
Plant Pathology and Entomology Capability Study

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Executive Summary

This study arose as an initiative of the Australasian Plant Pathology Curriculum (APPC) workshop held in Brisbane in February 2006. The workshop proposed possible models for enhancement of the APPC recognising important principles underpinning it, including the on-going need for training and education, flexibility in coursework, curriculum structure and the requirement for adequate national funding for its development and implementation.

Funded by the CRCTPP, the study was initiated in mid-2006 to meet the objectives identified at the APPC workshop and to provide the basis for the development of a curriculum with improved focus on the future needs of industry. Data was gathered by means of a web-based survey, supported by telephone interviews of randomly selected survey respondents. A total of 359 valid survey responses were received.

Plant pathology and entomology are important fields of science that impact directly on the well-being of society due to their fundamental importance in food and fibre production and in sustaining quality of environment. These scientific disciplines are crucial to the agricultural economies of Australia and New Zealand due to the impact of plant diseases and insect pests on production quality and yields of food crops and commodities derived from agricultural production. Not less important is the contribution of these disciplines to maintenance and sustainability of natural ecosystems that are critical to quality of life and preservation of national heritage.

Data from the survey indicates a very positive situation in terms of academic accomplishment with 53% of respondents holding a PhD degree. A further 12% hold a Master's degree resulting a total of 65% of respondents qualified with a higher degree. Both countries have demonstrated an ability to generate a good proportion of well-qualified graduates and postgraduates in these two disciplines.

The major employing organisations place significant importance on postgraduate achievement for entry. There is no indication from trends in agriculture and environment that the current needs for specialists will decline. Therefore, maintaining the current proportion of postgraduate expertise will require an on-going commitment to adequate training programs if current recruitment policies are maintained.

In plant pathology, mycology is the dominant sub-discipline accounting for 45.1% of plant pathology full time equivalents (FTEs). Nematology, bacteriology and virology appear to be somewhat fragile in their current capability, each represented by less than 10% of plant pathology FTEs. These low FTE levels mean that concerns for the sustainability of these sub-disciplines are valid. In order to maintain the existing capability and meet future requirements of industry and environment it will be necessary to strengthen training and retention programs in these areas.

Entomologists are a more homogeneous discipline, structured around application rather than academic discipline, although taxonomy/systematics is a common thread underlying most areas of application. Therefore, it is a key enabling sub-discipline, which, if not strengthened to improve the FTE application level could quite rapidly expose weaknesses

and therefore significant threat to many areas of agricultural production, biosecurity and environment.

Industry needs appear to be adequately met at present, although a high level of concern regarding work pressure is an indication that respondents do not feel that they are adequately meeting the demands of their work place. The survey and interviews each identified a high level of concern for future capability.

There is an increasing emphasis on biosecurity issues and the aspects of plant pathology and entomology that underpin biosecurity and quarantine such as epidemiology, taxonomy, diagnostics, risk management and emergency response programs. Over the last decade there has also been a significant shift in pest management practices driven by community concerns related to food safety and demand for environmentally sensitive practices. These trends call for increased capability in both plant pathology and entomology to meet the community's expectations.

60.4% of total plant pathology and entomology capability is located within the Gov1 sector, which theoretically has a strong applied focus. This sector includes, state departments of primary industries, forestry or agriculture, Ministry of Agriculture and Forestry, plant health, quarantine, biosecurity, environment and heritage.

20.1% of total capability is in the education sector, which includes universities, higher education institutions and vocational training (Edu). 11.4% resides in the Gov2 sector having a fundamental research focus such as CSIRO, ENSIS, Crown Research Institutes and CRCs. Only 5.2% of capability was identified in a commercial classification.

65.8% of all FTEs are in applied research. Only 10.2% of all capability is applied in direct extension or support services, despite 60.4% of all capability residing in the frontline Gov1 classification. It appears from these data that extension and support have become only a minor part of how Gov1 organisations apply their plant pathology and entomology capability.

Of even greater concern, only 4.4% of respondents indicated education/teaching as their primary environment. With 20.5% of FTEs in the survey from the Edu classification it is evident, therefore, that only about one-fifth of Edu capability is directly targeted at the education/teaching environment. Thus teaching is only a minor part of how Edu organisations apply their plant pathology and entomology capability.

In terms of industry and public sector focus, by far the largest allocation of capability is to the primary production areas of agriculture and horticulture. Heritage aspects such as botanical gardens and national parks rate 11.3% of capability and strong concerns are expressed about underdeveloped and under resourced taxonomic research of national fauna.

There is good representation of capability across all age brackets in the survey from 25 upwards. Surprisingly, there were no survey respondents that registered less than age 25. It is possible that relatively recent graduates of generalized undergraduate programs do not consider themselves as specialists without the completion of further study.

