



CLIMATE CHANGE RESEARCH, EDUCATION AND ADOPTION STRATEGY

For additional activities and investment in
Future Farm Industries CRC

FUTURE FARM
INDUSTRIES CRC

PROFITABLE PERENNIALS™ FOR AUSTRALIAN LANDSCAPES

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1. VISION

Farmers across southern Australia and the agencies and businesses that serve them will have promising new farming systems and technologies that:

- Make greater use of Profitable Perennials™ to improve farm profit,
- Are drought tolerant and adapted to climate change,
- Are more productive with less greenhouse gas emissions per unit of farm output,
- Increase groundcover throughout the year,
- Support biodiversity on a landscape scale,
- Provide new options for emerging carbon and renewable biomass energy markets.

Under this Strategy farmers will have:

Real Choices in a Changing Climate

For perennial plant-based farming systems already under development by the Future Farm Industries Cooperative Research Centre Ltd (FFI CRC), it will undertake work additional to the current Business Plan that:

- determines intrinsic economic, ecological and social benefits from adaptation to increasing droughts and climatic variability;
- reports on carbon, energy, nutrient and water stocks and flows relevant to agriculture's capacity to mitigate greenhouse gasses and supply biomass for renewable energy;
- informs farmers and service providers on the metrics of these systems and technologies prior to the 2013 decision on agriculture's treatment under the Carbon Pollution Reduction Scheme (CPRS) or complementary measures; and
- is supported by an enhanced training program and a new generation of scientists.

2. CLIMATE CHANGE AS A MAJOR ISSUE

Climate change is a major issue for Australian agriculture. The important considerations are:

- Technology development, needed for agricultural industries to adapt to climate change and continue to improve productivity under climate change stresses;
- Innovation to allow agriculture to reduce its net greenhouse gas emissions and contribute to mitigation; and
- Economic analyses and capacity building to assist Australian agriculture to adjust to climate change.

A key challenge for FFI CRC is how it will respond to these issues, and this is the basis of this Strategy.

Climate change is a broad area, and a large program of activities is developing across many research institutions and providers, some of whom are Participants in FFI CRC. The CRC's Strategy is targeted on farming systems and perennial plant technologies already identified for R&D, in order to capitalise on its core capabilities rather than embarking on a broad-ranging climate change R&D program.

3. THE NEW POLICY ENVIRONMENT

Climate Change

The Australian Government has ratified the Kyoto Protocol and announced its intention to develop an emissions trading scheme, the CPRS [1], and expand the Mandatory Renewable Energy Target (MRET) to 20% by 2020. The MRET includes the use of biomass. A parallel process has been the Garnaut Climate Change Review, which examined the impacts, challenges and opportunities of climate change for Australia [2]. The Garnaut Review will be used to develop the Government's position with the CPRS.

The sequence of events leading up to enacting of the CPRS are the release of a Green Paper in July 2008 and subsequent public consultation, release of a White Paper detailing the scheme's proposed design in December 2008, and introduction of draft legislation into the Australian Parliament in early 2009. It is proposed that the CPRS will commence in 2010, with the final design dependant both on the results of consultation and the Parliamentary debates.

Agriculture will be initially excluded from coverage in the CPRS (Table 1). However, it will still attract liabilities associated with transport and energy use. The CPRS Green Paper describes options for treating emissions and removals resulting from land use change and agriculture emissions. It also describes the uncertainty regarding how emissions from the land use sector will be treated in the future as a result of international negotiations. A decision on whether or how agriculture will be included is due in 2013, with possible commencement from 2015.

Until the appropriate legislation has been debated and passed into law, it is not exactly clear how agriculture will be treated in the CPRS and/or complementary measures. Similarly, the treatment of the agricultural sector in the post-Kyoto Protocol negotiations is not clear. However, it is clear that the introduction of the CPRS could profoundly affect Australian agriculture. There will be an active debate and this will require a strong scientific and economic underpinning. The FFI CRC will apply its strong scientific and analytical capabilities to farming systems under development and advise on the likely opportunities and impacts that arise from the instigation of the CRPS.

