



Landcare
ACT

*Climate change adaptation
what does it mean for landcarers?*

Workshop Report

Disclaimer

Landcare ACT Ltd, and its Directors, agents, contractors and employees do not guarantee, and accept no legal liability whatsoever arising from or connected to, the accuracy, reliability, currency or completeness of any material contained herein. The material in this report is intended to provide general background information arising from the workshop which is the subject of this report. The information does not purport to be complete. Information arising from this survey should not be considered as advice or a recommendation. Before acting on any information the user should consider the appropriateness of the information and its limitations.

Ownership

Unless otherwise noted, copyright in this publication is owned by Landcare ACT Ltd.

With the exception of (a) the Australian Government Logo and the National Landcare Logo, and (b) material where ownership is indicated as vesting in other parties, copyright in this publication is licensed under a Creative Commons Attribution 3.0 Australia Licence. This is a standard form licence agreement that allows you to copy, communicate and adapt this publication provided that you attribute the work to the Landcare ACT Ltd and abide by the other licence terms.

A summary of the licence terms is available from
<http://creativecommons.org/licenses/by/3.0/au/deed.en>

The full licence terms are available from
<http://creativecommons.org/licenses/by/3.0/au/legalcode>

Copyright for this publication should be attributed in the following way: ©Landcare ACT 2017.

Contact

For enquiries regarding this report please contact:
CEO, Landcare ACT Ltd
2 Lansell Court, Wanniasa, ACT 2903
E: admin@landcareact.org.au
ABN 30 611 732 971

Foreword

Landcare ACT (LACT) initiated our Flagship project “*building resilience in productive landscapes in the ACT region*” as one of the ways of meeting its role of serving our stakeholders, sharing knowledge and advocating for sustainable stewardship of land, that is meeting the needs of present and future generations.

The first activity under the Flagship project, the ACT Rural Landholders Survey undertaken in early 2017, identified a high level of interest in more information on climate change and its impacts.

In May 2017 LACT undertook this workshop on the topic *Climate change adaptation – what does it mean for Landcarers?* with a grant from the Australian Government’s National Climate Change Adaptation Research Facility (NCCARF). This report on the workshop captures the considerations of the day.

LACT acknowledges that this flagship project would not be possible without the support of the Australian government and its commitment to the landcare movement across Australia.

In undertaking this project LACT’s approach is a collaborative and non-aligned partnership with landholders, land managers, and community stakeholders.

I look forward to your ongoing support for our peak body and our many volunteers who carryout the necessary stewardship of our Territory.



Dr Peter Bridgewater
LACT Board Chair
May 2017



CONTENTS

Foreword	3
Introduction	5
Workshop Outcomes	6
Working together	6
Action planning.....	6
Climate-Ready Revegetation Guide	7
Conclusions	7
Attachment 1 Speakers Transcripts	8



LACT Flagship Projects *Climate change and landcare* Workshop Report

Introduction

This workshop “Climate change adaptation – what does it mean for Landcarers?” was undertaken by Landcare ACT (LACT) in May 2017 with a grant from the Australian Government’s National Climate Change Adaptation Research Facility (NCCARF).

Identified in the NCCARF National Adaptation Research Plan for Social, Economic and Institutional Dimensions¹, this ACT workshop was one of six in different parts of Australia aimed at connecting researchers with users of research in government, non government sectors and communities, around the topic “mainstreaming of climate change adaptation”.

The one-day workshop program consisted of presentations in the morning by Canberra based scientists to communicate to landcarers information about climate change in our region. Then afternoon deliberation by the participants in groups.

A pre and post workshop survey form was provided to all participants to gauge if climate change knowledge and attitudes changed due to the Workshop. The survey responses (by 18 of the 39 the participants), showed the workshop increased knowledge and awareness of climate change and its potential impact on Landcare activities, with more people likely to undertake activities such as monitoring and inspections for new weed incursions.

LACT invited landcarers from all interest areas, and the workshop was attended by 39 people including:

- 26 from community landcare groups,
- 2 from universities
- 4 from government organisations
- 7 from non-government community Landcare support organisations.

A participant profile² indicated

- 44% were in the workforce, 44% were retired
- 56% identified as being male, 44% as female
- 19% were aged 21-40 years, 31% 41-60 years, and 44% were aged 61-80.

The invited speakers were:

- Professor Mark Howden: the global challenge of climate change adaptation and how this might affect the ACT.
- Professor Peter Bridgewater: the role of Landcare in climate change adaptation
- Ms Alison Elvin: native grasses as natural adapters
- Mr Steve Taylor: weed management in the ACT under climate change.
- Dr Nola Hancock: spoke about the Climate-Ready Revegetation Guide.

The transcript of the speeches is at [Attachment 1](#).

¹ (Topic 9), Smith et al (2016), enabled by the National Adaptation Network for Natural Ecosystems

² based on response received from 18 of 39 participants



LACT Flagship Projects *Climate change and landcare* Workshop Report

Workshop Outcomes

Participants selected one of three topics for facilitated group discussions and the key outcomes are described below.

Working together

Working together – how and what do the community, government, and scientists need to do together to support Landcare in a climate change context.

Participants identified maximising resilience to climate change, adaptive management of the land should be a common goal. The suggested key priorities for how to best work together in future are:

- *Information*
Ensuring sufficient information, its dissemination and understanding by the wider community is critical, and advice needs to be consistent and standardised.
- *Consistency*
The policy position on climate change issues, needs to be consistent and reliable particularly from governments.
- *Partnerships*
 - A partnership approach is best to facilitate collaboration and action, with all partners having clear roles, equal standing and information access.
 - Potential partners include landholders with catchment groups; business with government; educational institutions with non-government bodies.
- *Funding*
Monetary support for landcare to extend its capacity for:
 - monitoring and evaluation of activities (such as revegetation) to determine if such activities are effective
 - organisational resources to ensure initiatives reflect strategic goals of both government and peak body.

Action planning

Action planning – what kinds of things do Landcare groups needed to be thinking about in the context of climate change including identifying some actions.

Participants identified key priorities for future (and or ongoing) action in climate change adaptation. The relevant entities to undertake these actions are shown in brackets.

- *Threats (all sectors - community, business, government, households)*
 - identification of the threats and assessment of risks from climate change impacts is necessary to determine priorities for action
 - fire is a formative factor in the Australian landscape and with the threat increasing, it remains an important consideration for planning and land management.



LACT Flagship Projects *Climate change and landcare* Workshop Report

- *On-ground works (all sectors - community, business, government, households)*
 - species selection for climate adaptation
 - incorporating indigenous culture and knowledge
 - reliable resources.
 - coordination and collaboration across jurisdictions and across sectors (community, governments, researchers, business).
 - assessment of effective adaptation responses (adaptive management)
- *Citizen science (government and business with the community)*
 - monitoring changes (where, what and when) is necessary to improve knowledge of climate change impacts
 - community inclusive programs are an effective mechanism for monitoring and engagement
- *Land use planning (government)*
 - Equal consideration for land uses other than urban development for example food and fibre production; nature conservation; tourism, leisure and recreation.
- *Communication (all sectors - community, business, government, households)*
 - On-going and consistent sharing of information about climate change impacts on the environment, economy and society.

Climate-Ready Revegetation Guide

How local landcare groups might use and apply the Climate-Ready Revegetation Guide.

Training was provided in the use of the online Climate-Ready Revegetation Guide³.

Participants envisioned application and use of the Guide by Landcare groups as a tool for assessment of plant species suitable for particular areas, or by Project coordinators to assist with local planting initiatives. Similarly, the Guide would have application for use by technical experts and professionals.

Other issues canvassed and considered important for climate ready re-vegetation projects were:

- Aboriginal use of fire in land management
- whether local provenance for plants is the best choice
- herbicide use under changed climate conditions
- remnant old trees retention for wildlife habitat and refuge in the landscape
- educational resources such as guidelines are desirable.

Conclusions

Information on climate change and its impacts, is desired by a broad cross section of the community. When provided with this information, there is a willingness to take actions that focus on adaptation and a systems approach to resilience.

Everyone has a role to play in responding to climate change.

³ http://anpc.asn.au/resources/climate_ready_revegetation



Attachment 1 Transcripts of speakers presentations

Professor Peter Bridgewater

LACT Board Chair opened the proceedings

I'd like to welcome you all here to this workshop, there is still one or two to come in, but given the state of the weather, it's not for climate this morning, I'm not that surprised. I see there are one or two faces in the audience that I haven't seen for decades, but I'm sure I'll catch up with you at morning tea at some point or another.

As usual in these events I'd like to acknowledge that we are meeting on Ngunnawal Country and pay my respects to traditional elders past and present and acknowledge any Aboriginal people in this room. And as the Vice Chancellor of the University of Canberra said the other day when he was making a similar acknowledgement, we shouldn't just get into the system of using these words as wrote, we should actually think about them seriously and when we say respect we should think about what that means. Maybe in some of the talks we'll get into a bit more about that.

Welcome to you all here this morning, I think it's going to be a very interesting workshop and I'd like to acknowledge particularly, Anne Duncan, the CEO of Landcare ACT who at very short notice identified the funding opportunity to get some money to bring all this together and has worked tirelessly to get the organisation to this level and it really has been incredibly well organised, so Anne thank you, thank you very much indeed [applause]. It was in a sense a bit happenstance to see this funding opportunity so I have to acknowledge the two funders, The National Climate Change Adaptation Research Facility which, if you don't really know what it is, they have a very nice logo and I'm sure you can Google them to discover more, and The National Landcare Program. With that I will close these opening remarks and hand back over to Peter, I was going to say Peter two, I better say Peter one or I get into trouble, to outline how the day will unfold, thank you.

Peter Stafford:

Thank you, Peter. I thought I'll just start with introducing myself again, Peter Stafford and I'm your facilitator for the day. Essentially, this morning we're going to do an exercise shortly which I'll discuss, we've got five presenters I'll be starting standing that will basically set the scene for building our knowledge and our understanding of schools, set the big picture firstly and in saying that we've got a wealth of experience in this room to draw from, which will basically be the mainstay of our discussions and following on from the speakers.

I might mention one thing, towards the second part of the day where we're talking about what we can do at a group level or a larger group, large delivery level. There's a couple groups to be formed, so selected for those and then we'll talk about that but there's also another group which is about collaboration, because for climate change, LandCare ACT believes that collaboration will be critically important and there's a number of stakeholders both sister organisations, such as [indistinct – 4.07] Bidding Australia, Conservation Volunteers and others and there's also significant groups that I might mention we were lucky here to have Professor Ian Falconer, who is the chair of the ACT Region Catchment Management Coordination Group, and having people like that trying to guide us into



LACT Flagship Projects
Climate change and landcare
Workshop Report

drawing things together will be incredibly valuable. Ian is also a member at one of the Landcare groups that are present here today.

That sums up the program. I might introduce the exercise that we've got to start with and as you know there's a questionnaire that's been provided and it's in two parts, before we start and after we finish, it's purely voluntary but if you would share that questionnaire with us at the end of the day by leaving it with us we'd really appreciate that, it will help inform how we travel as a group over the day and the benefits or otherwise of the opportunities that we're still yet to pursue in terms of developing this journey about adaptation. I should have said the purpose of the workshop clearly is working together to work out ways to adapt in the face of climate change, and what does it mean for Landcare.



LACT Flagship Projects *Climate change and landcare* Workshop Report

Mark Howden

Climate change in our region

Biographical notes: Dr Howden is Director of the ANU Climate Change Institute and works primarily on climate impacts and innovative options for systems with agriculture, food security, natural recourses, ecosystem, biodiversity energy, water and urban systems. He helped developed the national intergenerational greenhouse gas inventories which are the basis of the Paris Agreement and he has worked on climate variability, climate change, innovation and adoption issues for up to 30 years in partnership with industry, community and policy groups, and he's been a major contributor to the intergovernmental panel on climate change since 1991.

This morning what I'm just going to do is a quick introductory presentation, I'll cover a little bit on what's happening with our climate and why, what might happen in the future and a little bit on higher level issues to do with impacts and adaptation. I do that because I know that Nola and Peter and others are going to cover some of the detail in terms of adaptation options a little bit later.

In giving this talk, I'm drawing together work from many people. Just a really quick move through some of the elements; one of them is that the cause of climate change, that's the greenhouse gas emissions that humans are producing, keep on going up. They're going up a little bit slower as this graph would show, then they have been in the past but they're still going up. What this shows is just the carbon dioxide component, carbon dioxide being the main greenhouse gas, and you can see this going back to 1990, it's been going steadily up, there was a little glitch there with the Global Financial Crisis in 2008 and then within a couple of years it was back essentially on the previous trajectory.

You can see that over the last few years it's starting to flatten out a little bit, that's actually a really good news story and that flattening out is largely because of things like fracking, the energy intensity or energy density of electricity production, particularly has gone down; but also through the incursion of much great renewable capacity across the globe. That little flattening out is a really good sign, but flattening out of the carbon dioxide concentrations does not reduce the carbon dioxide at concentration of the atmosphere. What happens is that it just slows down the growth, but to actually bring climate change down we would actually have to bring that graph way down below the 22 mark, which is on the bottom of that graph and down towards zero. Whilst we're anywhere in this range we're just adding more and more carbon dioxide to the atmosphere and that can't be taken up to the full extent by the ocean and by the biosphere and so more and more is left in the atmosphere.

And to give you a feel for the sort of scope of that change is when I was born the carbon dioxide concentration was about 310 part per million, it's now about 407 parts per million. Within one lifetime we've added almost 100 part per million of carbon dioxide, almost a third of the total carbon dioxide concentration preindustrial has been added in my lifetime.



