Agricultural Competitiveness White Paper Submission - IP538
Australian Council of Deans of Agriculture
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Australian Council of Deans of Agriculture (ACDA)

Submission to the Agricultural Competitiveness White Paper

EXECUTIVE SUMMARY AND RECOMMENDATIONS

The ACDA is Australia's peak body for tertiary education and research. The ACDA is made up of those Universities in Australia that offer a degree course in agriculture or related agricultural areas (currently fourteen universities, spread across every State and located in both metropolitan and rural locations). Members of ACDA welcome the opportunity to contribute to this White Paper process. While our submission touches on most of the topics raised in the discussion paper, our focus is on issues 1, 2 and 4 (ensuring food security, improving farmer decisions and better farm gate returns, and enhancing competitiveness through the value chain)

- **Agriculture is defined as the value chain comprising on farm and off farm businesses**
- **There needs to be an agreed vision for the sector to guide direction**
- **R&D is the key to future prosperity and sustainability and needs to be directed across the value chain.**
- **The *government* contribution in matching industry levies needs to be directed to multi-disciplinary research (50%) and transformational research (50%) which lead to step change improvements. Such projects should be awarded through open competition and after peer review.**
- **Postgraduate research scholarship conditions need to be made competitive to attract more Australian students. Changes include, base stipend increased to ARC Linkage levels tax-free, taxation amendments needed to allow 100% top-ups, increments introduced for satisfactory performance, superannuation entitlements provided)**
- **A "land grant" system be introduced to the agricultural universities to address the extension shortfall**
- **Education effort to school students should be enhanced and cover the role and importance of agriculture and the range of promising careers available. The 'Career Harvest' innitiative warrants strong support**
- **A clear strategy that articulates the need for education and training and establishes career paths for new entrants into the sector must be developed.**

INTRODUCTION

Australian agriculture has depended heavily on research, development and extension (RD&E) for many decades to increase the gross value of agricultural production (GVP) and its sustainability. The work of Mullen and Crean (2007) indicates that agricultural GVP would be only one third of current value without R&D over the last 60 years.

The imperative for R&D to continue is unquestionable if the prosperity of the sector is to be sustained and enhanced at all levels of the value chain. This imperative however is challenged by the contraction of the state agencies in research and extension and the uncertainty of the CSIRO restructure and funding base. Universities, already Australia's major research providers, are increasing their contribution to this effort. The opportunity to create a new paradigm in extension through a 'land grant' university initiative ought to be taken to assist in reducing the lag time between research outcomes and industry adoption.

The Research and Development Corporation (RDC) system serves the sector well but the ACDA is concerned that not enough attention is paid to the strategic research agenda that will lead to transformational outcomes for the national prosperity and sustainability of agriculture. Compromising that effort is, amongst others, the need to improve the financial incentives for postgraduate study and the career paths for new researchers. Australian universities are finding it difficult to attract Australian students to undertake higher degrees and international higher degree students constitute an increasing proportion of higher degree load. Whereas international students make up around 30% of higher degrees generally, that proportion is closer to 60% in agriculture. Clearly this is of benefit to the scholars' home countries as the higher degree graduates return to positions of influence and contribute to the resolution of important issues such as food security and improving standards of living. They also act as cultural ambassadors, improving Australia's image, networks and market access. However the data show that there is much work to be done in attracting domestic students into research degrees.

The future of the sector is also dependent on a well educated and trained workforce. Despite a recent increase in new student enrolments in agriculture-related degrees in Australian universities, demand for graduates still outstrips supply by 5:1. There remains an acute shortage of skilled graduates for agribusiness. At Australian high schools, agriculture careers are still wrongly portrayed as unattractive, with few opportunities for advancement. Efforts need to be expanded to educate high school teachers, career advisors and school students about agriculture and the range of career opportunities available. The role of websites such as 'Career Harvest' and improving the brand of agriculture in schools and the community at large are critical in this process and warrant strong support. There is a need for a workforce strategy to articulate the need and role for education and training and to ensure that there are well established career paths for new entrants.

WHAT DEFINES AGRICULTURE?

