C1: Project Title: Impact of reforestation on the mitigation of climate extremes in eastern Australia resulting from global warming

C2: Aims and Background

Aims: Climate change is the most urgent environmental, economic and social issue facing Australia and the world. The concentration of greenhouse gases has grown rapidly in recent decades, and is expected to continue well into the 21st century, increasing the risk of dangerous climate change. The options for significant reduction of emissions are still being debated and as yet there is no global agreement in place. It is not widely appreciated that the world is facing unavoidable warming even if greenhouse emissions were reduced to zero (Solomon et al. 2009). A number of studies show that reforestation in the tropics and sub-tropics could be beneficial to mitigating global warming (e.g., Bala et al. 2007) as well as having other benefits such as carbon sequestration and maintenance of ecological services including biodiversity, clean air and water. Restoring native vegetation at a regional scale also has the potential to reduce the impact of climate extremes. This may be particularly important for eastern Australia, where Deo et al. (2009) recently demonstrated that climate extremes, in particular droughts and heatwaves, have been accentuated by historical land clearing.

This raises an important but as yet unanswered question: ***what is the potential impact of restoring native woody vegetation on mitigating the impact of climate extremes at a regional scale in a changing climate?***

Australia is already severely impacted by climate change, reflected in warmer and drier conditions with increased frequency of droughts, heatwaves, bushfires and floods (CSIRO & BOM 2007), which are projected to increase further during the 21st century (Garnaut 2008). There is an increasing realisation that it is going to be difficult to avoid dangerous and irreversible climate change and all viable options for mitigation and adaptation need to be explored urgently.

This project aims to evaluate the potential role of restoring native woody vegetation in eastern Australia to mitigate climate extremes in a warming climate. It will use the very-high resolution (~10 km) stretched grid CSIRO climate model (CCAM) to explore different options for targeted reforestation[1] in eastern Australia. The results of the model simulations will be used to assess the feasibility of implementing reforestation as an effective measure to mitigate the regional impacts of global warming, including climate extremes. We recognise that this raises important unanswered socio-economic, ecological and hydrological questions. However, our focus is on evaluating the effectiveness of reforestation as an option for the mitigation of climate change. These issues will need to be addressed separately if the proposed research identifies a beneficial role of reforestation.

Background: Global climate change, driven by elevated greenhouse gases such as carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons is the most urgent global issue (Steffen 2006; IPCC 2007). The IPCC 4th Assessment Report (AR4) projects an accelerating increase of global temperature of 2 ^{o}C to 4.5 ^{o}C by the end of 21st century, predominantly due to increasing emissions of greenhouse gasses (IPCC 2007). However, anthropogenic climate changes may be more rapid and widespread than predicted by the AR4 (Rahmstorf *et al.* 2007).

It is likely that global warming is already affecting climate in the Pacific region, where ENSO historically has been responsible for at least part of the climate's variability. A tendency for long-term

[1] Reforestation is used broadly to refer to the active (direct planting) and passive (natural regeneration) restoration of native forest and woodlands.

weakening of the Walker circulation in response to a warming climate has been shown by Vecchi & Soden (2007) to be a fairly robust characteristic of IPCC AR4 climate models. In addition to the weakening of Walker circulation, Lu *et al.* (2007) and Seidel & Randel (2007) showed that the circulation of Hadley cells, particularly the sub-tropical cell (15^{o}-40^{o} latitude in each hemisphere), have also weakened and moved poleward. This is resulting in an observed pattern of drying over the already dry sub-tropics e.g., Mediterranean, southern Africa, parts of southwest North America, and southeast Australia (Solomon et al. 2009).