LACT Flagship Projects *Climate change and landcare* Workshop Report

Of course we've known for a long time over 100 years that if you add carbon dioxide to the atmosphere you're going to warm the Earth so this is new information, we've actually known that since 1842 and this graph just shows the long term, month by month, changes in temperature, global temperature, that's been happening and you can see this put together by Ed Hawkins from the U.K. and you can see particularly in the last few years we're getting pretty close to 1.5 degrees Celsius. This is 1.5 degrees Celsius, that ring around here and last year several months were almost at 1.5, which is the aspirational Paris target. If you look at the last few years, 2016 was a record year, which beat the previous record which was in 2015, which beat the previous record which is in 2013 and it keeps going back. We're in record breaking territory, so even though we've started to tail off those carbon dioxide concentrations the temperature keeps going up and the carbon dioxide concentration in the atmosphere keeps going up as well.

More locally if we look say at Southern Australia, the same sort of story, the temperature just keeps on going up. This is started from the Bureau of Metrology for Southern Australia and you can see that dark line is the then year moving average, it's sort of an average line and you can see that just keeps on going up and up. There is no pause in global warming and the rate of that just keeps going up and up.

We've had changes in other climate variables, for example in Southeast Australia, again Bureau of Meteorology data, that change, this is the anomaly the sort of difference from average and so average rainfall in this region is about 460 millimetres and we lost about 50 millimetres of that rainfall, this is the southern wet season, I think it's from May to October. That's roughly about one eighth of the rainfall in our wet seasons that's actually already disappeared and this has a finger print of climate change on it. If you go over to Western Australia it's actually much worse than this, they've lost about 20 percent of their rainfall over in the Southwest, as a function of climate change, this is happening already. Unsurprisingly if you've got hotter temperatures and less rainfall it's already impacting on our system, this is work from ABARES, it just came out a couple of weeks ago, and what this shows is changes in crop productivity as a function of climate change, going back several decades and in some places, so to west of here there's been about a 20 percent reduction in crop productivity as a function of the climate change as we've already seen. And that happens right around our serial rain belts, where a lot of land care activity happens.

When they can start to look at what's causing this one of the really critical things is higher temperatures. Temperatures have multiple impacts on crop growth, on pasture growth, on trees when they're revegetating and that sort of impact varies depending on the sort of activity you're involved in. But this one, this graph is looking at crop yields as a function of temperature and this is actually in central New South Wales, the location was around Parkes. What that shows is if you look at the average temperature across the growing season and compare that with yield experience in that region, you can see there's a really



LACT Flagship Projects *Climate change and landcare* Workshop Report

strong negative relationship. It's a cool growing season, about 17 degrees, averaged across the growing season you're getting about six tons per hectare, you go up four degrees or so and you're halving the crop yield. This is actually what's happening, this isn't no modelling or anything like this, it's just what's happening, and if you're going up a few extra degrees you're almost getting down to zero. In terms of climate change, at the moment even with the Paris Agreement we're looking at three degrees, maybe four degrees even, just everything else being equal, the potential for crop yields in our part of the world is actually going to be severely comprised, and remembering we've already got a bit over a degree already.

People like Richard Eckard from the University of Melbourne were looking at what's happened over the last few decades and I was saying well how does that relate to projections of future climate change and things like pasture growth? And they actually compared scenarios of climate change, coming out of the global climate models and putting it through pasture growth models and animal production models and essentially what they were finding is that the last 15 or so years, essentially, exactly the same, or pretty much the same as a 2040 scenario. Their message is that those climate changes that we expect to have in 2040 are already happening right now. And pretty much across the board that's the message is that a lot of the modelling activity underestimates the rate of change and the significance of change, severity of change that we're already experiencing. It's not overestimating and exaggerating, as often seems to be the commentary in the media, it's actually underestimating the rates of changes and the risks associated with climate change; and I'll mention one of these in relation to Perth dams in a minute.

And of course these are just some of many changes that we're seeing as a function of climate change. Other ones which I will mention briefly here:

Rainfall zones moving south, essentially the tropics and some of the rainfall moving south. We've seen increased rainfall intensity, which is an almost an automatic consequence of having hotter atmosphere. As you warm up the atmosphere it can hold a lot more water, the next financial relationship between heat in the atmospheres and the amount of water it can hold. There's two consequences of that, if you think of the atmosphere as a big bucket it takes longer to fill the bucket up so there's bigger gaps between rainfall events, and when the bucket empties there's a lot more water in the bucket, so your rainfall intensity increases. That's an automatic consequence of having a warmer atmosphere. Things like heat stress, and I'll show a map of this of increasing some places, not everywhere. Storm severity, as you have an increase energy in the atmosphere, you're getting more severe thunderstorms and more severe cyclones, so your category four and five cyclones are getting worse.

Bushfire. Extremes fires, we've got Malcolm Gill in the audience who's an expert in this but if you actually look at the fire danger index a zero to 100 scale, the Canberra fires were a 113



LACT Flagship Projects *Climate change and landcare* Workshop Report

on that scale, the Black Saturday fires were 180 on that scale and in that same year we had an event across Southern Australia which was 215 on that scale, this is a zero to 100 scale and we were getting 215. Those changes are happening really, really fast and much, much faster than anyone would have predicted, if we actually would have gone back ten or 15 years and said we're going to have an event of 215 across Southern Australia people would have just laughed and said there's no way is that going to happen, but it's already happening.

If we actually look at climate related insurance events, they've actually quadrupled the hydrological and climatological hazards so that insurance side of things has really been exposed. We've seen changes in animal and plant distributions, in Australia and across most of the globe, there's thousands of example of changes in things like distributions and phenology and seasonality of plants and behaviours of animals, including pest and disease spread, we've seen natural resource impacts in some places. There's a whole stack of things which are changing and as a result I've sort of tried to send this message, just like Australian Securities in Investment Corporation says, past performance is not necessarily a good predictor of future performance in the same way we need to be thinking our past climate is not necessarily a good predictor of our future climate and we need to start thinking of how do we actually operationalise that in things like land care.

As a result if you just the little dot point at the bottom, in almost any system if you don't match your input, your management, your strategy, with the prevailing environment, now weather that's a climate environment or a technical one or a policy environment you overdo one of two things, you either incur unnecessary risk in terms of your operations or you underperform compared with what you could otherwise do; and for most organisations whether it's a business or a government neither of those is a particular palatable proposition. So we need to find out, how can we actually start to deal with climate changes that are happening already and again come down that pathway faster and faster.

Now to give you a bit of a feel for, in a sense, the urgency of this, this is a study that came out less than two weeks ago by a couple of people down in Melbourne, Henley and Keith, and what they had there is over a series of years going 2000 up to 2030 or so, this is the existing temperature graph, going up here this is global and then these lines, the blue and the red, are different phases of the Pacific. There's a thing called the Pacific Decadal Oscillation, operates on a roughly ten year phase and it's like a super El Nino system in the Pacific; and if it's in the warm phase, that's the red line, we could actually reach 1.5 degrees global temperature as quickly as 2026 - that's nine years away. So this is right in front of us, if we have this aspirational Paris target, effectively, there is no way at this point that we can actually meet that target. I would actually say that there's almost no way we can actually achieve two degrees at that current rates of emissions and these changes are not 2030,



LACT Flagship Projects *Climate change and landcare* Workshop Report

they're not 2050, they're like in the next decade. That's how quickly things are changing and in a sense how quickly we need to start responding.

Now just a few slides on future change here; obviously water is a critical one right across Australia and these graphs, I've got three of them, which just show the change in runoff per degree Celsius, given that we've already had a one degree Celsius impact you just need to interpret that but if we're going to say a Paris like three degrees then you take these numbers and multiply by them by three, that's the sort of idea. This is on runoff, which in a sense roughly equates to river flows and the medium estimate; this is the middle of the global climate models, remembering that they tend to be underestimates of change, medium estimates. This part of the world is minus ten, if you've got a three degree scenario you're going to lose 30 percent of your rainfall, over in the west it's minus 25, a three degree scenario means you'll lose three quarters of your run and up the north it's less clear. If you actually look at the best case scenario coming from this analysis; up in the north it's positive, you're getting increased rainfall, but down in this part of the world it's pretty much neutral, there's no particular sign one way or the other. But this is the worst case scenario and which tends to be where we're heading a bit more. As you can see down this part of the world it's a 20 percent per degree change, if we have a three degree scenario we're going to lose potentially 60 percent of our river flows. Over in the west it's a 30 percent per degree; and you might think well that's exaggerating what can happen but if you actually at Perth's dams, the long term inflows of those dams are about 330 gegalitres in the year, they're down to about 12, 13, 15 depending on the year or reading. Like a 96 percent reduction in inflows or reading largely as a function of climate change.

These are scary but they're not exaggerations if anything they tend to be underestimating the risks. If you look at the fire around the ACT this is work that Geoff Kerry from ANU did quite a long time ago now, but looking at the current climate, the historical records of fire interval and Ben did a scenario of a relatively modest change, I think it was like two degrees change, and that sort of change results in very significant change of fire regimes which needs to be included in fire planning and understanding the impacts on the ecosystems. If we look at things like heat stress, frequency, heat stress impacts on people if you're working outside particularly, impacts on animal production, impacts on plant performance, this is work I did last century [laughter], I've been working on this stuff for a while, if you look at the top left that's the historical frequency of heat stress days, up in the north about 70 percent of days are heat stress days, that's right at the top end, down in the south it's relatively benign, so less than ten percent. So in this case, around 2.7 degrees Celsius scenario, this is like Paris Agreement type scenario, if everyone does the right thing according to our Paris commitments at the moment, and right across the top end, pretty much every day becomes a heat stress day. If you're thinking about developing the top end, I don't know about you, but I think this is a pretty important thing to understand, and if you're looking down at Canberra, we've gone from the nice blue into the sort of conditions that use to be



LACT Flagship Projects *Climate change and landcare* Workshop Report

experienced outside of the Queensland border, so think Goondiwindi coming down to Canberra in terms of heat stress and if you've worked Southern Queensland you'll know that it is a fundamentally different environment in which to work outside than Canberra is, so really significant changes in those sorts of variables.

I've got a couple of slides here dealing with soil erosion, salinity, weeds, and species distributions and selection. But this is a really quick snapshot of what are often quite complex issues. In terms of things like soil erosion, the risk is likely to increase as a function of climate change, this is both due to reduced ground cover, because of that more difficult plant growth environment, but also because of that higher rainfall intensity associated with that big bucket emptied more heavily on our systems, rainfall intensity is a critical driver for soil erosion. In terms of dry land salinity probably a good news story which we've already seen, that risk in many cases is actually compliant because of the reduction in winter rainfall, the cool season rainfall and that risk made to climb further with one caveat, and that's in really low fertility environments where plants don't grow particularly quickly, higher levels of carbon dioxide significantly reduce the stomatal conductance, that reduces the amount that they evaporate, even though you might actually have less rainfall, you might actually increase your recharge in those really low fertility environments. In high fertility environments where plants can grow quickly there's an offset of that stomatal conductance element there, it's not so bad as it may otherwise be.

In terms of weeds, not surprising distributional changes, so things moving south and to some extent towards the coast from their existing distributions. New weed environments for weeds to invade because there's new combinations of environments, which the existing species may not be able to us as effectively. Potentially increasing competitiveness, particularly c4 plants, summer growing plants, versus your temperate species, your c3s, and a relatively little known part of picture is that elevated carbon dioxide, particularly seems to impact on the effectiveness of glyphosate herbicides, your Roundup and Zeros and those things. At the same time you're getting increased weed risk, some of our key tools for managing those weeds are likely to decrease in their effectiveness. Of course, if you've got increased extremes, that tends to increase the ability for weedy type species to disperse and also in some cases to establish. That I think on balance the sort of weed issues are going to increase in terms of their concern and the effectiveness of our management needs to be real on top of that.

In terms of species selection a really brief rundown and Nola's going to cover this a little bit more in her talk but the plants that grow best in the environments of the future may well be different for what's there now and this is not a new idea, I think this has been around for probably two decades or so, but I think it's important to put that in the discussions and revegetation guide that Nola's going to talk about already has these sorts of elements,



LACT Flagship Projects *Climate change and landcare* Workshop Report

climate adaptive versus climate predicted strategies about how you go about revegetation and conservation activities.

I mention this because there is that potential for conflict between different sets of values here. If you have a value set which is about conservation of species, your genetics and prominence or a conservation of particular plant communities and how those communities are structured with particular elements in there, that could well be different from a value set which is actually about having a functional plant set of species there as well. These are different value sets which need to be reconciled in some way; and again that's not a new idea, but I think it's important to raise.

The last point on the biodiversity side of things, this is a huge topic which I'm really collapsing, just mentioning that the approach that's taken to assessing biodiversity and climate change risks is often really highly dependent on the methods that are being used. This is something I presented quite some years ago now, but it was just taken three methodological approaches of looking at where biodiversity hot spots and climate change, so high risk areas may be across Australia and if you take a diversity based view you're going to get the Northeast Rainforests, the Alps and the Southwest are really critical areas where issues might arise.

If you take a community based view you end up with something like this, and if you take a dissimilarity indexed base view, like Simon Ferrier, you actually end up with the critical areas then up in Northwest and they're fundamentally different results about what are the places to focus on and what are the issues to focus on, and they're dependent entirely on methods. And I was talking with Nola just before and just saying for me that's really problematic. If as a land care group you go and engage with ANU you're probably going to get a different answer than if you do and engage with the CSIRO or if you're going to Melbourne University, or Queensland University, because everyone has their own methods and they all give different results and so how do you actually start to operationalise that; it's the same sort of issue about the global climate models that I mentioned before that made the underestimating rates of change and that how do you actually operationalise these decisions when you've actually got problems, systemic problems in the underlying information base that you're using. It's actually a pretty difficult thing to deal with.

In the last five minutes, just a couple of slides about adaptation, in the face of all of those sorts of changes along with all the other things that are going in our landscapes we will need to really think hard about climate adaptation, that's why it's such a good thing to have this workshop today. And if we actually look at other sectors in Australia including agriculture and sometimes groups like Defence they're already very active in terms of thinking about climate adaptation and putting in place the mechanisms needed to deal with both the change that's existing and the future changes that are coming. Generally speaking our assessment as a science community and those people that are working on it, is that if we're



LACT Flagship Projects *Climate change and landcare* Workshop Report

on the front foot, if we're actually proactive about this you actually tend to get much better results than if you try to clean up things afterwards being reactive and so again, it's really good to think about these things right here. And generally speaking, this is across different sectors than the conservation sector is that there's usually really high benefit cross ratios, like a little bit of climate adaptation now brings you a lot of benefit, both now and in the future, and so in a sense can make you money, reduce your risks and prepare you for the future.

