: According to Mark Howden the future low point of temperature variability is projected to be higher than the current high point of temperature variability. How can we learn more about what WA's species and communities have experienced in past? In addition there appear to be state changes occurring globally
- Phillip Kalaitzis: Shorter and medium term changes in land use could have a greater impact on biodiversity than longer term climate change.

- Geoff Stoneman: the key issue for forestry management through climate change are what the responses of the ecosystem likely to be from climate change, what uncertainties and levels of confidence are there and what real management options
- Keith Morris: there are likely to be some fauna species which will be winners from climate change as well as .
- Dale Roberts: There needs to be greater emphasis on the semi-arid zone and the Kimberley.

Research Framework Discussion

Colin Yates: the preceding discussion highlighted the need for biologists and ecologists to consider what the key climate parameters are for the biota they are concerned with. Frequency and depth of climate extremes appears to be a set of parameters which have been largely ignored until now. It would be useful to find a way of generating a better understanding about this.

Colin Yates: The framework was developed to link ecological responses to climate change with (a) research questions leading to research projects and (b) management options and questions. The framework is open

Comments about the research framework schematic:

- Nicky Allsop: It would be useful to have an specific section explicitly concerned with the interaction between climate change impacts and other ecosystem stressors such as clearing, fire,
- Grant Wardell-Johnson: These interactions could determine the fate of species and ecosystems.
- Paul Gioia: Data management requirements and existing infrastructure and investments need to be considered to ensure our research builds on what is already in place.
- Margaret Byrne: The framework indicates duplication of research activities under each research project under differing biological response headings. So there would be value to working through each heading and developing the research projects and activities relevant to that heading, then looking at where common activities, data requirements and resources occur and finally assembling and forming research activities that will contribute to a number of research questions and ultimately to a number of management questions and issues. This will avoid the WA research community embarking on a number of similar or even overlapping research projects.
- Will Stock: The research issues will have differing scales, requiring for instance climate information at differing scales. Having an indication of the scale at which research questions and projects operate would be a useful addition to the framework.
- Grant W-J: It would be useful to have a similar framework concerned with economic and social principles which will impinge on the capacity of WA's biodiversity and biodiversity management to cope with anticipated climate change.
- Pierre Horowitz: Research needs to operate at species, ecosystem function and services level.
- Senthold Asseng: The framework looks very useful for this exercise. ARWA has gone through a similar exercise and found it useful to put all research questions and project ideas on the table in the first instance. The group then reviewed the questions and projects to group them and find common themes. An external party was then asked to consider how the themes might be developed as an integrated set of research activities which could be shaped into a research program. At this point ARWA looked for champions for each project who would design the project from the bottom up and also look at how his / her project links with other projects.
- **Name??** : There remains a question about how scale can be included in this process. For instance, how would this process support a research program concerned with reconstructing a landscape near Perth in the event that Perth's future climate conditions resemble Kalbarri's current climate conditions? While the ecosystems will inevitably be different, some species will move, there are ecological principles and reconstruction questions and also decisions or a social and political nature concerning under what conditions indigenous species are allowed or encouraged to migrate to new locations well out of current range.

- Kevin Thiele: There appears to be a gap in relation to .... While we are tending to concentrate on species will are likely to contract and decline, we may find that existing weeds could decline both leading to new weeds but also to management options focused on reducing existing stressors using climate change as a management vector.

Project Sheet Discussion:
Colin Yates: The project sheet proforma is provided to better enable workshop participants to work within the research framework, to enable later processes to assemble similar research activities and to help interested research scientists to form collaborations.

- The intention is that scientists will work in groups to discuss key research issues and in doing so will share their research interests and ideas, with an expectation that collaborations will be formed where useful and effective. It appears that upcoming Commonwealth and COAG research funding will be more likely delivered to research collaborations than individual research scientists.
- This process will enable participants having a pet project to scope it while here and to seek ideas about collaborations, as well as to identify projects which will contribute to better understanding of climate change vulnerabilities and management opportunities.
- This process is aimed at new research projects which build on or expand existing research activities or which represent entirely new activities.

Lunch break:

Report on Afternoon discussion: Chair: Grant Wardell-Johnson

SW WA Group (Lachie McCaw)

- An open and brainstorming session has resulted in several pages of project descriptions being prepared (included in Appendix C).
- The main issue not caught by the research framework and the project sheets was the potential impacts of climate variability.

Kimberley Group (Dale Roberts)

- Main discussion was concerned with what data sets might be available to assess changes over the historical past – need to bring this together; what other indicators or distribution might be available
- Potential use of island – mainland comparisons to enable separation of climate change impacts from other impacts such as fire, grazing etc
- Rainforest surveys in 1980s may provide a data basis
- Changes in fire frequency could also be an indicator; island-mainland comparisons could also be useful for this aspect of the research
- Not convinced there is sufficient biodiversity data about the Kimberley to support useful research on observed changes.
- Summary: A data compilation exercise might be the best initial activity for a Kimberley climate change impacts research program.

Wet Forests Group (**Name??**)

- What information have we got, Can we go back to historical records, Can we use the data we already have? what are the deficiencies and gaps in this record, What things might have changed, targeting areas which might be useful for field work or for tracking change – eg in ...../ semi-arid parts of the south west, play with altitude and slopes to see what differences can be discerned, key functional groups that we can start learning about biological responses to climate change which would enable
- Refugia: granite outcrops, areas might become more important for flora and
- Targeting areas where change might appear on a relatively shorter time frame or which have high biodiversity values.

Semi-arid / arid zone group (Margaret Byrne & Neil Burrows)

- The group developed a set of projects concerned with data availability, review and development that could be applicable to all regions.
- The semi-arid and arid region is projected by GCMs to become warmer and wetter, as opposed to SW which is projected to become warmer and drier- in a sense a mirror image of SW.

Other comments:

Senthold Asseng: Clear possibility to link biodiversity-orientated projects with ARWA projects.

DoW representatives: keen to learn about changes to use of water by plants and ecosystems under climate change conditions, particularly in the first instance use of water by jarrah forest ecosystems in water supply catchments.

Dale Roberts: Much of the discussion today has been about research into the impacts of climate change on species or systems; would like more discussion about management responses to climate change vulnerabilities. The bigger philosophical issue of whether species loss of a certain scale is acceptable or not needs to be addressed at some point.

Colin Yates: Research which defines and scopes the scale of vulnerability of WA's biodiversity values to climate change may be the catalyst necessary to gain traction for effective policy and management decisions. Research of the type we have been discussing

Name?: Emerging climate change and its impacts on ecosystems is like evolution in action. Catastrophic loss of biodiversity is not desireable: what will happen in the absence of responsive management, what are the realistic options to alter or reduce these impacts and what are the socio-economic implications of implementing these options?

Lesley Gibson: When considering land clearing and predators, there are clear management responses to that, but there are not equivalent management responses to climate change as it cannot be mitigated except on a global scale and responses can only be on a species-level scale or on a regional scale

Margaret Byrne: Our observation approach to monitoring needs to generate more than a record of what has been lost, but must also inform our projections of impacts, validate models and threshold

Ben Miller: Scientists need to be honest to the community regarding what can be realistically done to reduce and manage climate change impacts on biodiversity and to guide management responses to climate change

Closing remarks: Neil Burrows:

- Climate change is a geat challenge for biodiversity conservation and land management and. Asscientists we have to contribute to the community's knowledge of the nature of potential and likely impacts and management options and responses. This is an opportunity to bring WA's scientisfic community together to develop a scientific program which we can in various partnerships and collaborations propose and promote the program in whole and in intelligent parts.
- There is a lot of data already available that we need to identify and make available for the vulnerability and other analyses required. We will also need to develop a set of key data which are required but not available and work strategically towards establishing the data base we require.
- Thanks to everyone for making their time available for this activity.

Day Two

Summary of the day's discussions (Chair: William Stock)

Kimberley (Dale Roberts)

- While there is a perception that there is limited information about the Kimberley, there should be significant information from the rainforest survey of the 1980s and through remote sensing there should be some capacity to investigate changes in patch size in the period to present. Targeted resurveys should also be able to generate useful information.
- It is well recognized that the Kimberley is affected by climate change and many other factors. However it should be able to compare island and non-island ecosystems / to help distinguish climate change impacts from other impacts.
- Should move beyond species representation and persistence to look at ecosystem processes such as trophic interactions and so on.
- The emerging key theme for this region seems to be the use of islands, which are representative of mainland ecosystems, as control sites for climate change impacts.

Arid / Semi-arid zone (Lachie McCaw)

- The discussion in this group trended towards ecosystem or landscape level issues rather than species-level issues
- Because the arid / semi-arid zone is so large an enhanced observation network is required for both monitoring ecosystem composition and processes and climate conditions and to validate GCM outputs and other climate research and projections on which so much of the climate science, policy development, planning and socio-political decisions are based.
- There is similarly a need to identify key sites where monitoring should occur.
- A critical issue for this is zone is to identify important components of climate variability for arid / semi-arid zone.
- As much of the area is predicted to have increased rainfall, the region is so large and differing parts of it are likely to experience differing impacts, the region should be disaggregated in realistic and useful ways for research purposes. For instance, the Pilbara is projected to experience much greater rises in temperature than is the Goldfields.
- This region already experiences significant impacts from weeds and feral animals and climate change is anticipated to exacerbate this issue. Should agriculture shift into this region more and new weeds could be introduced.
- Shifts in boundaries and proportion of areas in woody vs grassy areas and C4 grass presence need to be considered
- There is relatively little known about the physiological tolerances and thresholds and functional genetic adaptation capacity of species currently found in this region. This limits the capacity of models to generate credible climate change impact projections.
- There was an extensive discussion about refugia; how they might be identified.
- Several projects concerned with fire regimes were developed.
- A discussion about dispersal barriers focused on identifying the types of landscape features that might generate or constitute dispersal barriers for differing dispersal capacities or strategies and differing life history traits.
- Ecologists need to evaluate the extent to which the current practice of using vegetation as a surrogate many other aspects of biodiversity will remain valid and useful under climate change conditions.
- A key emerging key theme: May be dispersal, given the established "boom & bust" processes related to biota flourishing when and where water availability is good, with recolonisation playing a key role in long term sustainability of vegetation and species presence.

Aquatic Ecosystem (Adrian Pinder)

- This group discussed the kinds of information required to formulate key research projects, including how to prioritize wetlands and aquatic systems from a climate change perspective. This would enable research to focus on those deemed most vulnerable and to evaluate existing priorities to see if they adequately take account of direct and indirect effects of climate change.

- It was recognized that there are considerable data sets available for wetlands, but that it would be important to bring them together and make them available for research purposes.
- Monitoring is the third key theme, particularly to need to identify tracking or sentinal sites; how can existing monitoring activities be expanded to take account of climate change projected impacts.
- Despite all the foregoing, it was still felt that not enough is known to confidently develop a new research program and that a first critical step would be to develop conceptual models for climate change impacts on wetlands and their responses – including hydrological components, ecological aspects and biogeographical elements of wetland function.
- A key initiative would be to establish and maintain over extended periods ongoing tracking sites where the only (or the main) impacts would be climate change such as small wetlands entirely enclosed by well-managed nature reserves to enable scientifically credible measurements of climate change impacts. In addition some rivers on the south coast, such as the Shannon, may have these characteristics.
- Dunal and coastal wetlands also at risk from sea-level rise as well as from change rainfall or seasonality of rainfall or water availability.
- As for the other groups, the potential synergies of direct and indirect impacts require considerable conceptual investigation, experimental evaluation and monitoring.
- A broad collaborative approach was agreed to be important for this type of research.

South West Forests (Grant Wardell-Johnson)

- This group initially made a couple of general observations: 1: There is a lot of information from previous research activities – the assembly of this data would be a useful beginning; 2: It would useful to bring research activities together to a limited number of sites, including macro-climatic monitoring and remote sensing. Thereafter several projects were developed
- Project 1 - Nature of ecological communities: Structure, function and composition of ecological communities – does these change with differing types of stress – manipulative experiments focusing on communities anticipated to respond to climate change.
- Porject 2 - How do ecological communities respond to climate change: move, change, lose or gain components. Does soil play a role? Do old and young communities have differing trajectories / differing landscapes?
- Project 3 - Refugia: evidence, nature, location? – granite outcrops, greater complexity of landscapes and surrounding environments.
- Project 4 - Physiology: functional responses of co-occuring species. Are relictual or local endemic species more susceptible to climate change that widespread species?
- Project 5 - Categorizing plant functional groups responses to differing types and levels of climate change impact, such as potential responses to prolonged heat and water availability stress
- Project 6 – Some focus is required for particular life forms about which little is known such as geophytes.
- Project 7 - Combinations and interactions of stresses, including climate change, fire, Pc and salinity.
- Project 8 – The integration of disparate knowledge to support decision processes is a key element for all time scales.
- Project 9 - Water use by south west forests over the coming century, a matter which is critical for water resource planning. Infrastructure investments have significant social interest and are difficult to reverse once made.
- In response to question from chair to focus requests to climate modelers for specific climate data: Water availability would be most critical for flora, for amphibians water seasonality might be most critical.

Transformation (Pieter Poot)

- Species which are already threatened or rare are expected to be most vulnerable to climate change. For these a "gardening" experimental approach might be considered appropriate within boundaries, though it would inevitably be limited in scale.

- Broader-scale experiments relevant to community or ecosystem experimentation were then discussed, such as large scale transport of topsoil and ecosystem components to new areas. However because of the cost and complexity but this would be yet more limited, and some consideration of cost-effectiveness would inevitably need to be applied.
- The discussion then moved to what is known about the genetic capacity of species to respond to climate change, leading to a discussion about experiments concerned with testing physiological and other thresholds and boundaries. One such experiment would look at extremes of habits where supposedly some selection has already taken place of eg keystone species. In this control plots would be established to monitor health of species and communities together with eg soil moisture monitors and climate monitoring to enable functional relationships to be revealed should death or transformation occur. In addition, experimental temperature increases and rain-out experiments could also be applied. Comparisons of these manipulated plots with control plots could yield information about a range of matters, including thresholds, the response of potential actual invasive species and so on.
- By using keystone species and other carefully selected species from differing functional groups and also ecosystems selected on relevant criteria, generalisations should be possible from experimental activities focused on only a relatively small proportion of WA's biota.
- Physiological tolerances and genetic responses to changing ambient climate conditions should also be investigated, perhaps using glasshouse experiments. On a conceptual level at least, it would be useful to identify the key climate drivers of taxon presence, health and persistence.
- Research activities should differentiate between short-lived and long-lived species to learn more about genetic adaptation capacity, initially though breeding experiments with short lived species.
- Building on Day one discussions, it would be useful to apply experimental manipulation to certain habitats such as granite outcrops, hills, elevation and aspects.
- Social factors in climate change adaptation management, including public perception vs scientists perceptions, information to policy and other groups regarding .... Because transformation represents the greatest scale of change this issue might best be included in this group, though it would be important to all groups.
- In addition, a project was developed to investigate the relationship between scientists, community and decision-makers' perspectives on how transformation might be perceived and understood, and how responses might be formulated.
- In summary four main projects were developed:
- 1. Sociological effects of transformation
- 2. Ecological community translocation project, comprising a movement of soil and plant materials.
- 3. Physiological manipulative experiments.
- 4. Species based experimental research activities including reciprocal transplants experiments and others, taking account of differing functional types, project where species
- In a discussion about the terms "keystone species" or "framework species" it was conjectured that the meaning and use of these terms might not remain stable as climate change affects ecosystem composition, structure and processes and thus might need to be reviewed to remain useful.
- In a discussion about drought deaths that are now being observed (possibly as a first stage in a transformation process) it was suggested that in relatively undisturbed landscapes such as Kalbarri NP no response would be preferred at this time as connectivity and recolonisation is possible, but in the SW wheatbelt where fragmentation is a major landscape feature, revegetation to improve connectivity and / or reseeding may be appropriate and effective in the short term at least.
- The Gnagara could provide an opportunity for large scale transformation experimental activities.