Climate change projections for Australia show potential for significant changes, especially for high emission scenarios, with a projected temperature increase by 3-7^{o}C by the end of the 21st century and a change in rainfall of +5 to -30% by 2070 for southern Australia with the strongest decline in winter-spring. Step changes in rainfall and the impact on water resources are a major topic of research and the focus of policy makers (Cai & Cowan 2008a). In Victoria during the past decade, there has been a 50% reduction in autumn and a 10-15% reduction in winter rainfall (Cai & Cowan 2008a). A combination of dry soils during autumn and reduction of rainfall during the wet season (winter) resulted in unprecedented decline in water availability in the Murray-Darling River system. The full ecological impacts have not been assessed, although recent commentary suggests that the lower Murray-Darling is on the brink of irreversible collapse. Similarly central and southeast Queensland have experienced very strong rainfall reductions during recent decades, and in particular since 2001 (QCCCE 2007). Increased temperatures in southeast Australia are also contributing to hotter droughts, which are further reducing runoff volumes (Cai & Cowan 2008b). Increasing concentrations of anthropogenic greenhouse gases, especially CO_2, are frequently cited as the major contributor to the region's warmer and drier average and more extreme climate.

However, climate change is a multi-dimensional issue with multiple forcings (including land use and land cover change) and their interactions impacting on the climate system (Pielke 2005; McAlpine et al. 2009). For Australia, the historical clearing of native vegetation has been shown to be an important factor influencing climate (McAlpine et al. 2007; Deo et al. 2009). McAlpine et al. (2007) showed a statistically significant warming of 0.1-0.6^{o}C during summer in eastern Australia, while the mean summer rainfall showed a statistically significant decrease by 4-12% in southeast Australia. The 2002/2003 El Niño drought was up to 2 ^{o}C hotter (Figure 1 a-c). In a subsequent study using the same experimental design, Deo et al. (2009) found an increase in the number of dry and hot days, a decrease in daily rainfall intensity and wet day rainfall, and an increase in the decile-based drought duration index for modern fragmented land cover compared to pre-European land cover (Figure 1 d-f). These changes were especially pronounced during strong El Niño events. Given this impact of historical land clearing on the Australian climate, it is critical to determine to what degree restoring woody native vegetation would contribute to a reduction in the severity, frequency and duration of extreme events under global warming.

C3: Significance and Innovation

The study will, for the first time, simulate the contribution of reforestation to mitigate climate change, especially extremes, at a regional scale. It is highly innovative as it proposes that regional reforestation could be a viable option for mitigating the impact of climate extremes resulting from increased concentration of greenhouse gases. This has not been done at this scale in Australia or internationally. The project will also make a major contribution to an *Environmentally Sustainable Australia*, especially *Responding to Climate Change and Variability* by *increasing our understanding of the impact of climate change and variability at the regional level across Australia*. The significance and innovation of the project lie in several key areas.