Unfortunately as a nation we've disinvested in climate adaptation work as virtually as just a mere fraction of what was happening say ten years ago and our equivalent nations elsewhere are building their capacity up because they actually recognise this is a fundamental issue in terms of national security, in terms of effective protection of livelihoods, effective protection of environment and their societies, so we're going entirely in the wrong direction unfortunately. There are still some groups, Macquarie Uni and New South Wales Office of Environment and Heritage and various groups around different research institutions, but they are a small fraction of the people, the effort and their effectiveness of what they used to be.

If we're actually thinking about adaptation there are some really fundamental questions which need to be asked above all of these sorts of things. The really basic ones, who adapts, what do you adapt, how do you adapt, and I'll mention how do you adapt well, and when do you adapt; so really basic strategic questions and just a couple of slides on that. The question about how do we adapt well, how do you actually think about positioning yourself and doing this in a good way and I just have last slides on this. Right across different sectors there's a huge diversity of options and are like, we have written whole books on this, just for each sector, like agriculture, and this is the sort of agriculturally orientated thing, you can have adaptation, which is on farm or off farm, on reserve, off reserve; there's technical approaches, there's managerial approaches, you can do strategic or tactical, you can do incremental change to existing systems or transformational adaptation, there's institutional and social, and psychological dimensions and the list goes on. There's a whole different raft of options out there from which to choose and to choose well the things that are appropriate for your particular interests and organisations.

The reason why I actually put that fence line contrast up there is that all of those adaptation choices are fundamental on your value set, it's what you really want to achieve as an association, or as an institution, or as an individual and if you actually go on that fence line, you go up hill to the left is that the set of adaptation options for that flogger there is probably going to be very different from these of adaptation options for the person on the right hand side. Those adaptation options can vary on the scale of centimetres in this particular case; they're highly contextual and there's no one size fits all in relation to



LACT Flagship Projects *Climate change and landcare* Workshop Report

adaptation and all adaptation activities require some change in knowledge, leading to some change in action.

One of the really positive, important things we found through working with farmer groups over a long period of time is that when we work with the same group of farmers, the first farm we go up and talk adaptation it's all the technical stuff, it's all the agronomic detailed stuff, but as you go through this process with them where they actually land is that the really important thing is the strategic stuff, so it's the strategic business management and the management skills and capacity to actually implement that strategy which is the fundamentals of good adaptation. We can actually leap frog a lot of the detail and try to get the strategic right; that's actually a fundamental of what we've learnt over the last decade in terms of adaptation studies.

The last slide, is just thinking about decision paths, this is work from Andy Bryson from New Zealand, the top little diagram is just thinking about the decision path and particularly what we call path dependencies. If you do things now which actually limit your options in the future, that's often pretty dumb. What you need to think about is doing things which actually provide a pathway to build responses in an unknown future, because we don't know the future; it's actually about how you actually not knock off your options, how do you actually have adaptation strategies you implement now, which open up those future options rather than close them down. And the little diagram down the bottom is just saying, it's actually about adaptation and mitigation, the emission reduction strategies, in the end we have to do both, we have to walk and chew gum at the same time, and it's just that proposition that if we have flexible strategies, flexible adaptation strategies that respond to the unknown, are probably going to be much better bets in the long term. But it's just starting to give that sort of idea that we really need to be thinking about these things right now.

The key messages from my talk; climate is changing right now, more change is likely to happen that's going to impact on lot of things that we value including those associated with landcare and there are lots and lots of adaptation options that we can start to explore and we need to start to explore those right now, thank you.



LACT Flagship Projects *Climate change and landcare* Workshop Report

Professor Peter Bridgewater

Landcare driving climate change and action in the advocacy

Biographical notes: chair of Landcare ACT and has an extensive career in academia and biodiversity conservation both in Australia and overseas, and is currently a professor in the terrestrial and marine governance at the Australian University of Canberra. Past roles has included CEO of the Australian Nature and Conservation Agency, and at the global level Secretary General of the Ramsar Convention, Secretary of UNESCOs Biosphere Reserve Network, and most recently chair of the UK Joint Nature Conservation Committee.

So the two messages I think from us for which I hope are nicely combined are that you need to think outside the box and be prepared for the change that's coming. I want to start with a newsflash from Mulligans Flat, it was in Canberra Times yesterday, where the threatened species commissioner, 'the fenced off populations of Mulligans Flat which are now going to be increased into an even larger fenced off population were like no abound. To help us get into the long term goal of feral cat and fox across the Australian... by tackling feral cats, foxes, and fire particularly and by reconnecting habitat and rebuilding habitat, we give our species the best chance to adapt to the climate change we can't avoid'. So at least Threatened Species Commissioner has identified the climate change is about and that application is necessarily. The problem is that threatened species might not be the best way to talk about this, and I'll touch on that as we go through. I should also issue a health warning, that I'm going to be quite radical at some point in this presentation, not necessarily because I totally believe everything I say – I have been a long time bureaucrat – but because I want to make you think. And I think because that's also a message that comes through from Mark's talk: we need to think seriously about these things. And when he said that if you ask a wide variety of experts on where is the best place to do X, you might get a wide variety of answers.

In some ways we're on our own, and adaptation has to be something we do on our own and it's, in fact, what we call adaptive management. So let me start with some fancy thing from Microsoft.

Back into what, or for what, or against what. That, again, picks up on something that Mark was saying. These are questions that I think we need to think very clearly on. Adaptation, climate change, yes, but what does that actually mean? Well, what does our sponsor say, or one of our sponsors, they say terrestrial and marine iconic assets such as Great Barrier Reef are threatened in multiple ways by present day climate variability. Strategists who adapt to these changes are needed, and I think that comes through as it's about recognising, recording, monitoring, and managing ecosystem change; and as far as Landcare is concerned, all of those things are important, but particularly the last two: monitoring and managing ecosystem change. Managing for sure, Landcare is not necessarily as good as it might be in terms of monitoring, and that is something we do need to keep in mind and think about. The other thing they say is adaptation responses to climate change take place



LACT Flagship Projects *Climate change and landcare* Workshop Report

in the social, economic, and institutional contexts of society. And again, what Mark was saying, we have to think about the context in which we operate. And at the micro level, each Landcare operation has its own context and it might be different from the next door one and certainly different from one several kilometres away. So we need to think in that contextual way.

So a couple of recent scientific articles have been quite interesting in exploring some of this. One, an article in BioScience suggests in last April, where it said, 'conservation efforts traditionally were focused on protecting ecosystems within reserves and restoring degraded lands. However, climate change ignores reserve boundaries and creates a moving target: preservation and restoration. This is leading ecologist and traditional conservation strategies'. But there is part of the problem because professionally we really are challenged by models that don't measure up exactly, reality which is confounding what the models are suggesting, and the use of different models getting different answers. So we really are in a different kind of world than we were several decades ago when it all seemed rather simple.

And in one magazine produced by an international science product called Future Earth, an interesting magazine, talked about an example of wildness in natural abundance, flourishing here in abandon, practically in the heart of Rome, sustained by both neglect and stewardship: that's an interesting combination. Canberra unfortunately is so pure that we don't have much neglect, I'm sure we will.

I won't go into that, I'm trying to be nice to everybody. I could name some areas of neglect. It's talking about Rome, a very ancient city with all kinds of stuff; Canberra, we need to think about these happenstance issues as well. And finally that Reef again, Tony Hughes and colleagues in a very recent article in BioScience, 'we conservationists must no longer be seen as an attempt (inaudible) reefs in the past or to conserve their existing values, but rather to identify the parts of reefs that are essential for their continued existence. And, finally, humans main need to help with that.' So, he is actually being really positive. I'm afraid I regard him as being rather negative half the time, but here I think this article is really an interesting one. It's saying the reality. Things are going to change, and we have to help that change, we can't pretend it's not happening. In coming centuries reefs will transform into new configurations, and in fact, as for reefs, so for all sea and landscapes: we're all going to face transformational change. We don't yet know what that change will be and how we'll be able to manage for it. And I think that means Landcare needs to be a paradigm. We have to continue caring for land, but how we do it might have to change. Well, in my mind, it will have to change.

So can we to fix it? Well humanity basically is a point where we need to reinforce and reaffirm our stewardship, and I think stewardship is a really important word. It tends to be neglected a bit by the scientific community, we don't quite like it, but I think it's really important, and it's being used more and more, particularly in Europe: environmental



LACT Flagship Projects *Climate change and landcare* Workshop Report

stewardship has become now almost every... gets in many countries, governance and science; and it means that everybody is involved in looking after the land. There are many more people in Europe, much denser population than us. But when we look at where Australians are situated, we have the same problem, and so we do need to think about secure stewardship. And that means that we need to ensure that we have the model of our society and ecological management that works for where we are, who we are, and what we are, and the resources we have. And again, the word value, in that sentence, Mark touched on that very elegantly, and it really is important, it's what we value and how we value it, that is going to be important to the future.

Of course, eco-globalisation, which is basically a mixing of biodiversity across the planet, it's one of the key issues. So here we touch on something else, it's not just climate change. Climate change is the train that's coming down the tunnel at us, but it's the interaction between climate change and all the other aspects of global change. And eco-globalisation is a real world problem. In order to sustain ecosystem capacity to produce services, we do need to ensure that we're enhancing the resilience of our interests, and that does mean mending them in some cases, supporting them, managing them. Almost never does it mean preservation, which we've talked about. And protected areas, I'm sorry, but we're really going to have to rethink what protected areas are and if they will work, because they simply may not in another couple of decades. That's one of our radical bits.

Ecosystem resilience in this century may be exceeded, because not only of climate change, but with all the associate disturbances in global change. If you look at some of the planetary boundaries work which has been done by some people in Stockholm and others, one of the critical issues they identified is actually nitrogen pollution, something we forget about. But we use so much nitrogen across the world in enhancing our agricultural productivity to really high levels which is good for many people in terms of providing food, we are also poisoning the planet as a result, because a lot of it is running off, causing all kinds of ecosystem disturbances. So these are things that we need to think about. It's not just climate change we're adapting to: it's always the impact of climate change on all these other variables.

Also, everybody talks about forests, we just increase the forest, plant a few more trees, it wasn't quite as like(?), and tick a box which says, yes, I give some extra, and somebody somewhere will plant a tree, who knows who, and what that will do. Forests are important, don't get me wrong, but when they are an undervalued source on the planet, it's estimated that in fact coastal wetlands, mangrove forests, per area, sequester probably the most carbon on the planet. So we need to think about this. In the A.C.T. we have a lot of grasslands, we need to ensure their long-term survival, and that's very real because grasslands may not look like forest, but underneath what they're doing in terms of perpetuating and storing and sequestering carbon, is again, important.



LACT Flagship Projects *Climate change and landcare* Workshop Report

So you're now at that tipping point, I guess, what happens when we reach a certain point? And this is part of the problem that if you talk to politicians, they will say, and this is going back a couple of decades now, but when I did one day talk to a minister about endangered species legislation and whether it was appropriate or not, they looked out the window and said, yep, but it's not changed, nothing is changing, nothing is lost. Those trees grow back yesterday, they'll be dead tomorrow. Maybe they will, but this is the whole point, we actually sit in the system where things look as though they're not changing, unless you see some of the graphs and so on, that people like Mark produce. But people, ordinary people, do not feel this; and worse, our politicians don't feel it, so they don't get that sense of urgency. And try to understand how we're going to manage the system which suddenly goes into chaotic dysfunction. It is a real problem.

So the climate change response is not necessarily gradual. It will be sudden, plunging ecosystems into rapid and irreversible change. We do know that some species are moving, but these are actually a fraction of the earth's biodiversity. Most species are staying where they are; some may well survive, but we're going to see quite different species configurations and probably quite soon. And that does mean, again, reassessing how we think and how we approach our ecosystem. And I've used, again, that word resilience: providing we get resilience in the system, we may be able to head off some of these changes.

And I want just to put in an indigenous thought at this point: indigenous people, not only in Australia, but around the world use fire as a natural disturbance and a natural management tool for millennium; and it does play a major role in many societies. And the danger that is exacerbated by the use of fire, not necessarily in terms of how indigenous fire use was, but what is happening today using the current context in climate changing: again, indigenous people in Australia have used fire in the context of gradual climate change. How that will play out into the future, is again something to think very seriously about.

So the bottom line of all this is, and the paraphrase is one of Mark's lines as well, the only certainty is greater uncertainty in our knowledge of climate changes on the ecological and geophysical systems, and our ability to deal with that knowledge. The real problem is that all other species on the planet now depend on us finding the right solutions. There's a picture of the Jackass Penguin in South Africa wondering who the (inaudible) is. So while I'm still very brief in that, let's just go through a series of projects that were funded under various Landcare initiatives, and pick out in the coloured text the points I want to identify, because I think if we look at what's happening, how can we improve how we're doing to get into this application for it).

So first of all, here's a local one, looking at ecological restoration, there will be ecological restoration and establish a species with wetlands. So there are two things, restoration, but also a creation of a new system. Here's one in Orange: removing an environmental weed,



LACT Flagship Projects *Climate change and landcare* Workshop Report

Hawthorn, I'm genetically British so Hawthorn to me is not a weed. Replanting with local native species in grasses and record the progress, that's the monitoring thing. You don't see that too often, and that I re-emphasise. Here's another one from South East Queensland, the project where they are more engaged and knowledgeable Landcare community, they call this citizen science. You've got somebody in the frog watch in the room this morning, classic example of citizen science, and we need more of that, we need more watchers. And then here is a project from Birdlife Australia, raising awareness of the Hooded Plover, a threatened beach nesting shore bird, so awareness raising materials, workshops. These are things that we can do in addition to our hands on work in the bush. Workshops like this for, in a sense, the converted, are important; but we need to do this on a broader scale.