Carbon Cycle (Lachie McCaw)

- The group had a general discussion about carbon (greenhouse gas) accounting issues.
- The major benefit from carbon sequestration is mitigating climate change impacts globally, but it might be possible to take advantage of emerging opportunities from carbon trading, establish improved land management as a result of increased vegetation and to better understand risks associated with increased vegetation and resultant market activities. Three stages were perceived and scoped into projects.
- 1. Do a sensitivity analysis to identify the most prospective ecosystems / landscapes for carbon sequestration, such as revegation of agricultural landscapes, SW woodlands, tropical savanna, etc.
- 2. Develop improved greenhouse gas accounting models for landscapes across WA and develop means to extrapolate from known to little know landscapes.
- 3. Monitoring of selected areas to validate models.
- There was also a short discussion about the difficulties inherent in measuring changes to soil carbon content.

Refugia (Colin Yates)

- Broad discussion about how refugia are perceived and defined leading to several projects
- 1. Refugia conceptia: Understanding the relatively importance of aggregated refugia vs dispersed refugia
    - Aggregated refugia are granite outcrops, drainage systems, ironstone ranges, and so on.
    - Dispersed refugia may exist throughout the landscape, arising from subtle topographical variations.
    - Outcomes: 1. verification of current refugial concepts, 2. if concept of dispersed refugia is valid, it would result in reconsideration of some aspects of reserve planning principles and management practices, 3. support for effective inclusion of refugia in conservation planning and management.
    - Research program would prospectively involve research at Cape Range, across rainfall gradient in SW, drainage patterns on South Coast, and rainforest patches in Kimberley – ie choose target areas.
    - Test refugial concept by collaborating with climate modelers – overlay downscaled mesoscale climate projections over relevant areas, measure microclimate gradients and variation to see if the microclimate buffer might be effective in providing a refuge under projected future climate conditions.
    - Testing the concept of refugia with expanded phylogeographic data sets.
    - Assemble existing species distribution data to undertake pattern analysis of species complexity.
- 2. Turn the dominant concept of refugia on its head in wet cool areas along south coast:
    - Current warm dry areas in deep SW may be refugia for species which could recolonise transformed landscapes in an emerging drying and warming climate in this region. That is, there may be important refugia from wet conditions in SW that need to be protected and managed carefully.
- 3. Islands as fauna refugia from existing threatening processes may be susceptible to climate change impacts.
    - How susceptible are these islands to climate change impacts and how would this be ascertained?
    - Current project to reintroduce threatened fauna species to Dirk Hartog Island may place them at their northern climate boundary; perhaps islands further south should be investigated.
- 4. Refuges from sea level changes.
    - Particularly important for turtles and coastal / dunal wetlands (eg those at Cape Arid NP).
    - Further development of projects concerned with this aspect of refugial matters is required.

Persistence (Margaret Byrne)

- This group considered the meaning of persistence and what project could generate knowledge to support evaluation of management actions which would be required to support persistence. 6 projects were scoped to generate information about key aspects governing persistence.
- 1. Can the past predict the future – what is the historical evidence for persistence, using common phylogeographic patterns across the biota and inferring from a species approach to inform community and ecosystem impacts of persistence or lack thereof.
- 2. What characteristics predict persistence – what physiological characteristics and life history stages and traits are critical to persistence and what functional groups have these characteristics and are therefore more likely to be able to persist, considering all biota and the plasticity of their functional traits to climate change.
- 3. New frameworks for adaptive restoration; concerned with new paradigms to guide successful restoration under climate change conditions;.
- 4. Best practice translocation under climate change; The aim is provide mechanisms and protocols to guide management responses for taxa whose range is likely to contract below a critical size under climate change.
- 5. Interactions between climate change and other stressors and threatening processes, particularly those which are likely to be exacerbated by climate change impacts. This is particularly important where existing stressors are already significant threats to biodiversity, such as Pc in SW WA and many other places in Australia, South Africa and other countries.
- 6. Adaptive restoration and maintenance of species presence and landscape function at both site and landscape scale, through identifying processes that limit survival under climate change. What are the key functions that a community and an ecosystem provides and how can these be maintained under climate change conditions.

Chair: key linking themes that are emerging:

- Interactions between existing stressors, particularly Pc and fire.
- The extent to which we can learn from the past to inform the future.
- How spatial scale can overcome a lack of historical data.
- The need to assemble and make available existing data sets that can enable a historical understanding of changes to species distribution, ecosystem health and so on.
- Distinguishing between the impacts of climate change and the impacts of other stressors either as they have existed or as they
- The emergence of indigenous invasives as species disperse in response to climate change – some policy considerations is required to guide management responses, including translocation policies.

Discussion: Australian plants becoming invasive.

- Already at least 600 species of Australian flora have spread and naturalised beyond their original distributions.
- Invasives have been defined in very inclusive functional terms based on the classical weed definition (a plant out of place).
- Policies concerned with invasives need to be reviewed in light of climate change impacts on species distributions and landscape transformation responses.
- Translocations in particular may become problematic as there could be displacement of a species in one location by a translocated species.

Discussion of matters not raised at the meeting:

- Lack of discussion about the impacts of elevated CO2, on its own and in conjunction with other factors such as changed temperature and water availability.
- Lack of discussion of modeling in the workshop, perhaps because of the particular people present, a lack of faith in models to be able deliver useful projection and information, or a focus on the generation of information for use in models.
    - Does the apparent scale of impending climate impact preclude fine scale modeling and call for broader management responses?

    - Perhaps there is a growing recognition of the need to understand human responses to climate impacts on biodiversity at the individual, community at the personal and political levels. This raises a need for well-considered socio-economic research activities.
    - Perhaps it is because modelers are suffering more from a lack of good data rather than a lack of available models, so the discussion may have focused on the most significant and urgent requirement: the availability of good data.
- Colin Yates: The recent use of models has revealed the nature of information required to improve model outputs. Predictive science carries inherent and unavoidable uncertainties but remains a starting point to enable researchers to probe the unknown and develop hypotheses, monitoring programs and other activities. There will always be a tradeoff between reality and tractability. The key thing is that uncertainties and assumptions associated with any aspect of scientific activities and findings need to be transparently communicated.
- John Scott: Decision makers seek the kind of integrated advice that models can produce. Species distribution models support the allocation of significant funding even where the models are poor.
- Lesley Gibson: The workshop has discussed how a knowledge base can be built that will enable better models to produce better advice for decision makers and land managers with lower levels of uncertainty and less problematic assumptions. Development of dynamic models will enable emerging information about functional relationships such as climate responses to be incorporated in models.
- Jos Fisioli: It will be important to approach models as tools requiring ongoing improvement and development, and it makes sense to ensure that some models are relevant to WA's circumstances.

Tea Break

Final afternoon session

Final Comment Forms
The group completed final comment forms (see Appendix D).
Matters raised on the forms include:

- sdf
- sdf
- sdf
- sdf
- sdf
- sdf

Final discussion:

James Duggie: It would be useful for managers if scientists could now provide their best advice, even in the face of acknowledged uncertainties.
Jeff Richardson: As even a comprehensive research program will not overcome all types and levels of uncertainty; making decision in the face of uncertainty needs also to be an element of our research program.
Jenny Davis: One way of addressing underlying scientific uncertainty is to ensure there is good replication across relevant spatial and temporal scales to support extrapolation.
Suzanne Prober: Many current management actions, such as restoration and improving connectivity in many situations will be safe and useful in the face of any type and scale of climate change impacts, and should be continued. As we investigate new actions we need also to maintain existing actions that are useful.
John Scott: In response to a request for advice about actions which should be initiated now on the basis of current knowledge, all actions which are currently under way should be measured under a climate change context.
John Bartle: While the framework is useful, much of the framework is more defensive than necessary. Climate change responses can also provide complementary benefits such as

carbon sequestration resulting from revegetation, which could generate investment for biodiversity initiatives.
Colin Yates: Ensemble modeling is increasingly used to overcome uncertainties inherent in individual models.

Next steps:

- A draft record of meeting will be prepared and circulated for comment and further input, leading to a workshop report and a research program. Champions will be sought for each project in the research program. The Office of Climate Change will be coordinating a budget submission for the 2009-2010 financial year and thereafter.

Final invited comments:

- Phillip Kalaitzis (Dept of Water): Dept of Water has to balance water allocation between economic, social and environmental demands on a day to day basis, within a context of uncertainty of short term and long term supply. This workshop has demonstrated how important climate change is for all NRM bodies to collaborate on ensure robust science underpins decisions made at policy and planning levels, and has enable us to discuss a key issue of great importance to water allocation planning. DoW looks forward to further collaboration on the development and implementation of climate change research programs and activities.

- Nicky Allsop (SANBI): South Africa and Australia hold significant opportunities for mutual learning because we share biological evolutionary histories but have also experienced significant divergence, as well as high biodiversity and endemism and ancient landscapes. Conceptual models that reflect these characteristics can help biodiversity managers accelerate our understanding in both countries, particularly as both areas face an emerging global threat like climate change. All of these characteristics distinguish southern Africa and Australia from most of the Northern Hemisphere. To start with, sharing data on observation platforms in the two nations might be useful, to avoid duplication and to inform how we develop our separate and different but synergistic research programs. SANBI looks forward to ongoing collaboration with DEC and other WA scientists.

- John Scott (CSIRO and ARWA): ARWA's CAP has 12 projects, at least 4 of which would have an obvious overlap with biodiversity-orientated research: hydrology of landscapes, climate variability, downsizing of climate models for WA and biosecurity. Intelligent integration ARWA's CAP and the biodiversity program should make both more attractive to potential funding entities. It has been useful for CSIRO and ARWA to be involved in this workshop and further collaboration is invited.

- Dale Roberts (UWA): In addition to causality, random events can affect evolution. WA's biota are very old and have experienced significant climate variation in the past, and many are very restricted in distribution and have been restricted for extended periods of time. So there may be an inherent genetic capacity of many WA biota to respond to climate change. While human induced climate change is projected to occur in a very short period, some reptiles and amphibians have demonstrated rapid evolution in response to strong selection pressure. Thus some species at least may be able to respond effectively to significant changes to climate conditions which occur rapidly. However, we may be at the beginning of a climate change which will be greater in scale from the changes experienced in the past. Secondly, much of our discussion has been concerned with species responses to climate change, but there is also a need to understand how assemblages and ecosystems are likely to respond. Climate change may require a rethinking of ecosystem organizational rules – the driving rules behind assemblage composition – and how they might be affected by changes to climate conditions and the substrates and processes on which species, assemblages and ecosystems depend. Thirdly, much of the discussion has focused on the loss of species, ecosystems and landscapes, and there has been some discussion about gain, such as range expansion. However, even if climate change drivers are reversed in 100 years climate would continue for several hundred years.

In this instance, how do we choose to what to manage for, what goals our management is seeking to achieve. This again highlights the need to understand what the key processes or biodiversity assets or products are which we should be managing to achieve. This will involve both ecological and also social considerations and a focus on both short term of decades and also long term of centuries. The final matter I wish to raise is that while existing stressors need to be managed in the context of climate change impacts, it is critical to distinguish how climate change differs from the other existing stressors. Finally, however weak models are in projecting future conditions with high levels of certainty, they remain our key tool for this aspect of our research activity and development of management advice.

Closing

- Margaret Byrne (DEC): Thank you to all participants for attending the workshop and for bringing such a collaborative spirit. This will be a first stage in a process leading to a biodiversity climate change research plan for Western Australia. Please stay engaged with this process as it proceeds in coming months and use the material from the workshop in developing your other and possibly separate research proposals.

Appendix C: Initial Research Project Descriptions

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Climate change information system.**

2. **Project Aim:**
   - To develop a comprehensive climate change information system to support research projects.

3. **(a) IBRA Region(s):** All.
   (b) NRM Region(s): All.
   (c) DEC Region(s)/District(s): All.

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Research activities will become more efficient and effective from having easy access to existing data sets.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - ...
   - ...

6. **Research program (project description):**
   1. ...

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - National Ecological Meta-database.

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: Selwyn Willoughby **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
   - ...

13. **Outstanding issues noted:**

- The information system must address issues such as IP, GIS, databases, etc.

14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Collate existing biodiversity and other information.**

****** I had some difficulty with the photocopy of this project sheet so this is incomplete.***

2. **Project Aim:**
   - Make existing data available for research on biodiversity climate change vulnerability.
   - Provide a complete spatial meta-database of available data / information on all levels. Include references to current research projects which are utilizing these data

3. **(a) IBRA Region(s):** ...
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Improve availability of existing datasets.
   - Avoid unnecessary repetition of field research.
   - Improve use of research funds.
   - Identify areas where several types of data sets are available, potentially leading to an increased focus or future effort in these areas (focus field efforts to sites where sound data already exists).

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - Scientists, policy analysts, biodiversity and land planners, land managers, decision-makers.
   - Geographic information system.

6. **Research program (project description):**
   1. Create an index / database of all available hydrological , biological, geological, climate etc etc data, within a geographic information system. This would be an extension of the National Ecological Meta database, within a spatial framework.
   2. Identify gaps and overlaps between data.
   3. Areas where many, good quality, long term datasets area available may then become the focus of future research, sampling & monitoring to build available information. Alternatively, there may be sufficient information already available for credible and sound analyses.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - National Ecological Meta-database.

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: Asha McNeil **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ...

13. **Outstanding issues noted:**
    - ...

14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Collate existing ecological data sets.**

2. **Project Aim:**
   - Existing long term ecological data sets are identified and available for climate change analysis.

3. **(a) IBRA Region(s):** All.
   (b) NRM Region(s): All
   (c) DEC Region(s)/District(s): All.

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Enable the current impact of a key existing stressor to be reduced.
   - Support analysis of and planning for potential invertebrate pest and other species responses to climate change, especially outbreaks.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - Modelers and other research scientists.
   - National Ecological Meta Database; DEC's web-based ecological data sets; publications.

6. **Research program (project description):**
   4. ...

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - Pheno Arc – collation of historical phonological records from published literature and other sources (Lynda Chambers).
   - National Ecological Meta Database (www.bom.gov.au/nemd).

9. **Personnel:**
   Scientists: ...
   Technical officers: ...
   Collaborators: Lynda Chambers, Paul Gioia, ...
   Volunteers:

   Contact: ... **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
   - Commonwealth funds available for digitization (Lesley Hughes).

13. **Outstanding issues noted:**
    - ...

14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: An enhanced observation network for monitoring climate change and resultant effects on biota.**

2. **Project Aim:**
   - To develop enhanced capacity to:
     1. monitor climate conditions,
     2. validate predictions from global climate models and
     3. collect relevant biological data on response to climate change across WA.
   - Identify and trial adaptation responses to potential biosecurity risks.

3. **(a) IBRA Region(s):** All, but particularly Goldfields, Pilbara, Kimberley & South Coast.
   (b) NRM Region(s): All, as above.
   (c) DEC Region(s)/District(s): All, as above.

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Enhanced climate observation network.
   - Integrated network of monitoring sites providing consistent biological and hydrological data across biomes.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   Land managers & water managers:
   - Climate modelers.
   - Scientists studying effects of climate change.

6. **Research program (project description):**
   5. Review existing network of climate observation sites managed by BoM and other agencies and industry.
   6. Negotiate and resolve issues of instrumentation quality and data standards to optimize current data.
   7. Establish new climate observation sites to fill critical gaps.
   8. Gain agreement from key stakeholders on design, location and data management systems for a network of monitoring sites that will provide information about biological and hydrologic system *(lost a line from project plan?).*

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: ... **Phone:** ... **email:** ...

10. **Data custodian:**

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3

Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ...

13. **Outstanding issues noted:**
    - ...

14. **Group:** Arid / semi-arid

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Ecosystem phenology.**

2. **Project Aim:**
   - Determine species phenology, relationship to climate & interacting species phenology (ability to look for potential mismatches in timing and implications to ecosystem health & functioning).

3. **(a) IBRA Region(s):** All.
   (b) NRM Region(s): All
   (c) DEC Region(s)/District(s): All.

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - ...

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - ...
   - ...

6. **Research program (project description):**
   9. ...

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - Pieter Poot: proposed research in WA.
   - Climate Watch (Earthwatch) – a trial national project currently present only in Qld, NSW and Victoria.

9. **Personnel:**
   Scientists: ...
   Technical officers: ...
   Collaborators: Lynda Chambers, Pieter Poot, Earthwatch ...
   Volunteers:

   Contact: Pieter Poot **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
   - ...

13. **Outstanding issues noted:**
   - ...

14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title:**

   Understanding past, present and probable future trends in aquatic biodiversity in relation to climate and climate change.