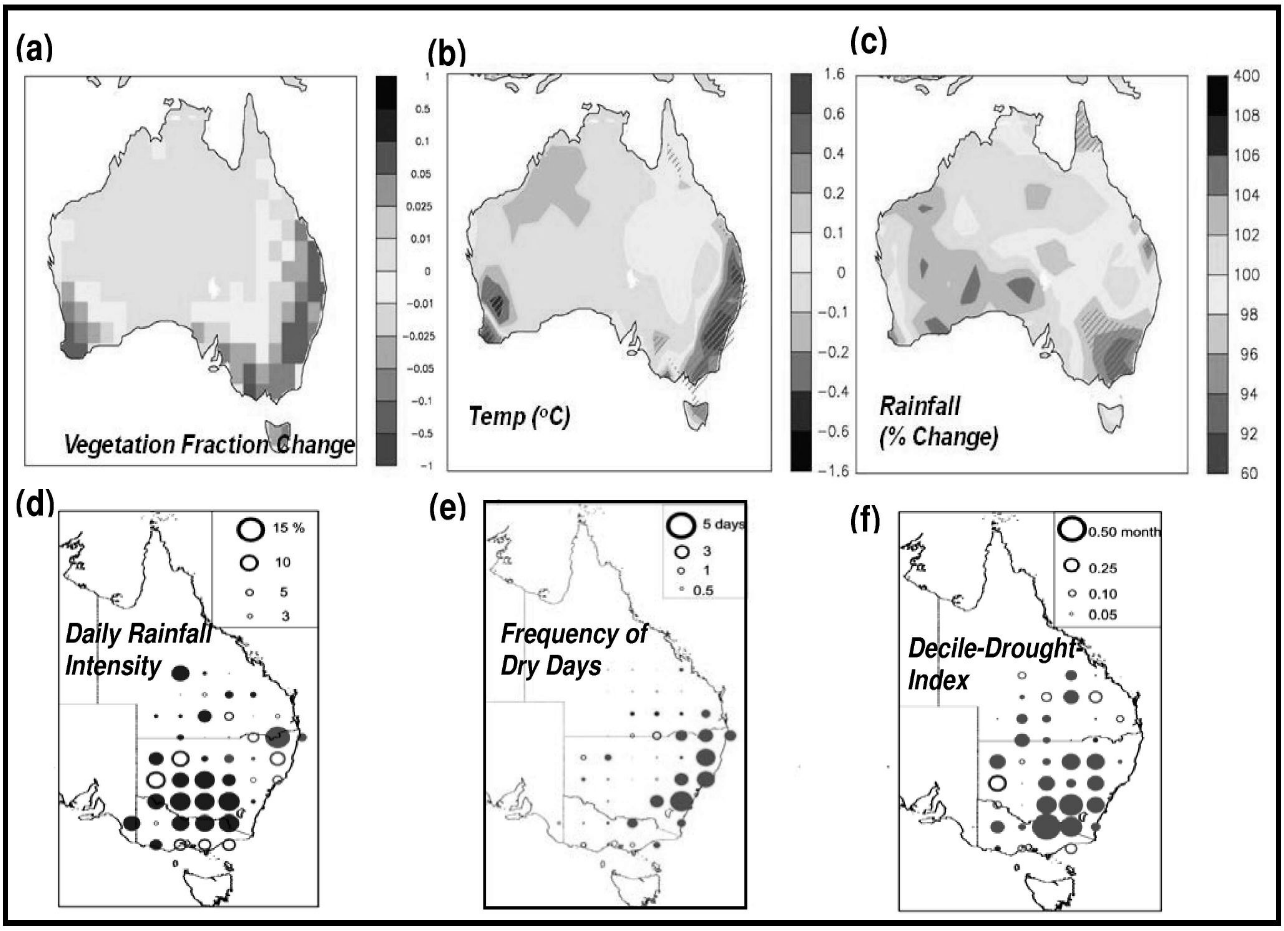

Figure 1: The changes in (a) vegetation fraction used in the CSIRO model, (b) annual mean surface temperature (°C), (c) annual mean rainfall (%), (d) daily rainfall intensity (%), (e) frequency of dry days (days yr^{-1}), and (f) rainfall-decile-based drought index (months yr^{-1}) for the period 1951-2003, Changes are for modern day vegetation cover compared to pre-European vegetation. For (b-c), the hatches show areas that are statistically significant, and for (d-f), black (closed) circles show increase and are statistically significant, white (open) circles are not statistically significant at $\alpha = 0.01$ (Modified from: McAlpine et al. 2007; Deo et al. 2009).

1. Use state-of-art representation of vegetation and land surface characteristics in a high-resolution climate model. The project will develop a comprehensive dataset of the vegetation/land surface characteristics for input into the CSIRO CCAM (Conformal Cubic Atmospheric Model) climate model. It will access the most up-to-date satellite mapping of vegetation characteristics over the Australian continent and translate this information into parameters suitable for use in the high-resolution CCAM model. This information will be used as a baseline for current vegetation conditions in Australia, which would allow us to develop future land cover scenarios, including various options for reforestation and the "business as usual" scenario. This dataset will be the first of its kind because it would consist of an accurate, moderate resolution (1 km) mapping of current vegetation and land surface characteristics. The future land cover scenarios are also going to be based on realistic assumptions with a focus on identifying a threshold vegetation fraction which could effectively mitigate the impact of climate extremes.