Whereas most people equate agriculture with farming, in reality it refers to the whole food and fibre value chain often referred to as the farm-dependent economy. It takes into account the pre-farm gate supply sector, on-farm production, the post-farm gate processing and marketing as well as the associated advisory and finance sectors. It also includes the humanitarian work undertaken as part of the international aid effort (Figure 1).

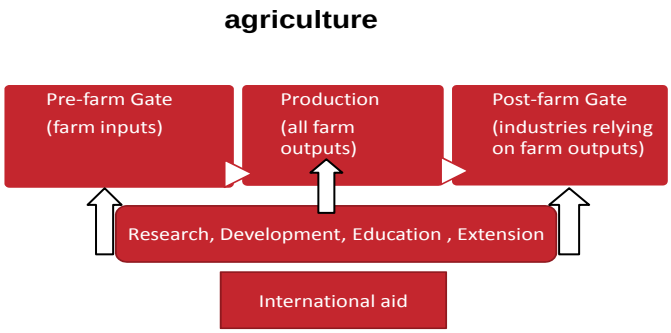

Figure 1 Agriculture components (NSW Review, 2013)

The White Paper provides a valuable opportunity to articulate where the agriculture sector might want to position itself in the foreseeable future. To that end articulating a vision is a useful place to start.

VISION

The Farm Dependent Economy currently employs 1 in every 6 in the Australian workforce. It is identified by all major parties at State and Federal levels as a key sector for economic growth. Despite this recognition, no strategic overview has been undertaken of this key industry sector as a whole. Thus, the Government's Issues Paper is timely and should be applauded.

The vision for Australian agriculture is a sector which:

- **Is profitable along the value chain and financially resilient**
- **Is export-competitive**
- **Is increasingly knowledge intensive requiring essential tertiary qualifications at most senior levels throughout the value chain**
- **Has established industry-driven standards and accreditation which are at world best practice**
- **Has a highly trained, professional workforce which is valued**
- **Provides an attractive work environment which is safe, socially inclusive and culturally diverse**
- **Is environmentally responsible and sustainable**
- **Delivers high quality, ethically grown, affordable and safe produce**
- **Has a high level of self-esteem and**
- **Has the respect of the community and the social licence to operate.**

Figure 2 A suggested vision for agriculture (based on NSW Review, 2013)

Whilst various industries or companies within the agriculture sector may have developed vision statements for their operations there is no clear statement for the sector as a whole. The challenge is to decide those aspects on which agreement might be reached and build from there. ACDA

considers that the vision expressed in Figure 2 is worthy of support. The need for commonality of purpose in the sector is urgent if the sector is to capitalise on its opportunities. Determination of the vision will thus direct the needs for research, education and training, and career development.

This vision foresees an agricultural sector with ambitious, yet socially responsible growth targets. To capitalise on the substantial opportunities and manage the multiple challenges, a well-trained and educated workforce is needed. Currently this constitutes one of the major constraints. Amongst others, the sector requires business and production skills on-farm along with sound knowledge of value chains and their interdependencies. The sector needs to promote itself as exciting, high tech and environmentally conscious with a large range of worthwhile and rewarding careers. RD&E are critical components that need to be embedded at every step within the value chain to improve the prosperity of the agriculture sector and the community more broadly.

THE RESEARCH AND DEVELOPMENT CORPORATION (RDC) SYSTEM

There is strong support for the Research and Development Corporation (RDC) model and the matching payment scheme for levies used for research. The model is highly regarded internationally as world best practice.

There are around 14 RDCs in the scheme but they operate independently. Thus researchers are faced with different forms for each RDC for applications for funds, for reporting, for intellectual property (IP) and contracts. Transaction costs are very high for researchers, their organisations and the RDCs. The ACDA considers that there should be a single "*Agricultural Research Administration System (ARAS)*" compatible with, but more practical than that of the ARC. Researchers would have individual ARAS registration numbers which when entered would populate the required forms with the unique information related to the researcher, leaving the research project information only to be entered by the researcher. A researcher registration number would simplify data collection to generate a more complete database of agricultural research. It would also facilitate and standardise the reporting requirements to government and ensure that all eligible grants are listed on the competitive grants register (some RDCs fail to recognise the importance of category 1 grant funding for universities, making themselves unintentionally less attractive to universities). The Research Councils of the United Kingdom (http://www.rcuk.ac.uk) use such a system, bringing together 10 funding agencies into one process.