2. **Project Aims:**

   i. To gather existing aquatic ecosystems data from WA research groups and analyse these for climate-related patterns.

   ii. To undertake a literature review of the responses of wetlands to climate change for policy and management lessons relevant to Western Australia.

   iii. To determine which existing projects need to be strategically continued and enhanced to provide useful information on climate-driven change in aquatic biodiversity.

   iv. To advise on what additional monitoring of aquatic ecosystems is required, particularly as sentinels to understand climate-driven impacts and degree of resilience or transformation, where other threatening processes have low or no impact. This will involve gap analyses to identify important wetland ecosystems that are not currently being monitored.

   v. Establish a framework for collaboration and communication within the State's aquatic research community to facilitate sharing of climate change related data.

   vi. To forecast probable wetland responses, with and without management intervention, to various climate change scenarios

3. **a) IBRA Region(s):** At least Avon Wheatbelt, Mallee, Geraldton Sandplains, Jarrah Forest, Warren and Swan regions.
   b) NRM Region(s): All in WA
   c) DEC Region(s)/District(s): At least Swan, Wheatbelt, Mid-west, South-coast and Warren.

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**

   If particular types of wetland ecosystems are transforming then management actions may need to be modified. This project will provide information on how aquatic systems are likely to be affected by climate change so that management practices and policies can be adapted as necessary.

   Long-term monitoring programs will allow the effectiveness of management practices and policies to be assessed and will provide essential feedback for adaptive management programs.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**

   Policy makers and wetland conservation managers in government (DEC, DoW) and community conservation groups. Published reports, papers, oral presentations and participation in working groups such as the State Wetland Coordinating Committee and technical advisory committees (e.g. for recovery catchments).

6. **Research Program (project description):**

Background

The various components of wetland biotas respond over different time frames to inter-annual variations in climate and longer term trends. The compositions of waterbird and invertebrate communities, for instance, respond immediately to inter-annual climate variation, whereas condition and composition of perennial vegetation generally responds more to longer term trends. These various scales of change all have the potential to provide indications of what the long-term responses to climate change might be. Several current monitoring programs, and other ecological studies, are providing time series data on aquatic biodiversity and condition, collected over the last 15 to 30 years. Examination of these will allow us to assess the degree to which we can detect and predict responses of aquatic ecosystems to both short-term (inter-annual climate variability) and longer term trajectories of climate change. In some instances, they may also allow us to investigate the mechanisms by which climate change will impact upon wetlands (e.g. through altered trends in surface flows, salinisation and groundwater availability).

Work plan

1. Western Australian aquatic researchers to meet to identify existing datasets, determine data compatibility, agree on analyses, design framework for literature review and a process for regular sharing of data and/or research results.

2. Undertake review of national and international literature to identify the nature of responses to climate change likely to be encountered in Western Australia.

3. Researchers or groups of researchers to undertake analyses of existing data to identify responses of wetland environments and biota to both inter-annual variation and longer term climate trends.

4. Undertake modeling that will enable probable wetland responses, with and without management intervention, to various climate change scenarios, to be forecast.

5. Based on 2 and 3 above, determine how current monitoring programs could be expanded or improved, or new monitoring programs designed, so that 1) we can better describe probable responses of aquatic ecosystems across the state to climate change and 2) we can feed new information into adaptive conservation management programs and policies. This will include identification of 'sentinel' sites whose condition is likely to be affected primarily by climate change and establishment of a monitoring protocol for these sites.

6. Publish results of items 2 to 4 above as a report and, as appropriate, scientific papers.

7. Short summary of background research:

Several research and environmental management institutions in WA hold wetland time-series aquatic biodiversity data and/or are undertaking wetland monitoring programs (+ indicates ongoing), including, but not limited to:

Department of Environment and Conservation: State Salinity Strategy wheatbelt wetland monitoring program (15+ years of biannual sampling of 25 wetlands for water chemistry, depth, groundwater depth and chemistry, waterbirds, aquatic invertebrates and vegetation condition). Natural Diversity Recovery Catchment Program (10+ years of intensive monitoring and investigation of several high value wetland assets in Wheatbelt). Sustainable Forest Management forest stream monitoring program (3+ years of south-

west forest stream aquatic invertebrate and water chemistry data). AusRiVAS project, about 100 sites sampled for water chemistry and aquatic invertebrates in multiple years in the 1990s. South-west wetland monitoring program (SWWMP; up to 30+ years of salinity, pH and depth data for 151 wetlands). Lake Gregory sampled over several years.

Department of Water: South coast wetlands monitored for ... (ongoing, need more detail).

Edith Cowan University: Gnangara Mound monitoring program.

Murdoch University: Jandakot Mound monitoring, Thompson and Forrestdale Lakes monitoring.

The University of Western Australia: South-west streams sampled in 1980s, 1990s and recently.

These data will be useful to varying degrees for examining short and medium term responses to climate.

8. **Related projects:** see above.

9. **Personnel:**

Scientists: One full-time scientist to be employed by this project.

Technical Officers: one, to assist with literature review, data gathering and management and report preparation.

Collaborators: Small time commitments from Jenny Davis (Murdoch), Ray Froend (ECU), Pierre Horwitz (ECU), Adrian Pinder, Michael Lyons, Michael Coote and Jim Lane (DEC), Andrew Storey (UWA) and a representative from DoW.

Volunteers: NA

Contact: Adrian Pinder ph: 9405 5153 email: adrian.pinder@dec.wa.gov.au

10. **Data custodians:** To be negotiated. Data will need to be accumulated centrally as part of this project, but individual research institutions to retain rights to own data.

11. **Budget estimate [anticipated expenditure]:**

	Year 1 ($)	Year 2 ($)	Year 3 ($)
Scientist	86000	90000	95000
Technical	70000	76000	78000
Hydrological modelling	100000	100000	
Equipment	10000	5000	5000
Vehicle	5000	5000	2000
Travel	5000	5000	2000
Other	10000	10000	10000
TOTAL	286000	291000	192000

12. **Potential funding sources:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Conceptual models for climate change in WA inland aquatic ecosystems**

2. **Project Aim:** To develop conceptual models that incorporate:
   - Hydrological components & models;
   - Ecological aspects;
   - Biogeographical & landscape models in the context of;
   - Uncertqainties (climate change and conceptual) and
   - Human-related and land-use related issues, responses and threatening processes (ie pressure drivers).

3. **(a) IBRA Region(s): All in WA.**
   (b) NRM Region(s):
   (c) DEC Region(s)/District(s):

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Conceptual models will centralize and drive aquatic ecosystem and climate change research in WA. They must, therefore, be broadly based and well-discussed and accepted.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   Land managers & water managers:
   - ...

6. **Research program (project description):**
   10. Desktop study of existing models:
   - hydrology – conceptualise for major regions where and when ecosystems derive their water;
   - ecology – conceptualise the nature of life history, environmental flows, water quality and quantity requirements of (wetland) biota;
   - biogeography – landscape -> patterns of endemicity, regionalization.

   11. This process should be done through an "expert panel" not a "consultant" approach.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:** ...

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: ?

10. **Data custodian:**

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			

Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**

13. **Outstanding issues noted:**
    - Florida wetlands research model may be a useful approach (Jenny Davis' suggestion).

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Documenting changes in distribution and key attributes of Kimberley fauna and flora**

2. **Project Aim:** Identify species having well-known distribution to identify changes in occurrence / distribution and how that correlates with climate variation.

3. **(a) IBRA Region(s):**
   (b) NRM Region(s): Rangelands
   (c) DEC Region(s)/District(s): Kimberley

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Persistence: Biodiversity monitoring. Use available data, not targeted in any way. Limited historical data but may be only clue to change.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   Land managers & water managers:
   - DEC, WAM.
   - Published in scientific journals.

6. **Research program (project description):**
   12. Herbarium, WAM – identify species with good historical coverage & collection effort.
   13. Target current and future monitoring to assess persistence or change.
   14. Contrast with island occurrences to control for non-climate change impacts (human fires, grazing, predation, etc).

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - This project will use existing data.

8. **Related projects:**
   - Rainforest patch assessment.

9. **Personnel:**
   Scientists: 1 – desktop exercise
   Technical officers:
   Collaborators:
   Volunteers:
   Contact: Dale Roberts **Phone:** ... **email:** ...

10. **Data custodian:** DEC, WAM

11. **Budget Estimate [anticipated expenditure]:** ...

12. **Potential funding sources:**

13. **Outstanding issues noted:**
   - ...

14. **Group:** Kimberley

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Remote sensing frogs & other acoustically signaling species.**

2. **Project Aim:** To generate techniques to remotely assess occurrence frog species and other acoustically signally taxa which can be used to generate data on occurrence, distribution and change.

3. **(a) IBRA Region(s):**
   (b) NRM Region(s): Rangelands
   (c) DEC Region(s)/District(s): Kimberley

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Persistence: Biodiversity monitoring. (a) occurrence, (b) range (c) changes in a & b.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   Land managers & water managers:
   - DEC, WAM.
   - ....

6. **Research program (project description):**
   15. Off-the shelf acoustic systems which are programmed for individual species are available for bird identification in some parts of the world. Identification is based on species-specific calls. The system enables calls to be identified, the presence or absence of a species to be recorded.
   16. Program and locate several systems in several remote locations to operate over the wet season.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - Technical literature on identification systems. Information about occurrence of bird and frog species.

8. **Related projects:**
   - Rainforest patch assessment. Kimberley survey.

9. **Personnel:**
   Scientists: 1 (0.5 ecologist; 0.5 computer scientist)
   Technical officers: 0.5
   Collaborators: Dale Roberts (UWA); P Doughty (WAM).
   Volunteers:
   Contact: Dale Roberts **Phone:** 6480 2224 **email:** droberts@cyllene.uwa.edu.au

10. **Data custodian:** DEC, WAM

11. **Budget Estimate [anticipated expenditure]:** ...

	Year 1	Year 2	Year 3
Scientist			
Technical	60k	60k	60k
Equipmant	200k	20k	20k
Vehicle	10k	10k	10k
Travel	150k	150k	150k
Other			
TOTAL	420k	240k	240k

12. **Potential funding sources:**

13. **Outstanding issues noted:**
    - ...

14. **Group:** Kimberley

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Data audit of the Kimberley.**

2. **Project Aim;**
   - Identify all data sets relevant to modeling, species distribution, biodiversity, assemblages.
   - Identify data gaps.

3. **(a) IBRA Region(s):** ...
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Support and enable projects relevant to Kimberley biodiversity vulnerability assessment: species, assemblages, communities, ecosystems.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   Land managers & water managers:
   - Conservation planners, biodiversity and land managers.
   - Publish on-line.

6. **Research program (project description):**
   17. Identify and audit existing metadatabases in major agencies (eg DEC, WAM, etc).
   18. Literature review.
   19. Assess modeling techniques and likely correlates.
   20. Survey of major land agencies (eg Landgate) for suitable products.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - Fire data base maintained by Tricia Handasyle???

8. **Related projects:**
   - All projects related to modeling or biodiversity assessment

9. **Personnel:**
   Scientists: 1 @ L5 for 3 months
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: Paul Gioia **Phone:** 9334 0480 **email:** paul.gioia@dec.wa.gov.au

10. **Data custodian:** DEC Science division

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist	20k		
Technical			
Equipmant	5k		
Vehicle			
Travel	10k		
Other			
TOTAL	35k		

12. **Potential funding sources:**

- ...

13. **Outstanding issues noted:**
    - ...

14. **Group:** Kimberley

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Kimberley ecosystem services & function**

2. **Project Aim:** To determine trophic interactions in plant & aquatic communities, c3 & c4 plants & shifts in composition.

3. **(a) IBRA Region(s):**
   (b) NRM Region(s): Rangelands
   (c) DEC Region(s)/District(s): Kimberley

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Climate change is anticipated to shift the balance of carbon using species. Assess ecosystem function & assemblage interaction rather than just species occurrence.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   Land managers & water managers:
   - ...
   - Published in scientific journals.

6. **Research program (project description):**
   21. ... stable isotope analyses ...
   22. ... to be completed ...

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - Know a reasonable amount about similar functions in the SW ...

8. **Related projects:**

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:
   Contact: Ray Froend **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:** ...

12. **Potential funding sources:**

13. **Outstanding issues noted:**
    - ...

14. **Group:** Kimberley

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Kimberley Rainforest Patches**

2. **Project Aim:** To measure and assess change that has occurred in Kimberley rainforest patches since previous surveys in the 1980s.

3. **(a) IBRA Region(s):** Kimberley
   (b) NRM Region(s): Rangelands
   (c) DEC Region(s)/District(s): Kimberley

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Measures of (a) changes in assemblage structure since 1980s surveys; (b) changes in number, distribution & size of patches as detected by remote sensing.
   - Research Plan Table: Persistence / climate effects / changes

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   Land managers & water managers:
   - Policy makers, decision makers & land managers
   - Liaison & publication

6. **Research program (project description):**
   23. Resurvey patches previously sampled in 1980s.
   24. Use islands as controls where they are not subject to non-climate disturbance (eg grazing, anthropogenic fire, invasives, etc)
   25. Compare contemporary remote sensing data with historical data in CIS environment to document changes in patch size, number and distribution.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - Existing publication relating to 1980s survey
   - Various minor surveys
   - Kimberley Island survey.

8. **Related projects:**

9. **Personnel:**
   Scientists: 6
   Technical officers: 5
   Collaborators: Various specialists.
   Volunteers: Yes.
   Contact: Dr Allan Burbidge, allan.burbidge@dec.wa.gov.au

10. **Data custodian:** WA DEC Science Division

11. **Budget Estimate [anticipated expenditure]:** Large ($5M+/-)

12. **Potential funding sources:**

13. **Outstanding issues noted:**
    - Rainforest change between 1980s -> now? Adequacy of 1980s surveys to enable documentation & attribution of changes?
    - Availability of island controls?
    - Utility of remote sensing of patches?

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Regional biological survey of the Kimberley**

2. **Project Aim:** To document the biological diversity of the Kimberley to provide a benchmark for ongoing monitoring of climate change impacts.

3. **(a) IBRA Region(s):** Kimberley
   (b) NRM Region(s):
   (c) DEC Region(s)/District(s):

4. **Anticipated project outcome(s) (including reference to Research Plan Table):** Species lists of selected sites representing the major geographical and climate gradients across the Kimberley. Consider including surveys of potential refugia or sites considered to be vulnerable to climate change impacts.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   Land managers & water managers:
   - Scientific publications, accessible database storage (internet).
   - Popular articles and presentations.

6. **Research program (project description):**
   26. Site based surveys targeting plants, land snails, reptiles, mammals, frogs, perhaps ants, aquatics (invertebrates & plants).
   27. Sites selected to represent environmental gradients.
   28. Wet & dry season surveys.
   29. Use of vehicles, vessels or helicopters as dictated by access options.
   30. Several teams working concurrently.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - Kimberley rainforest survey, Kimberley Island survey, WAM surveys.
   - Issues associated with persistence, contraction, dispersal, transformation & extinction

8. **Related projects:** Desktop investigations of what is already known – gap analyses, etc.

9. **Personnel:**
   Scientists: 15
   Technical officers: 10
   Collaborators: Specialist taxonomists, naturalists, WA Museum staff
   Volunteers: As many as logistics allow.
   Contact: Dr Lesley Gibson, lesley.gibson@dec.wa.gov.au

10. **Data custodian:** WA DEC Science Division

11. **Budget Estimate [anticipated expenditure]:** Very large ($20M+/-)

12. **Potential funding sources:** Resource industry, Commonwealth, World Heritage Trust, WA DEC

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Fire science in the Kimberley.**

2. **Project Aim:**
   - Evaluate the interaction of climate change, fire behaviour and biodiversity.

3. **(a) IBRA Region(s):** Kimberley.
   (b) NRM Region(s):
   (c) DEC Region(s)/District(s): Kimberley.

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Better understanding of relationships between climate change and fire regimes.
   - Improved knowledge of biodiversity responses to altered fire regimes.
   - Improved knowledge o ffire weather, fuel moisture and fire behaviour.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - DEC, NRM groups, pastoralists.
   - ...

6. **Research program (project description):**
   31. Establish a wildfire baseline using Landsat fine scar mapping, instrumented weather data and palaeoclimate records.
   32. Implement planned strategic burning and assess fire impacts / intensities using high resolution MODIS imagery.
   33. Ground truth / validate biodiversity and fire regime changes.
   34. Undertake studies on time series basis.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - Landsat fire scar mapping available since the 1990s.