2. First study where the potential for reforestation to mitigate climate change is investigated at a regional scale using a high-resolution climate model. The project will for the first time simulate impact of land cover change on the Australian climate at a high spatial resolution of ~10 km. This is very

important when considering the spatial heterogeneity of Australian vegetation and the nature of the Australian climate which has a strong latitudinal and longitudinal gradient (e.g., from rainforest to desert). The project will use the stretched version of the CSRIO CCAM model which is global climate in extent, which is self contained and does not require input from other climate models at lateral boundaries of the model domain. The land-soil-vegetation component of CCAM accounts for the impact of CO_2 concentration on water use efficiency of plants and therefore provides a more comprehensive assessment of the impact climate change on the hydrological cycle. This approach allows for robust simulations and the interpretation of model results is more straight-forward and easier to understand. The experimental design will use a comprehensive modelling approach to quantify the impact of large-scale reforestation scenarios on climate extremes such as droughts and heatwaves resulting from the impacts of increased concentration of anthropogenic greenhouse gases.

3. Increased understanding of how climate extremes are likely to change in the future in an un-mitigated scenario. Currently our understanding of projected climate extremes for Australia is limited as it comes from coarse resolution climate models. Statistics of climatic extremes such as intensity and magnitude are known to be more realistic in higher resolution models. It is vital to understand have robust projections of the frequency, duration and intensity of climate extremes at a regional scale because they have a severe impact on society, economy and the environment. We will use the high resolution CCAM climate model to compute an ensemble of simulations of incremental increases in vegetation fraction from the base scenario 2000-2010 and transient changes in atmospheric greenhouse gases for the period 1970-2070 (using the AR5 emission scenarios). The results from this experiment will allow improved estimation of historical and projected climatic extremes in Australia.

4. Help to reduce the risk of dangerous and irreversible changes. Although "dangerous" has become something of a cliché when discussing climate change (Schneider and Lane 2006), the reality is that climate change is occurring faster than predicted by the IPCC (2007) and that early warning signals such as melting of the Arctic and west Antarctic ice sheets are already occurring. Australia is not immune from dangerous and irreversible climate change and probably more vulnerable than most other countries. An irreversible shift to a more arid, drought prone climate represents a major inter-generational issue for Australia, and has a broader national significance due to its potential impacts on water security, agricultural production, the Great Barrier Reef and biodiversity conservation. The semi-arid regions of eastern and southern Australia are at greatest risk of irreversible environmental damage beyond the capacity of ecosystems and agriculture to recover or adapt. This will threaten the economic base of an already stressed rural sector and put added pressures on terrestrial and aquatic ecosystems to maintain basic structure, function and resilience (McAlpine et al. 2009; Howden et al. 2007). The issue of land degradation and desertification is a major concern in Australia (McKeon et al. 2004; Stafford Smith et al; 2007). The projected increase in drought frequency and intensity (Hennessey et al. 2008) will add further pressures on the semi-arid land use zone. It is important, therefore, to quantify the contribution of large-scale reforestation to mitigating the risk of dangerous and irreversible changes in Australia's regional climate.

5. Provide information on new options for policy development and natural resource management (NRM) strategies. The project represents an integrated analysis of the interactions and feedbacks of land cover change combined with climate change resulting from increased concentrations of greenhouse gases. The goal of the modelling experiments is to provide a quantitative evaluation of the potential contribution of reforestation in a changing climate to help mitigate the impacts of climate change. This will provide practical and policy-relevant natural resource and vegetation management options for the affected regions. Integrated climate change mitigation/amelioration and landscape restoration strategies need to be urgently developed and tested. Successful implementation could lead

to increased ability of the Australian landscape to buffer against climate extremes driven by increased concentrations of greenhouse gases. The study will be particularly relevant to tighter legislative controls on the clearing of native vegetation, including regrowth native vegetation in previously cleared landscapes of Queensland and northern New South Wales. It will inform policy development in terms of balancing the beneficial effects of increased deep-rooted woody vegetation cover (in terms of climate, salinity risk, resilience, biodiversity, carbon storage) against higher costs (in terms of loss of land available for agriculture and human settlement). The study therefore, has strong policy-management imperative, investigating the need for the maintenance and restoration of healthy native vegetation cover as part of Australia's climate change mitigation and adaptation strategies.

