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Intellectual Capital Audit for the Red Meat Industry

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EXECUTIVE SUMMARY

The long-term future of the Australian red meat industry is dependent on its ability to meet a wide range of future challenges both internal and external. Capacity to meet these challenges includes the availability of a significant intellectual capital (IC) base to provide the needs for market development and protection, R&D and technological adoption.

A significant erosion of public infrastructure over the past decade has led to either loss or reduction of many services with loss of staff with specific skills. Linked with these changes has been a decline in training activities in many relevant disciplines in universities, further reducing the IC base and the training capacity needed for the future.

The review found that there were significant concerns across many sectors in terms of capacity to supply future IC needs of the industry. Staffing losses have not been filled in many disciplines, which together with a considerable decline in the pool of postgraduate students, is likely to lead to future problems of matching supply with demand.

Problems identified were primarily in the animal health, animal production and plant science areas. For commerce/business and information technology, existing training capacity was judged to be sufficient to meet most needs to 2020.

It is estimated that about 580—600 additional postgraduates will be needed over the next 18 years if IC needs to 2020 are to be met, given normal attrition expected over that time. This will require an annual intake of between 25—35 commencing students across all disciplines, a proportion of whom would be supported by university funding and from other sources.

While it is not expected that MLA would assume major responsibility for all relevant postgraduate training, current training investments do need to be reviewed in the light of perceived demand shortfalls. A recommendation is that MLA should increase the number of commencing postgraduate studentships offered each year to a minimum of 12.

Mechanisms of collaboration with other scholarship providers need to be explored to see how leverage of funds could be best developed. Provision of additional top-up funding for other scholarships by MLA will maximise total numbers of stipends available to meet red meat industry demands.

Alternative models for supporting postgraduate education should be examined, one being joint venture arrangements between private and public sector agencies and universities in disciplines where this approach is feasible. MLA should be a facilitator of discussions on these alternative approaches.

Possible future strategic investments by MLA for strengthening university research training capacity must be targeted if maximum benefits are to be achieved. However before MLA makes decisions as to how or whether it can contribute to strengthening specific areas related to future industry demands, outcomes of current Commonwealth reviews of the tertiary sector, aimed at identifying institutional strengths, need to be evaluated.

In summary, a considered view is that in some disciplinary areas, supply will not meet demand for future IC capacity by 2020. These shortfalls will constrain some areas of industry activity and development. MLA can contribute in a number of ways to enhancing supply thereby minimising potential demand problems.

Conclusions

The review found that there were serious concerns in many industry sectors at the erosion of the intellectual capital (IC) or skills base of some disciplinary areas in the industry over recent years, both in terms of current capacity but as importantly in terms of capacity to meet future needs.

There was evidence that public infrastructure reductions, related to budgetary constraints, have resulted in a contraction in service levels in many areas, leading to staff losses without replacements, but also reflecting changed priorities for provision of public good services.

For some disciplinary areas, these have triggered similar run-downs in the tertiary sector with reduced levels of teaching, research and postgraduate training activities. Job opportunities with attractive salaries and conditions have attracted many into the work force on graduation who previously may have considered further postgraduate training.

The combination of these factors has led to a reduction in the pool size of postgraduates, some of whom have subsequently faced reduced employment opportunities resulting in departure of many people to take advantage of more attractive options overseas.

In summary, for many disciplines, losses at one end of the age profile are not being filled by younger staff, resulting in current skills shortages, a problem seen by many as worsening to a point where industry needs to 2020 for IC in some disciplines may not be met.

Respondent rankings for the importance of shortfalls constraining industry needs were influenced by how different sectors perceived possible impacts as affecting their own areas of interest. Thus responses to the relative importance of all disciplinary needs varied widely.

Regional influences also impacted on perceptions of future intellectual needs, where shortages in a particular discipline where seen to be more important in some regions than in others.

Many respondents expressed concern at the significant decline in capacity and skills that has occurred within the *animal health* areas, and many were of the view that neither the current IC base, nor estimates of future supply were sufficient to manage all potential disease and market threats, to undertake relevant R&D, or to provide the diagnostic requirements of the industry.

Based on an overview of current staffing profiles and activities, assessment of levels of and capacity for postgraduate training activities, together with industry perceptions of likely needs, it is estimated that there is a need for an *additional 200 staff* to be trained to postgraduate level in these disciplines by 2020.

While at first glance this estimate may appear excessive, it equates to an annual intake for postgraduate training across all specialities of animal health of *11-13 per year* over the next 18 years.

The questions that then arise are; does the Australian tertiary sector have the capacity to ramp up training activities in animal health? and can adequate facilities and resources for this level of student intake be provided? As current strengths and activities are judged to be relatively low in each of the disciplinary areas, capacity to supply and resources may be limited.

However, given that training is likely to be distributed across 5-7 universities with specialist skills in one or more disciplines, current capacity for these additional numbers is barely adequate, and in need of considerable strengthening. Further, support for re-building in specific areas within specific institutions needs to be targeted, since attempts to enhance activities in all universities will lead to a dilution of resources. Such strengthening and targeting may well occur as an outcome of the current Ministerial review of research and teaching strengths in the tertiary sector. But whether student interest and demand will align with capacity to train is another question.

In animal production disciplines a similar pattern emerges. It is estimated that by 2020 there will be a need for about 180 additional postgraduates with specialist skills. This represents an annual intake of 10-12 students to 2020 who could be distributed between 8-10 universities with historical or emerging strengths in specific production disciplines.

Again there is a need to consider which production disciplines in which institution need to be supported in any rebuilding exercise. Such questions have strong political overtones and decisions on these matters will probably be made at Ministerial level. Again the question of student interest and demand needs to be looked at.

In the *plant sciences* estimates are that approximately *75 additional* appointments of postgraduate trained staff would be required to meet demands to 2020. This represents a relatively small intake of about *4-6 per year*, distributed across 3-4 Universities with existing strengths in the pasture and rangeland sciences. Comments made earlier regarding capacity and relevance of particular institutions and student interest apply equally here.

The needs of the *commercial/business* areas for additional staff with postgraduate qualifications are estimated to be about 60 new appointments by 2020. This represents an intake of about 3—5 per year distributed across many of the 37 Australian universities. Capacity of universities to support these training needs are not seen as a constraint, while some of these potential postgraduate students may be supported by internal university training support, reducing the need for external funding of some students.

In the *information technology* areas it is estimated that about 70 new appointments would be needed to 2020. This represents an intake of about 3-4 per year, some of whom are likely to receive internal support.

In summary, estimates suggest a need for an *additional 580—600* staff with postgraduate skills and expertise over the period to 2020. Given that some will receive internal support, it is likely that between *20-25 students per year* would require *industry* support from several agencies. To suggest however that MLA alone should accept responsibility for a majority of these additional studentships is unrealistic, as this would increase current levels of investment in studentships by about 5 fold.

Quite a number of these additional studentships would be covered under a range of other scholarship programs, including CSIRO, State agencies, CRCs, APAs and, where commonality exists, other rural funding agencies.

Collaboration with and co-investment by other scholarship granting bodies should enable leverage of training funds provided either as top ups or as joint scholarships. This strategy will spread available funds more widely and increase the numbers of stipends that can be supported.

A previous review (MLA STU001) suggested that an appropriate ratio of merit based : disciplinary targeted scholarships would be about 70:30. Given the present identification of significant shortfalls in critical disciplinary areas, there is a strong case for re-examining this recommendation with a view to changing the ratio to favour a more targeted approach.

MLA may be able to act in a facilitating role to help explore opportunities for joint venture arrangements involving public and private sector organizations and tertiary institutions, creating greater opportunities for broader training of postgraduates in specific disciplinary areas. Similar arrangements involving the Beef and Sheep CRCs have been successful and extension of this model is warranted.

Some of the additional skills needed for the future involve areas where research is not the dominant activity. There are apparent needs in a number of sectors for development of greater integrative and interpretive skills, and for these requirements more flexible programs including coursework programs,

the MBA and professional doctorates would be more applicable. Consideration needs to be given to supporting studentships in these types of training activities.

Recommendations

Recommendation 1

That MLA should facilitate wider discussion with relevant industry and public and private sector organizations on planning and actions needed to ensure that the IC needs of the industry to 2020 are met. Resources needed, prioritisation of needs and development of strategies should be outcomes of this planning activity, which could also usefully involve all rural industry R&D agencies with interests aligned in some ways to the red meat industry.

Recommendation 2

Given the potentially serious shortfalls to 2020 in some areas, MLA should review its current investments in postgraduate training with a view to increasing the number of new scholarships awarded each year to about 12, representing an approximate doubling of current investment levels. This would mean about 30-50% of red meat industry IC needs were met through direct MLA support.

Recommendation 3

MLA in discussion with other scholarship funding groups, should examine mechanisms for the use of some additional funds for scholarship top ups and as leverage to maximise total numbers of stipends available for red meat industry training. The value of having named/badged scholarships is less important than adopting the most effective ways to maximise future postgraduate student numbers in order to meet future needs.

Recommendation 4

MLA should facilitate discussions with private and public sector organizations and universities to evaluate and progress alternative training models involving wider collaboration between these sectors, greater training and research opportunities and wider participation of students in more broadly based training programs. This approach would minimise the oft-heard criticisms that traditional training models do not always produce the best product needed by industry. The CRC model is an alternative approach.

Recommendation 5

MLA should re-assess a previous recommendation (MLA Project STU.001A) for an allocation model of 70:30 for merit based:targeted scholarships, given the potentially serious shortfalls in the skills base in specific areas identified here. It is suggested however that decisions on any new allocation models be deferred, pending the finalisation of ministerial decisions on targeting of research strengths in the tertiary sector.

Recommendation 6

MLA in the event it provides funds to assist re-establishment/strengthening of specific research/training strengths in universities should adopt a targeted approach to its investments where funds are directed towards specific discipline areas in identified institutions, rather than diluting investments across many institutions. However, as for Recommendation 5, it is suggested that any action by MLA on this matter be deferred until ministerial decisions on the tertiary sector are announced.

Recommendation 7

MLA should consider for those disciplinary areas and industry sectors where research postgraduate qualifications are not a pre-requisite, allocation of some training funds to more flexible coursework or professional doctorate programs. The relative balance between research and generalist training activities should probably be about 80:20 for many disciplinary areas eg. plant sciences and animal health, but for other areas eg. extension, economics, farm management, the balance could be as low as 20:80.

Recommendation 8

MLA should continue to monitor changes in the tertiary sector that will occur in the next few years as a result of the current Nelson enquiry, with a view to determining how best it can invest training funds in the future.

Recommendation 9

MLA should undertake a re-assessment of IC needs in 5----8 years to again determine the demand/supply balance for specific expertise, and to re-assess strategies for and levels of training investments.

INTRODUCTION

Since the early 1960s Meat and Livestock Australia (MLA) and its predecessor organizations the Australian Meat Research Corporation (AMRC) and the Meat Research Corporation (MRC) have provided support via scholarship schemes for postgraduate training of Australian students in areas of relevance to the Australian red meat industry.

These training opportunities have been offered for PhD, Masters, Graduate Diploma and Graduate Certificate programs, which have been primarily undertaken within Australian educational institutions, but where appropriate, also in institutions overseas.

The rationale for this training support was to provide for the red meat industry a pool of highly skilled research, technical and extension staff to service the needs of the component parts of the industry. A brief report in 1985 (AMRC Annual Report 1985) provided some summary statistics on the number of studentships funded to that time (181), and on high completion rates for PhD and Masters and other courses. However no information was available on the extent and level of contributions of funded postgraduate scholars, nor on the retention rates of these people in the industry.

Subsequently in 2001, MLA commissioned a review (MLA Project STU.001) of the postgraduate scholarship program covering the period 1975-2000. This review found that a very high proportion (67%) of scholarship holders in the period were still involved in various segments of the red meat industry, with another 12% involved in other aspects of Australian agriculture. This high retention rate indicates a very high level of industry interest and commitment by awardees. However many of the people funded in that period are now reaching or have reached retirement age and will be moving out of the industry. For other staff, changes in employment opportunities will also constrain their ongoing contributions to the red meat industry.

Concerns have been expressed in many quarters that these losses will not be easily replaced for a range of reasons which will be covered subsequently, and that over the next decade or more there may be staffing shortfalls in some disciplinary areas which will constrain the future intellectual capital requirements of the industry. Additionally rapidly changing technological, economic and marketing requirements within the industry mean that there are likely to be needs in the future to recruit staff drawn from new and emerging (non-traditional) disciplines.

A recommendation arising from the above review was that MLA as part of it's strategic planning process should undertake a review of intellectual capital needs to 2020 to best plan future needs for industry R&D and extension staff. Such a review would build on an earlier study (UMAC.001, 1992) some 10 years ago, funded by the Meat Research Corporation of availability and motivation of human resources for R&D in the meat and livestock industry. Since that study however there have been a number of significant developments in various sectors of the industry, in particular downsizing of activities in some public sector and educational agencies that have traditionally provided service and training support to the private sector. These changes have been partly due to declines in budgets and staffing levels, with corresponding declines in levels and range of support and training programs. Hence some of the findings of UMAC.001 in relation to availability of human resources may no longer be as relevant today.

Objectives

The project follows on from MLA Project No.STU.001A - Review of Studentships, that recommended the conduct of an intellectual capital audit for the red meat industry, in order to determine in which areas MLA should be seeking students.

The specific objectives of the project were indicated to be:

- To identify the intellectual capital needs to 2020 for the information and knowledge chain
- To recommend innovative approaches to supporting the growth of intellectual capital in these areas
- To forecast numbers needed to meet these future needs

Methodology

An important phase of the study was the broad ranging contacts made with different sectors of the industry with the exception of the processing and post-processing (wholesale and retail) sectors. Discussions and interviews were held with senior staff in a very wide range of companies, agencies and institutions involved in the red meat industry to attempt to determine their current and future needs for skills in disciplinary areas relevant to their organization. In addition needs for new and emerging disciplinary (non-traditional) areas were also identified and explored.