49.4% of all respondents have indicated that they are likely to leave employment in these disciplines within 10 years. With only 17.8% of all respondents in the 55+ age bracket, loss through retirement is by no means the most likely reason for departure. This survey foresees a substantial loss of capability from the younger age profiles, for reasons other than retirement.

Change of career and lack of job security related to limited tenure and short term project funding are major factors in this potential loss. 83 respondents (24.8%) indicated that they are likely to leave their career within 5 years. 34.9% indicated limited tenure or funding constraints as the likely reason for their departure, while a further 21.7% indicated likely departure within 5 years due to career development (new field of activity).

These figures represent substantial loss of capability within 5 years and the losses due to tenure, funding and new career directions (56.6%) should be considered very seriously from a human (and skills) resource management perspective. These loss rates have important implications for employing organisations with regard to replacement and re-training costs

The survey received a number of responses with regard to aspects of their employment and work that caused them concern. The most dominant theme identified was that of the relationship between funding mechanisms and job security. Issues such as lack of permanent status, short tenure related to project timeframes, insecurity, inability to plan career path, minimal or no succession planning and distraction due to the need to generate new project funding. These concerns were overwhelmingly expressed with many interviewees disturbed by the subsequent loss of expertise, lack of safety-net funding to hold valued young talent and limited programs aimed at retaining key researchers and experience.

Those respondents with a longer horizon before departing from work in their field had a stronger tendency to indicate retirement as the likely reason. Therefore, those who feel secure and are likely to remain within the system beyond 5 years have a stronger tendency to see career fulfilment through to retirement.

The high risk of loss of capability through reasons other than retirement is a critical issue emerging from this study. This translates to a substantial opportunity for retention of capability that can be addressed on two fronts. Firstly, to build confidence in short to mid-term security and career fulfilment, currently threatened by funding and tenure policies. Secondly, by undertaking strategic improvements in professional development, internal training and succession planning.

Most highly regarded competencies sought by employers are sound research skills followed by effective communication skills. These are closely followed by field and laboratory skills. Programs considered most likely to effectively develop the required skills are those that have a strong practical and field based component subsequently supported by targeted professional development and postgraduate specialisation. Undergraduate programs that are considered to be most valuable are those that provide for a high degree of integration with industry. These courses should retain a generalized approach with an emphasis on practical skills leaving specialisation to postgraduate programs.

Available data indicates that in Australian and New Zealand universities during 2005/6 there were 54 different plant pathology course offerings at undergraduate level including 4 at level 1, 13 at level 2, 31 at level 3 and 6 at level 4. There were 16 offerings at postgraduate level. In entomology (Australian universities only) in 2005 there were 3 offerings at level 2 and 14 at level 3. The majority of offerings are in an applied context as part of a broader course focus, for example as part of a degree in agriculture, viticulture, crop protection or environmental science.

The study revealed a need to pay much closer attention to professional development. It is classified in the highest priority grouping for effective training and could be made more accessible. Professional development and in-service training are vital components of maintaining and building capability in the sciences. Effective programs can ensure the

transfer of skills, diversity of expertise and rewarding career progression all of which improve and enhance capability as well as stability in staffing.

Industry support for education and training comes primarily through the provision of employment opportunities for postgraduates. Employment of undergraduates rated substantially less likely than postgraduate employment revealing an important opportunity gap for graduates. Consequently new graduates may be driven into postgraduate programs in an effort to improve employment opportunities and therefore do not have the opportunity to build on their undergraduate degree with workplace experience.

Training support through direct funding of scholarships or sponsorship tended to fall into the unlikely category. Employers appear to be reluctant to contribute in a direct financial way to education and training. There is a need for industry to show greater willingness to employ at the graduate level and be more prepared to invest in the careers of their people.

While the science skills, commitment and passion may be identical to other fields such as medical technology; agricultural and environmental sciences are not recognized with similar profile. The latter are often seen negatively and perceived to offer limited opportunities. Despite these perceptions there are considerable opportunities to attract students into the plant pathology and entomology disciplines by providing focus on the many positive aspects of a career in these areas that include significant public good in terms of food security, preservation of environment and biosecurity. In addition there is a rich diversity of activity, interesting challenges and the stimulation of a discovery environment. These positive career attributes should be presented in much higher profile at school career days, through industry promotion and case studies to generate student interest.

If student intake can be boosted and graduate employment opportunities improved there is strong potential for on-going capability building. These must be supported by adequate opportunities for post-graduate specialisation that will only be possible through innovative curricula and course delivery while ever university places are determined by volume. However, generation of capability must be supported by its retention. The study has clearly revealed concerns related to lack of job security, inadequate professional development and poorly defined succession-planning strategies which all impact retention negatively. It is essential for these issues to be addressed together with new approaches to curriculum in order to ensure that future needs will be matched by the required capability.