Table 1: Treatment of land use and agricultural emissions in the CPRS and Garnaut Review

<i>Kyoto Protocol</i>		<i>Detail</i>	<i>Recommended treatment</i>	
			<i>CPRS</i>	<i>Garnaut</i>
Annex A	Agricultural emissions	Emissions from cropped soils (nitrous oxide), livestock (methane) and the prescribed burning of savannas	Decision regarding coverage will be made in 2013. Savanna burning excluded, however not relevant to CRC FFI	Full coverage, once carbon accounting issues are resolved
Article 3.3	Reforestation, afforestation	Planting of forests on land that was not forested on December 31, 1989.	Optional inclusion of reforestation from 2010.	Optional inclusion of reforestation from commencement
	Deforestation	Clearing of forested land	Excluded; not relevant to CRC FFI	Liability for resultant emissions
Article 3.4	Grazing land management	Change in grazing practice, and resultant changes in carbon in soils and biomass (e.g. establishment of permanent pastures)	Excluded	Included
	Cropland management	Change in soil carbon contents (e.g. changes in tillage practices)	Excluded	Included
	Revegetation	Planting of land not considered to be reforestation (e.g. establishment of saltbush)	Excluded	Included

Drought

The Australian Government is reviewing drought policy and is likely to announce a new policy by early 2009. Three expert reviews have been conducted: one assessed the impact of climate change on the nature and frequency of exceptional climatic events; a second on the social impacts of drought on farm families, businesses and communities; and the third by the Productivity Commission investigated business and income support under current policy. While it is premature to interpret what the Australian Government's policy response might be, the Productivity Commission recommends that the current policy be replaced by strengthening the objectives of the *Australia's Farming Future Initiative* to recognise that the primary responsibility for managing risks of climate variability and climate change rests with farmers. Further, it recommended a renewed focus and increased government funding for R&D, extension and professional advice, and training to build self-reliance and drought preparedness.

Significantly this policy review draws a continuum through drought, climatic variability and climate change adaptation. There is an analogous continuum across the FFI CRC's current Business Plan and this Climate Change Strategy.

4. STRENGTH OF CURRENT BUSINESS PLAN PREPARED AND AGREED 2006

FFI CRC is a consortium of Australia's major industry R&D investors, R&D providers and many of its main extension and commercial service providers.

FFI CRC has a future focused program that is already developing a range of new farm technologies and farming systems. Under the current Business Plan 2007-08 to 2013-14 and the Profitable Perennials™ brand it will develop for adoption:

- Three farming systems – *EverGraze*, *EverCrop* and new woody crops;
- Innovative technologies that extend the reach of Profitable Perennials - such as *Enrich*, saltland production and perennial wheat;
- New cultivars and species and agronomic systems to continuously improve these farming systems and extend their adaptation to more challenging soils and climatic zones – *Pasturesearch* and *Florasearch*;
- Decision tools to optimise outcomes from adoption of these farming systems and plant technologies for farms, companies, catchments and regions – e.g. *Biorisk*, *SaltCAP/SaltDECIDE* and *EverCrop Decide*.

The three headline farming systems are:

1. *EverGraze*: A high performance grazing system based on perennial pasture plants. This is developing principles for boosting profitability, water resource management and biodiversity of the grazing enterprise of producers with livestock dominated businesses.
2. *EverCrop*: Options for incorporating drought tolerant perennials into crop dominated systems and businesses to deliver multiple benefits such as better soil and water management and drought resilience, lower cost organic nitrogen delivery, and weed and pest control.
3. New woody crops: Integration of new woody crops into established cropping and grazing systems for diversification of the farm business.

Evergraze farming systems will generally be practiced in the high and medium rainfall zones of southern Australia while *Evercrop* systems will be most applicable in the low and medium rainfall zones. The target zone for new woody crops is medium-low rainfall areas marginal to conventional forestry.

FFI CRC's current Business Plan has clearly defined paths to adoption involving public and private sector partners to achieve adoption of Profitable Perennials farming systems on 7.5 million hectares or 12% of the 60 million hectares under dryland farming, in southern temperate Australia, in 20-30 years.

There are now additional imperatives and opportunities for designing sustainable dryland agricultural systems:

- Responding to predictions of a drying climate,
- Better coping with adverse externalities – increasing drought, slowing productivity growth and cost pressures, and
- Participating in the new policy environment that is likely to value carbon and biomass from woody crops and may be extended to all agricultural emissions from 2015.