Discussions with respondents were held either in person, by telephone or by electronic communication, and involved more than 110 individuals. A full list of organizations contacted is shown in Appendix 1. These included a range of individuals, private companies, R&D and extension agencies both state and commonwealth, rural funding agencies, agribusiness and banking groups, biotechnology groups, agricultural consultants, universities and agricultural colleges and industry organizations.

Questions were posed and responses invited on a wide range of topics including:

- Needs or otherwise for recruitment of staff with postgraduate qualifications
- Short, medium and long term needs for staff in particular disciplinary areas, and identification
 of these areas
- Broad age distribution of current staff, and extent to which age attrition may reduce pool of available staff in both short and medium terms
- Extent to which attrition can be covered by recruitment in particular disciplinary areas
- Succession planning in place for staff replacements
- Recruitment ease or difficulties within particular disciplinary areas
- Suitability of recently recruited staff
- Potential impact of staff shortages/reduced recruitment potential on organisational activities
- Possible organisational changes or developments that may require employment of staff from new and emerging disciplinary areas
- Ways in which MLA training support policies could contribute to enhancing numbers and quality of people with post graduate qualifications to service future industry demands

In addition the consultant had meetings with senior DEST staff to discuss likely changes in policies related to undergraduate and postgraduate support in Australian universities. A number of changes in operations of the tertiary sector are likely following the release over the past 5---8 months of a number of Ministerial discussion papers on a range of aspects of tertiary education. These papers, and responses to them, will be distilled into broad tertiary education policies, some of which may impact on industry needs. However, at time of preparation of this report, these policies have yet to be finalised and released and it is thus not possible to make any definitive comments on these matters. They will, however, have to be monitored and taken into account by MLA before any changes in their policies relating to training support are implemented.

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Concurrently with this study, the Commonwealth Government announced in August a review of rural veterinary services. The Rural Veterinary Services review seeks to establish:

- The future needs of Australia's livestock enterprises and industries and animal health systems
- The expected roles and requirements for veterinarians in meeting these needs, and
- What will be required (in and by the private and public sectors) to ensure the required veterinary and veterinary related training and expertise are available where and when needed.

The outcomes of this review will clearly overlap to some extent with the present review where needs in some veterinary disciplinary areas have also been examined. However, at the time of writing, the preliminary report on the Commonwealth review is not expected for several weeks, and thus it would be premature to comment on outcomes, other than to say it is likely that similar problem areas will be identified in both reviews in relation to Animal Health and veterinary service issues.

The Commonwealth review has been conducted by Mr Peter Frawley, to whom the consultant made a review submission, and there has been some sharing of information from the two reviews.

The following sections of the report outline the approaches followed and conclusions drawn from the review of intellectual capital needs for the red meat industry. Where possible discussions and opinions are summarised and the level of importance of different disciplinary areas is prioritised in relation to needs for future training support.

Reviews of Intellectual Capital Needs in Australian Agriculture

MLA's predecessor organization the Meat Research Corporation commissioned a study in 1992-93 on the 'Availability and Motivation of Human Resources to Conduct Research and Development in the Meat and Livestock Industry' (MRC Publication UMAC.001). This review examined then current patterns and proportions of employment by industry sectors (defined as Market Knowledge; Product Development and Marketing, Efficient Conversion to Meat; More Efficient Production), profiles and attributes of personnel then employed, and assessments of then current and future staffing needs for different industry sectors. The review concluded that in most cases most attrition should be able to be met from new graduates and postgraduates entering the work force though some sectors would have difficulties.

However since completion of that study there have been several significant changes including greater employment and career opportunities in the private sector for recent graduates, which together with disinclination for further study by many, has led to reduced numbers of postgraduates in a number of areas. There appears also to have been a greater attrition rate than expected in certain disciplinary areas, driven in part by budgetary constraints and by decisions in both public and private sector agencies to downsize specific activities or relocate resources and staff to other areas. Thus reduced staffing levels have followed, while replenishment rates for older staff leaving the system have been much lower than expected.

Hence the extent of shortfalls is likely to be much greater than predicted from the UMAC.001 study. The current study in many ways builds on this earlier one, but adds a more current dimension to the future intellectual capital needs of the industry.

In an attempt to draw on additional and perhaps more recent experience that may have been developed in related reviews of the intellectual capital needs of other sectors of Australian agriculture, contact was made with senior staff in the majority of Rural R&D funding agencies in Australia as follows:

- Australian Pork
- Cotton RDC
- Dairy RDC
- Fisheries RDC
- Grains RDC
- Grape and Wine RDC
- Horticulture Australia
- Land and Water Australia
- Rural Industries RDC
- Sugar RDC

In addition several contacts in the USA and in New Zealand were approached to ascertain if they were aware of similar studies elsewhere.

None of the Australian funding agencies has yet undertaken an equivalent study, though a number indicated that this was needed for their industry and that they planned to do so. Similar responses were received from international enquiries. The Grains RDC had done some work, similar to that done by MLA, on scenario setting for the industry, while RIRDC indicated that they had received a proposal for an intellectual capital audit, but that this had not been funded.

RIRDC had however commissioned two other and related studies. The first (RIRDC publication No. 99/172; 1999) was on revitalising agricultural extension. This involved an examination of the US Land Grant Universities approach compared to the Australian agricultural extension structure, followed on to agriculture undergraduate student needs and attitudes, suggested directions for new modes of education, delivery and educational systems and suggested proposals for increased partnerships with industry.

The second (RIRDC publication No.00/104; 2000) was on aspects of the performance of undergraduate students in agriculture courses, particularly in relation to university location (urban, regional) and on development of a matrix of student attributes, industry criteria and course outcomes to provide guidelines for course development and articulation with industry employment needs. While both these projects provided useful resource material, neither directly addressed the subject of the current review of undertaking a needs based assessment of future intellectual capital requirements.

Thus it was not possible to draw on other experience and specific methodology from related areas of either Australian or International agriculture in undertaking the present review. This review has effectively opened up new ground in determining likely future needs for intellectual capital in a very large and important sector of Australian primary production.

The very nature of the review meant however that it was not possible to identify and contact every possible employer group within the red meat industry to determine their current and future needs for specialized staff. For most of those agencies contacted it was only possible to obtain information on broad trends in employment profiles, not specific data on rates of attrition or numbers of new staff appointed. There were similar difficulties in attempting to reach, within each sector, some estimates of the numbers of new appointments by disciplinary area that may be needed to meet industry needs to 2020.

Hence the approach is very much a 'snapshot' one where it has not been possible to provide firm quantitative data on the extent of losses and on exact numbers needed for the future. Despite these constraints, information from a wide spectrum of employers within different sectors has enabled a profile of needs to be developed, and from this a prioritisation of disciplinary areas where support for training should be directed.

-ESPECTED

REPORT – OUTLINE AND SUMMATION OF DISCUSSIONS WITH DIFFERENT INDUSTRY SECTORS

1. Animal Health

Amongst most respondents with whom this general area was discussed, there was concern at the risks Australia faces from the threats of exotic diseases and their impacts on production and market access. The most notable example quoted was FMD as illustrated by the major epidemic in the UK and Europe in 2001. An area equally important was the protection of Australia's image as a "clean, green" exporter of agricultural products including red meat, and the impact of changing demands of importing countries for certification of product including health status. The identification and certification of disease and health status of livestock, and the standards of processing facilities were frequently mentioned as key factors that determine conditions of entry and opportunity for access in some markets. These could be constrained by the reduced availability of staff in the paraclinical disciplinary areas of pathology, parasitology, microbiology and virology

There was also general agreement that for these broad areas, resources had been allowed to run down over time, despite increasing numbers of graduating veterinarians. This concern was translated into doubts expressed by some, of Australia's capacity to handle and contain major disease outbreaks. Such risks are not just related to animal health issues of course, but also to zoonoses such as BSE, and Nipah and Hendra virus infections.

For the purposes of this review several broad disciplinary areas within animal health were identified, and were discussed with respondents:

- Veterinary pathology and parasitology
- Veterinary microbiology and virology
- Toxicology
- Epidemiology

1.1 Veterinary pathology and parasitology

Australia's capacity to detect and respond to emerging disease threats will involve a cadre of well trained pathologists, and the capacity and capability of laboratory networks and surveillance systems to relate laboratory data to individual properties (or animals) is becoming increasingly important. However, this capability is being constrained by the decreasing pool of trained veterinary pathologists. A recent paper (R.Miller (2001), Aust Vet J 79:522-523) provided some statistics on this issue that confirm the concerns expressed by many in this review.

Miller reported that more than 50% of veterinary pathologists (including parasitologists) were in the 50—65 age bracket, with only smaller percentages younger than 40 years (22%) and in the 40—50 years age bracket (26%). This pattern was confirmed in discussions with staff in veterinary faculties who also indicated very small numbers of postgraduate students in pathology and parasitology (Miller's estimate 6 postgraduates at 2001). However, the lack of students undergoing formal postgraduate training at university level is partly offset by veterinarians undertaking membership and fellowship examinations in Pathobiology in the Australian College of Veterinary Scientists. Even here, though, there appears to have been a decline recently with currently only about 2-3 candidates per year undertaking examinations.

In addition to decreases in numbers of experienced pathologists and parasitologists, many of whose positions are not being filled on retirement from government agencies, and there appear to be reduced opportunities for employment due to contraction in the extent and level of diagnostic services. There is

some divergence of views on these current and emerging shortages. One respondent maintained that there was no shortage of people interested in developing a career in veterinary pathology; the problem was inadequate funding for positions and in creating an interesting and attractive work environment. In contrast, several others claimed that the disciplines of veterinary pathology and parasitology are close to extinction in Australia and that because of the current age structure, it is unlikely that sufficient competent people will be available in the next 10-15 years. The lack of career opportunities within state agencies is probably also contributing to fewer pathologists and parasitologists in training in veterinary schools, with a consequent decline in training resources in these disciplines in these schools. In other words, a critical circle of decline that must be addressed.

Additionally, a number of respondents made the point that the introduction of a "fees for service" by some state diagnostic laboratories has resulted in a marked reduction in submission rates and hence case loads for laboratories, thereby reducing opportunities for in-house, unstructured training, a further disincentive for prospective pathologists and parasitologists. Reductions in research and research opportunities were also cited as an additional reason for declines in these areas that have also seen some movement of graduates to positions overseas. Several state government agencies have also contracted out pathology and diagnostic services to private industry, and while most such private laboratories employ veterinary pathologists/parasitologists and are NATA accredited, the overall pool of trained staff has declined.

Similarly for parasitology, there has been a marked decline in numbers of positions in state agencies, universities and some areas in the private sector. With the exception of CSIRO Livestock Industries and the private sector where several positions in parasitology have recently been either filled or advertised, there appear to be reduced opportunities for employment and for research in this discipline.

One respondent also commented that the reintroduction of *Bos taurus* breeds into northern tick infected areas was likely to recreate a problem of tick/tick fever susceptibility, for which were was no current parasitological research capacity other than for vaccine production. Given the ongoing development of problems of anthelmintic resistance in the sheep industry, such shortages of trained staff could also impact on productivity within the prime lamb industry, though staff shortages do not appear uniform across states.

All of these views point to a critical need to encourage graduate recruitment into the veterinary pathology/parasitology fields and a range of models of training and funding need to be examined. Training or lack of training opportunities was a common issue raised in most discussions. Adequate training requires access to a wide-ranging case load or in some cases a specific case load. The declining resources of universities and state agencies to enable this case load to be supplied suggests that new training models need to be examined and developed. A partnership between government laboratories, university departments and private laboratories is one approach which would provide a greater and more diverse case load, and more exposure to pathology/parasitology mentors with a wider variety and level of diagnostic experience than would be experienced at any single institution.

Given that many people who may wish to develop a career in pathology/parasitology may not necessarily wish to undertake research, support for coursework type programs in these areas should also be examined. Similarly, professional doctorates, now available in a number of Australian universities and which involve a wide range of other disciplinary units not necessarily science related, are another approach to enhancing numbers of people available for non-research careers in these areas.

Due to reductions in numbers of staff with specialist skills in pathology/parasitology, there is a very high probability that industry needs and requirements to 2020 for such skills for disease control, biosecurity and preservation of market access will not be met. Urgent attention is needed to address this problem.

Case friend

1.2 Veterinary microbiology and virology

For convenience of discussion these disciplinary areas are included together. As for pathology and parasitology, with some exceptions there has been a rundown in the number of staff employed in state agencies in these disciplinary areas. Similarly, staffing levels in these disciplines within veterinary schools have declined significantly in recent years. CSIRO AAHL has, however, maintained and in some cases increased staffing numbers in Veterinary Microbiology and Virology. However, most respondents expressed concern at run downs in microbiological and virological diagnostic capacity and identified product integrity and freedom from meat product pathogens as an emerging area which will have to be addressed. There was also a view that more needed to be done in integration of new molecular biological techniques into development of rapid diagnostic capability for both field and laboratory diagnosis.

A critical issue for veterinary diagnostic laboratories is the rapid isolation and identification of disease pathogens particularly virological agents. Of increasing importance also are certification requirements now being imposed by importing countries in relation to the product integrity of meat and meat products. Both these areas require ongoing research inputs to improve diagnostic and/or monitoring capacity and increased throughput rate of specimens.

Additional support will also be needed in the medium to long term to capture the benefits of new biotechnological advances particularly those based on biosensors (nanotechnology) or crush side testing techniques.

There was also a supposition by several that the move by some stage agencies to outsource some diagnostic services to private laboratories would be followed by others and that functions of state agencies would shift towards emphasis on issues such as biosecurity, human health issues (eg anthrax, viral zoonoses) and passive surveillance. Such changes could impact on industry needs and could be a further disincentive for graduates to enter this field. Conversely if other models such as joint ventures between private, public and university sector groups can be developed these may in fact enhance the situation in terms of helping to satisfy industry demand.

A considered view is that the run down in specialist expertise in these areas, whilst a little less than that for pathology/parasitology, will also create shortfalls in meting industry needs to 2020. A new impetus is needed to attract staff to these areas.