C4: Approach and Training
The specific objectives of the project are:

1) Develop a robust experimental design and reforestation scenarios.
2) Develop a realistic and accurate representation of Australian land cover.
3) Conduct the baseline and reforestation experiments and analyse the model outputs.
4) APAI training: focus on role of vegetation change in rangelands.
5) Synthesise the research findings and communicate them to decision makers.

Objective 1. The conceptual framework underpinning the research approach highlights the synergistic impacts and feedbacks on Australia's regional climate resulting from elevated anthropogenic greenhouse gases, other climate forcings and land cover change (see McAlpine et al. 2009 for details). The conversion of native vegetation to crops and pastures has resulted in an increased fraction of available energy at the land surface used for sensible heating which contributes to higher average surface temperatures and more hot days (Deo et al. 2009). A warmer climate results in a drier lower atmosphere and decreased latent heating and regional rainfall. These effects are especially pronounced during drought events associated with El Niño.

The experimental design builds on the understanding of these processes. **The hypothesis embedded in the experimental design is that reforestation can help mitigate/ameliorate climate extremes associated with increased concentrations of CO_2.** It will consist of a series of ensemble experiments evaluating the relative impact of time evolving effects of reforestation, and changing concentrations of CO_2, for the period 1970-2070 based on the emission scenarios developed for the forthcoming 5th Assessment Report (5AR) of IPCC. We will use transient increase in concentration of CO_2 and other greenhouse gases. Current (average over 2000-2010) land surface characteristics including woody vegetation fraction will provide the base scenario, and will be used in the control climate modelling experiment. The results of this control experiment will be used to compare the results from the simulations where the woody vegetation fraction has been incrementally increased for targeted locations in eastern Australia. These reforestation scenarios will be constrained by land use, with highly productive agricultural lands and urban settlement excluded from reforestation. The purpose of these incremental changes in woody vegetation fraction is to determine the threshold value of vegetation which would result in significant impact on mean and extreme climate.

Objective 2: The purpose of this objective is to prepare new data describing land surface and vegetation characteristics for input into the CCAM climate model. We have already developed methodologies to integrate the data from satellite mapping of vegetation characteristics, empirical reconstruction and mapping of pre-European vegetation for use by the CSIRO climate model (Lawrence 2004). We will use this methodology to develop new high-resolution (~1 km) datasets of vegetation and soil properties aggregated to the resolution of CCAM. We will use MODIS satellite imagery to derive seasonally variable albedo, leaf area index (LAI) and vegetation fraction for eastern Australia. Consistent, accurate and up-to-date datasets of these variables suitable for application in high-resolution climate modelling currently are not available for Australia. These vegetation parameters used by the climate model will be used to develop future land use scenarios including incremental reforestation scenarios. To achieve this we will use land use mapping from the Bureau of Rural Science Australian Collaborative Land Use Mapping Program to identify areas suitable for reforestation constrained by current areas used for intensive agriculture and human settlement. This work will be done collaboratively with scientist with CSIRO, the National Centre for Atmospheric Research (USA), Boulder Colorado, and UK Met Office to develop these land use and associated datasets required for input into the CCAM climate model

Outputs: High resolution vegetation and land surface characteristics datasets for eastern Australia suitable for use in CCAM climate model.

<u>Objective 3:</u> This objective will be completed according to the following tasks.