8. **Related projects:**
   - AWC @ Mornington

9. **Personnel:**
   Scientists: 2
   Technical officers: 2
   Collaborators: 20 (Regional staff)
   Volunteers: Pastoralists?

   Contact: Drew Haswell **Phone:** ... **email:** drew.haswell@dec.wa.gov.au

10. **Data custodian:** DEC Fire Management Services Branch

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist	400k	450k	500k
Technical	200k	250k	300k
Equipmant	100k		
Vehicle	100k	250k	
Travel	200k	250k	250k
Other			
TOTAL	1,000k	1,200k	1,050k
		200k	
		100k	

		100k	
		200k	
		1,000k	

12. **Potential funding sources:**
    - ...
13. **Outstanding issues noted:**
    - ...
14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Interactions between fire regimes, climate and fauna assemblages in the arid zone.**

2. **Project Aim:**
   - To quantify and model the influence of fire regimes patchiness and scale and rainfall on the seral succession and assemblages of fauna (mammals, reptiles & invertebrates).

3. **(a) IBRA Region(s):** Pilbara, Gibson desert.
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Models to predict influence of climate-driven altered fire regimes on faunal biodiversity.
   - Management (fire) guidelines and prescriptions.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - Fire and land managers, pastoralists, restoration and rehabilitation workers.
   - ...

6. **Research program (project description):**
   35. Space – for – time surveys: establish sampling grids in a range of different ***but thrown (can't read two words)*** fire regimes and times since last fire (matched site attributes).
   36. Commence longitudinal studies to understand species response, seral stage development and species vital attributes and life histories.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - Fire regimes are anticipated to change under changed climate. Managers need to understand this and predict responses.

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists: 1
   Technical officers: 1
   Collaborators: DEC, Murdoch U.
   Volunteers: Yes.

   Contact: Neil Burrows **Phone:** 9334 0463 **email:** neil.burrows@dec.wa.gov.au

10. **Data custodian:** DEC

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist	100k		
Technical	80k		
Equipmant	50k		
Vehicle	40k		
Travel	20k		
Other			
TOTAL	290k		

12. **Potential funding sources:**
    - ...
13. **Outstanding issues noted:**
    - ...
14. **Group:** Arid / Semi-arid

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Interactions between fire regimes, rainfall and vegetation in the arid zone.**

2. **Project Aim:**
   - To quantify and model the influence of fire regimes (season and frequency of fire) on vegetation, floristics, structure and biomass increment on hummock grasslands.

3. **(a) IBRA Region(s):** Pilbara, Gibson desert.
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): Pilbara, Goldfields

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Prediction of influence of climate change on fire regimes and hence on biodiversity.
   - Improved fire management leading to biodiversity conservation.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - Fire managers.
   - Guidelines, prescriptions, adaptive management.

6. **Research program (project description):**
   37. Space – for – time studies: establish assessment quadrats in a range of sites of known but different fire histories and times since last fire (in matched sites in Pilbara & Gibson Desert IBRA).
   38. Establish longitudinal studies to investigate post fire seral stages and how these are driven by climate, especially rainfall.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - Understanding post fire responses, life histories and vital attributes of vegetation species will inform modeling the effects of altered fire frequency and season resulting from climate change impacts.

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists: 0.3
   Technical officers: 0.5
   Collaborators: DEC, ECU.
   Volunteers: Yes.

   Contact: Neil Burrows **Phone:** 9334 0463 **email:** neil.burrows@dec.wa.gov.au

10. **Data custodian:** DEC

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist	50k	50k	50k
Technical	40k	40k	40k
Equipmant	20k	20k	20k
Vehicle	20k	20k	20k
Travel	10k	10k	10k
Other			

TOTAL	140k	140k	140k

12. **Potential funding sources:**
    - WA & Commonwealth governments, mining companies.

13. **Outstanding issues noted:**
    - ...

14. **Group:** Arid / Semi-arid

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: key components of climate variability in the arid & semi-arid zone.**

2. **Project Aim:**
   - To define the key climate drivers of biodiversity for distinct regions of the arid / semi-arid zone.
   - To downscale GCM predictions for each region, particularly for episodic extreme events.
   - Validate GCM predictions against: (a) climate records for 20thC & (b) palaeoclimate records (past 200-300 years).

3. **(a) IBRA Region(s):** ...
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - An understanding of the reliability and limitations of climate change scenarios.
   - Contextual information to provide a baseline for anticipating changes in biodiversity in response to gradients of rainfall amount and seasonality, temperature and episodic extremes.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - Scientists investigating biotic response to climate change.
   - ...

6. **Research program (project description):**
   39. ...

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators: .
   Volunteers: .

   Contact: ... **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ...
13. **Outstanding issues noted:**
    - ...
14. **Group:** Persistence

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Evaluate CAR reserves under climate change.**

2. **Project Aim:**
   - How well do surrogates of pre-European vegetation currently used for CAR reserve design represent other components of biodiversity.
   - Determine whether current surrogates will remain valid under climate change.

3. **(a) IBRA Region(s):** All.
   (b) NRM Region(s): All.
   (c) DEC Region(s)/District(s): All.

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - An evaluation of the conservation effectiveness of the current reserve system and its effectiveness and adjustments needed to meet climate change scenarios.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - Policy analysts, land managers, land use planners, research scientists.
   - ...

6. **Research program (project description):**
   40. ...

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators: .
   Volunteers: .

   Contact: ... **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
   - ...

13. **Outstanding issues noted:**
   - ...

14. **Group:** Persistence

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: The relative responses of woody and grassy vegetation to climate change in the arid / semi-arid region of WA.**

2. **Project Aim:**
   - To investigate the interactive effects of changes to temperature, moisture (rainfall – amount and seasonality) and CO2 on the performance of specific functional types: woody (C3) and grassy (C4).

3. **(a) IBRA Region(s):** Many.
   (b) NRM Region(s): Rangelands.
   (c) DEC Region(s)/District(s): Pilbara, Goldfields, South Coast.

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Spatial changes in vegetation structure across the arid / semi-arid region will be predicted.
   - Better understanding of productivity and other ecosystem and biodiversity changes associated with changes to vegetation structure.
   - This information and knowledge will support effective predator, pest and invasive species management, fire management and rehabilitation and restoration.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - Land managers, fire managers, minesite rehabilitation, carbon offset traders.
   - ...

6. **Research program (project description):**
   41. Identify regions where climate change (eg seasonality of rainfall) is evident.
   42. Assess biodiversity & species changes in these regions.
   43. Assess vegetation structural changes in C3 / C4 balance through analysis of stable C isotopes SOM – ie has the shrub (C3) // grass (C4) interface remained constant in the historical past during which the climate change had occurred.
   44. Develop an understanding of physiological climate and CO2 tolerances of the differing growth forms / photosynthetic types.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - We already know that different photosynthetic pathways respond differently to seasonality of rainfall, temperature and fire. Knowledge that the system is episodic and event driven. This research will give greater understanding of persistence and transformation in this region.

8. **Related projects:**
   - Related to projects on fire, fauna and ecosystem function. Overlaps with project in NT and N Qld where tree / grass interactions are of interest.

9. **Personnel:**
   Scientists: Will Stocks + others (+ student projects)
   Technical officers: 1
   Collaborators: SANBI, CSIRO, ANU.
   Volunteers:

   Contact: Will Stock **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist	82k (PD) & 25k (PhD)	85k (PD) & 25k (PhD)	85k (PD) & 25k (PhD)
Technical	65k	68k	70k
Equipmant	45k	40k	40k
Vehicle			
Travel	12k	14k	14k
Other			
TOTAL	229k	232k	234k

12. **Potential funding sources:**
    - ...

13. **Outstanding issues noted:**
    - ...

14. **Group:** Arid / Semi-arid

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: The response of weeds and feral animals to climate change in the arid / semi-arid parts of WA.**

2. **Project Aim:**
   - To identify the changes in distribution of weeds and ferals.
   - To determine interactions of introduced predators.
   - To determine the responses of weeds to changed fire regimes.
   - To assess areas / species most at risk from expansion of invasive species.

3. **(a) IBRA Region(s):** Many.
   (b) NRM Region(s): Rangelands.
   (c) DEC Region(s)/District(s): Pilbara, Goldfields, South Coast.

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Understanding of how climate change will affect invasive species.
   - Understanding physiological, climate and CO2 tolerances of species.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - Land managers.
   - ...

6. **Research program (project description):**
   45. This project will examine the response of invasive species to climate change in the arid / semi-arid zone, and the potential impact of these responses on key species and / or locations.
   46. Identify key invasive species (actual and potential).
   47. Identify key native species and locations likely to be vulnerable.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - Fire regimes.

9. **Personnel:**
   Scientists: 1
   Technical officers: 1
   Collaborators: DEC regions, NRM.
   Volunteers: Many possibilities.

   Contact: Keith Morris **Phone:** 9405 55159 **email:** keith.morris@dec.wa.gov.au
   Lachie McCaw

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist	100k	100k	100k
Technical	70k	70k	70k
Equipmant	30k	30k	30k
Vehicle	30k	30k	30k
Travel	20k	20k	20k
Other			
TOTAL	250k	250k	250k

12. **Potential funding sources:**
    - ARC, CFOC

13. **Outstanding issues noted:**
    - ...

14. **Group: Arid / Semi-arid**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Ecosystem phenology.**

2. **Project Aim:**
   - Determine species phenology, relationship to climate & interacting species phenology (ability to look for potential mismatches in timing and implications to ecosystem health & functioning).

3. **(a) IBRA Region(s):** All.
   (b) NRM Region(s): All
   (c) DEC Region(s)/District(s): All.

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - ...

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - ...
   - ...

6. **Research program (project description):**
   48. ...

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - Pieter Poot: proposed research in WA.
   - Climate Watch (Earthwatch) – a trial national project currently present only in Qld, NSW and Victoria.

9. **Personnel:**
   Scientists: ...
   Technical officers: ...
   Collaborators: Lynda Chambers, Pieter Poot, Earthwatch ...
   Volunteers:

   Contact: Pieter Poot **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
   - ...

13. **Outstanding issues noted:**
   - ...

14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: An enhanced observation network for monitoring climate change and resultant effects on biota.**

2. **Project Aim:**
   - To develop enhanced capacity to:
     1. monitor climate conditions,
     2. validate predictions from global climate models and
     3. collect relevant biological data on response to climate change across WA.
   - Identify and trial adaptation responses to potential biosecurity risks.

3. **(a) IBRA Region(s):** All, but particularly Goldfields, Pilbara, Kimberley & South Coast.
   (b) NRM Region(s): All, as above.
   (c) DEC Region(s)/District(s): All, as above.

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Enhanced climate observation network.
   - Integrated network of monitoring sites providing consistent biological and hydrological data across biomes.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   Land managers & water managers:
   - Climate modelers.
   - Scientists studying effects of climate change.

6. **Research program (project description):**
   49. Review existing network of climate observation sites managed by BoM and other agencies and industry.
   50. Negotiate and resolve issues of instrumentation quality and data standards to optimize current data.
   51. Establish new climate observation sites to fill critical gaps.
   52. Gain agreement from key stakeholders on design, location and data management systems for a network of monitoring sites that will provide information about biological and hydrologic system *(lost a line from project plan?).*

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: ... **Phone:** ... **email:** ...

10. **Data custodian:**

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3

Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ...

13. **Outstanding issues noted:**
    - ...

14. **Group:** Arid / semi-arid

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Ecosystem movement, change or loss.**

2. **Project Aim:**
   - Do ecological communities move, change or lose components in response to climate change. Why? Comparison between regions where differing climate impact responses would be anticipated, such as rainforests in Cape York, the Kimberley and SW WA Kwongan.

3. **(a) IBRA Region(s):** ...
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - ...

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - ...
   - ...

6. **Research program (project description):**
   53. ...

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: Grant Wardell-Johnson **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ...

13. **Outstanding issues noted:**
    - ...

14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Ecosystem response to stress.**

2. **Project Aim:**
   - How do the structure, function & composition of ecological communities change with "stress" in areas – target GDEs – involve manipulative experiments (such as removing water).

3. **(a) IBRA Region(s):** ...
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - ...

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - ...
   - ...

6. **Research program (project description):**
   54. ...

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: Grant Wardell-Johnson **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ...

13. **Outstanding issues noted:**
    - ...

14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Reciprocal & common garden experiments of key flora over climate gradients**

2. **Project Aim:** To assess the capacity of selected species (eg dominant, keystone, range restricted) to establish and persist under a range of different climate regimes and outside their current climate envelopes.

3. **(a) IBRA Region(s): SW WA**
   (b) NRM Region(s):
   (c) DEC Region(s)/District(s):

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - An understanding of the ability of these species to persist under climate change.
   - How and when selected species would be used in ecological restoration projects.
   - Generalise from outcomes of selected species to other species having similar functional characteristics.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   Land managers & water managers:
   - Land managers and rehabilitators.

6. **Research program (project description):**
   55. Identify species based on functional groups approach (specifically including dominant an drange restricted species); selected species should be those chosen for ecophysiology glasshouse experiments.
   56. Generate environmental envelopes for each species.
   57. Identify climatic extremes and choose sites based on a climate gradient within the extremes for each species (as closely as possible matching soil types).
   58. Design for reciprocal transplants and common garden experiments in differing climate regimes.
   59. Monitoring regime over appropriate period of time.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - Existing translocation literature & data for WA species.
   - Existing data on reciprocal translocation and common garden experiments.

8. **Related projects:** Physiological thresholds of and potential genetic adaptation of keystone species.

9. **Personnel:** Assuming a minimum of 20 plant species.
   Scientists: 2
   Technical officers: 4
   Collaborators: *
   Volunteers: Lots

   Contact: ?

10. **Data custodian:** DEC Science Division

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist	180k		

Technical	280k		
Equipmant	340k		
Vehicle	70k		
Travel	35k		
Other	240k		
TOTAL	1,145k		

12. **Potential funding sources:**

13. **Outstanding issues noted:**
    - ...

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Impacts of climate change on forest production.**

2. **Project Aim:**
   - To develop a better understanding of the interaction between climate anc forest production to support sound projections of forest production under changed climate conditions.

3. **(a) IBRA Region(s):** ...
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Forest planning will have sound information to support future forest harvest plans and allocations.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - SFM and WA government decision-makers, industry, affected communities.
   - ...

6. **Research program (project description):**
   60. Use existing data sets about forest growth and climate parameters to generate knowledge about the relations between climate conditions and forest growth.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - National Ecological Meta-database.

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators: David LeMaitre (SA CSIR)
   Volunteers:

   Contact: Martin Raynor **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ...

13. **Outstanding issues noted:**

- ...

14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: The ecological response of invertebrate populations to meteorological variables.**

2. **Project Aim:**
   - Apply fine resolution long term meteorological data sets and available invertebrate population data sets to model and predict invertebrate responses to climate change.

3. **(a) IBRA Region(s):** SW WA and Lower Great Southern.
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): Donnelly, Wellington, Perth Hills.

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Enable the current impact of a key existing stressor to be reduced.
   - Support analysis of and planning for potential invertebrate pest and other species responses to climate change, especially outbreaks.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - Forest managers.
   - ...

6. **Research program (project description):**
   61. Examine population data bases of (eg) Gum leaf skeltoniser (Uraba lugens), Jarrah leaf miner (Perthida glyphoba), Red legged earth mite (Cardiaspina jerramungae) and match with long term meteorological data such as temperature and rainfall to model and establish trends and relationships.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists: ...
   Technical officers: ...
   Collaborators: ...
   Volunteers:

   Contact: ... **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**

- ...

13. **Outstanding issues noted:**
    - ...
14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Water Use in the Jarrah Forest.**

2. **Project Aim:**
   - Understand water relations and needs of the jarrah forest in respect to (a) the dominant species (E marginata) and other deep-rooted species and (b) understorey shallow-rooted species.

3. **(a) IBRA Region(s):** SW.
   (b) NRM Region(s): All
   (c) DEC Region(s)/District(s): Donnelly, Wellington, Perth Hills.

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - DEC SDKA 2.24 & 2.37
   - Design of reserve system / CAR.
   - Evapotranspiration & water use values.
   - Enable greater precision in water use models for prediction of climate change impacts on jarrah forest ecosystem, ecological water requirements and water production.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - Water resource planners and managers, biodiversity and land managers.
   - ...