1.3 Toxicology

There was a general view that this disciplinary area also appears under threat as a result of attrition, lack of training opportunities and perceived poor career pathways. General conclusions were that while some toxicological work (eg chemical residues) could and was being outsourced to private and medical laboratories, traditional plant and pathogen toxicological diagnostic capacity needs to be retained and strengthened. An emerging need for toxicological diagnostic capacity in relation to product integrity and food safety issues was also identified. Market and trade issues will also influence future needs for environmental toxicology and identification of potential problems of plant product toxins eg aflotoxins in meat and meat products.

Some specific toxicological expertise needs to be retained from the point of view of food safety and product integrity. Training and research activities need to be re-established in at least one veterinary faculty to ensure that industry needs to 2020 can be met.

1.4 Epidemiology

Given recent outbreaks of exotic diseases that could threaten the Australian livestock industries, both from a production point of view and in relation to market access, there is no doubt that adequate veterinary epidemiological capacity is an absolute prerequisite for the future of the red meat industry. There was a divergence of opinion from respondents on the intellectual capital needs within this

discipline, which can be seen either as a component of veterinary medicine or as a component of animal health studies.

There were some views that Australia has existing and significant capacity in this area, particularly in field epidemiological capacity. However, there were equally strong and contrasting arguments that there are significant shortfalls, particularly for staff with specialist epidemiological skills. The point was made by several that Australia is not well served in the use and utilisation of a range of skills related to epidemiology, including amongst others capacity for handling large monitoring/surveillance data sets, the use of GIS technology, logistical capacity in the event of disease outbreaks, risk assessment and analysis techniques, and application and interpretation of newer molecular biological techniques for rapid diagnosis.

While there is some evidence of a decline in specialist, but not necessarily generalist, epidemiological capacity in state agencies and perhaps in AAHL, the picture for the short to long term is brighter than for some of the health related disciplinary areas already discussed. Within the private sector one company has very significant strengths that are being utilised by a range of public sector agencies, including Animal Health Australia and AFFA, both of which also have significant epidemiological capacity. However, there were perceptions by some respondents that specialist epidemiologists with a good knowledge of the production, management and economic environment of the red meat industry were still too thinly spread.

A recent appointment in the University of Sydney Veterinary Faculty will further strengthen capacity whilst the epidemiology chapter of the Australian College of Veterinary Scientists has also been active in unstructured training programs in epidemiology. A current CRC application, if successful, would also provide additional training opportunities and research capacity. Other issues which highlight the importance of maintaining and increasing strengths in this discipline include those associated with antibiotic usage, chemical residues and zoonoses, all linked with market and trade issues.

While training capacity in this disciplinary area has recently been increased that will partly meet shortfalls, additional specialist expertise needs to be developed quickly to support existing capacity in field epidemiology. There is a reasonable probability that industry need to 2020 can be satisfied, provided training levels and numbers can be enhanced.

1.5 Animal health disciplines – overall comments

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It was clear from discussions that there were significant concerns from both the supply and demand perspectives of a current and worsening problem in relation to Australia's capacity to support a strong animal health diagnostic component. These concerns related to capacity to control the introduction of exotic diseases, capacity to handle biosecurity and capacity to respond to issues related to trade and market opportunities. The issue of capacity for risk assessment/analysis in relation to border security, export activities and disease control methodology was an area also highlighted by a number of respondents, and this needs to be examined in some detail.

Given the scenarios outlined of a rundown in both career opportunities and training capacity in a number of animal health disciplines, a question that needs to be addressed is whether all Australian veterinary schools can maintain expertise and training opportunities in each disciplinary area of animal health related to food animal production. Consideration needs to be given as to how Faculties can interact and collaborate in providing teaching and training opportunities across some of these disciplinary areas. Federal funding for expensive courses such as Veterinary Science is unlikely to increase. Hence some rationalisation and exchange of teaching material between the different schools is one approach in providing solutions to training problems in particular disciplinary areas.

An alternative approach involving joint ventures between the public, private and tertiary sectors in providing training and research opportunities in animal health disciplines also needs to be examined as a potential model for filling future industry needs. MLA may well have a facilitating role in developing this model to satisfy the requirements of it's stakeholders.

To summarise, this review has indicated that there are insufficient specialist veterinarians and scientists with postgraduate qualifications and experience in a range of animal health disciplines to satisfy industry needs both current and to 2020. Such shortages have the potential to have significant impacts on Australia's livestock industries. While the review of Rural Veterinary Services will probably also highlight this problem, it is also important in the context of this review in terms of recommendations for future investment of MLA training funds in particular areas.

2. Animal Production

Australia, as a significant livestock producer and a major exporter of livestock, livestock products and livestock genetic material, is critically dependent on high levels of productivity to ensure that profitability and sustainability in these industries is achieved. In 2001, the gross value of Australian livestock and livestock products was estimated at \$16.2b with exports worth \$14b (ABARE 2001).

Red meat production from cattle and sheep is based largely on pastures in a wide diversity of regions ranging from the tropical north, through drier inland pastoral areas to the higher rainfall temperate areas of southern Australia. These diversities of environments and of livestock management systems create a range of production constraints, solutions to which may be either of a generic nature or of a more regional based nature. Hence the levels and types of staff skills base needs for the future will show some regional variations.

The beef industry, based largely on pastures, has also diversified into feedlot finishing with currently record numbers on feed, partly due to drought conditions. Despite some current market constraints, there is however some expansion in this sector. The growth of live cattle exports over the past decade has been another important feature of the industry, providing an alternative outlet particularly for northern producers, and creating in the north a floor in the market not previously there.

In the sheep meat industry there has been expansion partly due to wool price downturns and diversification of production into meat, but also driven by expanding market opportunities. The live sheep market has experienced strong demand that is forecast to remain firm in the next few years. In the case of the prime lamb industry, this is generally confined to higher rainfall areas with a good pasture base. Profitability in this sector is partly dependent on high lambing rates, the potential for which has yet to be achieved and industry will need to adopt existing and future technological developments supported by adequate numbers of well trained research and extension staff, in order to maximise returns.

During this review a fairly wide diversity of opinions emerged regarding future training needs and staffing levels for R&D for specific disciplinary areas within the animal production area. In a few disciplinary areas respondents believed that staffing levels were adequate and that age profiles were such that attrition could be replaced by recruitment from a reasonable sized pool of younger people currently in the system. In contrast, for several other disciplinary areas, there were generally strong views that the skewed age profile of staff has or will result in significant shortfalls between now and 2020, and that there were insufficient people in younger age groups or currently in training to meet industry needs. This led many in different industry sectors to conclude that there will be specific critical shortfalls that may constrain industry profitability.

For the purposes of this review several broad disciplinary areas within animal production were identified and were discussed with respondents:

- Genetics (molecular and quantitative)
- Ruminant nutrition (including nutritional biochemistry)
- Reproductive management (including reproductive physiology)
- Growth and developmental physiology
- Meat science and technology.
- Animal behaviour and welfare
- Biotechnology and molecular biology
- Generalist training/management

2.1 Genetics

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There are currently a reasonable sized pool of well-trained quantitative animal geneticists servicing the red meat industry within state, commonwealth and tertiary institutions, in breed societies and in some areas of the private sector. There has been a concentration of genetics R&D and training capacity in certain locations (Sydney, Adelaide, Armidale, Orange) but this is not necessarily a bad trend as critical masses of expertise have been developed at these sites, and opportunities for postgraduate training have been enhanced. In general, the age profile of quantitative geneticists approaches a normal distribution, and there are a number of postgraduate students currently in training, though there is a perception that numbers are decreasing as in many other areas. However within some state agencies there are situations where retiring geneticists may not be replaced leading to a downturn in breeding services offered.

CSIRO Livestock Industries has recently recruited a number of positions in this field; but there do not appear to be a lot of additional employment opportunities in the short term, though there was a reported unmet demand from the agribusiness sector for an applied geneticist with postgraduate qualifications to service clients and provide in house training. Reduced employment opportunities will mean that some students currently in training will probably move overseas for post-doctoral experience, thus reducing the pool size of younger people.

Comment was also made by several respondents that classical quantitative genetics associated with improvements in product yield and efficiency (meat, wool, milk) needs to expand to also involve multidisciplinary programs involving interactions of genetics with parasite resistance, gut function, stress and a range of other areas constraining production. While some of these areas are the subject of current activities, additional effort could be warranted.

In summary, for quantitative genetics, it is concluded most industry needs could be serviced by currently available staff and those entering the system, with the proviso that losses due to normal attrition are replaced.

In the case of Molecular Genetics there was again some divergence of views regarding industry needs for the future. One respondent made the point that undergraduate students trained in molecular biology were often attracted away from agriculture related post graduate studies to the health and medical areas because of better studentships, research support and career prospects. Others emphasised the need for training to ensure molecular geneticists understood the systems and breeding objectives for the industries they were servicing. Others highlighted the need for strengthening of interactions and cooperation of molecular and quantitative geneticists in order to facilitate significant industry advances, and to make the molecular genetics work relevant and applicable.

The overall conclusions were that current postgraduate training activities in the molecular sciences, including molecular genetics, together with existing expertise in this area were probably going to be sufficient to meet industry demands to 2020.

The broad disciplines of functional genomics and proteomics were seen as areas where additional strengths need to be developed for future needs of the red meat industry. Australia is a leader in the area of plant genomics and proteomics, but progress in the animal field appears to have lagged. Some state agencies indicated that they would develop expertise in these areas to service future industry needs, while others indicated that CSIRO and Universities were better placed to provide such services. Biotechnology companies in particular saw a need to increase capabilities in these areas in order to provide an increased range of services to their clients in the future.

A general conclusion is that industry needs in these areas needed to be continuously monitored, and that postgraduate training should be strengthened as required. It was felt also that the red meat industry CRC's would be in a position to contribute to relevant training in these areas.

2.2 Ruminant nutrition

Australia has long been a leader in ruminant nutrition R&D, and the outcomes of much of this research have been adopted in the grazing industries to enhance production of both sheep and cattle. Similarly Australian basic research in nutritional biochemistry has contributed to a better understanding of gut physiology and function, of mechanisms of feed utilisation, and of wool and meat quality. However in recent years the momentum of both research and postgraduate training in these areas has slowed dramatically, while the capacity of some state, commonwealth and tertiary agencies to provide services and advice to the grazing and feed milling industries has also been reduced considerably.

As for other disciplinary areas, many positions in ruminant nutrition are held by people in the 50-60 year age bracket likely to retire from the work force within the next 5-15 years. Additionally, a fairly high rate of attrition of nutritionists in recent years from most agencies, has not been accompanied by replacement with younger staff. For example, in two state agencies the number of ruminant nutritionists now in employment is less than 50% of that six years ago. While this partly reflects budgetary constraints, it is also a reflection of reduction/reallocation of resources elsewhere than to the red meat industry.

In the case of university postgraduate training in this area, there has also been a significant decline in staffing numbers, which together with the growing lack of interest by many graduates in postgraduate training, has resulted in a very considerable decline in postgraduate student numbers. Several respondents also made the point that another reason for a decline in postgraduate training in ruminant nutrition was the relatively high costs of animal experimentation that, because of the funding model for postgraduate training, many universities could no longer commit internal resources to.

A reflection of these situations is in reduced applications from suitably qualified candidates for recent vacancies in CSIRO Livestock Industries and the Sheep and Beef CRCs, where some vacancies have had to be filled by overseas applicants. However, it is not only the public sector that has been affected in recruitment of suitably qualified and experienced staff. The feed milling industry has similar problems, one company reporting having had to recruit two senior positions from overseas after failing to attract interest from Australian graduates.

It can be argued that there may no longer be the same demand for the traditional ruminant nutritionist as in the past, since many nutritional management problems have been solved or technologies adopted. However there are clearly needs for staff with nutritional training in multidisciplinary groups to address industry problems. Examples include R&D on the physiology of growth and development; genetic interactions with gut function; parasite resistance and nutritional status, nutritional aspects of microbiological food safety; nutritional modification of gut function to address environmental/greenhouse issues; sheep feedlotting; sustainable grazing systems, as well as in emerging fields such as proteomics.

In addition to the reduction in generalist ruminant nutrition strengths, there are some specific specialist areas such as mineral and vitamin nutrition and in the post nutrient areas where capacity has or will decline very shortly.

Despite considerable expansion in the feedlot sector in recent years, there has not been a corresponding increase in demand for specialist feedlot nutritional services. Large sections of the industry continue to obtain much of their nutritional advice/analytical services from overseas. This may be due to a perceived absence of qualified and experienced staff in the Australian private sector, but probably also reflects the multinational ownership of many large feedlots who have established links with feedlot nutritionists, consultants and analytical facilities elsewhere.

While some state agencies have withdrawn from feed analytical services, for others, the introduction of a "fee for service" policy has seen a decrease in sample numbers with subsequent reductions in the viability of these services. Conversely there are cogent arguments that provision of these services should come from the private sector and that industry needs should be filled on a purely commercial basis. While this has occurred in a number of instances, it has not resulted in significant levels of alternative employment demand for people with postgraduate nutritional/analytical qualifications.

In some tertiary institutions, postgraduate enrolments in biochemistry/ metabolism are still at reasonable levels. In the general field of molecular biology, particularly that related to nutritional physiology/function, there were reported difficulties in attracting suitable postgraduate students and difficulties in integration of some molecular biology with downstream agricultural needs.

Reductions in postgraduate nutritional training capacity and demand together with attrition mean that it is doubtful if industry needs and requirements for nutritional services can be met to 2020, given the relatively small numbers of younger people currently in or entering the system.

Overseas recruitment is unlikely to fill emerging shortfalls, though there may be increased use of offshore analytical services. A model, similar to that suggested for training of veterinary pathologists, involving joint venture arrangements between the public, tertiary and private sectors should be examined as a means of meeting requirements for the future.