Task 1: In this task, we will complete an ensemble of control simulations for the period 1970-2070 using the very-high resolution (~10 km) CCAM model. These control experiments will use boundary conditions from the CSIRO Mark 3.6 global climate model using emission scenarios developed for 5AR of IPCC. The results from these simulations will be used as benchmark for assessing the impact of reforestation on Australia's regional climate. In addition, the results from these very-high resolution simulations will allow improved assessment of future climate change extremes in Australia. The second group of experiments will consist of a series of simulations for the period 1970-2070 using various scenarios with incremental increases in woody vegetation fraction as described in Objective 2. The purpose of these experiments considering the incremental changes in woody vegetation fraction is to determine a threshold value of reforestation which would result in a statistically significant impact on mean and extreme climate. These kind of extended (1970-2070) simulations at such high resolution and considering the range of vegetation scenarios have not been done previously in Australia, and will require a very significant computing resources The climate change simulations will be conducted on the Queensland Department of Environment and Resource Management Silicon Graphics ICE computing system and the Australian universities High Performance Computing Facility (APAC) based at ANU.

Task 2: This task will conduct statistical analysis of the model outputs to identify potential of the reforestation scenarios to mitigate/ameliorate climate extremes. We will analyse the mean, daily and seasonal model output for the vegetation and CO_2 conditions to determine the changes in: i) mean annual and seasonal temperature and rainfall: ii) probability distribution function (PDF) or daily temperature and rainfall; iii) daily extremes such as the number of days >35 ^{o}C and number of dry days; iv) changes in wet day rainfall and daily rainfall intensity; and v) the decile-based drought duration index. We will analyse the daily data for the whole model period and for El Niňo/La Niňa conditions. This will allow us to evaluate the climate sensitivities of the reforestation scenarios for various ENSO synoptic patterns in SST and regional circulation.

We will investigate the severity and duration of recent and future drought events based on projections of monthly mean rainfall and potential evaporation for climate change projections due to woody vegetation cover change. The drought indices include evapotranspiration (and hence be sensitive to rising temperature) to produce a measure of soil-moisture deficit, whereby drought is defined as a period of extremely low soil moisture. This information will then be used to highlight the risk to agriculture, water security and ecosystems resulting from a potential transition to a more variable and arid climate in eastern Australia (sensu McAlpine et al. 2009).

The simulated climate variables will be tested for statistical significance using bootstrapping pool-permutation procedure (i.e. sampling the model results with replacement) to determine statistical significance following the methods proposed by Preisendorfer and Barnett (1983), instead of using the more conventional statistical tests (e.g. t-test and/or F-test) which in some cases is not reliable due to problems associated with spatial autocorrelation and non-parametric sampling distributions. The bootstrapping procedures neither require an *a priori* assumption of normal data distribution, nor an *a priori* estimate of the number of spatial degrees of freedom thus allowing us to evaluate variables with non-Gaussian distributions.

<u>Objective 4: Training APAI.</u> The project will have an important training component. The APAI will focus on investigating the impact of inter-annual variability of climate on changes in vegetation cover in semi-arid and arid rangelands and feedbacks between vegetation and climate resulting from grazing pressure. To date, the major research emphasis of land cover change feedbacks on the Australian climate has been on the historical conversion of woody native vegetation to cropping and exotic pastures (Pitman *et al.* 2004; Pitman & Narisma 2005; McAlpine *et al.* 2007). The climate impacts of contemporary changes in land use and vegetation management in the rangelands has yet to receive detailed analysis (McKeon *et al.* 2009). A large fraction of eastern Australia, especially Queensland, is being used for extensive grazing. Hence, the three way interaction between climate variability and change, vegetation change, and land use pressures in the rangelands needs to be better understood. The APAI employed on the project will address this problem.

<u>Objective 5:</u> This objective will synthesise the research findings and the environmental and socio-economic consequences of the potential reforestation scenarios to mitigate climate extremes in a changing climate. It will engage and communicate with regional, state and Commonwealth decision makers the consequences of alternative policies designed to substantially increase the amount of woody native vegetation cover in eastern Australia at a catchment and regional scale. This will help inform regrowth native vegetation management in Queensland where regrowth protection provides a cost-effective option for large-scale landscape restoration. The research findings, if they demonstrate reforestation can help mitigate climate extremes, will provide a strong scientific case for reforestation to mitigate greenhouse gas driven climate change. CI McAlpine and PI Syktus have already conducted policy briefings to the Queensland Government and Commonwealth Departments, including the Department of Prime Minister and Cabinet and to the Joint Standing Committee on Treaties (Kyoto Protocol). This information will be used to develop internal briefings to the Queensland Department of Environment and Resource Management, the project partner organisation, which is responsible for the state's native vegetation management and climate change policy.