6. **Research program (project description):**
   62. ...

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists: ...
   Technical officers: ...
   Collaborators: Universities, CSIRO, Water Corporation, DoW, DEC, ...
   Volunteers:

   Contact: ... **Phone:** ... **email:** ...
   M Bari, Lidia Bonicka, Janet Farr, ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**

- ...

13. **Outstanding issues noted:**
    - ...

14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Can past persistence inform future persistence?**

2. **Project Aim:**
   - Evaluate historical evidence for persistence.

3. **(a) IBRA Region(s):** ...
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Determine what biota (species / communities) are likely to persist through changing climate.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - Conservation managers.
   - Scientists – in relation to other requirements for climate change response data.
   - ...

6. **Research program (project description):**
   63. Assess physiological patterns in species (plants & animals) in target regions and across target groups.
   64. Evaluate common patterns in biotic responses to climate change.
   65. Infer impacts of biotic persistence or lack of persistence for ecosystems / ecological communities.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - Current data suggests persistence has been a primary response of many species to historic climate change.

8. **Related projects:**
   - Genetic & physiological tolerances of species.

9. **Personnel:**
   Scientists: 2+
   Technical officers: 2+
   Collaborators: Margaret Byrne, Dale Roberts.
   Volunteers:

   Contact: Margaret Byrne **Phone:** ... **email:** margaret.byrne@dec.wa.gov.au

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist	200k	200k	200k
Technical	150k	150k	150k
Equipmant			
Vehicle	10k	10k	10k
Travel			
Other	40k	40k	40k
TOTAL	400k	400k	400k

12. **Potential funding sources:**

- ...

13. **Outstanding issues noted:**
    - ...

14. **Group:** Persistence

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: What characteristics predict persistence.**

2. **Project Aim:**
   - To understand physiological and life history stages critical to persistence.
   - To identify species / functional froups that have high plasticity versus those with limited plasticity and high vulnerability to extinction.

3. **(a) IBRA Region(s):** ...
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Persistence leading to management and selection of reserves.
   - To enable better prediction of range distributions of species under climate change.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - Modellers – incorporation into more sophisticated and targeted bioclimatic models.
   - Agencies responsible for land management.
   - ...

6. **Research program (project description):**
   66. Generate or assemble information about physiological tolerances (to changes in temperature, amount and timing or rainfall, CO2) of differing life history stages of selected fauna and flora with wide and narrow distributions.
   67. Characteristics to be investigated using correlative and experimental approaches:
       - Reproduction;
       - Germination, recruitment, dispersal;
       - Life cycle stage tolerances;
       - Finctional group responses.
   68. Plasticity (genetic base) of selected species and functional groups.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - To use species with wide and narrow ranges as identified from historical and genetic analysis.

8. **Related projects:**
   - Persistence 1 Historical evidence for persistence.
   - Persistence 3 Genetic variability & adaptive capacity.

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: ... **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3

Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ...

13. **Outstanding issues noted:**
    - ...

14. **Group:** Persistence

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: New genetic frameworks for adaptive restoration.**

2. **Project Aim:**
   - Link physiological and genetic variability across environmental gradients with potential ecological performance in newly changing environments.

3. **(a) IBRA Region(s):** Typically – agricultural of developed landscapes.
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Inform sourcing of genetic material for restoration and revegetation of resilient and adaptable communities and component species and processes.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - NRM councils, Landcare groups, Greening Australia, others involved in restoration of degraded systems.
   - ...

6. **Research program (project description):**
   69. Compare variation in adaptive and neutral genes across climate gradients.
   70. Link with key physiological traits (eg water use efficiency).
   71. Reciprocal transplant and common garden trials.
   72. Integrate outcomes for a range of species groups to develop predictive frameworks.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - Persistence: Hypothesise high levels of adaptability within populations of widespread species based on established high genetic diversity.

8. **Related projects:**
   - Requires study of a range of contrasting species in order to develop predictive frameworks.

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators: Suzanne Prober, Margaret Byrne, Will Stock
   Volunteers:

   Contact: ... **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - CSIRO post-doc program.
    - ARC linkage.

13. **Outstanding issues noted:**
    - ...

14. **Group:** Persistence

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Physiological & genetic variation of species (plants & animals).**

2. **Project Aim:**
   - To determine the physiological tolerances and functional genetic capacity for semi-arid biota.

3. **(a) IBRA Region(s):** Many.
   (b) NRM Region(s): Rangelands.
   (c) DEC Region(s)/District(s): Pilbara, Goldfields, South Coast.

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Knowledge underpinning principles of persistence & transformation.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - Biodiversity managers – relates to reserve system & ecosystem dynamics.
   - ...

6. **Research program (project description):**
   73. Determine variation in key physiological traits associated with climate parameters across species range and in common garden / translocation experiments.
   74. Determine variation in functional genes for traits associated with climate parameters across species range.
   75. Identify synergies between expression of physiology and gene diversity within species and between co-distributed species and between parapatric species.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - Many species have persisted through many historical climate cycles, and may therefore have broad physiological tolerance and high adaptive capacity. This underlies potential for persistence or lead to transformation.

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists: 4+
   Technical officers: 4+
   Collaborators:
   Volunteers:

   Contact: Will Stock **Phone:** ... **email:** ...
   Margaret Byrne
   Phil Withers, Peter Spencer, Dale Roberts (animals)

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist	400k	400k	400k
Technical	300k	300k	300k
Equipmant			
Vehicle	20k	20k	20k
Travel			
Other	60k	60k	60k

TOTAL	780k	780k	780k

12. **Potential funding sources:**
    - ...
13. **Outstanding issues noted:**
    - ...
14. **Group:** Arid / Semi-arid

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Physiological responses of co-occuring species.**

2. **Project Aim:**
   - To determine whether locally endemic species are more susceptible to climate change that co-occuring widespread species. Similarly: compare ancient to recently evolved species.

3. **(a) IBRA Region(s):** ...
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - ...

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - ...
   - ...

6. **Research program (project description):**
   76. ...

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: Grant Wardell-Johnson **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ...

13. **Outstanding issues noted:**
    - ...

14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Physiological thresholds and potential of genetic adaptation in keystone species.**

2. **Project Aim:**
   - To examine the physiological thresholds and potential for genetic adaptation to drought and high temperature.

3. **(a) IBRA Region(s):** SW WA.
   (b) NRM Region(s): SW WA.
   (c) DEC Region(s)/District(s): SW WA.

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Determine thresholds and genetic potential of keystone species (persistence, ecophysiology, ecological genomics).

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   Land managers & water managers:
   - Land managers.
   - Scientific publications, websites, popular media.

6. **Research program (project description):**
   77. Testing ability for root growth as dependent on local soil water potential.
   78. Select individuals from extreme ends of climate range and determine physiological thresholds to stress (drought, high temperature) and potential genetic differentiation between populations from extreme ends – choose keystone species from a diversity of functional groups.
   79. For short-lived species -> start breeding program for tolerance to drought / high temperature to ascertain how fast adaptation can occur.
   80. Phenotypic plasticity in drought / high temperature related traits.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - Survey of glasshouse studies on drought and temperature tolerance & breeding strategies.

8. **Related projects:**
   - Reciprocal translocation & common garden experiments.

9. **Personnel:** Number depends on number of species and communities chosen.
   Scientists: Plant ecophysiologists & plant breeders.
   Technical officers:
   Collaborators: Various Australian academic institutions.
   Volunteers: Many opportunities.

   Contact: Pieter Poot **Phone:** 9380 2491 **email:** pieterp@plants.uwa.edu.au

10. **Data custodian:** Pieter Poot (UWA & DEC)

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist@	50k	50k	50k
Technical	25k	25k	5k
Equipmant	50k	5k	50k
Vehicle	2k		
Travel#	2k	2k	2k

Other	5k	5k	5k
TOTAL	134k	87k	67k

@ 1 PhD & 1 supervising scientist
# conferences & visiting colleagues

12. **Potential funding sources:**
    - ARC linkage (with DEC).
    - WA & Commonwealth government climate change initiative funding.

13. **Outstanding issues noted:**
    - ...

14. **Group:** Transformation

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Categorising plant functional groups: potential responses to prolonged heat and drought stress.**

2. **Project Aim:**
   - To collect (or collate) hydraulic, morphological and plant water relation data as it relates to co-occuring species in response to periods of water and heat stress. To be conducted at several locations representing "typical" vegetation types and focal species.

3. **(a) IBRA Region(s):** Sandplain vs forest vs inland woodlands.
   (b) NRM Region(s): Sandplain vs forest vs inland woodlands.
   (c) DEC Region(s)/District(s): Sandplain vs forest vs inland woodlands.

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - ...

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - ...
   - ...

6. **Research program (project description):**
   81. Seasonal measurements of plant water relations cold be conducted over 2-3 summer periods.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - Plant functional groupings are a useful tool for cat.egorizing species based on the their ecophysiological (morphological) attributes. Knowing something about the functional response will help us predict and model changes in ecosystem function based on species / functional group composition.
   - Functional traits of widespread vs restricted species.
   - Adult vs seedling responses

8. **Related projects:**
   - Similar projects being conducted at UWA, ECU & CUT
   - Project knowledge needs to be combined and supplemented with the aim of using the data to predict functional response (with this proposed project).

9. **Personnel:**
   Scientists: Phil Groom (CUT), Ray Froend (ECU), Will Stock (ECU), Pieter Poot (UWA).
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: ... **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			

Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ARC linkage with DEC.

13. **Outstanding issues noted:**
    - ...

14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Biosecurity & biodiversity under climate change.**

2. **Project Aim:**
   - Identify biosecurity risks for biodiversity in WA.
   - Identify and trial adaptation responses to potential biosecurity risks.

3. **(a) IBRA Region(s):** All.
   (b) NRM Region(s): All.
   (c) DEC Region(s)/District(s): All.

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Listing of biosecurity risks with justification for priorities across all biosecurity areas (pests, weeds, diseases).
   - Identification of risk assessment methods applicable to biodiversity.
   - Identification of responses which minimize biosecurity threats.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   Land managers & water managers:
   - Land managers.

6. **Research program (project description):**
   82. This project is essentially a biodiversity equivalent of ARWA Project 12.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - This project is essentially a biodiversity equivalent of ARWA Project 12.

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: John Scott **Phone:** 9333 6647 **email:** john.k.scott@csiro.au

10. **Data custodian:**

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - WA & Commonwealth government climate change initiative funding.

13. **Outstanding issues noted:**
    - ...

14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: How climate change interactions with other threatening processes could affect persistence of species / biodiversity.**

2. **Project Aim:**
   - Identify how the impacts of existing threatening processes on species and ecosystems could be altered by climate change.

3. **(a) IBRA Region(s):** All.
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Greater understanding of the how climate change may affect existing threatening processes in WA.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - Land managers.
   - ...

6. **Research program (project description):**
   83. Down-scale climate change scenario models to provide details of likely climate conditions across WA by 2050 and 2100.
   84. Determine how the changing climate conditions will increase, decrease or not affect existing threatening processes.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - Assemble knowledge relating to climate change impacts on other threatening processes: fire regimes, plant diseases, hydrology, invasive species ...

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: ... **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**

- ...

13. **Outstanding issues noted:**
    - ...

14. **Group:** Persistence

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Links between land use and biodiversity conservation under climate change**

2. **Project Aim:** To understand how climate change may affect broadscale land use patterns in the arid / semi-arid zone and the flow-on effect to biodiversity.

3. **(a) IBRA Region(s):** Pilbara, Kimberley, possibly Goldfields
   (b) NRM Region(s):
   (c) DEC Region(s)/District(s):

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - A risk assessment framework for assessing new land use proposals in rangelands and northern ecosystems.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   Land managers & water managers:
   - Policy makers & land use planners

6. **Research program (project description):**
   85. Rainfall is expected to increase in northern areas of WA under climate change projections. This has prompted political and industry interest in enhancing agricultural production in the north, which may involve introduction of new crops.
   86. New crops may in themselves affect biodiversity if introduced on a broad scale in rangeland systems. Additionally, they may cause changes to fire regimes that potentially affect plant and animal communities (eg gamba grass results in more intense fires in tropical savanna; further spread of buffel grass ... *lost line on photocopy* ...)
   87. Compare contemporary remote sensing data with historical data in CIS environment to document changes in patch size, number and distribution.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:
   Contact: Adrian Pinder?

10. **Data custodian:**

11. **Budget Estimate [anticipated expenditure]:**
12. **Potential funding sources:**

13. **Outstanding issues noted:**
    - ?
    - ?

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: The effect of climate change on the distribution of P cinnamomi in WA.**

2. **Project Aim:**
   - To determine the predictive spread and impact of Pc under differing climate change scenarios.

3. **(a) IBRA Region(s):** ...
   (b) NRM Region(s): Northern Ag, Swan, South West, South Coast
   (c) DEC Region(s)/District(s): Swan, Midwest, South West, South Coast

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - DECSDKA 2..21.
   - Understand the threat of Pc to WA's biodiversity under changed climate conditions.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - DEC, NRM, LGAs, utilities, industry.
   - Direct information provision through professional networks including the Dieback Consultative Council.

6. **Research program (project description):**
   88. Undertake a literature review on the biology and epidemiology of Pc.
   89. Use current distribution data and projected climate change scenarios to model the predictive spread and impact of Pc in WA

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - Review all literature on Pc biology & epidemiology.
   - Model likely changes in the climate of WA in relation to PC spread and impact.

8. **Related projects:**
   - DEC: "The epidemiology of Pc on the south coast of WA."

9. **Personnel:**
   Scientists: Chris Dunne, Bryan Shearer.
   Technical officers: Colin Crane.
   Collaborators: Giles Hardy, Bill Dunstan.
   Volunteers: .

   Contact: Chris Dunne **Phone:** 9334 0308 **email:** chris.dunne@dec.wa.gov.au

10. **Data custodian:** DEC

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist	15k		
Technical			
Equipmant			
Vehicle			
Travel			
Other	15k		
TOTAL	30k		

12. **Potential funding sources:**
    - DEC, CPSM@ Murdoch U, WWF

13. **Outstanding issues noted:**
    - ...

14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Ecosystem services of remnant vegetation.**

2. **Project Aim:**
   - To determine whether the ecosystem services delivered by small vegetation remnants (eg wind breaks, erosion control) will change under climate change conditions.

3. **(a) IBRA Region(s):** ...
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - ...

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - ...
   - ...

6. **Research program (project description):**
   90. ...

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: Senthold Asseng **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ...

13. **Outstanding issues noted:**
    - ...

14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Grazing impacts on remnant vegetation.**

2. **Project Aim:**
   - To determine how occasional grazing during extended dry periods could affect the biodiversity values of of small vegetation remnants (eg wind breaks, erosion control).

3. **(a) IBRA Region(s):** ...
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - ...

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - ...
   - ...

6. **Research program (project description):**
   91. ...

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: Senthold Asseng **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ...

13. **Outstanding issues noted:**
    - ...

14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Water balance of remnant vegetation.**

2. **Project Aim:**
   - To determine how climate change could affect water balance of small vegetation remnants (eg wind breaks, erosion control) and its interaction with agricultural land.

3. **(a) IBRA Region(s):** ...
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - ...

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - ...
   - ...

6. **Research program (project description):**
   92. ...

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: Senthold Asseng **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ...

13. **Outstanding issues noted:**
    - ...

14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: The nature of refuges in the ??? of climate change.**
- **Conceptia Refugia**
- **How important will areas of topographic complexity be in acting as climate refuges.**

2. **Project Aim:**
   - Have areas of topographic complexity in WA acted as climate refuges during past climate change and what will their role be with future climate change.
   - To identify the importance of aggregated versus dispersed refuges.

3. **(a) IBRA Region(s):** ...
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Verification of current refugial concepts.
   - If dispersed refugia are real this opens a whole new approach to biodiversity conservation and reservation.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   Land managers & water managers:
   - Natural resources managers.
   - Other researchers.