The issue of IP is always contentious. The vast majority of research projects do not have significant IP yet this issue occupies substantial time and consumes precious research funds. Each RDC has its own IP requirement and CSIRO and some universities themselves are extraordinarily difficult on the issue. This draws out negotiations and provides much fodder for the legal profession. ACDA recommends the use of Easy Access IP as the standard, as it is gaining acceptance in the university sector (e.g http://www.nsinnovations.com.au), decreasing costs, increasing interactions with industry and ensuring fast, efficient IP arrangements.

RDCs are very cognisant of their stakeholders who seek quick, personalised results. The ACDA appreciates the focus but the approach results in a plethora of short-term projects which deliver at best small, incremental progress. An unintended consequence is the impact on the research community which operates in an insecure environment, resulting in loss of valuable expertise out of the industry. The RDC research budget comprises industry levies matched by government

investment. It is reasonable that the research paid for from the levies is directed towards the wishes of the stakeholders who provided them. It is ***not*** reasonable to expect that government contributions follow the same route. It is reasonable that the government provides the funds on behalf of the taxpayers with strings attached. It is the view of the ACDA that such funds be provided for interdisciplinary research (perhaps involving two to several RDCs and perhaps ARC, funding bodies from health, engineering, education, environment and other sources) and for longer term strategic research that aims to provide the best chance for transformational outcomes directed to industry prosperity and sustainability. The ACDA recommends that half the government contribution (*i.e*. 25% of the RDC budget) be allocated for the transformational research component, which should be by open application and evaluated by peer review to protect the intentions of the funds.

AGRICULTURAL EXTENSION – FEDERAL GOVERNMENT SUPPORT FOR A "LAND GRANT" SYSTEM

Research by Australian economists Pardey and Alston has demonstrated that lag time between research and widespread adoption in agriculture is around 10-15 years. A significant example in Australia is reduced tillage agriculture where the lag has been around 30 years. Adoption of research requires persistent effort by champions of the technology, often closely linked with researchers, to demonstrate benefits against resistance from entrenched but mistaken views. However, any delay in adoption of a practice is a major opportunity cost to efficiency and competitiveness of our agriculture.

Despite the need for extension to enhance adoption, it is the case that extension provision from government agencies has been severely contracted over the past two decades and this continues. It is recognised that some of this activity has been taken up by private sector consultants and internet development. It is also clear that the link between research and extension has been broken, particularly where it relates to system changes and public good issues. Without strong public extension provision, issues of sustainability, for example, will be difficult to implement.

In the United States, the Land Grant University model provides a strong link between university research and teaching and on-farm extension and adoption. University skills and assets in teaching provide a strong and natural base for the continuing adult education that is often called extension; it forms a fundamental part of what is often referred to as 'innovation platforms'. Numerous academics hold joint or partial appointments, specifically in extension. Personal relationships are typically established by academics with future industry leaders while they are students and these last for decades, enhancing the knowledge transfer process.

Historically, the US Department of Agriculture has provided cash support to US Land Grant Universities on the order of US$1 billion annually. Normalised for Australia's smaller population, the US federal cash support alone is equivalent to around AU$70-75 million annually. A key problem in Australia is that no such funding arrangement exists. Universities are funded primarily for teaching by student numbers, and any research grants are short term for specific projects. Budgets in agricultural faculties and schools are very tight, typically in deficit. In contrast to state agencies and CSIRO, there has never been a funding scheme to facilitate continued contact between academics and the primary producers beyond the end of grant-funded research projects. As a result, academics involved in extension often do it voluntarily. If they do not have a grant, they cannot pay for travel and accommodation, brochures, videos, websites, field demonstration sites and the like. It is worth noting that the GRDC annually awards "Seed of Light" recognition for outstanding accomplishment

in extension. Although GRDC has awarded about 25% of its funding to academic researchers, only two out of over 60 “Seed of Light” awards in the last 20 years have been awarded to academics.