2.3 Reproductive management

High reproductive rates are an important component of herd and flock productivity. The adoption and application of research outcomes on reproductive physiology and reproductive management of tropical beef cattle have enabled considerable improvements in fertility rates to be achieved in northern herds, though these are still below achievable levels for that environment. Similar advances have also been made in Merino flocks in the pastoral zone, though again levels of reproductive performance are probably still sub-optimal. To what extent these performance levels are constraining overall productivity as it relates to meat, as against wool production, is not clear but again improvements in this trait will enhance flock productivity. In the prime lamb industry, based usually on pastures in the higher rainfall areas, there is also fairly wide scope for enhancing reproductive performance. In conjunction with genetic improvement programs such advances would increase overall productivity and efficiency in an industry with considerable growth potential.

In the cases outlined, most of the advances achieved have been based on technologies developed from research programs undertaken in the three decades to about 1990. However, the momentum of Australian reproductive research ceased fairly abruptly during the 1990s and the opportunities for industry to take advantage of new research outputs relevant to local industry conditions is now reduced. Further, technologies developed overseas may not always be applicable to Australian environments, management systems or livestock genotypes. This rapid decline in disciplinary activity was related to a number of factors including staff attrition in state, commonwealth and tertiary

agencies; funding constraints both internal and external; changes in funding priorities of rural research funding agencies and a belief in some sections of the sheep and cattle industries that all reproductive management problems were solved. The net result has been an exodus from the disciplinary area for production animal expertise, and hence an inability to respond to industry needs for the future.

The exception to this decline, however, has been in the area of advanced reproductive technologies where some ongoing activities and advances are occurring. However opportunities within the cattle and sheep grazing industries to take advantage of such developments are more limited.

The review found that in most state agencies staffing levels in applied reproductive management are probably only 30% or less of what they were 10 years ago. Activities within CSIRO are also at very low levels, other than in advanced reproductive technologies. In the tertiary sector, training in this area for meat livestock is now only available in no more than 3-5 departments across Australia, all of which reported reduced staffing and very small numbers of postgraduate students. Lack of career opportunities, reduced funding for research projects and a general decline in interest in postgraduate training were all cited as reasons for these declines.

Shortfalls in teaching capacity in reproductive management are being partly filled by outsourcing these activities and concerns were expressed that capacity of new agricultural and veterinary graduates to meet industry service demands would be further reduced. The current age profile of relevant university staff suggests that this situation can only worsen and not improve. Outsourcing of teaching also does not allow any redevelopment of research capacity in the discipline.

In the case of some university departments still active in either reproductive management or reproductive physiology, emphasis has moved towards companion animals and/or equines or to advanced reproductive technologies. There is still however an active dairy cattle reproductive program at the University of Melbourne where cattle expertise has been retained. These trends are mirrored in the activities of one biotechnology company whose research and product development efforts have moved away from cattle to companion animals.

While the argument has been advanced that industry no longer needs substantial reproductive research, the reality is that industry productivity could still be enhanced through enhancement of reproductive performance. Equally, the adoption and application of modern breeding programs, particularly in the seedstock industry, can be further enhanced where reproductive efficiency is improved. An example is the adoption of research outputs from the MLA funded northern "Bull Power" project that is assisting industry to identify and select bulls with high reproductive efficiency, thereby enhancing genetic gains through the use of BREEDPLAN.

It is unlikely that the postgraduate training model suggested for veterinary pathologists and ruminant nutritionists, involving a three way partnership between public, private and tertiary sectors will be applicable for training in reproductive management. Other than for advanced reproductive technologies there has never been a significant private sector involvement in reproductive management. The rundown in stage agency and CSIRO activities also suggests that capacity to contribute to postgraduate training opportunities to and future industry demands will be minimal. This suggests that rebuilding of this discipline in several tertiary institutions may be one of the few ways forward. This will require external support if the approach is going to succeed.

The conclusions are that it will be difficult to satisfy likely industry demands to 2020 for people with specialist postgraduate skills in reproductive management to assist in enhancing performance of beef cattle and meat sheep.

2.4 Growth and developmental physiology

A number of recent industry developments particularly those related to meat quality and yield, adoption of objective genetic selection procedures, and increased market specification requirements

have stimulated research developments in this broad area. While these disciplinary areas do not impact directly on industry requirements they do however provide the underpinning science for other areas such as Meat science and technology. Studies on growth and developmental physiology have a long history in Australia but have tended to be from a physiological rather than an applied production background. Nevertheless, a number of individuals and research groups are active within this area, particularly through the 2 Beef CRCs and now the new Sheep CRC, in providing research and training capacity.

A majority of the research/teaching staff in these areas are in the 30—50 year age bracket. There are also a number (6—10) of postgraduate students in programs in at least four university departments. Demand for such specialists will come largely from CSIRO and state agencies, rather than directly from the meat industry. There have been some recent appointments in CSIRO and in state agencies and both Beef and Sheep CRC demands for research in this area will provide contract employment opportunities. A judgement is that there is unlikely to be much direct demand from the private sector.

Existing staff, together with those in the training pipeline will probably be sufficient to meet industry needs to 2020.

2.2 Meat science and technology

Recent developments in the red meat industry, including greater emphasis on meeting domestic and export market specifications, consumer demands for consistency of product and the need for a better understanding of the pre and post slaughter factors influencing meat quality attributes, have provided the stimulus for an increase in research and training activities in the areas of meat science and technology. Research activities have involved most state agencies, two divisions of CSIRO, both Beef CRCs and now the Sheep CRC, together with at least four university departments. A positive feature of these developments has been the interaction and collaboration between meat science research groups and industry, and between these and a range of other disciplinary research groups including those working on genetics, growth and developmental physiology, nutrition and stress physiology of food animals.

The age profile of scientists working in these fields approaches a normal distribution with perhaps a slight skew to the right. There are between 6—10 postgraduate students currently in training in 2-3 university departments and there have been several new appointments to positions in meat science and technology in research and teaching institutions. An industry funded and Beef CRC sponsored Chair in Meat Science at the University of New England in the early 1990s enhanced involvement of the tertiary sector in training and research in meat and meat products and with industry, and contributed to a strong postgraduate program that has increased the numbers of well trained meat scientists.

Research findings from the Beef CRC on factors influencing meat quality attributes have underpinned the Meat Standards Australia (MSA) program and contributions from the discipline are also expected in the development of a similar system for sheep meat. Industry demand has increased for in house training programs in meat quality and these appear to have been met by current staff. However, any further increases in such training commitments could put pressure on already stretched human resources.

There will be a continuing industry demand for skills in the areas of meat science and technology. Whilst for the private sector such skills may only be needed at the graduate or sub-graduate level, at the R&D level postgraduate training needs will continue. A related area is in food safety and food hygiene as well as the impacts of both pre and post slaughter factors on safety and quality. Increased requirements for certification by different markets have placed more emphasis on these areas. Multidisciplinary teams involving animal behaviourists, nutritionists, microbiologists and meat scientists will be needed to tackle these issues industry issues.

2.6 Animal behaviour and welfare

A number of research groups in Australia have for some time had an interest in various aspects of animal behaviour. However, only some of these have had activities and interests in behaviour of domestic livestock and impacts on productivity. However, despite increasing evidence of the importance of behavioural traits in influencing a range of production parameters including reproductive rates, growth rates, management ease and meat quality attributes, the level of these efforts has declined somewhat recently.

Viewpoints were also expressed that some studies on behavioural relationships to productivity were no longer needed or were not as relevant to industry needs. However, certainly in the beef industry, behavioural work for example by the Beef CRC was seen as both relevant and applicable, examples being the effects of weaning practices on subsequent feedlot performance, and current work on relationships of flight speed (measure of temperament) and meat quality attributes.

In relation to the red meat industries, there are probably only 2-3 groups active in the area, though CSIRO Livestock Industries has recently recruited three positions in the areas of behaviour and welfare. As for behavioural studies, welfare issues are not an area of significant strength, nor currently of postgraduate training capacity. A foreshadowed Chair in Animal Welfare at the University of Queensland may increase training capacity and research. Some concerns were expressed in relation to this development though that aspects of welfare related to meat producing animals may be redirected by interests and research funding more related to companion animals, and other species.

Studies on animal welfare are frequently an emotive issue and there is no doubt that some of the welfare work has been hijacked by vested interests more interested in animal rights than in animal wellbeing. Consequently industry interest in and support for some welfare studies is at best ambivalent and sometimes antagonistic. However, recent shipping losses in both cattle and sheep suggest that ongoing research on welfare issues and on stress physiology will be necessary. Most importantly however, are likely future trade and market issues for some countries that may require certification that principles of good welfare are applied to animals from which export products are derived. This is an important issue for the future, one which industry cannot ignore, and one that may need additional expertise to meet industry needs for certification. Thus behaviour and welfare areas could be seen as of emerging importance for the red meat industries that will be driven by the needs for market access and to meet legislative requirements rather than solely for scientific interest.

A considered view is that there will be a need to increase research and training capacity in aspects of behaviour and welfare, to meet likely industry requirements to 2020, though the priority is not as high as for some other disciplinary areas.

2.7 Biotechnology and molecular biology

These new disciplinary areas are underpinned by the basic sciences of biochemistry, physiology, microbiology and the paraclinical sciences. They are now providing new and fundamental development pathways for many disciplinary areas, including a number of branches of animal health, molecular genetics, advanced reproductive technologies, functional genomics and nutritional biochemistry to name a few.

In discussions on needs in this area, most comments were received from R&D and education groups in the public sector. Comments from other sectors of the red meat industry were minimal, probably reflecting a view that many developments, particularly in molecular biology, were enabling sciences and that interest was mainly only on applications of developed biotechnologies that could be used by industry.

Undergraduate training in these new areas is available in most science faculties in Australian universities, including some specialist degrees in Biotechnology, and interest in these areas appears high. Many students now undergoing postgraduate training in a wide variety of disciplines are involved in some aspects of molecular biology/molecular genetics and in some cases in biotechnological developments.

However, as indicated earlier, an identified problem is that scholarship funding, future job opportunities and conditions, levels of research funding and the hype associated with medical/health research, mean that many postgraduates prefer employment in these more "glamorous" areas than in agriculture. The extent to which this drift will continue is difficult to specify, but is a problem that needs to be recognised and addressed.

Another concerned expressed was that there is a need for building of substantial bridges between molecular biological research and the more applied research activities in a number of agriculture related disciplinary areas. Comments were made that in some cases the claimed high quality/cutting edge nature of research outputs of molecular biologists was not a realistic appraisal of the situation and that in many cases the potential for applications of such research were often less than originally claimed for them. Despite such negative images, there is not doubt that research in these disciplinary areas will increase biotechnological outcomes will be increasingly important on a number of areas particularly disease diagnostic capability and the application of molecular genetics.

On the evidence available there will be a reasonable sized pool of well trained and qualified molecular biologists over the next 10-15 years. The challenge, however, will be to attract such staff into and retain them in research areas relevant to the red meat industry and this may prove a difficult task. One approach to attracting and retaining such people could be the creation of postdoctoral positions in areas where need is greatest.

It is concluded that needs of the red meat industry to 2020 for skills in these areas, particularly in biotechnology, will be met from existing staff and those currently in the training pipeline. Support for postdoctoral positions in these fields should also be considered.

2.8 Generalist training / management skills

A downside of the extent of science and social science specialisation that has developed over the past 20-30 years has been the loss from the workforce of many staff with generalist/ managerial skills. In the academic arena, course curricula and postgraduate training activities have become more and more specialised and in some cases less and less integrative. There have been a number of important consequences of this drift.

There were frequent comments from a range of employer groups that many of the graduates of today did not have the holistic and integrative skills of earlier student cohorts. This point was made particularly by academic staff in several institutions, by agricultural consultants, by pastoral companies, by several state agencies and by the banking sector and applies to the agricultural/veterinary, economics and extension areas.

This is a difficult problem to overcome. Clearly curriculum design has to take into account the concerns of employer groups while still satisfying academic standards. In some disciplinary areas accreditation requirements also need to be considered. There is an argument for a critical re-thinking in many degree programs of the outcomes to be achieved and the competency standards of graduates. While such a notion will not sit comfortably with some sections of the academic community, it was felt by many that there is a need to broaden the approach of many agriculture and science degree programs to include not only scientific and technical components but also development of sociological, economic and communications skills of graduates.

In the case of postgraduate training, a fundamental re-think may also be needed, for the same reasons as just outlined. The demand appears to have slowed for research training in most areas of relevance to the red meat industry, both from prospective students and from prospective employers. In some areas and for those students where research is not a critical component, flexible coursework Masters and Professional Doctorate programs are an alternative approach. There may also be a need for enhanced levels of informal in-house training particularly in state agencies and the private sector. The question arises as to who has responsibilities including funding for such training.

There may also be a need for MLA and other rural funding agencies involved in the meat industry to consider partnership approaches with academic institutions to appoint staff who can provide the whole farm integrative approach which has disappeared from a large number of undergraduate programs. This process has already started with MLA supporting an Epidemiologist appointment in one university. This task will not be easy and will need strong industry/employer group support and pressure to achieve it. However, it needs to be done since a wide range of industry sectors have and will be affected by this run down in generalist/holistic skills.

There are needs by several industry sectors for employees with both graduate and postgraduate qualifications and skills in the generalist areas of integrative management and holistic approaches which are unlikely to be met by 2020.

2.9 Animal production disciplines – overall comments

There are indications that there will be a growing imbalance between supply and demand over the next decade in at least two animal production disciplines, nutrition and reproductive management. A number of respondents believed that the combinations of skewed distribution of age profiles, low postgraduate activities and reduced employment opportunities in some sectors will mean that demand will exceed supply by 2020 and that R&D activities and service activities will be constrained.

Clearly, all Australian universities will not be able to maintain postgraduate activities in all areas of animal production. Consideration needs to be given as to how best MLA can facilitate interaction and collaboration to provide teaching and training opportunities, particularly in those disciplines likely to be in demand and which are currently under threat. Additional funding to the university sector is unlikely in the short term and alternative strategies need to be examined.

Unfortunately, one alternative approach, involving joint ventures between public, private and tertiary sectors, as proposed for animal health disciplines, may not be so successful for nutrition and reproductive management, though this needs to be tested.

In summary, this review has found that shortage of expertise in at least nutrition and reproductive management will not enable demands to 2020 to be met. This may impact on future capacity of the red meat industry to increase productivity and efficiency.