One of the things that happened at the Mildura Bush Week a few weeks ago was a series of talks: these were very useful, I think, in trying to raise the profile of what we as a Landcare movement actually do and what we should be doing.

And finally, up in the Kimberley, using traditional knowledge. Traditional knowledge in Australia is a very substantial body of knowledge that is sometimes sniffed at by the scientific community as being, yeah, yes, OK, but how do you validate that? You validate that by living in the same place for 60,000 years: and that's something we do need to be a lot more conscious about and we need to take a lot more notice of. So can we fix all this? Well, to use the trademark, yes we can. And by the way, on that note(?), promoting ecosystem resilience, managing human ecosystem interaction to proactively – that's again coming from Mark – embracing the cultural underpinnings of environmental management, that's our own views, our own values, developing the way governance mechanisms, and communicating clear messages. This is really important: communicating messages. Here's a message that is not clear, or at least it's ambiguous. This was Diesel fashion empire promoting what they called, a few years ago, their global warming campaign: hardly helpful. And it's a picture of some tasteful people dressed in Diesel clothes in St Marks Floods(?) in Venice with Paris from the Amazon. Can I suggest that here is a positive on global warming? That fact that if global warming goes on at a pace that it is, they will actually be thigh deep in water in (inaudible – laughing) so communication is good but not like this piece, or at least that pose.

Anyway Landcare in dealing with it in great harmony with the biodiversity and it's enabling support system. Biodiversity we have to remember is the hierarchical connection between gene species and their pests, it's very often biodiversity (inaudible) species and we forget the rest. And it's not what biodiversity is about. So in the practice of Landcare, I think what we need to do and get used to doing, is look at ecosystems, see the species, and think about the genes. So the genes are going to be what will, in the end, help species to respond and adapt to climate change or not as the case may be. And those species will in turn resort themselves into new looking ecosystems.



LACT Flagship Projects *Climate change and landcare* Workshop Report

We should also remember the four Fs. Forget threatened species: now that may sound (inaudible), species commissioner. Some threatened species we have to forget because they represent the past. We have to focus on rarities. Now rarities are not the same as threatened species: rarities are different. And they represent opportunity. Some species which are very rare or not particularly common might well become much more common in the future. We need, and this will cause some of you to swallow, favour good invasives. There are some species which will take their role in new ecosystems as we go through, and we should disfavor weeds in all kinds of places. Now the problem is, and I hope that, I'm just going to talk a little bit more about this, is how do you tell the difference between those things? But we have to try, because I think there is a difference. I've spent a lot of time working on things which are now called novel ecosystems, and some people like that and a lot of people don't. But we are actually in a world where we are going to have to deal with novel mixtures, and that is going to be one of the tricks that Landcare is going to have to learn how to deal with. And there's no book on it: it's something we're going to have to work with and learn as we go through.

So final messages: we have real problems keeping faith in the Paris Agreement – it's great for litigation – but we also need to develop these strategies for adaptation. There are solutions, but they need good will, they need wise and great understanding, and they need commitment from national and international levels of course. But this will only work if it's done at a personal and local level, i.e. what you're all doing, and what I hope you will continue to do with the increased focus on looking at what you're doing, monitoring what you're doing, and how it can be improved. We all need to watch this space, work as a community together, and we need to bring together different world views to link traditional and modern knowledge. That is, again, and emphasised... something we really should think about. The local Aboriginal Landcare work is extremely good in the A.C.T., we need to embrace that more thoroughly and support it more thoroughly. Above all, we cannot stop environmental change. It's already happening. Even if we produced no more carbon dioxide as of this moment, if everyone could stop breathing, we can't stop the environment change, it's already here and built in. So we need to adapt to what climate change throws at us and manage it well, and it's the end work of manage that's important.

So Landcare, with the right governance, the right solutions, and human will – that's your will – can achieve these ecosystem resilience mechanisms we need, and that local contribution then becomes a contribution to our planetary stewardship. It's only by local actions across the planet that we will actually be able to manage the planet successfully into the next century, which I hope not to be in. And ultimately, into a sustainable world, or else we'll be with the creatures on the right, and they're quite revolting as you can see, just waiting for us to fail. But I'm sure given the candidates here and the productivity that I hope will come through later in the day, that we will not fail, and you will all be playing your role in ensuring Landcare is a key mechanism in adapting to climate change. Thank you very much.



LACT Flagship Projects
Climate change and landcare
Workshop Report



LACT Flagship Projects *Climate change and landcare* Workshop Report

Alison Elvin

Native grasses and farming pastures, Natural Capital Limited

Biographic Notes: Alison has been passionately involved with the interface between sustainable agriculture production and biodiversity conservation committee for decades. Working as an environmental consultant and as a rural educator, Alison is in awe of the complexities and innate resilience of our landscapes, and recognises that the lifetime work in this field barely scratches the surface of what needs to be understood. Focusing on local native pasture species, this talk outlines both strategies, these remarkable plants have evolved to ensure their survival through changing environmental conditions, and their invaluable contribution to biodiversity and agricultural production.

Just thinking of the beginning of today, when we paid acknowledgement to the traditional owners, the past and present, that I'd like to add to that an acknowledgement to all the plants in this region, and animals in this region, past and present, too. Because there is a huge interconnection between the people and the plants and animals that live together in the environment, and I just thought that they also need acknowledgement.

I'm here today to basically try and sing the song of native pastures. And I'm deliberately using the word 'pastures' rather than grasses or grasslands because although we have some high conservation value native temperate grasslands left, there's not a lot; but we do have a lot of native pastures left across the landscape in private hands with varying degrees of species, diversity, and complexity. And it is my belief that we can, if we encourage the people who are the land managers of those native pastures, we can increase their conservation value while also increasing their ability to adapt to the climate change which is already with us. And I believe that the native pastures and the suite of the grasses and their forms, there are mosses, there are lichens, they're the story tellers that are telling us what's happened to this landscape through time and how they've survived change since the beginning of Gondwana. It is an extraordinary story, and as said at the very beginning, there is so little knowledge, so little knowledge. We've hardly scratched the surface of what we know about the engine room of our ecosystems, the grasses, and the suite of plants that live within.

And I want to say, well why are they important? Why should we care about the grasses? And I was interested in one of the talks before morning tea, that we think of the forests, we think of the wetlands, we think of all the big things, and we forget that they're underpinned by the grasses and their accompanying symbiotic plants that keep that soil there, that keep that soil biota alive and going. And they're just absolutely ignored almost all the time. So I'm not here to try today to convince people to conserve them because I know that many in Landcare are doing that. Why I'm here today is to try and explain the little bit of knowledge that we have so far as to how resilient they are to environmental changes including all the farming impacts that have happened, and urban impacts have happened since white settlement, and what we can do about it.



LACT Flagship Projects *Climate change and landcare* Workshop Report

I was really interested, too, in one of the early slides presented, which talked about pasture growth and talked about how pasture growth declines as temperatures increase and rainfall drops. We didn't mention what kind of pasture, and I bet it was exotic pasture. If you were to look at indigenous grass pasture, you see that as the temperature climbs and the rainfall drops, it actually increases in the amount of species and the abundance of biomass that it produces. But we are focusing over and over again on exotic species that we bring into this country in terms of our agricultural production, whereas we are not looking at what we already have. The research to date suggests that we have about 1,000 species of native grasses in this country, and we have only studied 70 of those across Australia. That's not many. And as somebody whose business relies on collecting the seed and trying to sow and germinate the seed of valued grasses among other species, we have been absolutely gob smacked at the lack of information available and the lack of research through the times of European settlement in this country.

We know that indigenous people managed grasses with fire and with grazing management for tens of thousands of years. We also know that these species probably originated in the early Gondwana continent and that they emigrated with Australia as it drifted north. So we are talking hundreds of millions of years that these plants have been on this continent. They have survived sea level rise and sea level fall, they have survived extraordinary environmental changes, and they're still here today, and yet we have done everything within our power across most of our landscape to get rid of them.

Just last week I was out on a property just outside the A.C.T. border where the person was just about to get a light plane, to spray out that red rubbish on the hill. The red rubbish on the hill was a grass called red grass, and it was seen as completely and utterly useless although all his cattle were fat and shiny and they were eating the red rubbish, because an agronomist had advised that it was not appropriate to leave on the hillside. Spray it out, kill it, and sow clover, and exotic rye grass. There would be another grass that survives everything in this country would have been gone from that little local area.

We spent 100 years researching Phalaris, we've spent virtually no years researching our own native grasses. What do our native grasses and our native pastures do? Within a native pasture, there are usually a wide sweep of species, and you can see on this very first photograph, I had the fortune to go to a farm south of Canberra, probably 100 kilometres south of Canberra, where it had never been plowed, and they had never got rid of the native pasture. And it's fourth generation, which is very, very rare. And you can see all of that green is a grass called Microlaena, weeping grass, most of you would know that: that grows in a bed of soil. As you come out of the deeper wetter soil, you will see that there's Poa tussocks, there's Corkscrew grass, and so on. The person that owns that farm is now in their 80s and they got the top award last year at Royal Sydney Show for their fleece. Now I know when they come here it's not about farming, but it is aligned and affiliated with farming and



LACT Flagship Projects *Climate change and landcare* Workshop Report

it's terribly important to realise that that landscape and the fertility that comes from those grasses and the productivity is terribly important. Can you see any erosion in that photograph? Can you see any bare ground? Can you see any weeds? What I'm trying to say, is this is a property covered in native grasses and small forms that grow amongst them, grazed for four generations, there is no erosion on that land, there is no weeds, there is no bare ground. And the waterways have returned to a chain of ponds of waterways throughout that property. It was wonderful to see what is possible.

So that's a similar property, and astonishing where they even leave all their dead trees in paddocks for habitat.

OK, this is a more familiar view probably of our country in dry sclerophyll woodlands where you've got Joycea tussocks on the very poor soil, you've got a great tongue of Themeda grass, kangaroo grass coming down the centre; there are Poa tussocks running along the creek, and in amongst it there are a wide range of other species. On that hillside alone, I counted 110 species of grassland plants. That is holding that country together. It survives 40 degree days, it survives 10 years of drought, 20 years of drought, it's had a fire through it, it has survived. What is it that allows these native grasses to survive? And one of the things that has amazed me, and when I went through all the scientific literature I could find about the genetics of native grasses, I was absolutely blown away. Because we're all very keen to have provenance species planted in the right place at the right time, and rightly so because of the genetics that's appropriate to time and place. However, the research at the moment shows that the few native grass species that have been researched actually self-pollinate, they don't cross-pollinate, but they have more than two sets of chromosomes. We're all so used to everything having two sets of chromosomes, one for the male and one for the female, apparently a kangaroo grass can have up to six sets of chromosomes which it can turn on or off depending on the environmental stresses that that plant is undergoing. Weeping grass, *Microlaena*, has four sets of chromosomes, red grass and blue grass can have flowers spikelets, so you've got one tussock of grass with spikes coming out, and when tested for the genetics of the seed on the one plant, some have two chromosomes, some have four, and some have six. Their genetic variability is apparently absolutely extraordinary and it has hardly been touched in terms of research.

Wallaby grass, I'm not used to its new name, the new name has only been around eight years, anyway, it can be a diploid, a tetraploid, and somewhere in between using triploid bridges between plants in one panel. And the research has found that within one paddock of let's say ten or 15 species of native grasses, there can be such a range of genetic variability that they don't really know what to make of it, because it goes against what we think of provenance being determined by some degree of geographic isolation. And yet, for some reason, our plants are able to adapt constantly as the environment changes. Research has been done on large areas of native grassland: it shows that in any one season, one



LACT Flagship Projects *Climate change and landcare* Workshop Report

species can dominate more than others. That the seed will be there in the soil, but it won't necessarily germinate and grow unless it's season's correct. So it's constantly resilient to the changes within it's own climate. One of the other things that's really interesting, says that's it currently believed that the genetic diversity amongst populations of the same species of native grass is more much related to specific environmental stresses and not on the distance placed between them. To me, if that isn't an argument for the ability to adapt to climate change, I don't know what is. And it goes against so much of certainly what I was taught about the interplay between genetics and evolution.

As you also know, native grasses have a... they can either be a C3 grass or a C4 grass, so it was discussed earlier before morning tea. C4 grass, as you would probably all know, is a grass that is a summer active grass, it's a perennial; all Australian native grasses bar a few, by the way, are perennial. Another recent trial had them growing everywhere. They cover the ground year in, year out. C4 is dormant in the winter, and is active in the summer. I sing the praises of C4 grasses over and over again. Let me see what I've got here, oh yes, there's one of my favourite C4 grasses, this is down the Hume Highway near Tarcutta. Now, sadly, because I'm not a very good photographer, up above, that's kangaroo grass across the front of the slide, a great swathe of kangaroo grass on a tiny little bit of what's left of a roadside cutting. Above it, is the farmed paddock, and that farmed paddock was wall to wall St John's Wort; and all that was between the St John's Wort weed and the roadside cutting was five wires of fence, in other words, nothing. But the different ways that the land was managed, I got out of the car and was so astonished, I got out of the car and walked through all that kangaroo grass to see if I could see any St John's Wort growing down the bottom between the... I couldn't. That's not to say it doesn't happen, it does. But as something to push that weed in summer, you cannot beat a great swathe of kangaroo grass, just wonderful stuff.

Oh yeah, that's another one of kangaroo grass that had been burnt in the winter, in a cool burn on a farm that I used to own, and that's some of the forms coming up in spring, as soon as the kangaroo grass thatch was burnt in a cool burn there were just so many forms that came up. That's it running through a dam: that just filtered the water magnificently as it ran into the dam. So I'll come back to that slide in a moment.

So if you... most C4 plants like kangaroo grass were considered to be useless by the early agricultural farmers and settlers. So a great deal of trouble was taken to eradicate them, they were just seen as... that you couldn't fatten the land, you couldn't fatten the cow, useless stuff, let's get rid of them. Tragically, it's very hard to find great swathes of kangaroo grass any longer, it's very hard to find great swathes of red grass, of Windmill grass, of Panic, I could list them on, and on, and on. And every time I talk to farmers they'll say, yeah but that's a waste of time.