The ACDA therefore proposes that the Australian Government provides funds to the agricultural universities along the lines of the Land Grant model. This support should be direct to the university Faculty, School, or Department rather than to the central university administrations so that funds cannot be diverted to general university operations. There would need to be concise annual reporting of accomplishments. There does need to be attention given to reducing the lag phase between research and adoption. The opportunity cost of doing nothing in extension is too high.

INNOVATION WORKFORCE

Universities provide for graduates to undertake postgraduate research degrees that qualify them for a career in research and industry. Postgraduate scholars are an important contributor to the research performance of a university, on which funding and reputation depend. It might be assumed that the research training pathway is attractive enough to entice those with the appropriate intellect to consider that direction. That is not the reality.

To be eligible for postgraduate research, a student is required to have a four year undergraduate qualification with Honours. At this point an agricultural science graduate will have accumulated a HECS-HELP debt of around $30,000. That debt is payable through the taxation mechanism when salary reaches a threshold ($49,000 in 2013) and continues to accumulate interest based on CPI adjustment for the duration of postgraduate study and until fully paid. There is no further HECS-HELP for an Australian graduate undertaking the higher degree.

Scholarship arrangements for a postgraduate scholar are based on the ‘prestigious’ Australian Postgraduate Awards (APA) which are allocated to universities by formula. The stipend, which is tax free, is $24,653 per annum and also applies to ARC doctoral scholarships awarded under the Discovery Scheme. The stipend under the ARC Linkage Scheme, however, is $29,844. It is unclear why this discrepancy exists. The poverty line in late 2012 was around $25,200 and so $24,653 is below the Australian poverty line and is a disincentive, particularly when agribusiness salaries are well over double that figure for new graduates (Table 1). Comparison with average weekly earnings shows that the stipend continues to lose ground (Figure 3).The tax-free status, useful in past times, now makes little difference as tax scales have changed dramatically over recent decades with the tax-free threshold now being $18,000. The minimum wage in Australia in 2013 was around $31,532, 28% above the scholarship stipend. These stipends have no associated increments. Whereas the rest of the community now has superannuation benefits, these do not flow to postgraduate scholars. By any comparison, the remuneration is a disincentive for those whom we would wish to be attracted to the research pathway. It is a 20th century construct in the 21st century.

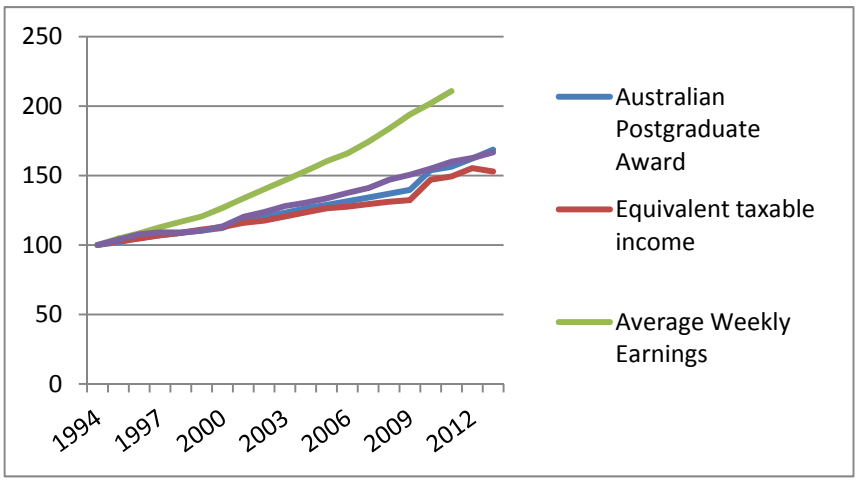

Figure 3 Relative increase in value of the APA stipend to the equivalent taxable income (Australian Taxation Office 2013), average weekly earnings in February for males (ABS, Cat. No. 6302.0, 2013) and consumer price index in February (ABS, Cat. No. 6401.0 2013), from a base of 100 in 1994