3. Plant Agriculture

Australia's livestock industries are primarily dependent on a pasture base. This applies even to the cattle feedlot industry, since some 70% of the life of a feedlot steers is spent at pasture. Thus maintenance of the pasture resource is a critical issue for animal production with the added complexities of managing environmental concerns from a wider range of the community on issues such as water quality, degradation and sustainability.

Over the past two decades there has been a strong recognition by livestock producers of the need for development of management systems to sustain the pasture resource and research supporting these efforts has been well supported by a number of rural funding bodies including MLA. In the north, pasture introduction programs, rangeland management programs, and in the south, plant variety testing and development of sustainable grazing systems have all been well funded in the past, and many of the R&D outcomes have been adopted by progressive producers. Well qualified research staff have also been supported by an effective extension network.

However, this situation has changed in recent years. Serious concerns were expressed by many regarding the future capacity and/or interest of agencies to provide staffing and support in the areas of pasture agronomy and rangeland management. The point was made that progress in pasture

agronomy and in introduction of new species had slowed dramatically in both the north and south and that current management systems and strategies were based on work done up until the mid 1990s.

3.1 Pasture agronomy

Most of the work in this area in northern Australia was done by state agencies in Qld, NT and WA together with staff from two CSIRO Divisions. Respondents indicated, however, that high levels of attrition due to age, budgetary constraints and institutional restructuring have meant only a token R&D capacity in this area. The age profile of remaining staff is skewed to the right, with relatively few younger staff in the system or being recruited. While some rangeland ecology work being undertaken by the CRC for Tropical Savannahs has partly filled this gap, work on new species introductions and several other agronomic areas was no longer being pursued.

It can be argued that the very success of pasture agronomic research in northern Australia in the past 20-30 years has meant there are no more problems to be solved or solutions developed. However, this argument ignores the fact that there are some emerging problems associated with stylosanthes introductions, that legumes for lower rainfall areas are still not available, and that pasture management strategies for some systems may still need further work.

The loss of staff in state agencies and in CSIRO is mirrored in reducing training capacity at university level where for the north, other than tree legume work, research activities have slowed and postgraduate numbers decreased. Many respondents believed that current staffing levels would impact on industry requirements and that there was a need for regeneration of activities. It was also suggested though that some staff had moved away from a traditional pasture agronomic/ecological approach to one of rangeland management where future efforts needed to be made.

A similar pattern emerged in discussions on southern Australian needs for future pasture agronomic R&D. There had been a decline in staffing numbers in all agencies, and employment opportunities in the public sector were fewer. There were reduced training capacities, research activities and postgraduate student numbers in this discipline in most southern Universities. A brighter spot however was increased job opportunities for pasture agronomists in agribusiness and consulting. Here however there were competing pressures for employment as crop agronomists in the grain and cotton industries.

3.2 Rangeland

Much of Australia's beef and some sheepmeat is produced in the rangelands encompassing the semiarid and arid areas of the inland, tropical savannas and grasslands and the temperature southern native grasslands. However for the purpose of this review rangelands were defined as those areas in northern and central Australia supporting extensive livestock production systems. In the period from the early 1960's to the late 1980's, considerable emphasis was placed on the development of rangeland management research and extension expertise by state and commonwealth agencies. However the impetus for this work has now slowed and in some cases been reduced considerably.

More recently the large northern pastoral companies and individual large pastoralists have utilised rangeland management scientists in developing sustainable management systems for their operations. Some of this effort has been driven by legislative requirements in terms of lease conditions, but there is also a strong economic motive to ensure that the pasture resource on which their operations are based is maintained or even enhanced.

Most scientists and extension staff in this area in northern and inland areas have been drawn either from an agricultural science background or a natural resource management background. It was suggested by some respondents that differences in philosophical approaches to rangeland management from scientists from these two backgrounds had created some tensions, particularly in the development and implementation of rangeland management strategies related to pastoral

production. It is difficult to determine the importance of these tensions, though it was suggested that there had been a need on occasions for in-house training of those with a natural resource management background in animal husbandry and management and other issues related to livestock production, rather than seeing rangeland management purely from an ecological/conservation perspective.

For the public sector these tensions appear less of a problem, and in fact a mixture of staff from these two broad backgrounds was often seen as a strength rather than a constraint. Accompanying some decreases in public sector employment levels as a result of attrition and non-replacement, there also appear to have been reductions in service levels that were of concern to some respondents. A flow on from these effects is in the tertiary sector where both staffing levels and postgraduate numbers have generally declined, though this appeared to be less in some departments of natural resource management or environmental science than in corresponding agriculture/plant science groups. The recent creation of an Australian Rangelands Institute based at the University of Queensland will hopefully act as a nucleus for enhanced training and research in this area, however it is too early to predict it's impact. Regardless, a view of the future is that most rangeland management staff could be drawn from a natural resources/ecological background, suggesting that some additional training in short course or course work type programs may be needed to enhance their employment opportunities in the pastoral sector.

For both pasture agronomy and northern rangeland management disciplines, a considered view is that there will be some shortfalls to meet industry demands to 2020, demands which are likely to increase in response to a range of environmental and production efficiency drivers.

3.3 Sustainable Grazing Systems

For the purpose of this review, sustainable grazing systems (SGS) were defined as programs based in more temperate areas often with an improved pasture/high input base rather than the native pasture/low input base more characteristic of the rangelands. This distinction is not absolute but adopted here because of differences in regional demand for those with pasture agronomy/rangelands management/grazing systems expertise. In the southern regions there has also been a longer history of more intensive R&D and extension involving introduced pastures, fertilizer and management requirements and development of grazing systems to both maintain pastures and enhance livestock productivity. This has resulted in a stronger human resource base though this appears to have declined also.

There has been considerable recent input by several R&D funding agencies including MLA into the development of SGS's for southern Australia that have been successfully adopted by many producers. There were a number of positive comments from different sectors on the success of these programs. However a number of respondents indicated concern at a possible inability to maintain this impetus, given staffing losses that have occurred across the public sector. This raises the question of who will provide the ongoing technical inputs needed to increase adoption rates of these technologies by producers.

In contrast to the situation in Northern Australia, temperate regions have a relatively large pool of pasture agronomists in both public and private sectors. The private sector through consultants and agribusiness is likely to provide a commercial service in the future for SGS technology transfer, which raises the question of what additional training may be needed for such personnel, is it available and relevant, and who should pay for such training? Should it be by the private sector as part of normal professional development programs for staff, or should it be by industry funding agencies that have sponsored the systems development R&D, in order to ensure a return on the research investment made by them on behalf of producers?

While such questions are probably outside the scope of this review, they need to be asked as they impact on assessments of future staffing levels to meet industry demands. Such training may not be

only for increasing research skills, but rather for more broadly based, perhaps informal and unstructured programs to enhance technology transfer and adoption of these new systems. Course work programs and flexible programs such as the MBA and Professional Doctorates may better fill these needs.

A considered judgement is that some additional resources may need to be committed to training to enhance the skills base, particularly of those in the private sector, to ensure that industry needs to 2020 for transfer and adoption of SGS technology are achieved.

3.4 Plant agriculture disciplines - overall comments

As for previous disciplinary areas, there are also indications of potential shortfalls here, such that demand to 2020 may be greater than supply. Relocation and/or non-replacement of existing staff in many institutions, coupled with reductions in training activity and more attractive opportunities for postgraduates in the cropping industries have all interacted to create a situation of reduced R&D and extension activities in pasture and rangeland management.

The potential impact on needs to 2020 is a little more difficult to determine. There is already considerable private sector involvement in pasture agronomy and to a lesser extent in rangeland management and SGS areas. Provided commercial opportunities arise, at least some of the likely shortfalls in the public sector and in universities could be taken up by the private sector.

There is a need, however, to examine how best to provide training needs for staff in all sectors, other than traditional Masters and Doctorate programs. MLA, in conjunction with other funding agencies, could facilitate a review of that type, which could also partly strengthen university capacity in these disciplines.

Within the livestock industries, environmental protection and production capacity constantly interact. The challenge is to produce staff with the capacity to manage both these issues. Some new approaches to curriculum content need to be examined to ensure that graduating students have skills and competencies in these integrated areas.

4. Commercial / Business

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A review of this type needs to cover not only the technical and scientific needs of the red meat industry, but a range of related disciplinary areas required to meet possible demands in the future. Whilst within this broad area of Commerce/Business many disciplinary areas overlap or have commonality with others, for the purpose of this review, comment is presented on individual disciplinary areas.

Discussions with some sectors of the industry focussed largely on these aspects, rather than on some of the scientific/technical issues which were addressed to other sectors. However, comments were sought on these but in many cases responses were general and were noted.

4.1 Commerce and agribusiness

In addition to state and commonwealth agencies and universities, contacts in this area were fairly wide. They included several banks, a number of agricultural consultancy groups, several private and public sector agribusiness companies, pastoral companies in both northern and southern Australia, a feed milling group, and a private veterinary pathology group.

With the exception of the veterinary pathology group, most private sector respondents indicated that they tended to recruit staff with graduate rather than postgraduate qualifications. Additional training was generally provided either in-house or through support for staff to undertake postgraduate studies in areas relevant to their employment. Most respondents indicated that recruitment of staff with

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postgraduate qualifications was not foreseen as a problem requiring attention. One exception was for postgraduate training for recruitment of private sector veterinary pathologists. Respondents in both the feedlot industry and pastoral companies suggested, however, that some postgraduate qualification in agriculture for commerce/agribusiness staff would enhance their effectiveness. Conversely, several agricultural consultants made the point that graduates with scientific or technical qualifications often lacked commercial or business skills which had to be developed on the job and in their view should be incorporated into agriculture degree curriculums.

Similarly, most public sector agencies did not see significant shortfalls in these areas in relation to future industry needs. Most Australian universities have commerce/ financial management/business management degree programs. However, the level of postgraduate activity, other than for MBA programs is generally low, reflecting the lack of significant demand mentioned above.

It is considered that shortfalls of graduates with commerce/agribusiness skills and qualifications to meet industry needs to 2002 are very unlikely. Demand for postgraduate training in these areas is quite low and mainly to meet demands from the university sector. Significant increases in demand for formal postgraduate training appear unlikely.

4.2 Economics

Enrolments in economics in many Australian universities have declined in recent years though this is really a reflection of increased enrolments in related areas such as commerce and business management. Agricultural economics and agribusiness programs are offered at a number of universities and several (UQ, Sydney, UNE) produce significant numbers of graduates each year, many of whom are employed in the private sector. As for commerce and business however, postgraduate enrolments (and demand for staff with postgraduate qualifications) are also low and unlikely to increase.

Most respondents in most sectors did not see shortfalls in economics graduates as likely to constrain industry activities to 2020. The low level of demand for postgraduate training is also not likely to impact on industry needs.

Supply of economics and agricultural economics graduates will meet industry needs to 2020. The low interest in and demand for postgraduate qualifications will not be an impediment other than in the tertiary sector.

4.3 Business / project management

Again, most Australian universities have significant enrolments in programs in these areas. Respondents from most industry sectors indicated that staff recruitments were not a difficulty and that in-house training rather than postgraduate training was generally more appropriate. One CRC respondent suggested, however, that additional skills needed to be developed in project management of technical and scientific programs. This was more related to broadening of the skills base of scientific project leaders rather than those with specific management qualifications.

Shortfalls in these disciplinary areas are unlikely and numbers of graduates and those currently in the workforce will be sufficient to meet industry needs to 2020.

4.4 Intellectual property (IP) management

The area of IP management and protection has assumed increasing importance in recent years as many scientific and technical developments are perceived to have possible commercial value. However, the reality, as many respondents indicated, is that considerable time and effort in IP management is often expended on the large numbers of developments which are later found to have limited commercial value or application. Notwithstanding, IP management has developed into a much

larger area extending beyond the traditional inputs of patent lawyers and licensing agents, for which there is a large pool sufficient to meet industry needs.

Enquiries indicated that most law/business law undergraduate courses in Australian universities contained elements of IP law and in some cases, IP management. In some instances, postgraduate training was also offered in these areas, which also formed a component of some MBA programs. Despite this availability of skills, some concerns were expressed by some respondents as to capacity to meet future needs for IP management.

However, there was a fairly wide divergence of views on this matter. Some believed that they had sufficient knowledge of requirements to be able to handle these issues at a technical level and then to hand over to legal/commercial interests to finalise. Others, particularly in the public and tertiary sectors, indicated either adequate in-house capacity or adequate outsourcing capacity to handle these needs. Another view was that this area needed to be strengthened to ensure that the red meat industry should ultimately benefit from the investments it made in R&D and that demands for the future may not be met. One commercial firm was identified which has as a core part of its business, the provision of IP management and protection services and has some experience in these areas in the broad field of agriculture.

These disparate views suggest that there is probably an intermediate point where existing legal, commercial and financial skills are available to handle most needs of the red meat industry to 2020. There could, however, be specific exceptions to this general conclusion.

It was concluded that current strengths in IP management and protection either provided through in-house services or outsourced were probably sufficient to meet industry needs to 2020.

4.5 Kills integration capacity

This is a difficult area to define precisely. However, it generally refers to an individual's/group capacity to take an holistic view of all components of an operation or industry and to develop an integrative approach involving different disciplinary areas. A good example is the pastoral property manager who needs to be able to integrate animal and pasture management personnel management, marketing and financial management skills into a package to ensure operations are viable and profitable.

Whilst the individual skills above are often developed singly or jointly, in many cases experience is the only teacher for their integration into an operational package. At the tertiary level, many agricultural and veterinary courses in the past concentrated on the development of capacity in "whole-farm", "holistic" or integrated thinking and application. However, with increasing specialisation, there was less emphasis now placed on development of such integrative approaches and this weakness was commented on by a number of respondents. Discussions with the pastoral industry, consultants and to a lesser degree feedlotters highlighted this problem.

Tertiary groups also recognised the problem but with budgetary constraints, were often not able to recruit staff with interest in or capacity to provide this skills integration capacity in courses.