Project Outcomes:

1. Quantitative evaluation of the potential of large-scale strategic revegetation programs to mitigate and ameliorate climate change impacts on regional eastern Australia. By addressing the research question, the project will equip policy makers and the agricultural sector with the knowledge, tools and strategies for a more comprehensive understanding of options of how to manage native vegetation in agricultural and rangeland landscapes to mitigate and ameliorate the effects of climate change.

2. Improved confidence by land managers and policy makers when making decisions about vegetation management that it will have a strong likelihood of positively impacting regional climate. This will provide them with actionable knowledge to help mitigate climate impacts at a regional scale.

C5: National Benefit

This project will make a major contribution to an Environmentally Sustainable Australia, especially 'Responding to climate change and variability'. It will also indirectly benefit Sustainable use of Australia's biodiversity', 'Water a critical resource'. The project will directly benefit Queensland and eastern Australia but has direct relevance for the whole of Australia. Many regions of eastern Australia have recently experienced unprecedented hardships and environmental pressures due to persisting and widespread drought conditions and above average temperatures, which are at least partly attributed to increasing greenhouse gas emissions. Persisting severe drought conditions in southeast Australia are impacting negatively on our ability to produce and export agricultural commodities, for example 2002-2003 and 2006-2007 El Niño conditions have been assessed to decrease Australian GDP by ~1%. This is also resulting in significant environmental pressures on natural resources and ecosystems, leading to increased land degradation, topsoil loss, sediment discharge and decreased water quality arising from excessive clearing of native vegetation cover. The project will help reduce these pressures by providing a compelling case for large-scale reforestation to mitigate regional climate change and its impacts.

The project is highly relevant to native vegetation management, biodiversity conservation, biosequestration, and climate change mitigation - adaptation options in Queensland and elsewhere in eastern Australia. Of particular relevance are the potential benefits of restoring native vegetation for catchment hydrology and increasing the resilience of regional Queensland to cope with the impact of projected increased frequency of climate extremes. There is also an increasing expectation of managing native and planted vegetation to act as a carbon sink. The emerging new global landscape requires a significant reduction in greenhouse emissions, and therefore there is increasing expectation that vegetation would be used to sequester atmospheric CO_2. Reforestation of cleared lands, although a policy-sensitive option, is a high-priority mitigation approach that can be adopted in tropical and sub-tropical regions (IPCC 2007). Recently, reviews aimed at arriving at mitigation strategies for climate change from increasing concentrations of CO_2 have strongly favored alternative priorities designed to target emissions from Australia's agriculture, forestry and other land use sectors (Garnaut 2008). The options for active reforestation as well as for the conservation of regrowth vegetation as a basis for reducing carbon emissions will provide enhanced opportunities for mitigation of climate change from anthropogenic land use (McAlpine et al 2009). Revegetation strategies however, will be difficult to implement without quantifying how much revegetation and where needs to be restored in order to achieve an acceptable solution. The project will provide new scientific evidence which directly addresses these questions.

C6: Partner organisation commitment and collaboration

The project proposal was developed jointly by Dr Clive McAlpine and Chief Scientist Jozef Syktus and builds on 10 years of collaborative research between The University of Queensland and the Queensland Department of Environment and Resource Management. McAlpine and Syktus successfully completed a previous ARC SPIRT project "Climate impacts of land cover change in Australia: quantifying and modelling impacts at the local, regional and continental scales" in 2003. This work was subsequently extended through a Land & Water Australia Innovation Call project "Modelling the impact of vegetation cover change on the Australian regional climate". This project is nearing completion (October 2009). The aims and objectives of the proposed project arise out of this previous work and are closely linked to the objectives/mission statements of the Partner Organisation. The Queensland Government has environmental and ecological sustainability as one of the core elements of its corporate plan. The outcomes of this project have the potential to directly feed into native vegetation management and natural resource management policies that aim to achieve environmentally sustainable outcomes for Queensland. This project will therefore make a significant contribution towards developing resilient and sustainable landscapes in Queensland and the State's capacity to mitigate and adapt to climate change.