6. **Research program (project description):**
   93. Choose target areas (eg based on expert opinion, preliminary data, first principles):
       - The Cape Range embedded within Pilbara-Midwest because of historical & predicted drying;
       - Granite outcrops across the rainfall gradient in the SW because of historical & predicted drying;
       - Drainage systems on the South Coast because of because of historical & predicted drying;
       - Rainforest patches in the Kimberley;
       - Subtle hydrological gradients ??? (mort?) of area not encompassed by topographic complexity.
   94. Test the refugial concepts with climate modeling and microclimate measurement ... ??? (a) the GCMs to force meso-scale climate models to predict regional climates over study target areas and then measure micro-habitat variability and environmental gradients in target areas. (b) Test the concept of refugia with expanded phylogeographic data sets.
   95. Pull together existing species distribution data and undertake pattern analysis to identify areas of species richness and phylogenetic diversity and to assist with choice of study sites.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:

Volunteers:

Contact: ... **Phone:** ... **email:** ...

10. **Data custodian:**

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ...

13. **Outstanding issues noted:**
    - Refugia non-adaptive persistence response.

14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Refugia – testing the hypothesis.**

2. **Project Aim:**
   - What is the evidence for the refugial hypothesis?

3. **(a) IBRA Region(s):** ...
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - ...

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - ...
   - ...

6. **Research program (project description):**
   96. Look for evidence of refugial sites across a region (eg) from high rainfall to lower rainfall, keeping other environmental factors constant. Eg: granite outcrops: evidence from geography, phylogeny, species composition, physical environment, watershed ...

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: Grant Wardell-Johnson; Colin Yates; Margaret Byrne **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ...

13. **Outstanding issues noted:**
    - ...

14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Dry refugia in a wetter climate.**

2. **Project Aim:**
   - Identify refuge areas where there may be no change or range expansion with predicted climate change:
     1. identify current dry refuge areas;
     2. identify species that may expand in distribution under climate change;
     3. model how species within these dry refugia may expand in the future;
     4. what management strategies could be put in place to allow transformations of this type.

3. **(a) IBRA Region(s):** ...
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Research issue: transformation – how will ecosystems / communities in an area change? Species that will expand in range as a response to climate change may represent a natural transformation of ecosystems.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   Land managers & water managers:
   - ....

6. **Research program (project description):**
   97. Use regional climate models to identify areas of dry refugia in current wet climate conditions
   98. Collect field data on climate variable such as temperature & rainfall to show dry refugia in otherwise wet environments.
   99. Use predictive statistical modeling methods to identify how the range of some species might expand with future climate change predictions.
   100. Compare predicted species ranges with current distribution.
   101. Investigate non-climate barriers (such as fragmentation) to species expansion.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: Jos Fissioli **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			

Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ...

13. **Outstanding issues noted:**
    - Species distribution modelling focus

14. **Group:** Refugia

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Identifying historical climate refugia in arid semi-arid region using genetic markers.**

2. **Project Aim:**
   - To identify historical refugia, for priority inclusion in a climate aware reserve system.

3. **(a) IBRA Region(s):** Many.
   (b) NRM Region(s): Rangelands.
   (c) DEC Region(s)/District(s): Pilbara, Goldfields, South Coast.

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Identification of refugial areas that should be included in the conservation estate.
   - Proof of a method for identifying such areas.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - Biodiversity managers – relates to reserve system definition.
   - ...

6. **Research program (project description):**
   102. Identify 5 species of plants and animals that are widespread in an arid zone region and that are likely to have had ***various (can't read word)*** distribution under past arid climate phases.
   103. Assess ***levels (can't read word)*** of population – level gene variation using suitable markers, to attempt to identify potential refugia (narrow area of high genetic variability) for each species.
   104. Assess commonality of patter from #2 (above) – are there multispecies (common) refugia, or does each species a unique history..

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - Research question: where will species contract to?
   - Where are future potential habitats located in relation to present distribution of species?
   - Relates to persistence / contraction of species and reserve design.

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists: 2
   Technical officers: 2
   Collaborators:
   Volunteers:

   Contact: Dale Roberts **Phone:** ... **email:** ...
   Margaret Byrne

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist	200k	200k	200k
Technical	150k	150k	150k

Equipmant			
Vehicle	10k	10k	10k
Travel			
Other	40k	40k	40k
TOTAL	400k	400k	400k

12. **Potential funding sources:**
    - ...

13. **Outstanding issues noted:**
    - ...

14. **Group:** Arid / Semi-arid

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: The impact of climate change on island biota and the future role of islands as refugia.**

2. **Project Aim:**
   - Identify projected climate change risks to WA's offshore islands.
   - Identify which island species are most at risk from climate change.
   - Provide information useful for future island management to ensure retuention of island biodiversity values.

3. **(a) IBRA Region(s):** ...
   (b) NRM Region(s): Rangelands ++.
   (c) DEC Region(s)/District(s): Pilbara, Midwest ++?.

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Defining protocols for translocations that incorporate climate change considerations.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   Land managers & water managers:
   - Land managers – DEC, oil & gas industry.

6. **Research program (project description):**
   105. WA islands are recognized as important, relatively undisturbed, refuges for a range of biota, including seabirds, turtles, mammals, invertebrates and many plants – endemic taxa, some threatened.
   106. Focus of this project could be Barrow and Bernier & Dorre Islands:
      - Barrow: higher sea level, wetter, hotter.
      - Bernier & Dorre: higher sea level, drier, hotter.
   107. Issues include changed fire regimes (drier, more lightning strikes), beach disappearance / growth due to sea level change, maritime influences (moderating), and some species at the edge of geographic range (eg Banded hare wallaby, Ash grey mouse, Loggerhead turtle).
   108. Source populations for translocation to other *... lost line in copying ...*

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - Good information about species on islands.
   - How global and regional climate change will affect key locations.
   - How climate change will directly impacts on biodiversity.

8. **Related projects:**
   - Fire regimes.
   - Translocations.

9. **Personnel:**
   Scientists: 1.0 FTE
   Technical officers: 1.0 FTE
   Collaborators: Many: oil & gas industry, DEC regional staff.
   Volunteers: Many opportunities.

   Contact: Keith Morris **Phone:** 9405 5259 **email:** keith.morris@dec.wa.gov.au

10. **Data custodian:** Keith Morris, DEC Science.

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist	100k	110k	115k
Technical	80k	85k	90k
Equipmant	30k	30k	35k
Vehicle	30k	30k	35k
Travel	20k	20k	25k
Other	10k	10k	10k
TOTAL	270k	285k	310k

12. **Potential funding sources:**
    - Oil and gas industry.

13. **Outstanding issues noted:**
    - ...

14. **Group:** Refugia

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Relictual species – their fate under climate change.**

2. **Project Aim:**
   - To determine the fate of relictual species under climate change.

3. **(a) IBRA Region(s):** ...
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Generate knowledge about the likely fate of relictual species under climate change: contraction to refugial sites? Persistence in place? Movement to anticipated new location?

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - ...
   - ...

6. **Research program (project description):**
   109. ... predictive modeling ...
   110. ... target life history strategy (eg long-lived vs short-lived) ...

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: Jos Fissioli **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ...

13. **Outstanding issues noted:**
    - ...

14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Dispersal barriers in the arid & semi-arid zone.**

2. **Project Aim:**
   - To understand which landscape features may act as barriers to dispersal of organisms with different life-history traits.
   - How will these barriers be altered by surrounding land uses?
   - How can these land uses be adaptive or sympathetic to biodiversity in the face of climate change.

3. **(a) IBRA Region(s):** ...
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - ...

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - Conservation land managers, managers of pastoral lands (pastoralists, mining companies), land use planners.
   - ...

6. **Research program (project description):**
   111. ...

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators: .
   Volunteers: .

   Contact: ... **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ...

13. **Outstanding issues noted:**

- ...

14. **Group:** Persistence

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Relative adaptability of species.**

2. **Project Aim:**
   - Dispersal ability & pollen exchange between and within relictual species vs co-occurring widespread species. Genetic variation in populations. Are relictual species less adaptive?

3. **(a) IBRA Region(s):** ...
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - ...

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - ...
   - ...

6. **Research program (project description):**
   112. ...

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: Jos Fissioli **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ...

13. **Outstanding issues noted:**
    - ...

14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Species movement – opportunity or risk.**

2. **Project Aim:**
   - Develop the scientific basis for resolving policy issues arising from climate-induced dispersal or translocation.

3. **(a) IBRA Region(s):** All.
   (b) NRM Region(s): All
   (c) DEC Region(s)/District(s): All.

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - A framework for assessing whether a species dispersing naturally or with human support (translocation) is an actual or potential pest or outbreak species or is contributing ecosystem resilience in the new area.
   - Understand the potential that species new to an area could detrimentally affect species already present in the area.
   - Understand the potential impacts of climate change on a species being actively translocated to a new region.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - Decision-makers, policy analysts, conservation planners, land managers.
   - ...

6. **Research program (project description):**
   113. ...

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists: ...
   Technical officers: ...
   Collaborators: ...
   Volunteers:

   Contact: ... **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**

- ...

13. **Outstanding issues noted:**
    - ...
14. **Group:**

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Adaptive restoration & maintenance of ecosystem & landscape function.**

2. **Project Aim:**
   - Identify management options to optimize species and ecosystem persistence & adaptability at site & landscape scales.

3. **(a) IBRA Region(s):** Agricultural & developed or degraded landscapes.
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Practical adaptive management options, possibly including greater imperatives for existing activities such as revegetation

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - Land managers, Catchment councils, Landcare groups, etc.
   - ...

6. **Research program (project description):**
   114. Identify processes limiting survival in drying / changing environments.
      - Eg: Groundwater-dependent vegetation, reduced capture of limiting resources, especially moisture due to degrading processes, dispersal issues.

   115. Identify and test potential management options to enhance key functions.
      - EG Soil amelioration; corridors.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - Build on strong body of prior knowledge on restoration & revegetation in degraded landscapes.

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators: Suzanne Prober, Lynley Stone, Jeff Richardson, Will Stock.
   Volunteers:

   Contact: ... **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ...
13. **Outstanding issues noted:**
    - ...
14. **Group:** Persistence

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Developing best practice in species translocation under climate change.**

2. **Project Aim:**
   - Provide a mechanism for persistence of vulnerable species whose range will contract to a critical size under climate change.

3. **(a) IBRA Region(s):** All.
   (b) NRM Region(s): All.
   (c) DEC Region(s)/District(s): All.

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Defining protocols for translocations that incorporate climate change considerations.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   Land managers & water managers:
   - DEC, land managers, threatened species network, community groups, AWC - CSIRO.

6. **Research program (project description):**
   116. Review previous translocations of fauna (state, national, international) to identify current best practices.
   117. Address how current best practices should be modified under climate change:
      - What types of models are appropriate for species with narrow ranges?
      - Recognize that multiple translocations may be necessary for persistence.
   118. Research the methods available to prioritise which species are most likely to require and to have the potential be successfully translocated – genetic diversity, fecundity, generation time, range connectivity.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - Previous translocations of fauna (state, national, international) to identify current best practices.

8. **Related projects:**
   - Projects measuring phylogenetic diversity.
   - Ecophysiological investigations of species tolerances.
   - Established or planned translocations.
   - Species distribution modelling.

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: Nicki Mitchell **Phone:** 6488 4510 **email:** njm@cyllene.uwa.edu.au
   Mark Cowan 9405 5184
   Jeff Richardson

10. **Data custodian:**

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ARC Linkage.
    - ARC discovery.
    - NRM.
    - OCC.
    - CSIRO Climate Adaptation Flagship.
    - Industry.

13. **Outstanding issues noted:**
    - ...

14. **Group:** Persistence.

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Social factors in implementing climate change adaptation management for biodiversity.**

2. **Project Aim:**
   - Identify and understand public perception issues that will impact on climate change adaptation management, particularly in relation to biotic translocations and transformations.
   - Identify, at all levels of government, policy and legislative barriers and enablers to implementing climate change adaptation.
   - Inform the public and policy decision-makers about legislative and sociological changes that will be needed.
   - Inform climate change communicators about the expectations of major stakeholders.
   - Identify different stakeholder groups (including indigenous groups) and the approaches needed for each.

3. **(a) IBRA Region(s):** All.
   (b) NRM Region(s): All.
   (c) DEC Region(s)/District(s): All.

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - A more informed community in relation to the achievement of biodiversity objectives under climate change.
   - Widespread community engagement in management for transformation in biological communities.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   Land managers & water managers:
   - Users: the broader community and governments at all levels.
   - This project is about the best means of technology transfer.

6. **Research program (project description):**
   - Research program is outlined under "Project Aim" (above).

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - Experience in land care, salinity abatement, weed management – published & unpublished.

8. **Related projects:**
   - There are potential links with projects related to economic benefits of ecosystem function, and biodiversity in general.
   - Projects looking at public perceptions of biodiversity assets and values.
   - ARWA project (DAFWA, CSIRO, UWA, Murdoch, CUT).

9. **Personnel:**
   Scientists: Sociologists, communication specialists.
   Technical officers:
   Collaborators: Scientists involved with translocation & transformation experiments.
   Volunteers: Many stakeholders contacts are well-informed.

   Contact: ?

10. **Data custodian: N/A**

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other*			
TOTAL	500k		

* workshops and communication packages

12. **Potential funding sources:** WA and Commonwealth government.

13. **Outstanding issues noted:**
    - Funding proposals need to relate to the ARWA project

14. **Group:** Transformation: Allan Burbidge, Lynda Chambers, John Scott, Selwyn Willoughby.

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: GHG – C accounting.**

2. **Project Aim:**
   - Develop GHG – C accounting models & methods with application across the range of key vegetation systems in WA.

3. **(a) IBRA Region(s):** SW native forests, rangelands, shrublands, western woodlands, tropical savanna, agricultural landscapes including trees.
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Take advantage of C trading – land managers gaining payment for C sequestration.
   - Better understanding of risks associated with including Kyoto Art 3.4options in ETS.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   - Land managers, C traders and investors.

6. **Research program (project description):**
   119. Sensitivity analysis to identify most productive ecosystems.
   120. Develop GHG – C accounting methods and tools for selected areas – site specific, possible uses of remote sensing, including fire and other factors.
   121. Monitor GHG – C fluxes in selected areas.
   122. Investigate biodiversity and other ecosystem services associated with new land management options.

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: ... **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ...
13. **Outstanding issues noted:**
    - ...
14. **Group:** Carbon

WA Biodiversity Climate Change Research Project Plan

1. **Project Title: Impact of future climate on GHG – C stores in WA ecosystems.**

2. **Project Aim:**
   - Develop and apply models of the impact of climate / global change scenarios to predict the impact on ecosystems and their associated GHG – C stores..

3. **(a) IBRA Region(s):** All of key selected areas.
   (b) NRM Region(s): ...
   (c) DEC Region(s)/District(s): ...

4. **Anticipated project outcome(s) (including reference to Research Plan Table):**
   - Better understanding of changes to GHG – C stores in WA ecosystems at 25, 50, 75, 100 and 200 years into the future based on future climate scenarios.

5. **Anticipated users of the knowledge to be gained and technology transfer strategy:**
   Land managers & water managers:
   - ....

6. **Research program (project description):**
   123. ....

7. **Short summary of background research (including reference to Research Plan Table – eg Research Issue and Question):**
   - ...

8. **Related projects:**
   - ...

9. **Personnel:**
   Scientists:
   Technical officers:
   Collaborators:
   Volunteers:

   Contact: ... **Phone:** ... **email:** ...

10. **Data custodian:** ...

11. **Budget Estimate [anticipated expenditure]:**

	Year 1	Year 2	Year 3
Scientist			
Technical			
Equipmant			
Vehicle			
Travel			
Other			
TOTAL			

12. **Potential funding sources:**
    - ...

13. **Outstanding issues noted:**
    - ...

14. **Group:** Carbon

Appendix D: End of Workshop Reporting Sheets

End of Workshop comments

1. WA's Key biodiversity vulnerabilities arising from climate change impacts.

- **Direct**

Loss of species & communities through changes to climate.

- **Indirect**

Loss of species & communities through ecological changes – ie increased weeds, changes in competition interactions, etc

2. Most important research question.

What do we know about the persistence of species through climate change & associated impacts.

- **Why**

If we know the answer to this question we can develop management responses.

3. Other important research questions.

Is spatial modeling the best approach to hypothesis about responses to climate change.

4. Most important issue not discussed at the workshop.

How to deal with uncertainty in planning for climate change (discuss with Jeff Richardson).

- **Why is it important?**

Because even if all the research discussed over the past two days is done we still need to define management responses and this will include many uncertainties.

- **Why do you think it was not discussed?**

Not the right group was present – it is out of the field of those present.