Table 1 Relationship between taxable income, based on 2012-13 tax rates, and postgraduate stipends (Australian Taxation Office 2013)

TAXABLE INCOME	TAX PAYABLE	NETT INCOME	SCHOLARSHIP EQUIVALENCE
$24,000	$1,102	$22,898	
$26,000	$1,482	$24,518	• APA • ARC Discovery scholarship • Poverty line 2012
$28,000	$1,862	$26,138	
$30,000	$2,242	$27,758	
$32,000	$2,622	$29,378	• Minimum wage level • ARC Linkage scholarship
$34,000	$3,002	$30,998	
$40,000	$4,547	$35,453	
$50,000	$7,797	$42,203	• GRDC top-up
$55,000	$9,422	$45,578	• Common grad starting salary

The stipend can be adjusted upwards without affecting its tax-free status. Under basic student eligibility requirements for an Australian Postgraduate Award (APA), as stated in section 2.10.1(1)(g) of the *Commonwealth Scholarships Guidelines (Research) 2012*, it is a requirement that a student must not be receiving an equivalent award, scholarship or salary related to their course of study providing greater than 75% of their annual APA stipend rate. Based on the 2013 APA stipend rate of $24,653, full-time students must not be in receipt of a combined amount greater than $18,489 from additional sources (for example – top up-scholarships), in 2013, to remain eligible for an APA. Under this basic eligibility requirement, income received from sources **unrelated** to the course of study is not taken into account and therefore should not affect their eligibility for an APA under this section. Only GRDC of the RDCs provides maximum top-up.

The other aspect of this training pathway for scientists is at the career end of that study. Over the course of the last two decades there has been significant erosion in the career prospects for

emerging scientists in agriculture. The Cooperative Research Centre (CRC) program has played a significant part in that change whereby much of the emerging research capacity was funded through CRC funds. This represented a partial substitution effect in respect of the state agencies (DPIs) which was fine at the time but which has not been redressed as CRCs complete. State agencies in particular operate much smaller research workforces now than occurred in the early 1990s. Increasingly, doctoral graduates are employed on research funds largely from the RDCs, usually on three year grants. This three year cycle is highly inefficient due to start up and wind down components, is demoralising for the postdoctoral scholars and eventually is wasteful of expertise as significant numbers leave the industry. Contracts for research grants often take an inordinately long-time to renew and no account is taken of the impacts on families and esteem. This system needs to change. Greater security and improved personnel management are needed and it is proposed that 5 year minimum postdoctoral projects be funded to provide that better security. There needs to be a review at three years where prospects for renewal, change or termination are determined. This provides the time for alternative actions to be initiated if necessary and for contractual arrangements if any to be in place well before the current contract concludes. If it is deemed that the project is not suitable for such funding or that there is a lack of confidence in the candidate then the project should not be funded in the first place.

LABOUR AND EDUCATION IN AGRICULTURE

Workforce issues are current for the agricultural industries on farm (*ie* behind the farm gate) and along the value chain (*ie* beyond the farm gate). Whilst the market has been responsive to the latter, there are more fundamental issues related to the on-farm workforce. Unless these are addressed it will be more increasingly difficult to attract suitably qualified people into the sector.

Behind the farm gate The issue of labour in the production workforce, 'behind the farm gate', is one of competing forces. On the one hand the employer wants to minimise the cost of labour in the interests of tight profits. In training there is a focus on skill sets rather than qualifications. On the other hand the employee needs to provide for his or her family and its future. Today, new employees are working to a different paradigm from that of the 20th century. Qualifications have become more important as they are the currency for workers to move jobs or take advantage of education and training pathways for personal and professional advancement. Agriculture has become a knowledge-intensive endeavour: most successful operators are not only qualified in traditional agricultural subjects, but they are also competent financial managers, have an ability to comply with complex legal regulations, are excellent communicators and negotiators, have a savvy understanding of domestic and international markets and are competent HR managers.