Jozef Syktus will be closely involved in all stages of the project, making a significant contribution to the design of the modelling experiments, land surface data acquisition and integration, the parameterisation and running of the CSIRO CCAM model, analysis of the model outputs, and publication of the model results. He has extensive climate modelling experience, and will bring vital complementary skills and resources to the project. The project would not be possible without his input. The Queensland Department of Environment and Resource Management will provide access to their high performance Silicon Graphics computer facility and data storage/management resources. Given the importance of the computer simulation modelling to the project, this will constitute a highly valuable contribution to the project. This close link between the project and the Queensland Government will greatly improve the likelihood that the research outcomes are integrated into State government climate change and native vegetation management policies.

The Partner Organisation has expressed a strong commitment to be part of this innovative and important project. It has also indicated an interest in ongoing collaborations with The University of Queensland in climate change research as a means of helping to secure the State's future. Therefore, it is anticipated that this project will provide a solid foundation for future long-term collaborations between the Queensland Government and The University of Queensland in climate change research, resulting in substantial societal and environmental benefits for the state.

C7: Communication of Results

The results will be communicated as follows: i) through a series of science-policy workshops involving the research team and key national and state policy officers. The workshops will aim to communicate knowledge, policy recommendations and landscape management practices that can influence regional, state and national decisions. We will aim to stimulate adoption of innovative policies and practices that are likely to result from research. ii) Media releases and interviews with a range of printed and electronic media disseminated through the UQ and Queensland Government media offices. The focus of these communications will be highlighting the research findings and their importance for government policy and land/native vegetation management. iii) Publications, both scientific, government, industry, rural and websites.

C8: Role of Personnel

The personnel have complementary expertise in climate change modelling and landscape science. **Dr Clive McAlpine (CI, 5 days per month):** Clive will be responsible for: the overall management of the project, and play a major role in all research components. He will work closely with PI Syktus and the Research Fellow in data acquisition and analysis of reforestation scenarios. He brings to the project 12 years research experience in land cover change studies and landscape science. **Mr Jozef Syktus (PI, 2 days per month):** Jozef will provide valuable input into all research components, especially transient land cover change modelling. He brings to the project extensive experience in climate modelling and climatology. The **Research Scientist (in-kind - Department of Environment and Resource Management)** will work on design, setup of climate model experiments, data archival and extraction and computing of climate extreme indices. **UQ Research Fellow 1:** The UQ Research Fellow 1 will: conduct a synthesis of the literature relating to deforestation and reforestation on regional climate; analyse the statistics of mean and extreme climate resulting from reforestation; and work on interpretation and synthesis of modelling results. He/she will lead the synthesis and preparation of publication of project findings. **UQ Research Fellow 2:** This person will be employed full-time in Years 1 & 2, and will play a leading role in the processing of the MODIS satellite imagery and assisting PI Syktus and CI McAlpine in the parameterisation of the CCAM climate model. McAlpine and Syktus have strong international connections in this field of research, especially with Dr Peter

Lawrence (National Centre for Atmospheric Research, Boulder Colorado), Professor Roger Pielke, University of Colorado, Boulder, and Dr Richard Betts UK Met Office. These international collaborators will be Associate Investigators on the project. **Prof Roger Pielke** is a world leader in the study of land-atmosphere interactions, and will provide technical reference and mentor to the project. **Dr Peter Lawrence** is an internationally recognised leader in the development of land cover data for climate models, and will provide assistance in the development of the high-resolution land surface parameter datasets. **Dr Richard Betts** is an internationally recognised climate modeller with extensive experience in modelling land surface - climate interactions. The **APAI PhD** will conduct separate modelling experiments evaluating climate impacts of land and pasture degradation in Queensland's rangelands which are not affected by vegetation clearing (Objective 4).

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