5. Key WA researchers not at this workshop who should be included in future collaboration.

More managers

6. Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.

7. Data that might provide insight to climate change impacts since 1950.

Existing plots, depths gauges.

8. Any other comments.

It was excellent (for the first day at least) to have responses to management responses.

End of Workshop comments: 21

1. WA's Key biodiversity vulnerabilities arising from climate change impacts.

- **Direct**

Protection of water resources for biodiversity outcomes.

- **Indirect**

2. Most important research question.

How will climate change affect the impact of pest plants on biodiversity – weed flora – species range expansion & contraction. What species should be targeted for eradication now?

- **Why**

Increased CO2, more extreme weather events that may provide opportunities for invasion and shifting of some species, eg tropical / subtropical grasses, woody shrubs, southward.

3. Other important research questions.

Land use change and impact on management pests.
Land use change and potential benefits to biodiversity, eg perennial plantings on agricultural land that help provide connectivity in the landscape.

4. Most important issue not discussed at the workshop.

Social impacts
Public perceptions – how to engage.

- **Why is it important?**

- **Why do you think it was not discussed?**

5. Key WA researchers not at this workshop who should be included in future collaboration.

Agricultural systems scientists; forestry; social scientists; ...
Nature conservation (DEC) & EPA to shape policy

6. Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.

7. Data that might provide insight to climate change impacts since 1950.

Hydro.

8. Any other comments.

End of Workshop comments: 35

1. **WA's Key biodiversity vulnerabilities arising from climate change impacts.**
   - **Direct**

The species diversity.

   - **Indirect**

That much of the SW is fragmented.

2. **Most important research question.**

Impact of climate change combined with other threatening processes.

   - **Why**

It's very difficult to understand and manage.

3. **Other important research questions.**

What are the options for management of the biota and ecosystem functions with a rapidly changing climate.

4. **Most important issue not discussed at the workshop.**

   - **Why is it important?**

   - **Why do you think it was not discussed?**

5. **Key WA researchers not at this workshop who should be included in future collaboration.**

Marine scientists.
Research scientists from Notre Dame University.

6. **Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.**

7. **Data that might provide insight to climate change impacts since 1950.**

8. **Any other comments.**

End of Workshop comments: 24132

1. **WA's Key biodiversity vulnerabilities arising from climate change impacts.**
   - **Direct**

Narrowly adapted species – cool stenotherms(??); mesic species.

   - **Indirect**

Fragmentation; dispersal barriers.

2. **Most important research question.**

How will climate change influence the impact of other threatening processes?

   - **Why**

Because the sum of these are likely to have a greater impact than direct effects of climate change; ecosystems may be able to resist / transform more easily if they are nothaving to also cope with existing stressors.

3. **Other important research questions.**

4. **Most important issue not discussed at the workshop.**

   - **Why is it important?**

   - **Why do you think it was not discussed?**

5. **Key WA researchers not at this workshop who should be included in future collaboration.**

Andrew Storey (UWA); Barbara Cook & Peter Davies (UWA Albany)
DEC regional ecologists – at the forefront of implementing conservation actions and often good local knowledge.

6. **Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.**

7. **Data that might provide insight to climate change impacts since 1950.**

Aquatic – Andrew Storey's SW forest stream data – streams have become more seasonal / ephemeral;
Invertebrates – DEC wheatbelt wetland monitoring – inverts, veg condition, waterbirds ...

8. **Any other comments.**

End of Workshop comments: 93

1. **WA's Key biodiversity vulnerabilities arising from climate change impacts.**
   - **Direct**

   - **Indirect**

Increased competition for water use – water abstraction increases exacerbating reductions in water availability.
Further land clearing & habitat fragmentation – from the development pressures that will ikely result from the the need to re-locate coastal housing away from sea level rise & storm surge impacts.

2. **Most important research question.**

Based on current knowledge, what are the defensible recommendations for Biodiversity Adaptation Actions for WA. And what level of confidence for each recommendation?

   - **Why**

It would be valuable to compile what we can advise now based on first principle and current knowledge – and distinguish that from what areas of adaptation policy / strategy / programs that need further science before any sensible advice can be given.
So we can get on with taking the actions we already know are necessary, without unnecessary delay.

3. **Other important research questions.**

4. **Most important issue not discussed at the workshop.**

   - **Why is it important?**

   - **Why do you think it was not discussed?**

5. **Key WA researchers not at this workshop who should be included in future collaboration.**

Andrew Storey, David Morgan, Peter Davies.

6. **Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.**

7. **Data that might provide insight to climate change impacts since 1950.**

8. **Any other comments.**

End of Workshop comments:

1. **WA's Key biodiversity vulnerabilities arising from climate change impacts.**
   - **Direct**

Species loss / decline – fragmented or degraded landscapes; cool-moist distributions; edges.
Loss of ecosystem function & productivity.

   - **Indirect**

Interactions with fire regimes and invasive species.

2. **Most important research question.**

How to enhance ability of ecosystems & species to adapt to change.

   - **Why**

Low risk option with positive outcomes under most scenarios.

3. **Other important research questions.**

Genetic frameworks for adaptive restoration, plasticity etc.
Physiological response groups, key vulnerable stages of lifecycle.

4. **Most important issue not discussed at the workshop.**

Groundwater dependence & relationships with expected climate change.

   - **Why is it important?**

Understanding & predicting species responses & hence solutions.

   - **Why do you think it was not discussed?**

Fairly specific issue.

5. **Key WA researchers not at this workshop who should be included in future collaboration.**

6. **Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.**

7. **Data that might provide insight to climate change impacts since 1950.**

8. **Any other comments.**

End of Workshop comments: 101

1. **WA's Key biodiversity vulnerabilities arising from climate change impacts.**
   - **Direct**

Identification of existing data sets and current work in the area – establishment of a database.

   - **Indirect**

2. **Most important research question.**

Identifying areas of refugia and predicting what might happen to the species / assemblages within them with climate change predictions.

   - **Why**

In terms of biodiversity conservation we need to know what areas / species are most vulnerable and if we can do anything to promote resilience.

3. **Other important research questions.**

4. **Most important issue not discussed at the workshop.**

Tools available to help us understand our research questions (ie species distribution modeling).

   - **Why is it important?**

Identify who has the skills.
Identify areas we lack or will need.

   - **Why do you think it was not discussed?**

Focus of workshop was more on what the research questions or problems were – didn't move from this to look at ways to address in given time frame.

5. **Key WA researchers not at this workshop who should be included in future collaboration.**

6. **Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.**

7. **Data that might provide insight to climate change impacts since 1950.**

Permanent plots in SW – revisiting these.

8. **Any other comments.**

If the science community came to respect the importance of contributing a dataset to the same level that we hold to contributing a published paper / research outcome, then perhaps this would facilitate the sharing of data more easily. Need better recognition of "publishing a dataset".

End of Workshop comments: 99

1. WA's Key biodiversity vulnerabilities arising from climate change impacts.

- **Direct**

Species restricted to discrete refuges, water dependent: aquatic, riparian, elevated sites.

- **Indirect**

Spread of invasive species.

2. Most important research question.

Impact of climate change on current threatening processes – weeds, disease, introduced predators, etc.

- **Why**

These are already difficult to control and will be exacerbated by climate change.

3. Other important research questions.

Climate change impacts on island biota & ecosystems and their role in the future as refuges.

4. Most important issue not discussed at the workshop.

Spread of native species.

- **Why is it important?**

Competition with residents eg galah spread into SW.

- **Why do you think it was not discussed?**

5. Key WA researchers not at this workshop who should be included in future collaboration.

6. Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.

Commonwealth Dept of Climate Change.
DEWHA
Relevant CRCs, eg Invasive

7. Data that might provide insight to climate change impacts since 1950.

8. Any other comments.

A good workshop, improved my understanding of extent of climate change issues and possible solutions.

End of Workshop comments: 99

1. **WA's Key biodiversity vulnerabilities arising from climate change impacts.**
   - **Direct**

Medium term – likely massive loss of biodiversity.

   - **Indirect**

Possible loss of ecosystem services in many areas.

2. **Most important research question.**

How do we manage to maintain ecosystem services in the face of likely loss of biodiversity?

   - **Why**

If we fail, we may be faced with loss of productivity across much of the landscape, with difficulties in maintaining a sustainable environment.

3. **Other important research questions.**

Which landscape scale management actions are required? (will be different in differing landscapes).

4. **Most important issue not discussed at the workshop.**

Marine & coastal issues.

   - **Why is it important?**

Because there are important interactions between marine, terrestrial and atmospheric systems.
May be more important in northern WA – eg impact on mangrove communities and fish resources; coastal floodplains.

   - **Why do you think it was not discussed?**

Logistics & the scale of the problems and interactions.

5. **Key WA researchers not at this workshop who should be included in future collaboration.**

Marine & coastal researchers.

6. **Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.**

There are lots of potential people, not sure if any are essential.

7. **Data that might provide insight to climate change impacts since 1950.**

8. **Any other comments.**

End of Workshop comments: JDR??

1. **WA's Key biodiversity vulnerabilities arising from climate change impacts.**
   - **Direct**

Restricted species loss – because the rapidity of climate change and the likelihood that restricted species will not have enough genetic variation to respond.

   - **Indirect**

Impacts on other threatening processes: dieback, fungus on frogs, fire frequency,

2. **Most important research question.**

Disentangling assemblage composition rules & then whether species or communities shift / go extinct under climate change scenarios.

   - **Why**

We can't plan or manage for individual species nor credibly pick indicator species so we need to think about what we are talking about as communities / assemblages and whether non-plants follow vegetation patterns.

3. **Other important research questions.**

Overview of capability to make an adaptive genetic response to climate change vs moving or going extinct.

4. **Most important issue not discussed at the workshop.**

Modelling techniques to predict responses.

   - **Why is it important?**

Have to make predictive outcomes to manage responses.

   - **Why do you think it was not discussed?**

Not enough modelers or it is to o late to manage for individual responses.

5. **Key WA researchers not at this workshop who should be included in future collaboration.**

Pauline Grierson, Plant Biology UWA, who knows a lot about trophic interactions, especially in arid systems.
Jason Kennington Animal Biology UWA, genetics of capacity to respond to selection.

6. **Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.**

MKearnes, Zoology Melbourne Uni; individual species modeling based on known physiology.

7. **Data that might provide insight to climate change impacts since 1950.**

8. **Any other comments.**

Interesting exercise – good set of people to meet even though climate change is not really me!

End of Workshop comments: 97(i)

1. **WA's Key biodiversity vulnerabilities arising from climate change impacts.**
   - **Direct**

Land use changes exacerbated by climate change is the key issue for understanding the vulnerability of biodiversity.

   - **Indirect**

2. **Most important research question.**

Having a robust understanding of how ecosystems function within the hydrologic cycle and then how this function is impacted upon by climate change.

   - **Why**

To enable better information for policy development and planning of water resources.

3. **Other important research questions.**

Understanding biodiversity on its own is OK for research sake but needs to be woven into the social and economic framework for better understanding.

4. **Most important issue not discussed at the workshop.**

The availability of water is the driver for ecological and social systems and this should be the next generation of discussions, followed by management and policy.

   - **Why is it important?**

Climate change will impact on water availability.

   - **Why do you think it was not discussed?**

This workshop forcussed on getting the biodiversity research bedded down.

5. **Key WA researchers not at this workshop who should be included in future collaboration.**

Rob Donahue (Dept of Water) – aquatic systems – in-stream ecosystems.

6. **Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.**

7. **Data that might provide insight to climate change impacts since 1950.**

8. **Any other comments.**

End of Workshop comments: 57

1. **WA's Key biodiversity vulnerabilities arising from climate change impacts.**
   - **Direct**

How do we predict species responses; which species will persist, contract or go extinct.

   - **Indirect**

Impacts of climate change on other stressors.

2. **Most important research question.**

What are the genetic and physiological tolerances of species to future climatic conditions.

   - **Why**

3. **Other important research questions.**

What is the nature and role of refugia.

4. **Most important issue not discussed at the workshop.**

What / where / how is the change from managing current ecosystems to allowing / facilitating transformation of ecosystems.

   - **Why is it important?**

Need to know how to respond / manage ecosystem change at biome boundaries.

   - **Why do you think it was not discussed?**

Difficult: High level ecosystem function means it's not thought about much. Needs strategic thinking to inform policy settings.

5. **Key WA researchers not at this workshop who should be included in future collaboration.**

6. **Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.**

7. **Data that might provide insight to climate change impacts since 1950.**

8. **Any other comments.**

End of Workshop comments: 11(a)

1. WA's Key biodiversity vulnerabilities arising from climate change impacts.

- **Direct**

Impacts on WA forests with respect to its structure and function.

- **Indirect**

Impact on water resources.

2. Most important research question.

How the forest evapotranspiration will change with the increasing temperature and declining rainfall.

- **Why**

To determine how much water will be used by the forest. This is necessary to correctly predict the changes in water availability.

3. Other important research questions.

How the changing land use is going to impact on biodiversity – the competition for space and water.

4. Most important issue not discussed at the workshop.

The description of land cover using the latest technology.

- **Why is it important?**

The precise description of changing vegetation cover assists in detecting changes in vegetation and in making planning decisions.

- **Why do you think it was not discussed?**

5. Key WA researchers not at this workshop who should be included in future collaboration.

CSIRO – Land & Water Division; Remote Sensing
Bureau of Met.

6. Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.

7. Data that might provide insight to climate change impacts since 1950.

Remote sensing data.

8. Any other comments.

It was very interesting to participate in this workshop.

End of Workshop comments: JRS

1. WA's Key biodiversity vulnerabilities arising from climate change impacts.

- **Direct**

Isolated reserves.

- **Indirect**

Southern sandplains.

2. Most important research question.

What is the public perception of climate change impacts on biodiversity and what should be done.

- **Why**

Public interest = political action = funding for science.

3. Other important research questions.

How do we filter desirable invasives (ie natives spreading and adapting to climate change) from exotics doing the same thing.

4. Most important issue not discussed at the workshop.

Threat of invasives not currently invading (existing sleeper species; quarantine threat)

- **Why is it important?**

New climate = new set of invasives.

- **Why do you think it was not discussed?**

Difficult – largely in the realm of risk assessment.

5. Key WA researchers not at this workshop who should be included in future collaboration.

ARWA scientists – see Andy Patterson @ DAFWA

6. Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.

CSIRO Climate Adaptation Flagship – contact Andrew Ash or Trevor Booth.

7. Data that might provide insight to climate change impacts since 1950.

Invertebrate data sets

Forest: Jarrah leaf miner – see Janet Farr re Mazanek & Abbott data
Autumn gana?? moth

Pasture (1950s): Red legged earth mite & lucerne flea & predators – see John Scott re J Ridsdell-Smith data

8. Any other comments.

Excellent workshop.

End of Workshop comments: 97.3

1. WA's Key biodiversity vulnerabilities arising from climate change impacts.

- **Direct**

Loss of biodiversity.

- **Indirect**

Incapacity to do anything useful to prevent it -> focus on adaptation.

2. Most important research question.

Do we really know why a single organism is where it is?

- **Why**

Error bars may make most of our management actions have dubious value – fiddling while Rome burns.

3. Other important research questions.

Where is it better to not manage, or manage with benign neglect.

4. Most important issue not discussed at the workshop.

Whether it is worth trying to understand the change that will happen.

- **Why is it important?**

Because our knowledge may not be able to change one thing, and there are far more important issues, such as food and fuel availability.

- **Why do you think it was not discussed?**

Because we would be out of a job if we didn't come up with something. We're biologists, dammit. We're committed legally and morally to do something but the sad truth may well be that we can do little except minimize anthropogenic disturbance and let Nature respond to what man has caused. We must still try to work to protect what we have.

5. Key WA researchers not at this workshop who should be included in future collaboration.

6. Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.

7. Data that might provide insight to climate change impacts since 1950.

Better soils data & physiological data.

8. Any other comments.

End of Workshop comments: 54

1. WA's Key biodiversity vulnerabilities arising from climate change impacts.

- **Direct**

Effects on biodiversity of changes in water availability associated with climate change: volume, season & annual variability.

- **Indirect**

Interaction between climate change and other threatening processes – land use, CO2, atmospheric N deposition, weeds, etc.

2. Most important research question.

Genetic & physiological tolerances of local fauna and flora.

- **Why**

Needed to improve predictability of prediction models.

3. Other important research questions.

Interaction between CO2 and water availability – rainfall (all aspects), ground water and ecosystem balances.