There is a wonderful book of research, the only one I've found so far, put out by the University of South Australia, and I'm very sorry, I forgot to write it down so I'll send it



LACT Flagship Projects *Climate change and landcare* Workshop Report

through on email. It took a lot of finding, scouring the Internet: five years of research on 20 species of native grasses as to their nutritional value for herbivores. I have never read anything like it. Normally to read something like that would send me to sleep within a page. I actually stayed up all night and read table after table because it looked at all the micronutrients that are in a grass that we would go, oh, what a waste of time, Corkscrew grass, go on it contaminates the fleece, does this, does that. The micronutrients, the zinc, the selenium, I could list all the micronutrients that were found in grasses like that which we really need as mulch to go back on the ground to restore mineral balance in the soil, it's all been discredited, all been... nah that's useless. Doesn't fatten them quickly Get rid of it. Anyway, I'm going on, but...

Other things that make these grasses so adaptive to change is they depend not only on breeding sexually and producing seed, but they also have an amazing tillering system with buds just below the surface of the soil that allow them to withstand most bushfires, not the horrible intense fires that we talked about this morning, but just a bit less than that, some of the first plants you will see returning will be the native grasses because of this ability to send out tillers under catastrophic things like fire. They also produce stolons and rhizomes that allow them to go through the soil, and *Microlaena* is a very good example of that. They also have incredibly long dormancy periods in their seed if the seed falls to the ground and it doesn't germinate because conditions aren't right. In some of them, the little bit of literature I've been able to find, some species of wallaby grass are known to remain viable in the soil for up to 30 years. Now that is on par with our friends serrated tussock and African Love grass. OK? So there is a competitive advantage. But they are... because they're not a colonized species like most weed species are, they don't take every opportunity to germinate like a serrated tussock, or an African Love grass seed would, and consequently they're outcompeted. But we've found that their viability in the soil lasts for a very long time.

Another thing that is absolutely fascinating is that you have a... I wish I had one here to show you, a great big tussock of native grass, many stems, all flowering, and all being pollinated. Those flower seed start to ripen at different rates. So if you are harvesting the seed, when you harvest, let's say that patch of whatever it is, you will know that some of that seed is not ripe yet, although some of it is so ripe it's falling off. What is the adaptive advantage in that? Huge. Because you're not losing all your seeds in one fall into an environment where they may be taken away, not germinated, lost, or whatever. You kind of play your cards depending on the environmental conditions at the time. The seeds, as I say, ripen over periods of weeks, if the conditions are good they will flower many times in a season. This year, because it's so late for the frosts to come, the *Microlaena*, the weeping grass is into its fourth flowering in some places with ripe seed. How good is that? Do we let that seed fall in our pastures? No. We graze, and we graze, and we graze. So the soil bank of the native



LACT Flagship Projects *Climate change and landcare* Workshop Report

grass and native pasture seed is often not there when the catastrophe arrives like a fire. Hopefully it will be, anyway, I'll get to that in a moment.

Talked about the C3 and C4 grasses, a really healthy, vibrant, resilient, adaptive, native pasture paddock must include C3 and C4. But one of the difficulties that the farming community face with this sort of information is, well, the only two grasses any good to fatten my stock are weeping grass and wallaby grass, and they're both C3 grasses. And I'm not having any of that rotten kangaroo grass and red grass and so on. OK, what happens is you then have your exotic grasses coming into the end of summer, they can't cope in the heat, they can't cope in the dryness, and they die. And they are high fire risk. Whereas if they had allowed our C4 grasses to remain, I would hope that this would be confirmed by some of the fire studies, and again, I'm not talking catastrophic wildfire, a bit less intense than that. But the breeding of C4 pasture and native pasture often slows a fire down dramatically in summer time. Whereas a pasture of phalaris, rye grass whatever we grow in this region, it's all just dead stalks, and the fire races through it. So that's one other advantage of the resilience of these species.

Another thing that's really important in their ability to adapt is they don't require anything from us in terms of inputs. They don't need fertilisers particularly, in fact some of them will die with them. They don't need any of those things: they will just happily do what they do if we allow them to do that.

So I'll just go through some more of these slides: that's a picture of, as I said, a wallaby grass with some Corkscrew and other wallaby grasses, that sort of hillside you see very, very strangely in the A.C.T.. Sadly I've been to many people wanting to subdivide their land in this region, and wanting to put houses on, the first thing they want to get rid of is that one. Red and wallaby grass it just seen as a complete waste of time. Where they grow is on slopes of the most extraordinary skeletal soil, very rocky, no fertility, pH of about four, highly saline, why would you get rid of them? They have adapted, they are growing in conditions which might increase in climate change. That's wallaby grass, wire grass, spear grass. Spear grass is considered a complete and utter waste of time. That ground is covered, you can see a rock in the front. That used to be a rock originally. Bare rocky ground, blowing the dust in any wind storm. It's now completely covered with a nice sprinkle of the exotic Cats ear as well.

And we haven't talked – well I haven't talked at all – about the resilience of repairing of areas. And I think one of the most important grass species of riparian areas is the *Poa lab.* I'm not going to say the whole word because I can never, ever say it properly, so I'll just call it river *Poa* tussock and I hope you all know what I'm talking about, it's embarrassing, I always get my tongue caught around that species. I have been to so many farms and so many places where people thought hey, this is the best soil, alluvial, deep, get rid of that rubbish, and plowed it out, dug it out, poisoned it out, burnt it out, done everything they



LACT Flagship Projects *Climate change and landcare* Workshop Report

possibly can to get rid of it. What happens? Of course, erosion, straightaway erosion. And what I love, it comes back because it's put so much seed in the soil, that no matter how bare the people have tried to make that ground, generally it will come back. Poa tussock at the edges of water where the roots are completely inundated year round. Then you go into the watercourse and although they're not part of the native pasture necessarily, good old bulrush and (inaudible) creating a bit of a choke point naturally in a flowing body of water. They are also highly resistant to environmental change and highly resilient.

That's just a picture of a Microlaena and red grass. I often used to get down at ground level and walk alongside a cow chewing just to see what they actually chewed. And I know it sounds extraordinarily silly and it was, but gee, I learnt a lot. And they would... so that was on my hands and knees next to a cow walking. You can see... so there's C4 grass, the red grass, which is... you can see this one here, you can see the red tinge in the stem. There's lots of Microlaena, there's a little bit of exotic clover come in there, but not a lot, and there's a few of the naturalised clovers as well. And that is weeping grass, for those who don't really know, you can see what a great swathe that makes across the ground. Weeping grass is also extraordinarily nutritious so it is something you can push to farmers, but it's also a great C3 grass, highly resistant to environmental change, and resilient to it, that will also choke out weeds. And it's one of the easier grasses to sow and to get to germinate and grow.

I realise that I've only got limited time left and, of course, there's always much more to say than there is time. What I think... I was going to talk about the extraordinary advantages and I suppose the environmental services that native pastures offer all of us. But I think most of you know all that. So what I think would be more, I would like to say in the closing, would be to say how shocked I've been in the last 20 years of working with collecting these seeds and trying to grow them, is how little knowledge there is, and how little either anecdotal, on the ground, or written. And one of the things, for example, because we ran a seed business, we needed to be able to ensure the viability of our seed. So one of the things we were doing would be to send it to a laboratory in Melbourne to get them to check the viability. And we would get, initially in the early days, get results back saying, no, they won't germinate. But we stood in it in the paddock, what's going on? And it was nobody's fault. The people who... the only seed the Biofarmers seed testing laboratory in Australia that we could get to had never tested native seed. So they were still pouring on all the solutions of anti... fungicides and pesticides into the seed, stuff to break the seed cover, none of that... see they didn't need any of those, it killed them. And so we worked together to try and simulate what the environment would be offering to try and have the right temperature, to try and not have too much moisture. And then we started to get fantastic germination notes. So that was one thing, nobody knew in the last 20 years.



LACT Flagship Projects *Climate change and landcare* Workshop Report

A second thing is: if you collect the seed, how do you store it? How long does it last? Should the seed be collected on the stems and then laid down further where you want them to germinate because the stems will create some degree of mulch and microclimate for the seed to find the right conditions to germinate? There is so much unknown, so I guess to say at the end of this talk about adaptation to climate change, is the dearth of knowledge, the dearth of experience in something as critical as the ground cover of the entire region, the grasses in their associated forms; to me, the sooner that we start working on that, and understanding it, and being able to sell the message, and get it out to the farming community as well, the better. I think I'll probably leave it there.

Q&A

Q1 How can you get this information to the bulk of farmers? What avenues are we trying or can we try?

A1 I can only speak from experience, I'm afraid I'm a bit ignorant of that. There are... I find that modern land services, Landcare A.C.T., many of those bodies are actively running workshops all the time to try and educate the local rural land holders. And certainly there are workshops being run all over the state. But I better not get too political here so I'll keep my mouth shut, but there is a lack of funding, I'll leave it at that. And there's also a real push for high production agriculture that's come back, that real push to get rid of native pastures and replace them with high production pastures, is really in full swing at the moment. But obviously I can praise highly enough A.C.T. Landcare, surrounding Landcare groups, and ELS bodies all around the A.C.T., they really do run a lot of courses.

Q2 Yeah, you know the people out of the Land Institution in Kansas in the U.S. have been spending 40 years trying to develop perennial grasses for human consumption; they've been doing a lot of work on developing perennial grasses for a lot of really good reasons. You're saying that we have a whole bunch of these here already. Are they good for eating?

A2 OK, that's a wonderful question, and that was one of the many things I was going to go on with when I realised I was running out of time: there is some research going on in Victoria at the moment and has been ongoing now for about 15 years to the production of weeping grass as Australian rice. It doesn't have gluten, blah, blah, blah, all that stuff, but the problem, the real problem is one of its resilient characteristics, and that is all the seed doesn't ripen at the same time. So you want to make a commercial business out of the grain, you know that you've got to put your harvesting machine over it and get all that ripe seed. So that's something they're working on. Also, panic, and hairy panic, is actually, you would not believe it, but it is one of the highest protein grains in the world. And indigenous people used to make damper out of it, that tiny little grain that you see blown up on the stalks against everyone's fences and garages at the end of summer, it's almost definitely, a



LACT Flagship Projects
Climate change and landcare
Workshop Report

little bit of research has been done on making that into a food. The third species is the Australian millet, which is also being trialed to be made into a saleable food.

Q3 You mentioned that the early farmers, graziers, whatever, the native plantings wouldn't fatten their cattle: is that full story or I'm just questioning your indication of...?

A3 I should qualify what I said: I tend to get a bit carried away. The early graziers used to talk of the native grasses being the engine room of Australian agriculture. So the first 80 to 100 years, and the incredible wealth that we made from wool, it was all off native pasture. But once we started trying to fatten animals quickly for market, we found that if you put them in a paddock with lucerne or some high protein feed, that would fatten an animal more quickly than the slower fattening process of native grasses at the time. And it was also... I don't know whether as humans we always think the grass is greener on the other side, so if somebody comes along and says, man this Phalaris, you just should see it. So everyone goes, oh yeah, wow, you should have seen what I got for that carcass of meat or whatever. SO it's more this last century where a lot of the native pasture has been destroyed. I hope that answers your question?

Q4 Do we need a different grazing system, do we need to make our (inaudible)?

A4 OK, I know that... I don't want to use up any more time, there are many, many, many farmers; I cannot say... personally think there would be 30 to 40 percent of all farmers are now changing their grazing management systems. They are trying to look at sustainability into climate change. How can we do it so we don't get bare ground when the next drought hits or the fire comes, or whatever. So there is a big change underway. It isn't across all farming, but it is a really big change of a sort that I imagine everybody here would see as highly



LACT Flagship Projects *Climate change and landcare* Workshop Report

Steve Taylor

weeds and climate change

Biographic Notes: Steve has a long history with natural resources, prior to being weeds officer, ACT Government Parks and Conservation Service he started out in the early days of environmental bush regeneration in the early '80s, mid '80s, and he has a passion for conservation, native vegetation, and biodiversity.

I'm gonna try and draw in some lessons we learnt from the previous speakers, because I think I can with what I'm gonna give. So I'd just thought I'd start with some definition, for what are weeds, they're plants which are growing where they're not wanted, but what I want to focus this talk on, is about environmental weeds, that suppress native vegetation, there's other sorts of weeds, weeds of primary production, weeds of surf areas, weeds of forestry and so on and so forth, so what I'm talking about is, the one's that affect biodiversity, and in the literature they're sometimes called desert plants, in the American literature or impressive weeds books one.

Yes this government invests a fair amount of money besides the A.C.T. in trying to reduce the impact and spread of environmental weeds, as you can see on the slide. They are for our existing reserve system, which is the nature reserves and national parks, and then the new offsets areas, which are a much smaller area, and that actually takes up an equal amount of money, which it's interesting, 'cause that shows you that a lot of the offset's areas, are areas that haven't been managed for weeds appropriately over the years, so we prompt how it works, and that showed you how costly it is if you don't act, and have ongoing management of your land.

OK, just looking at reasons for the plant invasion, and how climate change will interact that, so there's quite a lot of literature out there, on different aspects of climate change affecting both native and exotic plants, so, there's interesting research done on how to [Inaudible 2.52] fertilization, and indications that buying types of species, will benefit more than others from that, so that will improve the competitive ability of some of our existing weed species, like English Ivy, and some of the emerging ones which used to be thought of as only more north of here, or more coastal species, such as [Inaudible]. There's, I guess, what Alison was referring to in her talk, about this tendency to want to always bring in something else, because things aren't working, so we're getting back to climate change, things aren't working, we ought to bring in something else, and that's the idea of, you know, bringing in hard yard plants from somewhere else, usually overseas, and that'll lead to, I guess, this more, a new form of product or pressure on our native plant communities, that some of those plants will become [Inaudible 3.52] then there is, there are many plant communities itself now going to be affected by climate change, it exhausts availability, as we know nature hates the vacuum, if drought stress creates, more inter-tussock spaces in our grasslands, it will be invasive species that fill that first, and that's something we need to deal with, and there's also what they call facilitation, which is, could mean changes in complex things



LACT Flagship Projects *Climate change and landcare* Workshop Report

happening with animals that, or other plants that might facilitate the spread of invasive weeds, so it's why it's interesting researching.