To some extent the two sides do not appear reconcilable but they need to be. The 21st century paradigm for employment in the Australian workforce is based on it being well educated and trained where pathways for progression are provided. Agriculture is well out of step with the rest of the nation's workforce, and its international competitors, to the extent that it will find it increasingly difficult to attract the younger generation to join the agricultural industries. The cotton industry is a notable exception to this rule.

Data show that the sector has embraced traineeships but not apprenticeships. Informal advice suggests that apprenticeships have a longer employer time commitment plus award requirements in terms of wages paid after completion. Closer attention needs to be given to issues of training so that

agriculture can be in line with other sectors that provide career pathways. In that process, the opportunity to be innovative needs to be taken. Several factors need to be considered in this issue:

- The majority of farm businesses are small operations and have only a small workforce, perhaps one or two employees. The proportion of small businesses in agriculture is greater than in all industries
- The number of farm businesses is in decline but the size of farm businesses is increasing as farms are amalgamated. Corporate farms are gradually increasing in number, suggesting that these larger operations will have a workforce larger than, and different from, that of their smaller counterparts. Prospects for career progression may become better as a result
- Much work is seasonal, particularly in the horticulture industries, and there is widespread use of casual labour, often on visas. The proportion of casual labour in the primary industries is around 43% of all employees, almost double that of all industries
- The age profile on farms is distributed towards older categories relative to the Australian workforce.

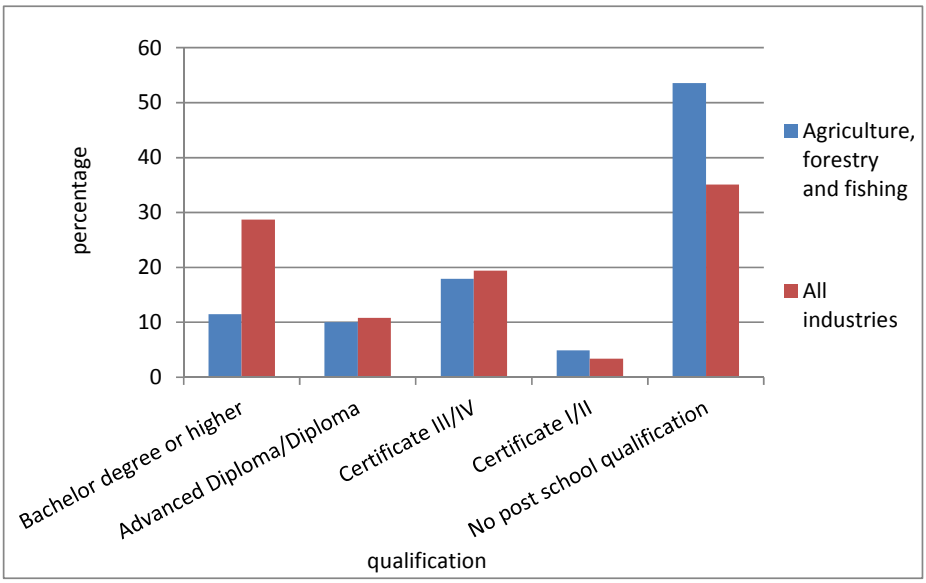

Figure 4 The highest qualification of people working in agriculture, forestry and fishing in Australia, relative to those of all industries (ABS, Cat. No. 6227.0, 2012)

There is participation in all aspects of the education framework but two statistics stand out: the low proportion of the workforce with degree qualifications relative to the population at large; and the much higher proportion of the primary industries workforce without any post-school qualifications (Figure 4). Between industries within the agriculture sector, however, the data vary substantially.

Farmer organisations need to position the industry so the educational and training achievements of its workforce compare well with the rest of society. Employment post-training seems to be a particular blockage, particularly where the implications are higher salaries for a permanent job. The initiative taken by Narrabri Shire Council with its 'Make it Work' strategy is an innovative solution to the problems of fluctuating workloads on farm throughout the year.