5. A NEW CLIMATE CHANGE RESEARCH, EDUCATION AND ADOPTION STRATEGY

This Climate Change Research, Education and Adoption Strategy builds on the Business Plan by identifying and working on additional researchable questions that will prepare its suite of farming systems and technologies for climate change and changes in climate change policy and resultant new markets. The Strategy will build on the significant existing investment by FFI CRC in these activities, evaluating the future adaptation and mitigation potential of these new farming systems compared to existing farming systems. Where necessary it will draw on new resources and new synergies with the CRC's Participants, while recognising that other collaborative ventures (many involving the same Participants) are better placed to pursue key climate change research questions beyond the scope of this Strategy.

The FFI CRC will by 2013:

- Undertake an accelerated program of testing the greenhouse gas/carbon, energy, nutrient and water use attributes of its the key farming systems and perennial plant technologies, with particular emphasis on preparedness for climate change;
- Upgrade farm economics and ecosystems services analysis, next user engagement and policy advice, with particular emphasis on determining the benefits or otherwise of engaging fully in the CPRS or complementary measures,
- Scope the new role for medium-low rainfall woody crops in mixed enterprises, to meet greenhouse gas and renewable energy targets, and contribute to on-farm sustainability, and
- Provide coherent advice and relevant training on this new environment to the CRCs stakeholders.

Farmers will be able to decide and plan adaptation technologies, enterprise changes and mitigation options prior to 2013.

6. SPECIFIC PROJECT DESCRIPTIONS AND OUTCOMES

Theme 1. Livestock Industries

Climate change will have major impacts on livestock industries, their animals and pasture feed base. Most importantly there is the need devise grazing systems that result in reduced net emissions, as methane from livestock represents a considerable contribution (12%) to Australia's national emissions [3]. On the other hand there will be incentives to increase total production and livestock numbers to maintain profitability and to develop and adapt pasture species and systems that maintain productivity in a drier environment subject to greater season to season variability

Several major initiatives are being developed to address these challenges, and these include consortia coordinated by Meat and Livestock Australia. FFI CRC's role will be to (a) specifically assess the greenhouse gas emissions from the new farming systems that it is developing (benchmarked against current systems), in collaboration with others, (b) target specific plant and systems innovations that can reduce methane emissions by livestock, (c) develop plant technologies that deliver improved adaption within current systems and (d) develop novel drought tolerant technologies, particularly for the lower rainfall margins of arable agriculture. When combined, this work will inform commentary on agriculture's capacity to mitigate greenhouse gasses.

FFI CRC has developed the skill base for farming systems innovation to address the additional challenges imposed by climate change and changes to the carbon and energy economy. This will involve new initiatives and the expansion of work already initiated. Expanding work within *EverGraze* and as part of *Enrich* (shrubs in systems) will provide a path to delivering increased adaptation to drought and more erratic rainfall while providing greater productivity and system resilience. The mitigation potential of livestock systems will be delivered through more efficient conversion of feed, the use of anti-methanogenic compounds in plants, and above and below ground carbon storage. Data generated through the activities above will be an important resource for the National Carbon Accounting System (NCAS).

FFI CRC has invested considerable resources in linking pasture and livestock innovation to its potential for economic benefit. In the future bio-economic modeling used for such analysis will be updated to include implications of greenhouse gas emissions and carbon sequestration for new livestock systems.

Activity 1.1: Benchmarking and life cycle analysis of new grazing systems

The context for this activity is assessing emissions across all agricultural industries. This is required if agriculture is to be accurately informed with regard to its emission status. FFI CRC is well placed to use its existing livestock systems research sites as examples of leading edge high output production systems. For example, we will use the existing *EverGraze* network, which is a network of farm-based research sites across the high rainfall zone of southern Australia. These sites have been established to gather soil, water, pasture and livestock input and output data from different farming systems based on exotic perennial pasture species and native perennial pastures. It will be important for FFI CRC that this work includes comparisons with lower input production systems currently in wide scale use.

This activity will assess the net greenhouse emissions and energy balances associated with the new livestock farming systems being developed by the CRC. The work will have four components: (a) measuring the changes in methane emissions from the animals in response to differences in feed sources and qualities, (b) measuring the nitrous oxide emissions from pastures, (c) determining the changes in soil carbon storage associated with perennial pastures, and (d) determining the energy balance of the new systems. For this work to be effective it will need to be part of a nationally coordinated initiative where methodologies for measurement are standardised. FFI CRC will draw in national expertise and resources to quantify net greenhouse emissions and energy balance on research sites that are setting the benchmark for future livestock productivity.