Um, will invasive grasses be the main climate change beneficiaries? I mean this is an example of how to grass monoculture right next to a nature reserve, and the reasons that climate change might benefit that species, as humans we do lots of things which help these plants along too, such as mowing invasive grasses when they're in seed, a great way to spread it.

One thing I looked at in the literature and I've, at the recent week's conferences I've attended, there's been a lot of talk about our high country and the mountain areas that have been, and areas which could be most severely affected by climate change, and there's indications that this is the case, because in the past, these have been a bit less disturbed, there's been what they call aligning barriers, industry and climate which is protecting the foundations, that the indications are of research, that this is going to be different, we're gonna get niches opening up which will allow plant invasion, but also movements of native species, um, a more specific study, some of you may have, some of you [Inaudible] Google, they looked at our high country, so Namadgi, Victorian Alpine parts, Kosciusko, Brindabella National Park, and they indicated these species existed there, are higher priority for control, because if ever they're gonna have increased habitat super ability with climate change, or they're gonna be better able to take advantage of climate change. So, as land managers we need to think about if we've got infestations of those species, maybe they should be our absolute priority to get them out of the high country, and for those who want to look at this thing more, Paul Downey and a number of colleagues from both, from the University of Canberra, and also the Macquarie University, they've got a very interesting website where you can look at fitness species and see what, how that suitability changes that might be under climate change scenarios, and those are some of the species that have popped up for our region as having more habitat suitability, so, one in particular that my colleague Jeff Hummly who's here, if anyone knows, he's controlling Mexican feather grass, which is *Nassella cosbi* grows a serrated tussock and we've got a program for eradication of that species, so we're trying to use as much of this information as we can to better adapting too.

These are some of the tools we try and use to get information, anything from fantastic texts through botanists and ecologists, a field day or working tools, such as the weed collector app. We're getting clear information from the ground on distribution and new infestations and that all feeds into a risk assessment matrix, which helps us make decisions on where we should put our limited resources, balancing weed risk against feasibility of control, and we're going to have to review this, because you're gonna see in a few slides, interesting things that we've been observing, and one of the various seeds mentioned. We're already seeing change in the environment, and we are actually seeing this in plant movements in the A.C.T. region, no one would ever have thought protestant care of Western, North Western New



LACT Flagship Projects *Climate change and landcare* Workshop Report

South Wales rare species could establish in the A.C.T., but we recently had to control an infestation of that. The question you ask, “Is this just a casual infestation, is it fully naturalised, and become an early invader?”. Certainly, I’ve managed to stick my fingers together when I was removing them....

One plant I never thought would become a weed species, the Spanish Lavender, as opposed to French Lavender, increasing reports of infestations on Canberra nature map, and from our staff in the field mapping.

I’ve already mentioned Mexican Feather Grass, so that’s showed up in Mr Downey’s Weed Futures Model on rare species to be concerned about in the future, so we’re putting a wild effort into eradication, we’ve got about five or six sites. As you can see there’s a lot to see.

Spanish Heath already known, being a bad environmental weed in parts of Victoria, but we’ve had to deal with some badly spreading infestations on the reserves.

These are just some of the new species that we’ve had to start managing, a lot of them I just would never of expected.

Q&A

Q1 How were these weeds spread

A1 It was clearly bird spread such as Chinese Pistachio, and as part of our approach to try and be more, I guess, on the front foot with all this, is, Jenny Connolly and I went to a talk from one of the weeds staff in Victoria, and she was talking about how they’re doing, they want to do an assessment of all the old heritage gardens in their National Parks, to make sure that there’s not high risk species in them, so we started the process here, and we discovered a number of species at some of the old tracking stations which we’d started to remove, and unfortunately in one case, a plant had already spread through the adjacent forest, over a number of kilometres, so it’s very timely that we are doing this work as well, and I think all this work will contribute to making these forest communities more resilient when they come back to us, so that we don’t have these plant invasions, and the native plants have got a chance to regenerate, and we can actually achieve things, you have the right resources and skilled people to do the work.

So I was talking to you about the early invaders, now whilst there are established weeds, I really think it’s the invasive grasses that we have to watch most closely, just because they’re quick response, they’re rapid spread, able to take advantage of resource availability when it appears quickly, they’ve got a competitive advantage at germination, that Alison alluded to, to the native grasses, because they just germinate quickly and grow quickly and that’s why bush regenerators, landcarers and rangers, often have trouble re-establishing native grasses in areas that have been dominated by exotic grasses, particularly if there’s been less grass



LACT Flagship Projects *Climate change and landcare* Workshop Report

there, and Blackberry in particular is a concern for the mountains, 'cause in areas where we've seen vegetation communities, where they're at the edge of their range, where there might be a bit more open, or if there is a fire affected, you get major blackberry spread, and that's what we saw post 2003 fires.

In small native grassland and woodland reserves skilled contractors have been employed to go in and get these spots sprayed, to stop weeds taking over the whole reserve, so that sort of management is very intensive, and it's the three of us right across this region.

So, I did a talk recently at the Academy of Science, and presented this slightly modified version of what's called the Passenger Driver of Renovation of Invasive Species, and it's, the idea of, while it's been around for a while, it's a way of looking at things, is this, so called weed species there because it's just a passenger of environmental change, or is it driving the change, and also, you can also of course have weed species that are passive drivers, so they might not arrive there 'cause we've done something to create a lot of environmental change, but once they're there, they start taking over and taking a wheel and driving the change to suit them. So, it's a very useful model actually to think through, because you get certain what ifs, well why aren't we getting native plant regeneration after a removal of weed control? Or there's been a mutual, a mutual season, so you know, [Inaudible] is not correct, and then you get to the point where with a couple of the seeds we've spoken about today, of what their invasive species ecology is termed invasional meltdown, where you see cascading effects on the passive species, and the community is no longer, no longer presentable, even above ground or below ground with what you have before, so no matter how hard you try to keep controlling the weeds, you just keep getting secondary weed invasions of, you know, colonising weed species, and that's where the concept comes in where I guess, before I mentioned the model eco system, well you just, once you control the nature of threat, the invasive species that's going to spread across your landscape, do you just accept that, that area is just going to be a model eco system, or do you invest money and time to change the environmental conditions back to what they were, so you've got a [Inaudible 18.10] that could impact some of the original species, or you draw upon some of the research that's happening, I heard a couple of weeks ago that the New South Wales [Inaudible 18.22] is looking, is looking at the genetics of a whole range of native plant species, to try and help in revegetation programs, and the next speaker will be talking about the collect courier selection of [Inaudible] species for current climate change, so maybe just accept, OK, we can't have it the original reference community, that chance is gone, so we'll go for something that is feasible, and at least it provides, it's a functional community and it provides integrated system services and it's a stable community, so that, I guess, that's something we're going to have to decide on more and more, we're going to be in that point.

And then up the top, on your right, I really feel that we're going to have to make some hard decisions, and keep areas where we're going to have to put a lot of resources in reducing



LACT Flagship Projects *Climate change and landcare* Workshop Report

both the area occupied, and the density of some of the most higher risk invasive weeds, and it will need quite a lot of sorting, but we'll have to work out our thresholds of control, so that we know, you know, if there's a huge catastrophic fire comes through here, and fire frequency increases, we know that we'll be able to cope with the exotic weed species response, and be able to control it, and not lose control of those species, and then we can create a native plant community that's resilient, and we won't be able to do that if work with simple [Inaudible] resources to do that, but we have the ability, we know how to do that, because we've had lots of successes in controlling invasive weeds over the years, when the resourcing has been stable, and all the right things have been done, minimising damage, looking after native seed banks, you know, doing your follow up control and so on. And that's it, and how interesting was that.

Q2 Would you like to talk about which might be good invasives.

A2 OK, well I guess it depends on terminologies and stuff, I mean there's already a lot of naturalised historical species out there, that we just accept, particularly herbaceous, and we just, you know, the [Inaudible] species for instance, you know, [Inaudible] weeds are even through really good native grassland, fragments they're usually present, even up in the mountains, the Snowy Mountains plan, they're present often. So, there's like a lot of native, non-local, native species, and exotic species the damage they do is minimal, they do perform a role, and we accept them, when they're there, you have to do a bit of a risk assessment on this, because there's certain species for instance, let's pick one that I was I just talking to Judy Butler about, Radiata Pine in the mountain forest, so if you never controlled that, what would happen is that it rapidly does actually increase its density in the forest areas, particularly around, areas around northern Namadgi National Park, and you get to a point where if the next big wildfire came through, it would increase the intensity in, and rapidly bring that fire into a ground fire, and would show that the earmark of the '03 fires, you go "Oh wait all the Radiata Pine's been sizzled..."

Q3 it's just that the immature trees don't survive?

A3 the amount of germination you get of Radiata Pine is quite phenomenal, so you clearly, if you've got just Radiata Pine dominating the landscape, the services you get from that landscape would be greatly diminished, and salt moderation would increase, all sorts of cascading effects might occur, and you might even end up in that invasional meltdown concept, so that's one, Mexican Feather Grass, I've never quite seen a plant spread as rapidly as that anywhere... it's astounding, luckily it's prohibited imported into Australia now, but online sales are an issue, people sell seeds through the internet, and it seems to get past quarantine, so to give you an idea of, if you were to let a species like that go, it's predicted it would overrun serrated tussock and African Rye Grass, and one of Jenny's control sites down in Morton, sold us what, four plants from Bunnings, or more, I can't remember, and she bought them in the lead up to Christmas holidays, came back from a



LACT Flagship Projects
Climate change and landcare
Workshop Report

lovely stint of six weeks at the coast, and couldn't get in her front door, because there was so much seed that went right up to the top of the door, that was lucky for us, what happened was, all the prevailing winds had blown all the seed in towards her house, there were 350 in that space of time, some had already gone to maturity and were already seeding themselves, and we removed all seed of course, top soil of her garden and the mulch, and we're still controlling it for that site, so, clearly that one you wouldn't leave. So, you do have to do a risk assessment and make some hard decisions and hopefully the models you use for the risk assessment are robust, otherwise you pay a big price.

Q4 Following that, there does seem to be an argument to agree with legislative controls over the sale of some of these plants, and I mean, I speak as one who would not only have control over the sales, but also granted fines for when they're on someone's property, and I say this as someone who's just been fined \$200 for controlling St Johns Wart, but I don't really want to get more fines myself, but I'm just wondering, to what extent we should be using the stick to control this as weed's carers?

A4 Well, yeah, you're basically right, whatever, once we decided, you know, a species is a high risk species, and it's listed under legislation, then yes it's part of a whole process of making our landscapes more resilient to be able to bounce back to themselves, we need to enforce control, I mean, Mexican Feather Grass, as a case in point, sales are slipping through with online sales into the A.C.T.

Q5 So how do you decide what to put resources into?

A5 We're choosing which species to put all the resources into, you need to have your risk assessments done really well, and luckily we do have access to some group ecological models, through our contact with the Universities, but sometimes this is, there's just this problem of what one ecologist called recently in a journal article called, Plant Likeness, because it's easier for us to relate to animals, we can often see problems with animals occurring quicker, but with weed species, not often, so it's sometimes hard to get even senior managements in government, in government environment departments, to treat issues with the seriousness they need, because of this plant likeness approach, and one example, you know, Alligator Weed in our regions is becoming an increasing problem, and yet all the assessments indicate it's a high risk. So the problem is, when some people go see a new infestation of Alligator Weed, there might not be much there initially, so their attitude is, "Oh it's not a problem, we'll come back and visit", and then that attitude, it creeps into government and it creeps into decision making with politicians.

Q6 Just on that Steve, we did have in the A.C.T. at the beginning of all the weed work, we had an excellent system going, where we had a community person and a government officer going around every nursery in the A.C.T., we actually signed them up contractual to not stop weed species, and that has fallen totally away, now we've got to start back in the



LACT Flagship Projects
Climate change and landcare
Workshop Report

industry to get some of these things off the shelf, and the only way it's going to happen is the same sort of system.



LACT Flagship Projects
Climate change and landcare
Workshop Report

Dr Nola Hancock

Climate-ready Revegetation. A Guide for Natural Resource Managers

Biographical Notes: Born and raised in the Mallee, South Australia and many decades later she found herself working in the Natural Environment Industry in Sydney as an Environmental Project Officer and a Bush Care Supervisor from local councils. As a mature age student she completed her PhD in 2013 on the role of plant provenance in restoration ecology under climate change. Since then she's worked at the Macquarie University, Sydney, as a Research Fellow of many projects within the Biodiversity Node of the N.S.W. Adaptation Research Hub and a Lecturer on Biodiversity Conservation. Nola's current research focus is on improving ecological restoration practices in biodiversity conservation in the face of climate change and she was recently lead author of 'Climate-ready Revegetation. A Guide for Natural Resource Managers'.

OK, so today, like everybody else who's presenting researching things I'm here on behalf of my co-authors so the co-authors for the 'Climate and Reveg Guide', which is what I'm talking about today, are some people you may know. Rebecca Harris, she is a modeller from the University of Tasmania; Linda Broadhurst, some of you would know her well from C.S.I.R.O. she is the provenance queen; and Lesley Hughes from Macquarie University, so she is a really excellent communicator on climate change, works through the I.P.C.C. and gives many, many talks, television, radio, you name it.

So today we are going to have a look at the Guide. You should have a copy of that on your table, you're reading it right now, and there is also an update sheet that goes with it. Unfortunately when you're fusing web-based tools they change. Within about a week of publishing that they will actually make some changes to their website, which is extremely annoying. So today I'm just going to actually put the Guide into context. I'm going to go through the steps that are in the Guide and give you a bit of an idea on how to use it, try to give you some ideas on how can you use it in practice, and of course give some key take home messages as well.