It can be argued that integrative skills should better be developed either at postgraduate level or through a combination of experience and intensive in-house training. The latter approach is certainly the most common in the private sector where emphasis was laid on the importance of "on the job" training. However, there is an increasing demand by employees for formal training/qualifications to enhance their career opportunities and here opportunities are more limited.

Whilst programs such as an MBA help in these areas, it was difficult to identify postgraduate programs in the life sciences where such training could be obtained. As previously indicated, several universities now offer flexible professional doctorate programs which may satisfy these needs. This is -

an important area for the red meat industry where skills integration play a critical role in ensuring productivity and profitability.

A more detailed study needs to be undertaken to identify or perhaps help develop tertiary level courses which will enable graduates to develop generic integrative skills. These are probably best developed through a combination of job experience, in-house training programs and appropriate tertiary training. It is unlikely that there will be shortfalls in these areas to 2020.

4.6 Human resource and industrial relations management

These important management areas have assumed greater importance in the past 20 years with changes in employee perceptions of job needs, together with social considerations related to employment and to occupational health and safety issues.

Most universities offer units or courses with aspects of HR and IR management and law, particularly within business and law degree programs. Many larger organizations, particularly in the public sector, have large HR/IR/OHS divisions, whilst for many private sector groups, policies and procedures for these areas have either been developed internally or with external assistance.

The importance of postgraduate training in these areas was seen to be greater by respondents from the tertiary sector compared to other sectors. This reflected tertiary sector preferences for employment of staff with higher degrees.

The general view across most industry sectors was that HR, IR and OHS staffing needs could be recruited from existing pools of expertise. Some respondents commented, however, that continually changing legislative requirements, particularly in OHS matters, meant that additional skills training was needed, which placed strains on smaller organizations.

A general view is that red meat industry needs to 2020 for staff in the areas of HR, IR and OHS management can be met through normal recruitment processes and that postgraduate training demands are low.

4.7 Marketing

The red meat industry generally has well developed marketing programs involving all sectors of the industry, including individual and corporate producers, meat processors, wholesale and retail butchers, state and commonwealth agencies and MLA as the marketing and market promotion arm of the industry. Market levies from producers and processors finance much of this activity, which is absolutely necessary if Australia is to stimulate domestic demand, and maintain and improve its export markets.

As for other business disciplines, marketing is an integral part of many Australian undergraduate programs with specific marketing degrees being offered by some. Some years ago there was an attempt to appoint a Chair in Meat Marketing at UNE. When this did not develop as planned, a certificate course in Meat Marketing was then introduced which has had moderate enrolments.

For most of the private sector, including the wholesale and retail meat industry, recruitment of market and marketing staff is not seen as a problem, staff being drawn from a range of disciplinary backgrounds. Similarly for state agencies staffing and provision of services in agricultural marketing has not been a problem to date, though there are indications that agency activities in these areas may be declining.

While Australian universities offer undergraduate programs in marketing, there has generally not been a large demand for postgraduate programs other than through MBA programs or from prospective academic staff who are generally expected to have postgraduate qualifications. For this broad disciplinary area, conclusions were that industry needs to 2020 could be met from existing staff and from recruitment from students in undergraduate programs.

4.8 Commercial / business disciplines - overall comments

Few areas of critical concern in these disciplinary areas were identified by respondents. In most cases strengths in these areas could be drawn from within existing graduates and there was generally less emphasis on the need for postgraduate qualifications and experience. An exception was in the area of IP management, where some thought additional strengths needed to be developed, though other respondents did not agree.

It was also suggested that there was a need for some overall strengthening of postgraduate training capacity in the general area of skills integration. Traditional research postgraduate programs will not fill this gap and more broadly based flexible programs such as the MBA and Professional Doctorates may be more appropriate.

5. Information Technology

New developments in information technology are constantly changing the life styles, attitudes and skills of individuals in all sectors of the industry. These include ways in which information and data is accessed, collected, stored, analysed and distributed, the way in which communications are developing, and routine business is transacted. Computer usage at the farm level continues to grow fairly rapidly as it did earlier in most other sectors. An issue largely solved for these latter groups is the availability of experienced, well trained staff to service IT needs and developments. However for some sectors of the production chain and in some regions, adequate delivery and servicing capacity for IT technologies still remains a problem, and is a constraint to operations.

While issues related to IT were raised by all sectors, most comments were from the production, R&D, and service agency sectors, since generally these matters were not a major concern for commercial and business groups.

5.1 Bioinformatics

There are a number of definitions of this relatively new disciplinary area, one of which is 'the study of the inherent structure of biological information and systems, bringing together information on systematic biological data (eg genomes) with the analytical theory and practical tools of mathematics and computer science.' A more simplified definition and once used for the purpose of this review is 'the creation and maintenance of data basis of biological information'. To take this definition one step further, the science also involves the compilation of information from different sources and often from databases with different structures that can then be used for research of management purposes. This latter process may also be called the development of 'relational data bases'.'

Bioinformatics has the capacity to be a very powerful tool, not only within the original concept of research, but also from a management point of view. An example of the latter is the vast amount of data and information on production and genetic traits in beef cattle, costs of production, carcass attributes and values and economic returns, much of which is held in separate data bases. In some cases such data has either not been analysed or linked together to aid management decisions. In discussions with a wide range of respondents, many identified this area as one needing support in the future.

There where however disparate views on the types of training and expertise required to support future industry needs for bioinformatics. On the one hand there was a view that biologists/economists with a flair for mathematics and computing were best placed to provide these needs, since they could also provide the biological/economic interpretations of data. The converse view was that people with basic

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mathematical and/or computer science skills were best suited to develop and handle complex data sets and analytical problems and could be assisted by others with biological and/or economic expertise in data interpretation. The practical reality of course is that teams with joint expertise are likely to be needed.

While there are these differences of opinion, there was collective agreement that additional strengths should be developed in this broad area to meet potential needs for the future. There are many existing undergraduate degree courses in the life sciences, agriculture, economics, mathematics and computer science that include components of this broad area. However other than as a component of postgraduate programs in other disciplinary areas eg genetics and computer science, there appears to be little active and direct postgraduate activity in the area.

There are many with postgraduate qualifications in IT and computer sciences, a majority of whom are employed in the IT private sector with good working conditions and high salary levels. This means that recruitment into the public, tertiary and agriculture sectors is more difficult. It is thus possible that there could be shortfalls in future requirements that need to be monitored closely. However expertise in bioinformatics could also be developed in specialist private sector firms supplying services to industry on an as-required basis.

It was concluded that most future needs of the red meat industry to 2020 for expertise in this area could be met, though some of these needs may be supplied through outsourcing rather than through the development of in-house skills.

5.2 Communications

Communications technology is developing at such a rapid rate that it is difficult to predict the methods by which future needs will be met. For the broad agriculture sector, political issues are likely to govern the provision of communications services to those in rural areas. While there may be some delay in the provision of such services to non-urban areas, in the longer term equality of service will occur. Thus communications technologies are unlikely to constrain activities in the red meat industry.

Communications strategies within the industry have also undergone massive changes, from original reliance on face to face presentation techniques, hard copy information, and radio/television to also include the wide array of electronic communications now available or which will be available in the future. These strategies are very important in getting messages and information across and there is no doubt that communications techniques and approaches have become more sophisticated and more user friendly. Some of these issues are also touched on in the next section.

A general conclusion is that the skills base needed to provide communications networks and strategies will be available and at adequate levels to meet future needs of most sectors of the industry.

5.3 Extension and technology transfer (technology adoption)

Extension and technology transfer strategies and service levels have changed significantly in the past two decades. There has been a reduction in all public sector activities in these areas, but only a partial uptake of service provisions by the private sector, most of which has been in crop rather than animal agriculture. Many respondents commented on these trends, and their likely impacts for the future.

It appears unlikely that state agencies will maintain even existing levels of service, and that most likely the private sector will become even more important in the provision of these services, and in supplying training requirements for the future. This scenario raises the question of who should pay for these services; the end-user who has already paid levies for the R&D from which new information is derived? R&D agencies to ensure that there is a return on their investment? Government agencies outsourcing their previous activities? Whatever the mechanism, these are areas of concern in meeting future needs. As indicated, staffing levels in these areas are a fraction of levels a decade ago, and this is also reflected in educational and training capacity within Universities. Although extension and communications units are offered in most undergraduate agriculture and some veterinary science programs, there only appear to be two universities still offering courses or degrees in extension/technology transfer at postgraduate level. In one program, most enrolments are now from the non-agriculture sector.

The Beef CRCs have had active technology training programs in place that have been successful, but the new Sheep CRC has adopted a different approach where private providers will be utilised for technology transfer. Meat and Livestock Australia has also had a very active and successful education program for producers that is being expanded with the use of private providers because of a shortage of public sector staff. This trend will continue. Despite these efforts there is legitimate concern in many sectors at future capacity of both public and private sector providers to meet industry demands for technology transfer and to assist with technology adoption. Some of the issues noted as to who pays for such services will also have to be addressed.

It is a considered viewpoint that it will be difficult to meet industry demands to 2020 for information and advice on adoption of relevant research outcomes. An assessment is that there will be a significant shortfall in the skills base needed to provide these services. There is also a need to address how such services are provided and paid for in the future.

5.4 Management techniques

The broad area of IT also covers the application and use of some specific technologies including Geographical Information Systems (GIS). This technology has had fairly wide application in a variety of agriculture related areas including climatology, rangeland and property management, land-use assessment, defining salinity problems, and hydrology to name a few. There are however a range of other areas of potential application that may be developed in the future. One example is the application of GIS technologies in animal disease epidemiology eg feral pig distribution in remote areas; another in developing integrated pest management strategies..

There is considerable expertise in this broad area in a range of state and commonwealth public sector agencies including several divisions of CSIRO, and the BRS. The technologies are also being increasingly used in land use management by pastoral companies in monitoring pasture health and landscape regeneration, while there are a range of other users.

Most Universities with environmental science/natural resource/applied geography programs have both undergraduate and postgraduate training and research capacity in the application of GIS technology. Similarly, units on this technology are taught in most agriculture programs. There are a range of employment opportunities for people with skills in the application of these technologies, particularly in agencies and private organizations with agricultural/environmental interests. There also appear to be opportunities that should be explored to apply these technologies to other science disciplines such as epidemiology. Given the numbers of existing staff with GIS skills together with postgraduates developing these skills, it is unlikely that shortfalls in intellectual capital needs will occur. However team rather than individual efforts will be needed in applying these new technologies to other disciplinary areas.

Industry needs to 2020 for staff with specific expertise in the application of GIS technologies to agriculture should be met.

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5.5 Information technology disciplines – overall comments

Only two areas, Bioinformatics and Extension/Technology Transfer, were identified by respondents where potential problems of shortfalls to 2020 may occur.

In the case of the former, future opportunities for private sector provision of services and support may create some training demands at postgraduate level. More likely, however, expertise will be developed by adding to graduate training a combination of in-house training and on the job experience.

For extension/technology transfer there is also likely to be a future and significant private sector involvement and the level of postgraduate training capacity needed to support this was not seen to be high, other than by public sector respondents. Current training capacity is focussed on only one University but given reductions in extension capacity which have occurred across most public sector agencies, most postgraduate needs could probably be met from that institution.

6. Summarised Results

6.1 Determination of retention (attrition) rates of R&D and extension staff in the red meat industry

As previously indicated it proved an impossible task to obtain firm quantitative data to confirm the generic (and often anecdotal) evidence of most respondents of significant run-downs in many disciplinary areas making up the intellectual capital base of the red meat industry. Not only was it not possible to identify and contact every single employer group, but for most agencies, detailed historic staffing profiles were not available. However respondent estimates of run-downs ranged from 30-60% for different disciplinary areas over the past 10-15 years. Whilst in the professional judgement and experience of the reviewer these estimates are probably correct, an important question was how, in the absence of firm data, could these be substantiated in some way.

Several approaches to this problem were attempted. The first involved a re-examination of the data generated in a recent MLA Project 'STU001- Review of AMRC, MRC and MLA Postgraduate Scholarship Schemes' (2001). In summary, this review found that some 67% of all scholarship holders over the period 1975-2000 had continued involvement in different sectors of the red meat industry (ie. attrition rate of 33% over 25 years). Summarised raw data of student numbers by disciplinary area is shown in Table 1. This data was further re-examined to calculate retention rates (attrition rates) by decade as a possible way of substantiating statements of significant run-downs in expertise (numbers by disciplinary area within decade were too small to give meaningful answers).

This analyses showed a clear relationship of overall retention rate (attrition rate) with length of time since completion of postgraduate studies. Of those completing in the 1970's, only 44% were still actively involved (attrition rate 56%) while corresponding figures for the 1980's decade were 55% (attrition rate 45%), and for the 1990's 84% (attrition rate 16%). While these trends are not unexpected, they add confirmation to the claims of recent run-downs in older age groups in the skills base.

A second and also somewhat crude approach to estimating staff retention (attrition) involved examination of publication records of R&D personnel in some selected publications at two points in time. There are considerable difficulties and potential errors with this approach, including the fact that relevant R&D is published in a number of journals either national or international, and hence absence of a publication in a single journal is not necessarily evidence of inactivity on the part of an individual. However, for a number of production disciplinary areas there are at least two professional association proceedings where many Australian R&D personnel publish information of relevance to the red meat industries.

In the case of genetics and animal breeding, most Australian livestock geneticists attend at and publish information relevant to the red meat industry in proceedings of the annual conference of The Association for the Advancement of Animal Breeding and Genetics (AAABG). The approach involved scanning the proceedings for the 1992 and 2001 conferences to establish the proportions of R&D and extension personnel who contributed to each. Only authors with papers relevant to the beef and sheep meat industries were included. Despite the potential errors, it was calculated that approximately 75% of those active in R&D and extension in 1992 were still active in 2001 as judged by AAABG publication activity.

In other branches of animal production including nutrition, growth and development, reproduction, meat science and general management, the proceedings of the Australian Society of Animal Production (ASAP) have been widely used as a medium for publication. A similar analysis of publications in beef and sheep meat from ASAP proceedings of 1990 and 2002 indicated significant decreases in publication activities between these two dates. Only about 49% of those publishing in 1990 also published in ASAP in 2002.