Outcome: Greenhouse gas and energy balances quantified for the new farming systems being developed by FFI CRC.

Activity 1.2: Specific mitigation technology development

FFI CRC initiatives should be part of the total effort to reduce methane emissions by livestock. Plants containing chemicals that suppress methane emissions from livestock (bio-actives) have been identified by the CRC. We will build further on this by;

- identifying plant chemicals with activity in reducing production of methane in the rumen,
- locating sources of these bio-actives in pasture plants (particularly Australian native species),
- optimising the levels of bio-actives in pastures by selection and breeding, and
- developing grazing systems that will allow the identified plants to be used effectively for emissions reduction in profitable livestock systems.

This is a natural extension of current FFI CRC work which draws together discipline skills in plant genetic resource collection and evaluation, plant breeding, plant chemistry, animal physiology (particularly rumen function), livestock grazing behavior and management, and farming level system integration. These skills have been recently exploited to produce cultivars of *Lotus corniculatus* with plant tannin concentrations expected to optimise rumen function and to identify Australian native shrub species with methane emission reduction potential (the *Enrich* project).

Outcome: Plant production and grazing system tools for the livestock sector to decrease its greenhouse gas emissions.

Activity 1.3: Development of climate change tolerant species and cultivars for commercialisation

Aspects of climate change that may affect future pasture plant production include changes in both mean and extreme temperatures and changes to available water. To improve adaptation requires development of plants and associated production and management systems to cope with or avoid these increased stresses. In general, the genetic variation within well established commercial pasture species will allow breeding and selection for traits which deliver the necessary adaptation to maintain productivity and persistence. In other circumstances novel plant options may be required (see section 1.4 below) The use of plant improvement as a primary tool for delivering adaptation needs to recognize the time scale over which outcomes are delivered. Adapted cultivars will take a decade to deliver as a commercial entity (seed in the hands of growers) so action is needed now in anticipation of the emerging climate changes.

Central to adaptation will be the assembly of genetic diversity needed of future breeding and selection. Examples of selection traits (targets for the diversity search) will be those that allow growth under water stress (i.e. rooting depth), effective reproduction (i.e. earlier flowering) and stress avoidance (enhanced summer dormancy).

FFI CRC has projects delivering these characteristics in a limited number of herbaceous perennial pasture species (i.e. tall fescue, cocksfoot and birdsfoot trefoil). These well established approaches, supplemented by molecular bio-technology where appropriate, now need to be applied to a much wider range of species. Additional breeding will be focused on white clover, red clover, strawberry clover, *L. pedunculatus* and Chicory, assuming lucerne breeding continues in the hands of FFI CRC partners.

Outcome: Cultivars of key agricultural plants (particularly perennial forage species) with traits that are adaptation to climate change stresses for key regions and farming systems.

Activity 1.4: Development of novel plant options for marginal areas

The low rainfall margins of the arable agricultural zones of Australia are a special challenge for farming system adaptation to climate change. Current land uses dominated by cereals and annual pastures are struggling to remain viable in the face of combined climatic and economic stresses. The rangeland production systems located on the dry boundary of these regions are low input / low productivity systems and are of limited value in providing a model for technological adaptation to a drying climate. In addition, there are few examples of well adapted perennial pasture species which might be further developed to tolerate even greater climate stress (lower rainfall and higher temperatures). Development of livestock systems based on novel technologies and systems offers the best opportunity for agricultural adaptation.

Research activity will involve spatial and economic analysis to identify the regions at greatest risk and the sub-environments where existing cropping technologies can be most logically replaced by low input livestock production. Technology and system development will involve identification (prospecting, selection and breeding) of appropriate herbaceous perennials and shrubs that combined with existing annual species will produce a livestock feed base. This plant adaptation will need a parallel effort to develop the best adapted grazing management using animals genetically suited to the low input system.

FFI CRC has existing projects (*PastureSearch* and *Enrich*) which can be expanded and accelerated to provide the novel technologies and systems for this target region.

Outcome: Low input livestock production systems based on perennial pastures and shrubs to replace crop based systems.