So just to tell you how this came about, some of the co-authors and I, about 18 months ago we were going to practitioner type workshops and we were finding that the audience was just absolutely overwhelmed with how to manage native vegetation, how to do revegetation under climate change; so the presenters were standing up here and saying 'it's going to be bad, you're going to have to do something about it' and the questions were coming back, 'well, what do we do?' and that's obviously a very difficult thing to answer as a presenter up here at that kind of level. So we wanted to put something together. We know that there are tools out there that will be helpful, we know that they're not in the right places at times, so we just bring them so that you can read them and sometimes there's just not instructions on how to use these things. So that's what the Guide is all about. It's a guide to using these online tools, you can call it a toolbox if you like that's probably what it is, and it gives step by step instructions on how to use these tools; so that's what the Guide is.



LACT Flagship Projects *Climate change and landcare* Workshop Report

It's just as important that I tell you what the Guide isn't. So it is only about climate change, so as you all know when you're doing any sort of planting, any sort of revegetation there are all these other things that you have to consider like aspects, soil to poverty etc., etc. So this is only about climate change. So for that reason we can't give specific recommendations. This is where your local knowledge comes in once you've got, looked at the tools, that's when you start to apply your local knowledge.

So it's come out in this hard copy of the Guide, it's on the website, it's being hosted by the A.N.P.C., so if you googled 'climate-ready reveg A.N.P.C.' you will find the link there. There's also there a downloadable P.D.F. so if you have friends that would like a copy they can actually download it from the website as well. All of that is written in the Guide as well.

OK, so we've had some excellent talks about climate change and in fact all of the talks today have been excellent and it's not my job to bring it together but I would just like to say, we're all kind of this singing from that same hymn sheet here. So I would like to reinforce perhaps that, maybe not repeat what's been said; but it's nice to know that in this period of such high uncertainty there are some common themes that are going through all of these presentations.

So I just wanted to say one thing about the Paris agreement which Mark touched on. So yes the agreement is there that we are going to try and limit increases in temperature to well below two degrees. It's just really important to remember that the pledges as they are now, this is even before the U.S. has decided to withdraw, those pledges had up to almost three degrees. So part of this whole accord was every five years the signatories need to actually strengthen their resolve and actually start cutting further and deeper and harder. So we are looking at this stage at three degrees unless we actually get in there and start doing more and that's not always clearly understood I don't think. So to just say we are going to limit it to two degrees, much, much more work needs to be done yet to get to that sort of a level.

So this is just another anomalies chart which Mark showed a different one. I just put this up because I wanted to say 'we have to keep thinking climate change is happening now' and that's something everyone's been saying as well. It's not something that's going to happen in the future, it is already happening now. So as this chart is showing this is the temperature anomaly, so the global and average temperature for the 20th century. For the last three years we've been saying 'globally, it was the hottest year', so that's the last three years in a row. I'd just like to say too, the Climate Council is a really good source of climate information and that's freely available information.

So last year a lot of records were broken; the last summer in Sydney it was an absolute stinker, I don't know what it was like here, and there was a real moment I think for a lot of people and it really connected with people that this isn't just an anomaly, this is what's going to be happening now. So a lot of records were broken, just to highlight a few of them.



LACT Flagship Projects *Climate change and landcare* Workshop Report

In 89 locations it was the highest, the record highest kind of rainfall, and in 66 locations the record highest summer temperatures; 50 locations had a record number of summer days over 35 degrees. So it's not just average air temperatures that are increasing, it's these extreme weather events, they are also increasing in frequency, and in some cases they are increasing in intensity, and this will continue.

So this is going to be problematic for some species, and what makes it difficult when we are managing native species is that species will differ in their vulnerability to climate change, and that will depend on their ability to disperse, so that means that to be able to keep up with climate change to go to somewhere where the climate's a little bit better. It will depend on their genetic breakup within their population, the gene flow through populations, whether that's still there (we've fragmented a lot of population) and whether they've got enough what's called 'thermogenic plasticity', whether within themselves they have these tolerance levels that mean they can actually withstand hotter days and fewer days rainfall, that sort of thing.

So also species differ in their ability to keep pace with climate change. So as Steve said, species are already moving, it's not just weeds. Native plants and animals are moving as well, but they're moving at different rates. So things like trees actually, well they're much slower, they're pace of movement is much slower compared to say animals that can move really quickly, so that makes it hard to manage. So where we can we look for sort of generalisation. One generalisation we can make is that species with wide distributions, they're thought to have a broad tolerance of climate, of different climates. So they should be advantaged over those species that have very narrow distributions. But one thing that's really important to remember, even if a species has got a wide distribution it doesn't mean to say that the local population will be OK, and we'll talk about that in a little bit more detail shortly.

So we rely on models to inform us what these climate change projections are likely to be and how species responses are likely to be. But these models are imperfect, and just for an example if we have twelve models trying to give us the output or some sort of a variable you'll probably get twelve answers, but one thing that these models do agree on is that habitat is going to contract. In some cases whole vegetation communities are projected to actually disappear; and of course there's many different ways with modelling, as Mark mentioned it depends on what sort of modelling that you use; but one I'd just like to show that I think is quite poignant is this one here by Michael Dunlop from Melbourne C.S.I.R.O. It was done in 2012. So they said under a high CO₂ emissions scenario if we have that emissions scenario where would environments be similar and dissimilar? So where on the map you can see the green, that's saying that the environments would be similar; so this map is projecting what these environments will be like in 2030. And as you can see in some places they're projected to be the same, but when you get to 2070 it is saying that there is



LACT Flagship Projects *Climate change and landcare* Workshop Report

going to be a lot of dissimilarity, environments will be completely different in some of these places. So we are seeing some quite big changes already. Globally we are seeing salt marshes being replaced by mangroves and in the Arctic we are seeing lichen and mosses communities being changed into forest. But here in Australia we are seeing some big changes and just talking to people throughout the morning I've gathered that there are some changes going on here as well with the dieback of certain species, so it's relevant. So we have had a climate change extinction, it is an animal, it's the Bramble Cay melomys (if I have pronounced that correctly) because of sea level rise. So there are lots of examples of dieback of forests in Western Australia, Kelp Forest, mangroves in the Gulf of Carpentaria, you know about the coral bleaching, and the flying foxes are really being hit very badly on really extreme temperature days and of course they're very important pollinators for a lot of our farmers, so it's all inter-related.

OK, so to get now onto the actual Guide. We think there's three steps that we can take to try and work out which species and which populations are going to be sustainable, that's a hard word to say quickly, and under climate change. So those steps are trying to get climate projections as close to your site as possible, looking at the species distribution and climate envelope to work out what's likely sustainability prospects, and then remembering that even if the species does look to be sustainable you have to then think about the local population as well, so we can put provenance strategies in step three. So there's a lot of sub-steps in there, I won't go through them all today, we'll just have a look at some of them.

So the first one is to get climate projections for your site, so there are two ways to do this. There is a very good website on climate change, the climate change in Australia website which divides Australia up into eight clusters. So here in the A.C.T. you're actually in with the Murray Basin cluster and as you can see that's quite a big area. A really good website with lots of different tools in there. So all of these links are listed in the guide so you don't need to write those down but there's lots of different tools in there that you can have a little play around and it's got some very good information, background information as well. So that's one way that you can do it, or you can actually go to another website which is setup by the A.C.T. Government and the N.S.W. Government which actually divides N.S.W. into about ten regions and the A.C.T. has its own region. So that's what we call a downscale projection, so that gives you some much better information at a more local level than looking at that big climate change in Australia.

So it's very easy to get these projections off the NARClIM site, so that's the one that I will concentrate on. Has anybody used this website, got projections off this one at all? OK. So the step by step instructions are in the Guide for this as well. So what this does, it actually gives projections for two time periods in the future. So the first one is called the 'near future' and that's 2030, a 20 year period around 2030, and the 'far future' appeared around 2070 and that's based off the average climate variables for a baseline period of 1990 to



LACT Flagship Projects *Climate change and landcare* Workshop Report

2009. So into that website you go to 'climate projections in N.S.W.' and then there are two ways you can get information from there. The first way and the easiest way is to scroll down here, you'll see the A.C.T., click on that and you'll get this snap shot P.D.F. version and that might be all that you need, so that's how you save to get a summary. So that'll give you some really good graphs and I think it's really important to understand these [Inaudible]. So this one I've looked at here is 'average air temperature'. Now throughout the Guide we use average air temperature and average precipitation, that's just to sort of have a bit of uniformity and keep it to what was once an eight page document turned out to be 16 pages. You can't do them all. You know your site, you know your species, you know whether it's the number of frost days or cold nights or whatever which is more important for your species and for your site; so that's where using your common knowledge comes in. So just for the purposes of this I just use average temperature and average rainfall.

OK. So this chart has a lot of information on it. So what we can see first of all, average air temperature, and we have an annual and we have it broken into seasonal as well. So for temperature here we can look at the yellow graph for 2030 and the red bar for 2070. So just having a look at here breaking this down, these lines that go across here must be shaking and going 'aww' so there are some little lines in there, little grey lines. There are 12 of those, so there are 12 kind of models that are used to give these projections, so as I said every model gives a different projection. So here we have them all here for you to see where they are. The black line there is the average of all of those models. So how you can use this information is you can say annually the temperature is projected in 2070 to range between about one and a half and almost two and a half with an average of about two degrees, but then you can actually, if the summer is going to be more important to you, go and have a look at summer and see what that actually says there, and as you can see it goes up around about three degrees. So there is a lot more confidence that 2030 air temperatures are probably going to happen, the further out you go of course there isn't quite as much confidence. Temperature is much easier than precipitation or rainfall to project. This is where it actually gets really quite murky and perhaps you [Inaudible]. So the first thing you'll note here, you can see that there are some very big ranges here. So we look at the annual average here, you can see the 2070. That's actually saying that rainfall will be unchanged on an annual basis, but if you look at where all the models are it spans both as raining and wetting, and so the rain there is something that could be ten degrees dryer, 10% dryer above the baseline period or it could be 13% wetter. That's the sort of range that you're dealing with, but when you start to look at it through the seasons, have a look at autumn, again that's saying a drying and wetting but it's a huge range. You can see one model is saying down to round about less 10% up to another model saying it could be 53% or more, but you can see that it's a long way, you can't quite see that here. Have a look at how far away the models are with their projections as well, so if you have a look in spring you can see that all of those models are saying that in spring it's likely to have less rainfall than is being received now. So I think it's really important to go in and have a look at what it's



LACT Flagship Projects *Climate change and landcare* Workshop Report

saying on a seasonal basis as well, don't just have a look at the annual because that might not tell you what you want to know. So that might have all sorts of implications for when you actually do your planting as well.

So you can also go in a little bit further into the website, so you would get the P.D.F., you can go into the website further and you actually get more detailed projections. So they are really the same graphs as we just saw but what you can get there is the actual values, so the actual values of the range and the actual value of each of those 12 models. So that might be something that you want to go into as well.

So the take home messages for looking at that step one, for looking at your climate projection, just remember all models are imperfect, there's a whole range of their abilities there that affect what goes into those models and what goes out. It depends a lot on what we actually do about our greenhouse gas emissions. So those marking projections, they are all based off the highest trajectory.

OK, and to see R.C.P. This is explained in the Guide. A 'Representative Concentration Pathway', it's really I suppose saying how much greenhouse gas emission's going into the atmosphere. If it's low it's 42.6, if it's high it's 48.5. We are currently tracking that trajectory. It's important to look at the seasonal variation not just the annual variation. Have a look at that level of confidence as we saw in the spring, all of those models were saying it's negative for some of the seasons, it is spanning both the drying and wetting. Don't just look at the mean, make sure you go and have a look at all of these other things as well. It's probably going to be the extreme events that are going to have the biggest effect on the species, so have a look at all those other things that are important to your species as well, maximum temperatures, frost night, the things that you know that affect the species that you're looking after and wanting to replant. So because there is so much uncertainty one of the recommendations is to, when you're looking at climate projections, is to use a worst case scenario. So that might be that there's going to be a drying of 30% at some stage, that could be a worst case scenario; have a look at the best case scenario which might be that increase of 50%, and have a look at the mean. So that's quite a bit of work but it does mean that you are covering all of those bases.

So moving onto the next step we want to actually start thinking about, can we tell if a species is likely to be sustainable or not and should we be including this in revegetation. So all of this is done within the Atlas of Living Australia. Now has anybody used the Atlas of Living Australia before, the A.L.A? Yep; good, OK. I have a bit of a love/hate relationship with it I must say. Sometimes it's a bit difficult to work with and other times it's fantastic but it does give us some very good information. So all of this is done in the mapping and analysis section and this whole part of step two comes from a paper that Trevor Booth did in 2012. Trevor Booth actually works for C.S.I.R.O. and I acknowledge his contribution to this paper as well, he was a co-author.



LACT Flagship Projects *Climate change and landcare* Workshop Report

OK, so the first thing we want to do when we're thinking about the species is know the distribution of the whole species and within the A.L.A. we can very easily get up a map of the current distribution of the species. What we want to do then is add the location of your planting site to that distribution map so that you can see where your site is in relation to this distribution. So remembering that we're saying that species that have got a wide distribution are likely to have this broad [Inaudible] and so you would think that probably they're going to be OK, and in the case of this one which is eucalyptus melliodora, which is one that I think you all know, and the site that's used is Albury, it pretty much looks like there's quite a bit of variation and a big distribution, not exactly in the middle there but I would look at that and say 'that looks to me quite sustainable'.