There is a strong mindset in the sector that labour is a cost to the business rather than an asset. If it

is only a cost there must be a question mark over whether it is needed. Labour should contribute to the profitability and sustainability of the business. The more skilled and qualified the employee, the greater should be that contribution to compensate for higher stipends allied to better qualifications. Making the workplace family friendly, particularly for women, is another issue to be addressed.

Beyond the farm gate The decline in graduate numbers from universities over past decades has culminated in a concerted publicity campaign led by the ACDA. There has been significant response from employers and salary packages are now very competitive with those in other sectors of the professional workforce. Some employers have been critical of universities for not training such graduates in particular skills and not having them 'job-ready'. What has been a concerning trend in some companies has been the negative attitude towards new employees in terms of early mentoring and in general professional development. The dearth of qualified graduates has resulted in the targeting of individuals between businesses to the extent that it has been difficult to retain staff. Salary packages have risen as a result, making the industry more competitive with other employment options.

This 'churn' in the employment market, however, has resulted in some employers deciding not to provide professional development for staff in the expectation that such staff will be enticed away and the investment will be wasted. Whilst on one hand the economics could be argued, on the other the practice is short-sighted and it is likely that the company will not become the employer of choice as word gets around. Regular anecdotes occur of relatively new employees leaving their job because there had been no mentoring and they could not see that the company valued them as employees. Some have been lost to agriculture altogether and it needs to be recognised that an agricultural education is attractive to other sectors because of the range of skills of graduates and their capability for discipline integration and problem solving (e.g. banking).

It is also important to identify that in many businesses, even those with a sizeable workforce, there are poorly identified career paths for new employees. The new employee enters the company to find that long serving staff, although paid more, are not accorded senior status. Nor are there any guidelines as to how to move towards senior positions. The way forward is for agribusinesses to define a clear and attractive career path, monitor salaries in the market place, broaden the scope of each employee through training and networking, provide modern technology and invest in professional development.

A critical issue for the sector has been the poor promotion of career opportunities to prospective students. To this end the ACDA established the website "Career Harvest" to provide a one-stop shop on the range of careers in agriculture across the value chain. This has now progressed in its offerings through the collaboration with companies Rimfire Resources and Redhanded. Much of the work is undertaken on a voluntary basis and ongoing support is needed to fulfil the goals of informing students of their options and creating a positive, progressive image for agriculture.

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Appendix

In this section we provide a framework in which universities can play a pivotal role in the range of RD&E activities through which agricultural profitability is increased and sustained. This links into the general submission that suggests a new way of funding the RDC, the proposed $100M new investment in RD&E, and the general research capability required for agriculture over the next 10 years.

UNIVERSITIES TRANSFORMING AGRICULTURAL PROFITABILITY

Universities in Australia drive innovation in agricultural research. They undertake the majority of competitive agricultural research projects, deliver the education for the award of agricultural and related degrees and supply the research training through higher degrees. The commitment of universities to agricultural R&D is growing while all other providers are reducing their investment.

Universities, unlike any other provider, harness the widest range of disciplines and facilities, from the most fundamental to the most applied science, allied with the social and economic disciplines. Together they take a unique, integrated, trans-disciplinary systems approach to the complex challenges in today's agriculture. Together, they represent one of the largest and most successful teams in the world. In addition, unlike other Australian agriculture R&D providers, universities are intrinsically part of international research communities; indeed they are measured on their ability to demonstrate this. They thus capture 'best in state of the art' in relevant areas.

However, no overarching strategic imperative allows Australian universities to work together on a collaborative basis to drive agricultural profitability for the nation. Current funding opportunities for universities, despite the success of individual institutions, do not permit large, long-term, strategic initiatives that focus the critical mass of researchers in Australian universities to concentrate their efforts on increasing profitability for Australian agriculture.

ACDA is recommending a goal-oriented funding initiative, that encompasses both innovative and directed strategic research, to enable the nation's best researchers to collaborate in driving research innovation towards greater and more sustainable agricultural profitability. By harnessing the collective strength and breadth of the universities it is planned to bring about a step-change in the way in which research is delivered. The primary objective is to increase profitability of agriculture, for farmers and other stakeholders in the value chain, such that the sector generates greater benefits to the Australian economy. It will be achieved this ensuring that all researchers have responsibility, and resources, to deliver the goal.