When this approach was attempted for health disciplines even more difficulties and potential errors were identified. For veterinary pathology for example, there are at least 25 different journals widely used for publication, as indicated by citations quoted for pathology papers in the Australian Veterinary Journal. No further attempts were made with this approach to try and estimate retention (attrition) rates in animal health disciplines. A more detailed analysis of this nature using the Citation Index approach to determine publication activity at two points in time was beyond the scope of this review and was not attempted.

There are some general similarities that have arisen from these two crude and approximate analyses. Firstly retention rates (attrition rates) calculated have ranged from about 40-80% (attrition rates 20-60%) that are not dissimilar to those cited by many respondents, and which were found in the previous MLA study. Secondly, and not unexpectedly, there are age trends in retention (attrition) as judged by analyses of the MLA data, and as suggested by an examination of publication activity. Thirdly there appear to be (and again not unexpectedly) disciplinary differences in retention rates where more geneticists and animal breeders still appear active compared to some other production disciplines, most probably a reflection of differing age profiles. The data of Table 1 showing the large number of people trained in genetics in the 1990's as against previous decades confirms this.

6.2 Ranking by respondents of the importance of disciplinary shortfalls in meeting industry needs to 2020.

Previous sections of the report provided a descriptive outline of responses from a wide range of individuals and organizations on different disciplines and their future needs by industry. This section provides comment on the relative ranking of these responses from different sectors in terms of the importance of shortfalls in the intellectual capital base for each disciplinary area. These are summarised responses with importance rankings from low (*) to high (***). Blanks indicate either not considered important or commented on, or not applicable to a particular industry sector.

Table 2 provides a summary of responses and a relative ranking. Interpretive comments on the data of Table 2 follow which are restricted to those areas where industry concerns regarding shortfalls were greatest (either medium ** or high *** ranking).

Veterinary pathology/parasitology

Of the 12 different industry sectors, 8 regarded shortfalls in these disciplines to 2020 as of medium to high importance. State and commonwealth agencies with responsibilities for animal health issues, universities with responsibilities for training in this area, and industry peak councils were the sectors that placed high importance on the impact of shortfalls. Most believed that demand would exceed supply by 2020.

Veterinary microbiology/virology

Shortfalls in these disciplines were seen to be of medium to high importance by 7 of the 12 respondent sectors. Again state agencies, universities, the feedlot industry, and industry peak councils judged these to be of high importance, most suggesting that industry needs to 2020 may be compromised by the unavailability of skills in these areas.

Toxicology

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Most respondents were less concerned at disciplinary strengths in this area, and it was ranked of medium importance by only 2 sectors. However the skewed distribution in the age profile means that the increasing importance from product integrity and market access perspectives may result in demand exceeding supply

Epidemiology

Some 7 of the 12 respondent groups believed this area was of medium to high importance in terms of meeting needs to 2020. State agencies and industry peak councils in particular judged this to be an area of high priority and that epidemiological strengths need to be enhanced to meet future needs.

Genetics

A majority believed that existing and pipeline strengths in genetics and animal breeding were sufficient to meet demands to 2020. This view was not universal though, as CRC's, universities and biotechnology companies believed that further strengths were needed for the integration of quantitative and molecular genetics.

Nutrition

Shortfalls in this area were judged to be of medium to high importance by 6 respondent groups, mainly representing R&D agencies and the feedlot industry. Industry groups did not view potential shortfalls as a constraint. Downturns in training capacity in nutrition may mean however that demand in the latter stages to 2020 could exceed supply.

Reproductive management

A shortfall in disciplinary strengths was seen to be of medium to high importance by 8 of the respondent groups. All R&D agencies, and northern pastoral companies believed that existing shortfalls and those likely to 2020, would have an impact on industry demand which will exceed the supply of services and technology.

Growth physiology

This was seen primarily as an enabling science by many sector groups, but was judged to be of medium importance by 5 R&D agencies and the feedlot industry, and strengths were seen as largely sufficient to meet needs.

Meat science and technology

Pastoral companies, feedlots, industry peak councils, state agencies and universities ranked possible shortfalls as of medium importance, but general conclusions were that industry needs to 2020 would not be constrained.

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Theses areas were seen as important emerging disciplines, and 6 of the 12 respondent groups considered shortfalls to be of medium to high importance in meeting industry needs to 2020.

Biotechnology/molecular biology

Only 4 out of 12 respondent groups saw these areas as of medium importance in meeting industry requirements to 2020. Existing and future strengths should be sufficient to meet demands.

General/management

The shortfall of staff with generalist and managerial background skills was judged to be of medium to high importance by 7 of 12 respondent groups. Particular emphasis on these skills came from state agencies, universities, pastoral companies, consultant groups and peak councils. Current levels of training activities suggest that there will be significant shortfalls by 2020 for these skills.

Pasture/forage agronomy

Shortfalls in these areas were seen to be of medium to high importance by 5 sector groups and demand is likely to exceed supply by 2020.

Rangeland management

Shortfalls in this area were seen by state and commonwealth agencies, universities, pastoral companies and peak councils to be of medium to high importance, where supply is unlikely to meet demand by 2020.

Sustainable grazing systems

Potential shortfalls in these skills were rated to be of medium importance by 7 sector groups, and there is a fair likelihood that needs to 2020 may be met.

Commerce/agribusiness

A majority of respondent sectors considered that needs to 2020 in these areas could be met from graduate recruitment.

Economics; business/project management; HR/IR management; marketing

These four areas are for the purpose of summation considered together since there were few indications that demands to 2020 could not be met from normal graduate recruitment.

IP Management

With the exception of 2 public sector respondents, a majority considered this area was adequately serviced by existing legal/commercial services and that needs to 2020 could be satisfied.

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Skills integration

The capacity to integrate techniques, approaches and skills from different disciplinary areas into whole-farm situations was considered by most sectors to be an area where shortfalls may occur and where future industry needs may not be met.

Bioinformatics

A majority of sector respondents did not rate as of importance by 2002.

Communications

Existing and future levels of expertise in these areas were seen to be sufficient to meet future needs.

Extension/technology transfer

Future shortfalls were rated as of medium importance by 6 sector groups, including state and commonwealth agencies, CRC's, universities and Ag colleges and the pastoral sector, all of whom were concerned that rates of adoption of new technologies could be impeded, and that capacity to meet industry needs would be insufficient by 2020.

Management including use of new technologies (GIS)

With the exception of state agencies, a majority of respondent sectors believed that supply would meet demand requirements by 2020.

6.3 Estimates of levels of activity in postgraduate training

An estimate of levels of activity in postgraduate training in disciplines relevant to the industry is provided in Table 3. These estimates were arrived at following discussions not only with university staff, but also with respondents from a range of other sectors who had knowledge of postgraduate training activities. From these discussions, an estimate of levels of activity by disciplinary area within some relevant Australian universities was developed. Activity levels were assessed on a three point scale (* low; ** medium, ***high). From this data some predictions can be made of likely replacement rates for particular disciplinary areas. There are some general trends which arise from these analyses, which are summarised as follows:

- In all animal health areas, levels of activity range from low medium, with no single institution having high levels of activity in any disciplinary area
- In the case of animal production disciplines, there are high strengths in genetics in three institutions, meat science training activities are medium high in three universities, and a majority have medium high strengths in biotechnology and molecular biology. Some five universities have medium activity levels in nutrition, while only two have medium strengths in reproductive management, both of which are primarily orientated towards advanced reproductive technologies. Growth physiology and behaviour/welfare strengths reside in only a small number of institutions, and activities in generalist/management areas are non-existent.
- Plant agriculture postgraduate strengths are also relatively weak, particularly in rangeland management and to a slightly lesser extent in agronomy and SGS.

- There is medium level activity in commerce/agribusiness and in economics, both of which tend to be taught in a large number of universities. Postgraduate capacity appears to be non-existent for business/project management and IP management and at low levels for HR/IR management. Marketing training is also at low — medium levels.
- Bioinformatics is represented by a medium level of postgraduate activity in only 2—3 institutions, as is communications. In extension there is now only one institution with any postgraduate strengths and most activity there is now in non-agricultural areas. Management, including GIS techniques, has medium levels of activity in only three universities.

The data of Table 3 paint a somewhat dismal picture for future recruitment capacity in many agricultural related disciplines. They also sound a note of pessimism for current capacity to meet current needs of some areas in the red meat industry. It is suggested that opportunities to replace normal attrition with younger people entering the work force will be very limited in some disciplines in the future, unless action is taken to rebuild targeted strengths.

In summary, while the data may have some subjectivity and hence some potential in-built errors, they do point to an emerging problem in many fields in the red meat industry. Graduating numbers are probably less than losses due to attrition. An additional exacerbating this situation is the overseas drift (brain drain) that has occurred in many disciplinary areas and which has been reported on frequently. An attempt was made to estimate the extent of this drift for relevant areas, but good data, particularly from the Australian Bureau of Statistics, was not available.

This then raises the issue of trying to estimate what additional needs to 2020 may be, given current staffing profiles. At best, predictions of additional staff numbers required for different disciplinary areas across different sectors will have some errors though general trades can be predicted and an estimates of likely demand made.

6.4 Ranking of disciplines where significant shortfalls may occur by 2020

From the data presented earlier and from a condensation of respondent viewpoints, a priority listing of disciplinary areas was developed and is shown in Table 4. Within a priority area, no attempt at ranking was made and the sequence of disciplinary areas listed merely follows the sequence in which they were presented earlier in the report. There will undoubtedly be debate on these rankings, which would be a useful outcome of the review to assist further decision-making. However, it is believed that the ranking provides a reasonable assessment of future needs. Many of the areas identified as of concern and which were judged to be in priorities 1 or 2 in this table are also those where postgraduate activity is low. This raises significant concerns at capacity to meet further demands and further highlights the fact that training levels in some specific disciplines need to be increased in the short to medium term.

6.5 An overview of future needs for the intellectual capital base of the red meat industry

Given the background and scenarios outlined earlier, an attempt was made to estimate likely demands for additional staff with postgraduate qualifications to meet industry needs to 2020. These estimates are provided in Table 5. For some disciplinary areas, and for some sectors, estimates are not provided, since information indicated that in some sectors, postgraduate qualifications were not a prerequisite, or that in other sector, needs for particular disciplinary skills do not exist (eg animal health in the banking sector).

Estimated needs are for additional appointments over an 18year period to 2020. Thus for epidemiology with an estimated need for 56 positions, this would equate to about 3 new postgraduates graduating each year in order to satisfy potential demand. Over all the disciplinary areas, an estimate is that from 27—36 new postgraduates per year would be needed. Discussion on individual disciplinary area needs is summarised in the conclusions section of the review. These numbers are

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some 5----6 times greater than current MLA support levels for postgraduates and could not be provided solely by the organization.

Hence there is a need to look at alternative mechanisms whereby these levels of support could be provided in order to meet future needs. There would also be a need to attempt to align increasing postgraduate numbers with outgoing attrition levels since different age profiles in a disciplinary area may mean different timing of demand over the next 18 years.

Whilst the numbers estimated do not have a high degree of precision, there are some general trends which confirm assessments outlined earlier. These include:

- Demand for people with skills and expertise in all *animal health* disciplines will most certainly exceed supply capacity unless there is a significant increase in training activities within the next 5—10 years. The importance of these shortfalls has been identified by all sectors and if industry needs are to be achieved, additional resources will have to be committed for redevelopment of animal health strengths. All evidence suggests that needs will have to be primarily met from Australian graduates and that the capacity for overseas recruitment will be low. Consideration needs to be given to a targeted strengthening of disciplines in particular faculties or schools, since attempts to enhance activity in all disciplines in all universities will only lead to dilution of resources.
- For some *animal production* disciplines, supply will not meet demand to 2020. Again, emphasis needs to be placed on re-establishment of specific disciplinary strengths in specific institutions and a blanket approach to disciplinary enhancement should be avoided.
- Postgraduate activities in *plant agriculture* should be enhanced to meet future needs. The Rangelands Australia concept of a strong and virile single institutional focus with peripheral nodes for teaching and research is a model that could be applied. Land use management and environmental issues will demand strengths in these areas in the future and action is needed now to ensure future demands can be satisfied.
- Evidence suggests that demand for postgraduate skills and capacity for training in the *commercial/business* sector is not high, many respondents indicating that generic rather than specialised skills would be needed for the future. The current and future supply/demand scenario is reasonably well balanced, a possible exception being IP management.
- In the *information technology* areas, bioinformatics and extension/technology transfer are areas where some additional training resources may be needed to satisfy demands to 2020.

7. General Overview

At the present levels of training activities and with current and likely levels of attrition in the future, the significant imbalance of supply/demand equation for intellectual capital will worsen by 2020. It is concluded that for some areas future needs will not be met by those trained in Australian institutions and a similar pattern appears to be emerging overseas eg the level of veterinary expertise in the UK. Thus shortfalls may not be met by overseas recruitment and there were reports that this is already occurring.

At first sight the estimate of needs for the future of between 27—36 new postgraduates entering the workforce each year may seem alarmingly high. However, relative to industry values of about \$10b/yr, an investment for the future of about \$1m/year in training is not extreme.

This is not to suggest though that MLA should be the sole provider of such investments and a range of alternative funding options need to be explored. Additionally, funding for other than research degrees needs to be available to support generic needs in several industry sectors.