Now I've got a question mark up there saying 'add location planting site'. The A.L.A. changed the way we do this so you may not want to go ahead with this, you might just want to utilise where your site is because now you need to have log in and all sorts of things to be able to do that step. There's an update sheet there and the instructions on how to do that are there. But we can actually get more and better information on that distribution and to do that we want to create a climate envelope of that species, so we want to see where it's distribution fits within two environmental variables. I'm just keeping with our theme of using mean average temperature. We've got temperature along the bottom line here of the graph and we have precipitation on the 'y' axis so this is called a 'scatter plot'. So what we've done is we've taken those distribution points there and we've plotted them in a scatter plot against it's temperature and it's precipitation, so now you can actually see where the majority of the distribution of that species lie and we import our carbon site and that gets put in there. So we can actually see that this is where, again this is Albury, the current temperature was about 14.5 and I think it was about 700 for the precipitation. At the moment that site is right in the middle of the species climate envelope, so that actually looks quite sustainable to me. To add the planting plot you do need to actually put in decimal lat. longs. into the Atlas of Living Australia and the instructions, it's very easy to do, the instructions are in that update sheet so you can refer to that, which really is the matter of going to the map, hover over where your site is and that'll be in the right hand corner. So once you've actually got that setup, you've got your climate envelope, you know where your site is there, you then have to visualise where your site might be within that time climate envelope into the future, so there are all sorts of possible scenarios that could play out here.

So just looking at these, first of all we might find using a best case scenario that in actual fact the site won't be that much different to what it is now and so, yeah, that species probably looks to be OK to plant. We might get a situation where the site could actually be somewhere towards the edge of the current climate envelope and then of course we have to sort of start thinking about the species and I have to say, we have to be careful not to overestimate what a species can do and we have to be careful not to underestimate it. If we sort of think 'oh I don't think this is going to work' then we actually start to reduce



LACT Flagship Projects *Climate change and landcare* Workshop Report

biodiversity if we don't keep planting it; if we do keep planting it and we have failures then of course there's that expense has gone by the wayside, so we have to be able to weigh that up. But one thing we would do here is start thinking about 'well if it's moved that much will the local population be able to handle that new environment that it's going to be under?' Another example of course is quite clearly the site will no longer be in the species climate envelope and again does that mean that you just don't bother replanting it? As we know with these projections are a little bit uncertain but we don't know, as Alison pointed out, there's so much we don't know about species anyway, so there's probably not a question about provenance there because it's going to be very difficult for the species, but we talk about provenance at the end. Well that's all visualising so don't actually do that in the A.L.A. You just apply those projections and print the graph out and see where your site will go that way.

So we have to just think of the limitations of what we're using as well. The A.L.A., the records that go in there are put there by people from the public and there are a lot of mistakes made and they aren't all clean, so we have to be prepared to question some of their site information. So there are a couple of ways to do that and these are [Inaudible] to do that. So you can remove the point or you can draw polygons around the area that you just want to look at if there were lots of mistakes. That can be a little bit fiddly so I think you can probably just use common sense and you can also put a point on, hover over with your mouse on the point and it will show you on the distribution map where that is. So if you were worried about that point you can see that it's in there, you can... probably someone's just put in a wrong lat. long. and that probably is that species. And I should add too, that sometimes, so when we look at this point up here, I'd really question whether that was the species or not but I went in and I had a look where that record came from and I think probably that is eucalyptus melliodora but I think it's in the botanic garden not [Inaudible]. So that does tell us some information about the species, it says probably it can tolerate the temperature up there but we don't know if it's watered or not.

Well the other thing we can do, there is another tool that isn't actually detailed in the Guide. The Guide is written for a national audience. We have got a tool called the 'Niche Finder' which I believe is in the Guide. It has advantages over the A.L.A. in that it uses fringe(?) and variant data and you can be pretty confident that it is the species that you're getting the data for but it may include those ones that are planted. It is much easier to use than the A.L.A. but it is only for N.S.W. species so that's why we didn't put everything about it in the Guide, but you have a lot of common species obviously with N.S.W. that's pretty good for you guys to use. So the red dots are on N.S.W. distribution and the blue dots are the rest of Australia. The thing with this is though you can't add your site to those scatter plots. So if you go to the handout sheet the instructions on how to use that are there but very quickly we're looking at another one of your local species all you have to do to get to here is click on 'species', click on 'view niche read data', you'll see that the whole thing of different



LACT Flagship Projects *Climate change and landcare* Workshop Report

environmental variables there for soil topography, all sorts of climate stuff you can use. Click on the one you want to use, I'm using annual mean temperature again, you get that graph, you go over to where it says 'y' axis, what you want to put there, I say precipitation again, and we get that straight across. So it sits in a couple of [Inaudible] so pretty easy. So you can actually check out live here by clicking on there and it shows you on the distribution that there it is, so again I think it is that species but I think that that has obviously been put in there incorrectly somehow and that didn't get picked up. So the other thing you can do is go back and check the records from the A.L.A. of course too. So you need to know where your site is, you need to know where it is currently, so you need to know what your current whatever environmental variable it is you're using, in this case it's average temperature, average rainfall, visualise it on that scatter plot and then use your projections again to visualise where it will go. So that's everything you need to know.

OK, so the next step is to think 'OK if we've decided that the species is likely to be around we now have to think about the local populations likely to be able to keep pace with climate change, able to adapt'. So we're talking about, Peter was talking about paradigms before, our paradigm in the bush regen. industry has been to overuse local provenance and the reason we used that was because it's grown there, it's been grown there for a long time, adapted to the local conditions therefore it should be in there. But as we now know local conditions have changed, they are changing and they will continue to change, so I think we really do need to question that paradigm that that's the appropriate one to use in this day and age. So there's lots of things that come into consideration with your local population. Have we fragmented it? Is there any gene flow there? You need gene flow to be able to genetically adapt to new conditions and to prevent inbreeding depression. And if we have got any sort of concerns with any of those things I think we have to consider now not to mention the local provenance with non-local provenance. So there are some different strategies, but I don't think you'll have time to go into them all today. These are outlined in the Guide and the good thing about, if we use this paper from [Indistinct 36:35] et al that's available online, so that leaves it in the reference section of the Guide but I reckon then that you can believe all this [Indistinct 36:44].

So we can really look at these different strategies and just say, instead of using the cross into the site and around we've got there is just usually local provenance, so instead of just using local provenance there are different strategies like composite to increase gene flow, still use local but start getting seed from areas nearby and then to a lesser extent further out to try and replicate that historic gene flow. The add mixture approach, again still use some local but it's a bit of a scatter grown approach. Get your seed course and all around the place and that sort of is trying to take care of any eventualities for that climate projection and to increase the ability of the species of the populations that are about to change. I'm jumping all around here. This is the newest one, the climate adjusted strategy. That's for when you've got a climate grading, say that's from the wet, so wetting to drying. Still use some



LACT Flagship Projects *Climate change and landcare* Workshop Report

local but start getting your seed in the direction of how the climate is changing. It's not exclusively that way so don't go exclusively to a drying, but tend off that way. And the last one is a predicted climate change, predicted provenance strategy, which says, 'look, if your site now is just so different, if your site is just so different and nothing you can do, using local's not going to work, just go straight to what you think it's going to be like'. That may or may not be appropriate to you, certainly I think in restoration sites where the soils go completely different maybe that's an appropriate thing to do. So that might be controversial but I have just gone through those quickly and so we just don't have perfect knowledge and we never will have as we know it is really quite disappointing how little information there is out there on the species, the common species even. But we have to balance that urgency with 'we have to make decisions now' without waiting for that perfect knowledge, so I'd implore you all if you are able to do any sort of experimental revegetation that is the way to go. We need to monitor what we're doing and we need to be able to document that and communicate it within ourselves, that's the only way I think you're going to get there.

So take home messages for those last two steps are, I think it's a really good idea to practice using these tools by getting the same outcomes that are in the Guide. There are a couple of places in the A.L.A. where you can come unstuck and just make sure that you're doing all those steps properly. And you can also cross reference of course with niche finder. So quickly go to niche finder, do your scatter plot and then make sure it's the same as the A.L.A. and then you know that you're [Indistinct 40:02] planting about the right site.

Check, do your accuracy checks on some of that data if you think it's not looking right, understand the caveats of all those online tools, know what you're working with, acknowledge that there's still so many uncertainties and so many unknowns and we don't know about species evolutionary potential or even what their genetic diversity is. We sometimes don't even know how they disperse and that's a fairly basic thing to understand. This is quite an important one, available niche or realised niche. So where a species is now that's its realised niche but we don't know what it is that's actually keeping it in that niche, is it something other than climate? So be very aware of that. It could be soils, it could be pollinators, it could be anything and of course just remember there's all these other planting requirements. We are only talking about climate change here.

So we wrote this off our own bat, we got pretty concerned that there needed to be some more information out there so R.E.H. very kindly has funded some workshops and I've been running round N.S.W. like a Leyland brother giving workshops and seminars and things, so that's been quite good fun. So I ask people over this period, 'how do you think you would use this? Pass that on, I think we can all share in what we're doing.' So some of these people said 'well we're using this as being able to sort of get us a list of species we think we have to watch, so we're not doing anything but we've got this list of ones, we're just seeing



LACT Flagship Projects
Climate change and landcare
Workshop Report

what they're doing out in the field. We're validating what's going on in the ground to see that the climate.' And other people find that they're actually using this as a training guide for their staff to learn how to understand species distributions, what that means and one person said 'well they actually will be using it to develop climate adjusted tree strategy'. So that's just some of the things that it's being used for.

I was going to just talk a little bit about Themida OK, so when I did my PhD I looked at six species and looked at whether local was the best for these six species from the provenance perspective. They weren't for four of them, the local wasn't the best, but two of them that were are the species that are very common here. So one of those is Themida So Themida is just widespread and so you think what could possibly go wrong? One of the things I guess that can go wrong is when we have these different chromosome numbers in populations, and I really don't have the knowledge to say whether that's a big problem for Themida or not. Maybe it's not. You look at that distribution and say 'well it's been fine for however long, so', but I just need to raise that, that there will be some issues from time to time that you may want to just delve a little bit deeper as well.

I think I should leave it there, I hope that last bit didn't just muddy the water there. So thank you all very much for coming and for those people that have given some funding to the Guide as well.



LACT Flagship Projects
Climate change and landcare
Workshop Report

Q&A

Q1 Thank you. It's more of a comment to all the speakers this morning and I thank you for raising my favourite topic which is 'fire effects on biodiversity' and Nola may not have mentioned fires directly but in the pamphlet it says 'frequency and severity of high regimes is very likely to be one of the most important drivers of eco system change in coming decades'. Now the comment I want to make is that the effects of fires depend on four things and such like the effects of grazing regimes are similar. One is the type of fire which can be above or below ground, I won't go into all the details. Another one is the interval between fires and Steve raised [Indistinct] question not to say it could have been got rid of by another fire after the 2003 fire, there's wide variety. The third thing is the season, and I think Steve again commented and I think it might have been the lady there showed the difference between different seasons for fire occurrence. And the last thing is the intensity of the fire which was raised particularly by Steve. So that's my comment and if you use those four variables for grazing as well and other disturbances. So it's a general issue and I commend all those things to everybody to think about in considering these questions. Thank you.

Q2: In relation to provenance and sourcing seeds, as somebody who does a little bit of work in the rehab space, trying to verify the provenance of your seed can be difficult. Is there any, I don't know, is there any way we can address that issue?

A2 I hear you, I had those problems when I was doing my PhD as well. I was absolutely astounded that I would get in seed and basically I was told 'Oh that came from the south coast of N.S.W.' and that was as much information as I could get. So I think you just try and lobby within the industry that you need to have this information, you need to know what the population numbers are, you need to know where it was, and you need a lot more information. Some of the seed banks have done a fantastic job with that. I did get some really good information, so I can only say you just need to keep lobbying and then getting our seed from chains where you can get that information, it is critical.

Q3 Mark, one of the very last things that you spoke about was the change from learning from technical knowledge and really growing forward: how do we start with a leap forward?

A3 I think Peter started to talk about that, which was actually really thinking about what we're trying to achieve. And so it may no longer be things that in the past we were trying to achieve. So preservation was this moving view of conservation and active management approach etcetera, and so I think in a sense you've really got to start to say, well, what are we here to do, what are our goals? Because unless you actually set those goals, it doesn't really matter what you do at the lower levels, you've got to think of that big picture strategy.

Q4 One for Peter Bridgewater about... you said to look at the ecosystems, see the species, a lot of us I think do that to a large extent, and you said think about the genes: so



LACT Flagship Projects
Climate change and landcare
Workshop Report

what we need is the information about plant and other species, because they all interact, genetics. What can you say about that please?

A4 Like the Paris Climate Change Agreement, it's an aspiration, because that information is not so easily available. What I meant by that is that you do need to think about the possibility that there are some individuals in a population that will actually be able to adapt and withstand climate change better than others - of the same species, that is. It may be that we can get better genetic profiling on some species, key species, but I think we don't have time to wait for all that to be done. The message I wanted to impart was: think about the genetics of what you're looking at and whether the species is a native species, a weed species, a plant, or animal: it's controlled by its genetic profile and genetic variation is quite strong across some species. I will confess I did something when I moved from Western Australia to the A.C.T. some years ago I brought some seed of a clover species which grows on the dunes south of Perth. And I managed to germinate them and I planted them out in my garden in a suburb which I will not mention. And I thought, well, this won't survive given Canberra's climate: Perth is not the same as Canberra. They thrived. Which is just one anecdotal illustration of the fact that a lot of the species we think are in precise situations, but they in fact have the ability to move into all kinds of different niches under pressure. So don't just see what you see and think that's going to die, because it may not, it may have the potential to evolve and move into different branches. Just be open minded about things.

Q5 Mark, just a little point of what you were talking about, but you mentioned that there'd be (inaudible) across Australia: I was just wanting a summation of the explanation to get to that point, would you say for the increased vegetation, increase of evaporation...?

A5 So it's largely a function of the rainfall and the evaporation, so between those two things, so what comes down and what goes up. And right across Southern Australia, particularly in the winter months, our wet season May to October sort of thing, that's where a lot of useful rainfall will occur, and also evaporation then, but that really cuts into summer months in the northern directions (inaudible) tendency to increase rainfall (inaudible) which balances out evaporation.

Q6 And does that increase the intensity of rainfall?

A6 And it does. But that's very dependent on local conditions, so depending on what the condition of your landscape is, that will determine that relationship between intensity and runoff. So in well managed environments it can actually be very substantial.