In line with Australia's strategic research priorities ACDA plans to target 4 inter-connected areas:

1. Securing Farm Resources

a. Healthy soils and sufficient water underpin agricultural profitability. Despite significant sums already spent in this area, only incremental improvements have been made and these fall well behind the large improvements required to drive step changes in increased and sustained profitability. For some of the technical challenges, the intention is to take a bio-engineering

approach: harnessing natural processes in fertile soil and resilient plant communities to design soils and farming systems for specific functions; plants producing surfactants to take more water up with less energy spent; soil biology to naturally generate stable and fertile soil structures; plant roots engineered for their environments; and novel sustainable systems for weed and pest control.

b. An information-led resource management approach taking advantage of the latest technology to gather data remotely; and to control farming remotely through automation across many farming practices, thereby reducing inputs and maximising outputs. To be successful this requires a socially inclusive approach that ensures that benefits are accrued for all value-chain participants, including consumers and rural communities. Transformational technologies will only be effective when they have gained their social licences up-front.

2. Precision Breeding

Australia has an enviable position globally of the largest ratio of *arable* land per capita, distributed over a wide range of latitudes and across temperate to tropical production regions. Maintaining agricultural production to feed a growing population is one of the greatest challenges in a period of rapid global climate change. Although the Green Revolution resulted in high crop yields through the development of new varieties, irrigation, and the abundant application of chemical fertilisers and pesticides also resulted in negative environmental impacts and unsustainable resource use.

a. Like many other commodity food crops, global average wheat yields increased dramatically (by 250%) during the last 50 years of the twentieth century Around half of these improvements can be attributed to genetic enhancement and half to advances in farm practice. The challenge facing Australia is to develop new step change approaches to enhancing the genetic performance of cereals and other crops and to capture the value of those advances for Australian industry. A radically different approach to crop improvement will be adopted including: deploying novel, non-GM methods of inducing precision mutations that alter gene regulation and gene function; amending the heritability of traits (soft inheritance) to adapt varieties to local conditions; and using genome diagnostics to personalise the match between variety and location. Food crop breeding from Australian universities leads the world in terms of commercial success. This position will be exploited to ensure developments made in the program preferentially benefit the Australian industry.

3. New Products and Processes

Australia's wide range of climatic regions and its entrepreneurial agricultural sector provide an excellent base for innovation focused on enhancing profits by adding value to primary production. This will be done by:

a. Harnessing recent insights into the genetic and biochemical basis of raw materials quality; there are specific opportunities to generate smart, 'green' alternatives to the vast global mineral oil-based supply-chains and markets, including crop-based bio-lubricants, refactoring of fibre-based raw materials and other biopolymers, and advanced engineering of other non-food agricultural products.

b. Delivering food products (functional foods) to meet global concerns of human diet and health, addressing e.g. diabetes, obesity and nutritional deficiencies by targeting low-GI intake and

providing protection against chronic disease. Delivery of personalised medicine requires knowledge-driven, personalised diets.

4. Waste reduction and utilization

Losses and wastage of primary and processed products greatly reduce effective productivity and profitability of agricultural systems, whilst effluent production from intensive farming systems increases risks of adverse environmental impacts. Globally, product losses through the supply chain exacerbate food insecurity. An integrated approach harnessing biomaterials science, biotechnology and bioengineering innovative solutions will be developed to: (1) reduce postharvest losses in storage, processing and distribution of key commodity products; (2) increase utilisation of waste materials for production of added-value products or for recycling to reduce external inputs to farming systems; and (3) manage effluents better to optimise soil, water and atmospheric environments.

5. National Graduate and Training School for Agriculture

A national graduate school for agriculture will be developed, pooled across the ACDA universities. Universities will open their agricultural facilities to all participants in the graduate and training program, representing a new way of delivering education and training for the nation. This will act as strategic underpinning and training for the RDCs, DPIs, CSIRO and private sector users, including multi-nationals. The aim is to deliver the best professionals with the most up-to-date skills.