Theme 2: Cropping systems

The major climate change related issues for cropping systems are:

- The nitrous oxide emissions associated with dryland cropping, currently thought to comprise 8% of Australia's emissions,
- The possible inclusion of soil carbon sequestration in future carbon trading arrangements under Kyoto Article 3.4 "Cropland Management", and
- Developing adaptation strategies that integrate the management of water and nitrogen.

FFI CRC has a modest direct commitment to crop technology (development of salt and water-logging tolerant wheat and perennial wheat) but a high level of commitment and expertise in the technologies and land uses associated with crop production in mixed farming systems, particularly increasing the use of perennial pastures as a rotational element with crops. FFI CRC will concentrate on adaptation of these crop rotation systems to meet the demands of a changing climate but set against the context of parallel adaptation in crop technologies in response to climate change.

Additional work within *EverCrop* will increase; adaptation to more frequent drought and more erratic rainfall through the provision of perennial pasture options to complement opportunistic cropping (depending on soil properties and seasonal outlook) and strategies to cope with externalities, including the provision of organic nitrogen from leguminous perennials to offset high fertiliser prices, and mitigation through the integration of woody crops and herbaceous perennials for carbon sequestration. Assessment will be made of cropping system options for new environments, including more cropping in the high rainfall zone and opportunistic cropping in the low rainfall zone.

Activity 2.1: Benchmarking and life cycle analysis of new cropping systems

This area of work is part of a much wider need to assess emissions across all agricultural industries and systems. FFI CRC will assess the net greenhouse gas emissions and energy balances associated with new cropping systems incorporating perennials being developed by the CRC. This will involve using methodologies and resources provided by others but focused on systems and sites of wide relevance and representative of leading edge technologies. The research will have two components: measuring the changes in nitrous oxide emissions and the changes in soil carbon associated with the crop production systems.

Fundamental to the life cycle analysis will be the opportunity to benchmark:

- Crop only systems - high nitrogen fertiliser input,
- Crop systems with an annual legume grown in rotation – low nitrogen fertiliser input, and
- Crop systems with a perennial legume grown in rotation – low nitrogen fertiliser input (FFI CRC technology)

The importance of this work is that it will allow the application of emission metrics to the entire production system and not just the crops in isolation from their farming system. While differences in both nitrous oxide emission and carbon accumulation between annual and perennial plants are likely these differences need to be quantified. Specific nitrous oxide mitigation technologies would not be a focus of this work.

Outcome: Quantification of the greenhouse gas emissions and energy balances associated with the CRC's new cropping systems, incorporating perennials.

Activity 2.2: Development of drought tolerant plants for cropping systems, including novel plant options for marginal areas

Adaptation in cropping systems can take place by:

- Changes to crop technology in the cropping phase of rotations,
- Changes in the non-crop (generally pasture) phase of rotation, and
- Changes in the mix of crops and pastures in the system.

Changes in the crop/pasture mix can occur as a result of strategic and long term decisions or as a result of short term tactical decisions (see Activity 2.3).

This activity will concentrate on adaption technologies relevant to the non-crop phase of rotations while taking account of the implication of crop phase adaption on the non-crop phase. It will focus on the development and use of plants adapted to greater climate stresses (see Activity 1.3) and novel plants for marginal areas (see Activity 1.4), for their multiple crop and livestock benefits. The only exception to this plan will be to undertake research exploring the potential offered by perennial crops (wheat). This is an existing activity but can be extended to explore the opportunity to reduce production risks in variable and drying climatic setting.

Outcome: Wider range and choice of drought tolerant perennial species and cultivars for their benefits to the cropping system while adapting to likely climate changes.

Activity 2.3: Tactical options for cropping systems to adapt to climate change

FFI CRC will develop options for farmers facing a tactical reduction in cropping in seasons with below average yield potential, as a consequence of climate change. This will require the linking of better climatic forecasting (within a season and undertaken by others) to the work of the CRC, and involve:

- Risk analysis (bio-physical risks linked to economic implications and delivered as an extension of *Evercrop Decide*), and
- New perennial pasture technologies that deliver a perennial pasture suited to be grown as a companion with crop in good years but pasture only in poor seasons.