There are a large number of potential mechanisms to address the problem of imbalance in the supply/demand equation and some more relevant ones indicate:

- Creation of more attractive terms for postgraduate support. Evidence suggests that stipend levels are a significant factor in decisions made for postgraduate enrolment.
- Examining approaches and developing strategies for use of postgraduate scholarship funds for leverage and for top ups to other sources of postgraduate funding, eg joint scholarships with eg CRCs, CSIRO, ARC and other funding agencies including state agencies some of whom are considering re-introduction of bonded post graduate support.
- Recognising that interest in postgraduate training is often stimulated by interest developed at undergraduate level (eg Honours), some specific support for innovative activities in disciplines where demand will exceed supply may enhance subsequent postgraduate interest.
- Changing selection procedures for allocation of scholarships with more emphasis on targeting in those areas of greatest need.
- Assisting the public sector to identify future needs and encouraging the creation of greater job opportunities in those areas where demand is likely to be greatest or which have been identified as critical for the future well being of the red meat industry
- Identifying and assisting selected tertiary institutions in the rebuilding of targeted areas of expertise
- Facilitating and promoting joint ventures in training between public, private and tertiary sectors in those disciplinary areas where this approach is relevant

Planning theory suggests that future needs can be clearly identified and linked with current scenarios to develop an action plan. In the context of this review, this means succession planning, a concept well developed and accepted and claimed by many to be in practice. For many organizations, however, the reality is that budgetary constraints have subsumed succession planning to the point where it is often meaningless and not capable of being implemented. These difficulties have occurred particularly in public sector and university institutions, and thus while it could be argued that lack of succession planning has created some of the present and future problems of imbalance in the supply chain, these have been primarily driven by budget issues. Under these situations practical and political reality suggests that succession planning can be little more than a broad and fairly rough brush to address issues of supply and demand. How to plan to meet future demands in a constantly changing environment is extremely difficult but some scenario setting approaches could help.

MLA could facilitate this process as a means of bringing together interested partners in all sectors to examine all the strategies available to meet demands to 2020. This could be done in a similar way to earlier Strategic Directions/Scenario Setting workshops that have been undertaken by MLA and other rural research funding agencies. At least for the animal health/animal production workshops outcomes of the current Review of Rural Veterinary Services could also assist this process.

The wide ranging contact with senior staff in all sectors of the industry enabled a summation of collective views and hopefully has diluted any interpretations or views that were driven by self interest. There was a degree of unanimity in the general conclusions reached by many sectors on the importance of critical shortfalls in a number of disciplinary areas, and the potential impacts on long term viability of the industry.

A major difficulty was in getting good quantitative data on losses due to attrition. Most of the evidence was non-specific, but for many organizations and sectors it was possible through personal contacts and professional judgement to verify many statements and claims made on the decline in staffing and levels of service that have occurred.

Calculation of the

However, perhaps the greatest difficulty arose in attempting to develop estimates of future needs within disciplinary areas. As mentioned, it was not possible to identify and contact every potential employer group in all sectors and thus a "snapshot" or "window" approach had to be used. Needs estimates were derived for broad sectors based on current strengths, some judgements on likely attrition in the next 18 years, the relative ranking of importance suggested by different respondent groups and the professional judgement of the reviewer. The accuracy and precision of these estimates is difficult to assess, though some colleagues provided estimates not dissimilar to those determined here. However, the overall trends in numbers are apparent as are the priority rankings matched against levels of current postgraduate activity, though translation of these figures into action plans may require some independent estimates to either disprove or verify the figures here.

While the data and the conclusions drawn indicate some pessimism regarding current capacity to meet future intellectual capital needs to 2020, strategic investments now from a range of different sources would enable rebuilding of strengths in targeted critical areas, and create a sense of optimism for meeting future demands.

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ACKNOWLEDEMENTS

It is a pleasure to be able to acknowledge the contributions from a very large number of people, too many to be named here, from all sectors of the industry and from other rural industry funding agencies in undertaking this review. All gave willingly of their time in responding to queries, and were generous in sharing their experiences and views with the reviewer. Many also provided further information and inputs both written and verbal following the initial contact, for which the reviewer is very grateful.

A majority of respondents were genuinely concerned at shortfalls they saw emerging in terms of the intellectual capital needs of the industry over the next two decades, and believed that a review of this type should stimulate action by all parties to address potential problem areas.

The interest and stimulation for this review by staff of Meat and Livestock Australia is gratefully acknowledged. The initial stimulus came from Dr Hutton Oddy, and particular thanks are extended to Ms Gabrielle Kay for her help, useful suggestions and support. Dr John McKenzie is also thanked for his support and interest in the project.

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Finally, special thanks are due to Shelley Harvey for her assistance in the preparation of this report.

TABLES

Table 1. MLA Postgraduate Scholarships holders by broad disciplinary area for the three decades between 1975-2000.

	Decade)		
	1970's	1980's	1990's	Total
Animal Health Path/Parasitol/Immun Micro Virol Epidemiology	1	5 1 1	4 7 5	10 8 <u>6</u> <u>24</u>
Animal Production				
Genetics Nutrition Reprod Physiol Meat Sc/Tech	1 3 1 1	1 4 13 4	29 6 4 5 14	31 13 18 9 <u>15</u> <u>86</u>
Plant Agron/M'ment				
Pasture Agron Plant Path/Physiol Rangelands M'ment	2 1 1	1 1	3 2 5	5 4 _7 <u>16</u>
Extension	12	3	1	<u>15</u>
Other	11	6	8	26
Totals	34	40	93	167

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Table 2. Summarised ranking by	v different i	ndustry	sectors of th	e import	ance of shou	t falls in na	ticular discin	linary areas				
				* low: **	medium: **	* high impo	rtance: blank	- N/A	-	1.		
		1.00	S. S. Level		,		Sector					
13113	STATE AGRIC.	CSIRO	C'WEALTH AGENCIES	CRC'S	UNIVERSITY	AG COLLEGES	PASTORAL COMPANIES	FEEDLOT	BIOTECH CO.	AGRIBUSINESS & BANKS	CONSULTANCY; ACCOUNTANCY;	INDUSTRY PEAK
Disciplinary Area											LAU	COUNCILL
1. ANIMAL HEALTH												
Vet Path/Parasitol	***	***	***	**	***		**	**				***
/et Micro/Virol	***		**	**	***		**	***				***
Toxicology	**				**							•
Epidemiology	***	**	** .	*	**	*	**	**				***
2. ANIMAL PRODUCTION												
Genetics	*		•	**	**	*			**			
Nutrition	***	***		***	***		•					
Reprod M'ment	***	***	***	***	***	•	**		**			**
Growth Physiol	**	**	**	***	**			**				*
Neat Sc/Tech	**				**		**	**				•
Behaviour/Welfare	***	**	**	***	**	*		*	•			**
Biotech/Mol Biol	**			**	**				**			
General/M'ment	***	**	*	*	***	**	***				***	**
3. PLANT AGRICULTURE												
Past/Forage Agron	**	**			***		**					
Rangeland M'ment	***	***	**		**		***					**
Sust. Grazing System	**	***	**	*	**	**	**					**
A. COMMERCIAL/ BUSINESS												
Commerce/Agribusiness	*	•				*	**	**	**	*		
Economics			•	*	**				*			
Bus/Project M'ment	**		•	**			•					*
P M'ment	**	***	**	**	**							
Skills Integration	**	**	**	**		**	***	**		***	***	***
HR/IR M'ment					*							
Marketing	•		•		**	•						-
5. INFORMATION TECHNOLOGY												
Bioinformatics	**	*	**	*	**		**	**				
Communications	*											*
Ext/Tech Transfer	**	*	**	**	**	**	**					
M'ment (GIS)	**	*	*									

				* low; ** me	dium; *** high	levels; blank	- N/A					
		University										
	ADELAIDE	CHARLES STURT	JAMES COOK	LATROBE	MELBOURNE	MURDOCH	NEW ENGLAND	QLD	SYDNEY	TAS	WA	WESTERN SYDNEY
Disciplinary Area												
1. ANIMAL HEALTH												
Vet Path/Parasitol	*		*	•	**	**			**	•		
Vet Micro/Virol		•	**		•	**	•	**	**			-
Toxicology					**		*	**				
Epidemiology			*		**	**	*	*	**			
2. ANIMAL PRODUCTION												
Genetics	**				***		***		***			
Nutrition	**	•		*	**	**	**	**	**	*		•
Reprod M'ment		•	•		**	•	*	*	**		**	
Growth Physiol		•	•			**	**	•	•		*	
Meat Sc/Tech					**	**	***	*				
Behaviour/Welfare	*	*		-	**		•	**	•			
Biotech/Mol Biol	***	**	**	***	***	***	**	***	***	**	***	*
General/M'ment	•	•			*		•	*				•
3. PLANT AGRICULTURE												
Past/Forage Agron		•			**		•	***	**	*	*	
Rangeland M'ment	•						*	**	•		**	
Sust. Grazing System	•	•		*	**		**	**	•		**	•
4. COMM/BUSINESS												
Commerce/Agribusiness	**	**		**	**		**	**	**			*
Economics	**	**	**	**	**		*	**	•			
Bus/Project M'ment												
IP M'ment												
HR/IR M'ment					•			•	•		*	
Marketing					**		*	**	**	•	*	•
5. INFORMATION TECHNOLOGY												
Bioinformatics					*	*	*	**	**		*	
Communications	*	•			**			**	**	*	**	
Ext/Tech Transfer								***				•
M'ment (GIS)		•					**	**	•		**	*

Table 4:Priority ranking of disciplinary areas likely to experience significantshortfalls by 2020, related to levels of current postgraduate training activities (low*; medium **)

Discipline	Relative level of training activity
Priority 1	
Veterinary pathology/parasitology	*
microbiology/virology	*
epidemiology	*
Nutrition	**
Reprod management	*
Rangeland management	*
Priority 2	
Behaviour/welfare	*
Generalist/management	non-existent
Skills integration	*
Sustainable grazing systems	**
Extension — Technology transfer	** 1

¹But low for agriculture areas

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Table 5. Estimates of addition	al numb	ers of pe	ople with s	pecialist	post graduat	e qualificatio	ns required to 1	ulfil likely ind	dustry dem	ands to 2020		
	Sector											
	STATE AGRIC.	CSIRO	C'WEALTH AGENCIES	CRC'S	UNIVERSITY SECTOR	AG COLLEGES	PASTORAL COMPANIES	FEEDLOT INDUSTRY	BIOTECH CO.	AGRIBUSINESS & BANKS	CONSULTANCY; ACCOUNTANCY; LAW	ESTIMATED TOTALS
Disciplinary Area												
1. ANIMAL HEALTH												
Vet Path/Parasitol	40	10	4		12				4	10		80
Vet Micro/Virol	12	8	4		10				6	4		44
Toxicology	8	4	4		6							22
Epidemiology	20	8	12		12 [`]	2				2		56
2. ANIMAL PRODUCTION												
Genetics	6	6			4					2		18
Nutrition	10	8	2	4	10			6				40
Reprod M'ment	10	4		4	12		2			2.		34
Growth Physiol	6	4		4	6							20
Meat Sc/Tech	6	6		2	4					4		22
Behaviour/Welfare	4	2	2		4							12
Biotech/Mol Biol												
General/M'ment	10	2			6		4			6	6	34
3. PLANT AGRICULTURE												
Past/Forage Agron	8				8					4		20
Rangeland M'ment	8	4	4		4	2	4			4		30
Sust. Grazing System	6	2	2		4	2				4		20
4. COMMERCIAL/BUSINESS												
Commerce/Agribusiness	4				10					4		18
Economics					10					4		14
Bus/Project M'ment												
IP Management		.2	2									4
Skills Integration					8					4	10	22
HR/IR M'ment												
Marketing												
5. INFORMATION TECHNOLOGY								-				
Bioinformatics	4	4		2	6							16
Communications												
Ext/Tech Transfer	12	2	10		4					· 4		32
M'ment (GIS)	6	2	6		6							20

APPENDICIES	
APPENDIX 1	
Sector	Organisation
Rural Funding Agencies	Australian Pork Cotton RDC Dairy RDC Grains RDC Grape and Wine RDC Fisheries RDC Horticulture Australia Land and Water Australia Meat and Livestock Australia Rural Industries RDC Sugar RDC
State Departments of Agriculture or equivalent	NSW Agriculture NT Dept Primary Industries & Fisheries Qld Dept Primary Industries SA Primary Industries and Resources Tasmanian Prim Ind, Water & Env. WA Agriculture Vic. Dept Nat Res & Env. S.A Research and Dev Institute (SARDI) Animal Genetics & Breeding Unit (AGBU)
Commonwealth Agencies	Agriculture, Fisheries, Forestry Australia (AFFA) Australian Centre for International Agricultural Research (ACIAF Resource Sciences Bureau CSIRO Livestock Industries Aust Animal Health Laboratory Plant Industries Cooperative Research Centres — Beef
Agricultural Colleges	— Sheep Tocal, NSW Emerald, QLD Victorian Colleges
Universities	Adelaide Canberra Charles Sturt James Cook Latrobe Melbourne Murdoch New England Queensland Queensland Southern Queensland Sydney Tasmania Western Australia Western Sydney
Biotechnology Companies	Genetic Solutions Peptech

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Pastoral Companies

Feedlot Industry

Peak Councils

Agribusiness/Banks

Consultants/Accountants/Lawyers

AA Co NAPCO Stanbroke Twynam Clyde Agriculture

Australian Lot Feeders Assoc Twynam Rockdale Beef D. Rinehart AMH

Australian Lot Feeders Assoc. Cattle Council Sheep Meat Council

Elders Wesfarmers Westpac NAB ANZ CBA Ridley Agric. Business Res. Institute (ABRI) IDEXX Pathology

Hassal & Associates Canbio URS P. Frawley A. Crombie P. Mendes R. Barlow K.Little

APPENDIX 2 BROAD DISCIPLINARY AREAS ON WHICH VIEWS WERE SOUGHT Broad area Discipline/sub discipline Animal Health Veterinary Epidemiology Microbiol/Virology Pathology/Parasitol Toxicology Animal Production Behaviour/animal welfare **Biotechnology and Molecular Biology** Genetics (molecular and quantitative) Generalist training/skills integration Meat Science and Technology Ruminant Nutrition/nutritional biochemistry Physiology (growth, development) Reproductive management **Plant Agriculture** Pasture agronomy Rangeland management Sustainable grazing systems Commercial/Business Commerce/agribusiness Economics Business/project management Intellectual property Skills integration HR and IR management Marketing Information Technology **Bioinformatics** Communications Extension/technology transfer Management (GIS)



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