4. Most important issue not discussed at the workshop.

Where to go with predictive modeling.

- **Why is it important?**

Needed to gain credibility (more certainty) with projected species changes.

- **Why do you think it was not discussed?**

Composition of workshop members.

5. Key WA researchers not at this workshop who should be included in future collaboration.

Dr B Wilson: DEC, Gnangara Sustainability Strategy.
Dr L Valentine: EUC, Reptile habitat, weed invasion.
Dr R Standish: MU, undertaking a project on restoring banksia woodland under climate change using rainout shelters
Dr Hugh Pringle

6. Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.

Prof Lesley Hughes

7. Data that might provide insight to climate change impacts since 1950.

Changes in plant pathology – bird migration data – evidence of range reductions (plants & animals)

8. Any other comments.

End of Workshop comments: 42

1. **WA's Key biodiversity vulnerabilities arising from climate change impacts.**
   - **Direct**

   - **Indirect**

2. **Most important research question.**

How to minimize the costs of climate change to biodiversity & sustainable human development.

- **Why**

Human impacts may lead to increasingly compromised decision-making regarding biodiversity conservation.

3. **Other important research questions.**

4. **Most important issue not discussed at the workshop.**

Devising a framework of information management to maximize research options and information reuse.

- **Why is it important?**

To reduce the time and effort to develop proposals for which supporting data is absent; to avoid duplication in resource-limited circumstances.

- **Why do you think it was not discussed?**

Does not fit easily within high-level framework discussions on research priorities since it is a support function at a more detailed level of project specification.

5. **Key WA researchers not at this workshop who should be included in future collaboration.**

6. **Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.**

Dr Guy Midgley, SA

7. **Data that might provide insight to climate change impacts since 1950.**

Changes in weather patterns especially significant indicators for biodiversity eg frost days.
Changes in fossil water reserves & water tables.
Changes in fire regimes.

8. **Any other comments.**

End of Workshop comments: 39

1. **WA's Key biodiversity vulnerabilities arising from climate change impacts.**
   - **Direct**
   - **Indirect**

2. **Most important research question.**

Plant – water use under increased CO2 and temperature and low rainfall.

- **Why**

Will affect how much rainfall will end up in streams and groundwater.

3. **Other important research questions.**

What is the nature and role of refugia.

4. **Most important issue not discussed at the workshop.**

South-west forests – how much will it transform under differing climate scenarios.

- **Why is it important?**
- **Why do you think it was not discussed?**

5. **Key WA researchers not at this workshop who should be included in future collaboration.**

6. **Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.**

7. **Data that might provide insight to climate change impacts since 1950.**

Stream flow
Rainfall
Temperature
Sea level
Pan evaporation
Forest fire frequency

8. **Any other comments.**

End of Workshop comments: DG

1. **WA's Key biodiversity vulnerabilities arising from climate change impacts.**
   - **Direct**
   - **Indirect**

2. **Most important research question.**

How will climate change impact on human livelihoods. It has been discussed indirectly - -> it is more about effective communication.

- **Why**

This will help maintain Government focus on the issue and help direct funding.

3. **Other important research questions.**

4. **Most important issue not discussed at the workshop.**

How to create a mechanism to continue broad stakeholder engagement. Perhaps create an inter-agency forum on climate change.

- **Why is it important?**

The momentum to collaborate must be kept.

- **Why do you think it was not discussed?**

5. **Key WA researchers not at this workshop who should be included in future collaboration.**

6. **Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.**

7. **Data that might provide insight to climate change impacts since 1950.**

Remote sensed data.

8. **Any other comments.**

A very interesting workshop -> provided an opportunity to strengthen relevant research questions.

End of Workshop comments: 25

1. WA's Key biodiversity vulnerabilities arising from climate change impacts.

- **Direct**

Coastline – wetlands.

- **Indirect**

Fragmentation
Low dispersability of many species in relation to the speed of climate change.

2. Most important research question.

What is the ability of species to persist with predicted climate change scenarios.

- **Why**

Mostly modeling approaches so far – need some real data on

- physiological tolerances
- genetic potential
- manipulative field experiments

3. Other important research questions.

In what way is climate change going to affect existing stressors – identification of most vulnerable communities – brainstorming / surveying management options.

4. Most important issue not discussed at the workshop.

Changing public perception of the speed of climate change, its effects and the urgency of action (major changes in our current societies).

- **Why is it important?**

Because it will do more in terms of preserving biodiversity than most of the research suggested.

- **Why do you think it was not discussed?**

Because scientists think more about their research and grant money than about their role as independent thinkers in society.

5. Key WA researchers not at this workshop who should be included in future collaboration.

Erik Veneklaas (UWA)
Kingsley Dixon & Siegy Krauss (BGPA)
Neil Enright

6. Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.

7. Data that might provide insight to climate change impacts since 1950.

Aerial photography
Satellite imagery
For local ecosystems: older people's perception of change.

8. Any other comments.

End of Workshop comments: 37

1. **WA's Key biodiversity vulnerabilities arising from climate change impacts.**
   - **Direct**

South coastal species/ communities already confined by rainfall and temperature to the cool / wet conditions of that region.

   - **Indirect**

2. **Most important research question.**

Systematic allocation of priority to options across all scales from biomes to local communities.

   - **Why**

To target R&D investment to where greatest benefit will accrue.
To give lead to operational investment in management.

3. **Other important research questions.**

Identification of complementary benefits (eg sequestration options) and assessment of these as added factors in priority.

4. **Most important issue not discussed at the workshop.**

   - **Why is it important?**

   - **Why do you think it was not discussed?**

5. **Key WA researchers not at this workshop who should be included in future collaboration.**

6. **Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.**

7. **Data that might provide insight to climate change impacts since 1950.**

8. **Any other comments.**

End of Workshop comments: PH

1. **WA's Key biodiversity vulnerabilities arising from climate change impacts.**
   - **Direct**

Cool moist adapted flora & fauna.

   - **Indirect**

Human responses – develop scenarios based around governance & attitudes (and probably consumption patterns). Then apply these to our understanding of biodiversity.

2. **Most important research question.**

See answer for 1 Indirect (above).

   - **Why**

3. **Other important research questions.**

How question: the process of doing research in a sharing collaborative way will exponentially improve the quality of the outcome by allowing for a more widespread dissemination of what is important and what is not.

4. **Most important issue not discussed at the workshop.**

See 3 above ...

   - **Why is it important?**

... allowing for a more widespread dissemination of what is important and what is not.

   - **Why do you think it was not discussed?**

Because we are not trained to think of how we should work together (and our institutions do not allow it ...)

5. **Key WA researchers not at this workshop who should be included in future collaboration.**

Social scientists, health & biodiversity researchers.
Apart from Pc we did not discuss diseases & vectors & pathogens at all – not just human but all of them. Health professional would enhance such a discussion.
Social science would improve the reality of human responses.

6. **Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.**

I haven't named people but rather suggested the types of people who would contribute.

7. **Data that might provide insight to climate change impacts since 1950.**

8. **Any other comments.**

End of Workshop comments: 4

1. **WA's Key biodiversity vulnerabilities arising from climate change impacts.**
   - **Direct**

Water delivery from natural and semi-natural ecosystems.

   - **Indirect**

Dislocation between key ecosystem processes resulting in non-functionality & / or non-sustainability of biological assemblages.

2. **Most important research question.**

What will be the impact of climate change interactions with other global change stressors be on biodiversity.

   - **Why**

This is the top level question, in that this group can develop their research frameworks from.

3. **Other important research questions.**

How do we adapt or mitigate the impacts of climate & global change on biodiversity.

4. **Most important issue not discussed at the workshop.**

Interaction of global change with climate change esp elevated CO2.
Conceptual ecological frameworks within which to develop research questions.

   - **Why is it important?**

Many biodiversity issues are first threatened by other global change factors and only second by climate change.
Synergies / interactions between global change and climate change factors are going to determine outcomes.

   - **Why do you think it was not discussed?**

Political reasons.

5. **Key WA researchers not at this workshop who should be included in future collaboration.**

6. **Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.**

7. **Data that might provide insight to climate change impacts since 1950.**

8. **Any other comments.**

End of Workshop comments: G W-J

1. WA's Key biodiversity vulnerabilities arising from climate change impacts.

- **Direct**

South west high rainfall environments – species, associations and ecological communities.

- **Indirect**

Interactions between climate change and already existing and emerging threats (eg fire & phytophthora).

2. Most important research question.

What and where are the refugia? (Both in the sense of species withdrawal to and expanding out of dry-loving refugia in wet environments to being winners in a drying environment in the wet south west)

- **Why**

Need to understand and manage.

3. Other important research questions.

Structure, composition and function of ecological communities.

4. Most important issue not discussed at the workshop.

Integrating knowledge and databases – to develop decision support tools which integrate social and ecological in a participatory sense.

- **Why is it important?**

Future decision-making will be more complex and take place in a more complex world with more implications.

- **Why do you think it was not discussed?**

No social scientists at workshop.

5. Key WA researchers not at this workshop who should be included in future collaboration.

Angela Wardell-Johnson
Scientists listed in Terrestrial biodiversity climate change adaptation network proposal.

6. Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.

As above.

7. Data that might provide insight to climate change impacts since 1950.

8. Any other comments.

Enjoyable workshop.

End of Workshop comments: JAD

1. WA's Key biodiversity vulnerabilities arising from climate change impacts.

- **Direct**

Loss of aquatic ecosystems in SW due to drying climate – lack of water.
Sea-level rise – loss of coastal wetlands.

- **Indirect**

Competition for water for anthropogenic use -> less water available for aquatic ecosystems.
Climate impacts may amplify existing pressures - eg weed invasion, fire frequency & intensity.

2. Most important research question.

Can we distinguish the impact of climate change on selected aquatic ecosystems from other stressors – eg eutrophication, salinisation, acidification, pollution?

- **Why**

We need to know how systems are responding to climatic changes to managed them, to decide if intervention is necessary or possible and to inform policy and planning decisions.

3. Other important research questions.

How are ecological processes in aquatic systems affected?
What are the life history and other traits of keystone or icon or dominant species that will make them resistant / vulnerable to climate change impacts?

4. Most important issue not discussed at the workshop.

Icon species – not discussed.
Different to keystone species – icon species may engage wider community with respect to support for research / management.
How can we enhance collaboration?

- **Why is it important?**

We need to have the big picture – across habitats, biota and ecosystems.

- **Why do you think it was not discussed?**

Difficult area to consider.

5. Key WA researchers not at this workshop who should be included in future collaboration.

Michael Coote – DEC
Kerry Traylor – DoW
Prof Richard Hobbs – MU
Dr Vicky Cramer - MU

6. Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.

7. Data that might provide insight to climate change impacts since 1950.

Wetland monitoring on Jandakot & Gnangara groundwater mounds supported by DoW.

8. Any other comments.

End of Workshop comments: 15

1. WA's Key biodiversity vulnerabilities arising from climate change impacts.

- **Direct**

Lack of topographical refugia.
Lack of elevation.
Fragmentation of many landscapes.

- **Indirect**

Increase in abundance of invasive species – eg cat, fox, rabbit.
Competition for water between human / agricultural needs vs maintenance of ecological communities.

2. Most important research question.

What proportion of short range endemics have high diversity in functional genes.

- **Why**

If diversity is high, then species may have the capacity to adapt provided generation times are short. If diversity is low, then managers will need a basis for assigning conservation priorities to which species are translocated & which species will be left as is.

3. Other important research questions.

How will legislation to conserve species be modified? When will it be modified given that loss of many species is inevitable?

4. Most important issue not discussed at the workshop.

How much finding is likely to be available?

- **Why is it important?**

Helps to determine the scale of a project.

- **Why do you think it was not discussed?**

No-one knows yet.

5. Key WA researchers not at this workshop who should be included in future collaboration.

Peter Newman & other members of the Sustainability Institute.
Christoph Hinz – UWA.

6. Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.

Michael Kearney – U Melbourne
Ari Hoffman – U Melbourne
Hugh Possingham – UQ

7. Data that might provide insight to climate change impacts since 1950.

Climate models that test whether clearing the wheatbelt for agriculture contributed to modifying the climate of SW WA. If there was an effect, what magnitude is it compared to predicted climate change?

8. Any other comments.

End of Workshop comments: 25

1. **WA's Key biodiversity vulnerabilities arising from climate change impacts.**
   - **Direct**

The likely inability of species already occurring on the margins of their preferred range to adapt to increasing temperatures & / or decreasing rainfall.

   - **Indirect**

Interactions between existing stressors & climate change – eg fire, weeds, Pc,

2. **Most important research question.**

How much do we currently know about effects of climate change (including elevated CO2 and sea level rise) on ecosystems and do we have the right data / tools to deal with the issues.

   - **Why**

Need to assess current base before moving to more complex & unknown issues.

3. **Other important research questions.**

Interactions between species, climate & other processes.

4. **Most important issue not discussed at the workshop.**

Community perceptions of the value of biodiversity.

   - **Why is it important?**

Need to effectively implement / conserve / transform ecosystems / biodiversity & to change / influence policy.
Feeling of a current disconnect between younger generation / city dwellers & the environment.
Belief in some / many that there will be a technical fix for everything.
More & more humans are expanding urban areas & using non-urban areas.

   - **Why do you think it was not discussed?**

Less "science" based & mix of people present did not include social scientists / educators.

5. **Key WA researchers not at this workshop who should be included in future collaboration.**

Educators, social scientists, science communicators, fire researchers.

6. **Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.**

Dick Williams (NT) fire & biodiversity & climate change.
Tim Lowe – invasive species & climate change.
Elvira Poloczanska / Nick Hobday (Hobart) marine & climate change.

7. **Data that might provide insight to climate change impacts since 1950.**

Data from literature, museums, amateur naturalists, etc

8. **Any other comments.**

End of Workshop comments: 7

1. WA's Key biodiversity vulnerabilities arising from climate change impacts.

- **Direct**

The likely inability of species already occurring on the margins of their preferred range to adapt to increasing temperatures & / or decreasing rainfall.

- **Indirect**

Interactions between existing stressors & climate change – eg fire, weeds, Pc, and the follow-on effects on biodiversity (ie species & communities).

2. Most important research question.

Do we as conservation biologists expend resources on trying to "save" species likely to go extinct in response to climate change?

- **Why**

This is a likely expectation of society which is probably a waste of resources.

3. Other important research questions.

Which species will persist with climate change and what is their functional role in the ecosystem?

4. Most important issue not discussed at the workshop.

The reliability of models to predict future scenarios.

- **Why is it important?**

Models are often used without question of their reliability (or certainty).

- **Why do you think it was not discussed?**

Lack of knowledge in terms of modeling approaches.

5. Key WA researchers not at this workshop who should be included in future collaboration.

Carl Wyrol (UWA)
Mark Garkaklis

6. Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.

Angas Hopkins

7. Data that might provide insight to climate change impacts since 1950.

WAM records.

8. Any other comments.

End of Workshop comments: 99

1. **WA's Key biodiversity vulnerabilities arising from climate change impacts.**
   - **Direct**

Species and communities already threatened.
Species and communities reliant on cool wet conditions.

   - **Indirect**

Interactions with other stressors – so as above species and communities with other threatening processes

2. **Most important research question.**

Key physiological tolerances to new predicted conditions – derived through mesocosm experiments.

   - **Why**

Will highlight those entities likely to be adversely affected.

3. **Other important research questions.**

What species and communities most vulnerable and likely to contract or go extinct and require considerable management action.

4. **Most important issue not discussed at the workshop.**

Better distribution of climate stations across WA.
Dynamic SDMs.
Population viability analysis (PVA).

   - **Why is it important?**

Need for baseline data so can correlate observed climates with species and communities current distributions / requirements.

   - **Why do you think it was not discussed?**

5. **Key WA researchers not at this workshop who should be included in future collaboration.**

6. **Key researchers from other parts of Australia or elsewhere not at this workshop who should be included in future collaboration.**

7. **Data that might provide insight to climate change impacts since 1950.**

Herbarium data.
Old data set from monitoring plots.

8. **Any other comments.**

Requirement for more climate stations to enable more climate data to fill in gaps in regions – will provide finer scale info for populating models that will five more accurate baseline data – will aid experiments.

Appendix E: Participants

Files to big to email, will be included in final PDF version

Appendix F: Presentation images

Files to big to email, will be included in final PDF version