Current FFI CRC research activity in perennial pasture improvement aimed at phased rotations has identified plants with traits that suit them for this new concept of companion species to crops in mixed crop/pasture systems. To exploit the opportunity and the available germplasm, additional resources will be required.

It is anticipated that the technology will be applicable to all rainfall zones and:

- focus on summer active perennial legume development (delivering counter cyclical growth pattern to the crop and nitrogen supply),
- focus on parts of the farm with low crop yield potential, and
- involve system development to emphasise soil sustainability (soil cover and fertility enhancement), weed management and grazing management to exploit the out of growing season

The farmer's decision to crop or not in any year requires information on crop production, water availability and climate prospects, and economic analysis within a risk framework. FFI CRC will extend its development of *Evercrop Decide* to cover these additional scenarios.

With climate change the demand for perennial pasture technologies changes. In high rainfall zones reduced water-logging will encourage cropping and hence the need for species in phased rotations. The research strategy needed is broadly similar to that outlined in Activity 1.3 but demands the additional traits of ease of establishment and removal after and before cropping. Activity 1.4 outlined the planned R&D for new plants and systems for low rainfall areas where cropping is becoming unprofitable on some soil types. In these contrasting settings a common need is for the bio-economic modeling and risk analysis that gives rise to the right plant being used in the right landscape position (*Evercrop Decide*)

Outcome: New perennial pasture species in more resilient cropping systems.

Theme 3: Integration of woody crops into farming systems for carbon mitigation

This Theme will focus on the potential to develop and expand the use of woody perennials in mixed farming systems in southern Australia. It will allow farmers to understand their emissions profiles, actively develop technologies to reduce these emissions and remove carbon dioxide from the atmosphere via the reforestation of farmland. The projects are aimed at reducing net emissions from the sector, and thus assisting Australia to meet its emissions reduction target. This component will build on existing FFI CRC efforts to develop innovative farming technologies including *Evergraze*, *Enrich*, *Evercrop*, *FloraSearch*, *Biorisk* and saltland production.

The additional activities that can be incorporated into the new woody crops program are based on the modeling and data collection for carbon sequestration in harvested versus un-harvested stands, the expansion of woody crops into lower rainfall zones along with their strategic placement in landscape, and the metrics of integration of woody crops in whole farm businesses under NCAS. Bio-economic modeling for the optimisation of woody crops within farm businesses will be updated to include a feasibility analysis, plus a sensitivity analysis to carbon and renewable electricity prices.

Data obtained from the bio-economic modeling will be used to inform public discourse and provide policy advice, in view of the likely CPRS with emissions trading by 2010 and expanded MRET.

Activity 3.1. Productivity of reforestation in variable landscapes

Woody crops are attractive to farmers with their role as a carbon sink and as a bio-energy feedstock, particularly with the imminent introduction of the CPRS and MRET. The potential and optimum spatial arrangement of a range of woody crop systems suited to the dryland cropping and livestock regions of southern Australia will be evaluated in terms of carbon mitigation and also the impact on other greenhouse gases. This will include reforestation that is both harvested (e.g. timber, bioenergy plantings, fodder production systems), or non-harvested (biodiversity plantings). Plantings could be in a range of designs from strips (alleys), integrated with farming, or as discrete blocks.

Outcome: Determine optimum reforestation system designs for greenhouse gas mitigation different rainfall zones using spatial information and economic analysis.

Activity 3.2. Examining trade-offs and synergies

Future reforestation must take into account cross-cutting interactions such as changing water and energy use, biodiversity conservation and food security. This activity will examine these interactions and aim to minimize negative trade-offs and maximize synergies. Values will be determined for these ecosystem services.

Outcome: Understanding of the synergies and trade-offs resulting from reforestation.

Activity 3.3. Capability of new woody industries

Carbon mitigation on farmland, using woody crops increases when the stand is harvested. Maximum competitive prices for woody crops are potentially achieved for landowners using species that have short rotations and regenerate or can be harvested by grazing. Species from various Australian genera including *Eucalyptus*, *Acacia* and *Allocasuarina* can be used in coppice rotations for chipped biomass production. Species such as *Atriplex* can be used in grazing systems. However, market outlets must be established to achieve maximum profitability. Eucalyptus mallee has several promising market options including the extraction of Eucalyptus oil from the leaves, as chipped biomass and fuel pellets for renewable energy and as medium density fibre (MDF) board. Woody fodder shrubs can be integrated into livestock production systems.

Outcome: Estimation of carbon mitigation potential and market options for Australian woody species in coppiced short-rotation stands and grazed fodder shrub systems.

Activity 3.4. Increasing soil carbon sequestration in reforestation systems

Soil carbon can be considered as a pool within Kyoto Article 3.3 reforestation, and may thus contribute to a project's value. This Activity will examine methods to increase the storage of soil carbon within reforestation systems. It will examine factors such as low-impact site preparation systems and the addition of ameliorants.

Outcome: Increased understanding of soil carbon sequestration within reforestation systems in zones where forestry is not traditionally practised.

Theme 4: Integrating Theme, Bio-economic modeling of farming systems

Within ecosystem services robust decision-making processes will be developed for climate change policy implementation, biodiversity activities will be expanded across all farming systems and the benefits of saltland reforestation will be reassessed in view of reducing greenhouse gas emissions, sequestering carbon and protecting water resources. In both biodiversity and saltland reforestation the aim will be to increase benefits without using trade-offs.

Socio-economic analyses will include new whole-farm bio-economic modeling to incorporate risk and climatic variability (see the above program activities), and the development of a Future Farm Business model as a learning and tactical decision analysis tool to be used for adoption planning and strategy provision for farmers under a changing climate.

Path to adoption activities will include raising the awareness of the implications of the CPRS and provide education and training to the agricultural industry and leading farmers for participation in new policy environment. A phased adoption strategy will be developed in relation to evolving CPRS strategies comprising three phases; an immediate tactical response, a transition to longer-term activities and promotion to full adoption of the new systems.

Farmers will respond to climate change and associated policy changes by adopting new technologies and systems. The challenge is to integrate these influences into their business while uncertainty remains about the extent and direction of changes. Bio-economic modelling that encapsulates climate change scenarios and incorporates the implications of future policies will provide important guidance about the future direction of farm businesses. Increased climate variability and the consequential risks landholders take when managing their businesses is an important component of farm management that is missing from most economic analysis.

The Future Farm Industries CRC has the track record in bio-economic modelling from which to:

- allow the implications of climate change to be interpreted at the individual farm business level,
- ensure that industry initiatives can be put into a full farming system context,
- allow region specific elements to be understood and incorporated, and
- expand modelling frameworks to accommodate the increased risk associated with greater climate variability.

Other specific components that will be required in the models are the comprehensive inclusion of woody crops as part of the farming system, including a recognition of the value of carbon sequestration and the value of reforesting landscapes with perennials to manage salinity and waterlogging, increasing the persistence of biodiversity and improving water quality, both on-farm and within catchments.

Activity 4.1. Development of a suite of bio-economic models of dryland farming systems incorporating climate change scenarios and policy settings

The activity will involve the identification of key mixed farming regions of southern Australia and build on existing analytical tools to produce a comprehensive suite of models within which climate change scenarios and policy settings can be analysed. These models will allow industry level technology and policy variations to be evaluated in a comprehensive way taking account of changes occurring in all related industries.

Outcome: Capacity to predict the farm level economic implications of changes in climate and associated climate policy to be used as a feedback mechanism on policy development, as a tool to inform the direction of farm technology development and as a tool to guide the direction of farming system and farm business change.

Activity 4.2. On-farm bio-economic analysis including woody perennials in the farming system

The risk and management of including woody crops in farming systems, in combination with changing crop and livestock systems to include perennial plants in response to a changing climate are required in bio-economic models. In response to this, existing models will be reviewed and adapted to provide a whole-farm bio-economic model that incorporates these additional components for key regional settings in southern Australia.

Outcome: Provision of an updated bio-economic model that incorporates the components of risk and increasing woody perennials in the farming system in response to a changing climate.

Activity 4.3. Use of 'Biorisk' to measure the off-site effects of planting woody crops in catchments affected by altered hydrology

'Biorisk' is a value- and asset-based decision management tool that will improve management decisions for biodiversity assets, particularly those threatened by altered hydrology including increasing salinity and decreasing water supply to water-dependent ecosystems. Climate change has the potential to significantly change the hydrological context in individual catchments. In addition, new land use strategies being applied on-farm will have off-site implications for threatened assets. Broad scale revegetation with perennials is the technical intervention that, effectively designed and implemented, will have the greatest impact on ecosystem processes affecting the persistence of biodiversity. However, this impact may be either positive or negative, depending on the structure and composition of new perennial vegetation.

Outcome: Effective use of catchment specific climatic models to predict outcomes for water-dependent ecosystems of biodiversity importance.

Theme 5: Pathways to adoption

FFI CRC has established human capacity to develop and deliver training to agricultural industries including farmers and their advisors. This capability will be directed to the development of material to effectively communicate the implication of climate change and climate change policy to farmers and those that advise them.

FFI CRC has an established network of regional adoption initiatives which provide an opportunity to interpret the changes to farming systems dictated by climate change. These networks draw together

researchers with public extension services and agri-business to deliver material that has tested relevance to producers.

Activity 5.1. EverFarm™ information integration

FFI CRC will integrate the data on the response of its emerging farming systems from an array of sources through its commitment to collaborate and make its sites available to measurements by others. Farming systems scientists and economists will be in a position to test the resilience of these new systems under the pressures associated with climate change and climate change related policies.

Outcome: New perennial based farming systems with demonstrated resilience in the face of likely climate change scenarios

Activity 5.2. EverTrain™ delivery of climate change information to producers and their advisors

Information about innovative farming systems that deliver greater profit and resilience under climate change scenarios needs to be available to the potential users of the information, particularly farmers and their advisors. FFI CRC has skilled participants who will design and deliver formal training modules to farmers on new climate change ready farming systems. These participants will be activated to focus on the extra challenges faced by farmers in introducing new technologies against a backdrop of climate change. FFI CRC will also develop a spatially explicit farming systems 'game' into which all aspects of climate change decisions will be incorporated. Those playing the game ('FutureFarm Business') will be able to develop an understanding of the impact of climate change on the increased risks associated with farm business decisions

Outcome: Leading farmers and their advisors introducing new more profitable farming systems with confidence that they have been analysed and tested for the implications of climate change.

Activity 5.3. On-farm adoption

FFI CRC has a comprehensive regional network structure to oversee adoption of new farming system technologies and systems. Systems that will deliver profitability and resilience within the emerging climate change context will have aspects that will require components that are strongly region specific.

Outcome: Farmers with new technology and system opportunities available to them that have been developed with regionally specific elements that will reduce the risks associated with new technology adoption.

7. HOW THE STRATEGY WILL BE IMPLEMENTED

A four phase approach is recommended:

1. Climate change, climatic variability and drought are mainstreamed within the existing Programs and Projects, with Program and Project Leaders identifying what additional project-level work and resources are required to adequately address the themes of this Strategy,
2. New funding is sought for projects as opportunities arise. Proposals will be highly targeted and informed by this Strategy. Where the funding is targeted at the CRC's core strengths, the CRC will bid in its own right. Examples include the *Australia's Farming Future Climate Change Research Program* (September 2008) and potentially a supplementary bid to the CRC Program. Where the CRC's farming systems and technologies are logically part of larger climate change responses, typically mitigation of greenhouse gases, then it will be more appropriate to partner with other research ventures in a support role.
3. Formal links are developed with other groups working on climate change that will allow access to key modeling and data sets. This will include access to future climate change scenarios and impact assessments, methane and nitrous oxide measurement, and technologies outside the core capabilities of FFI CRC.
4. In the lead up to key policy decisions on how agriculture will be treated under climate change policy, a series of situation statements will be prepared for FFI CRC farming systems and technologies. They will be prepared by multi-disciplinary teams drawn from across the CRC, combining science, economic analysis and the practical experience of industry and next users. Working documents will be presented at conferences and forums, and published in the refereed literature. The situation statements will allow the CRC to put evidence before the agricultural sector in the unfolding public debate related to both climate change and emissions trading.

8. REFERENCES

- [1] Australian Government. Carbon Pollution Reduction Scheme: Green Paper. Canberra: Department of Climate Change, 2008: pp. 516.
- [2] Garnaut R. The Garnaut Climate Change Review. Melbourne: Cambridge University Press, 2008. pp. 720.
- [3] Department of Climate Change. National Greenhouse Gas Inventory 2006. Accounting for the Kyoto target. Canberra: Department of Environment and Heritage, 2008: pp. 31.