1

Introduction

The fields of plant pathology and entomology are vital disciplines for Australia and New Zealand across a range of activities including agricultural and horticultural production, forestry, biosecurity, environment and heritage. In a briefing paper presented at the 2005 Australian Plant Pathology Conference (Irwin, 2005) the gross value in production of Australia's crop industries alone was put at \$20 billion, representing the nation's most important agricultural asset, overtaking the livestock industries by more than 25%.

The importance of these disciplines with regard to environment and heritage is difficult to quantify but management of disease and invertebrate pests is a serious issue for public facilities such as national parks, botanical gardens, museums, local parks and gardens and public health.

Despite the importance of plant pathology and entomology to the national economies; the natural environment and public amenity there is the perception that university courses and specialist training programs in these disciplines are becoming less available and student intake is on the decline. It is argued that there has been a downsizing of education and training in these fields, largely as a function of the trend towards rationalising university courses with smaller enrolments, a trend that is unlikely to be reversed any time in the near future (Irwin, 2005).

A recent audit of Science, Engineering and Technology (SET) skills in Australia (DEST, 2006) indicates that in the broad SET area domestic enrolments at undergraduate level slightly declined over the period 1989 to 2004. In its submission to the audit the Faculty of Biological and Chemical Sciences, University of Queensland quoted a 2004 study by Dobson that demonstrated marginal growth in science enrolments over the period 1989 to 2002 but this growth significantly lower than overall course enrolments.

At the postgraduate level the audit considered enrolments in the Natural & Physical Sciences (NPS) and the Agricultural, Environmental & Related Studies (AERS) as a percentage of overall postgraduate enrolments. The audit noted that over the period 1993 to 2003 NPS share of enrolments halved while AERS enrolments declined by about one-quarter. It is not possible to relate plant pathology and entomology data directly to these observations due to course classification criteria, however, it is almost certain that these disciplines are similarly caught up in the decline of postgraduate share of enrolments.

If this decline in enrolments is reflected in a decline in capability within these areas, it is possible that established programs in rural production, environment and heritage may be confronted with limited access to skill and support and therefore potential economic loss or damage. At the same time, emerging issues such as biosecurity, new plant breeding techniques and related trade issues emphasize the importance of maintaining, if not building capability in plant pathology and entomology in the national interest.

In an effort to address these concerns the Cooperative Research Centre for Tropical Plant Protection (CRCTPP) hosted the Australasian Plant Pathology Curriculum (APPC) workshop in Brisbane in February 2006. With its focus specifically on curriculum issues the aim of the workshop was to produce a model for the APPC and outline strategies for

developing content, administration and funding. Representatives from academia, government and industry attended the workshop and provided input on a range of issues affecting national capacity, student enrolments, curriculum content and industry requirements.

The workshop proposed possible models for enhancement of the APPC recognising important principles underpinning it, including the on-going need for training and education, flexibility in coursework & structure, and the requirement for adequate national funding for its development and implementation (McKell, 2006).

While the workshop recognised these important aspects for appropriate curriculum development it was clear that a better understanding was required of the current plant pathology capability, perceived threats and future requirements of industry. The CRCTPP agreed to fund a study in an effort to achieve this understanding and provide better data to support the completion of a business plan aimed at developing a more viable curriculum, better targeted at meeting the future needs of industry.

The discipline of entomology impacts industry, environment and heritage in a similar way to plant pathology and is clearly confronted by similar issues. A workshop funded by CSIRO, GRDC, the University of Queensland and the Australian Entomological Society was held in Brisbane in November 2004 to explore collaborative approaches to curriculum development. This meeting reached consensus on a number of aspects relating to the training of entomologists including the potential for a national, collaborative curriculum. It was therefore considered appropriate to include entomology in this study, thereby providing base data that can contribute to curriculum development within that discipline as well.

2 Methodology

The study was intended to be both quantitative and qualitative. Data was gathered by means of a survey targeted at plant pathologists, entomologists and administrators having responsibility for appointment of staff within these disciplines. The survey gathered both quantitative and qualitative information and was also supported by qualitative interviews.

The Survey

The survey was designed to identify a number of aspects of current capability in plant pathology and entomology and to obtain information regarding future capability requirements. A basic structure was developed and then reviewed and refined in consultation with personnel from the following organisations:

- CRCTPP,
- Plant Health Australia,
- AFFA,
- CSIRO Entomology
- Two State Agriculture departments, and
- One university.

Once the survey design was completed, online survey company, Informatix Pty Ltd (Brisbane, Qld), was contracted to host the survey via a weblink and provide the initial analysis of data. This format proved to be easily completed by survey recipients and provided a rapid initial analysis of the data. The complete survey is attached to this report as Appendix B.

The survey was constructed in two parts, each divided into a plant pathology section and an entomology section. Part A collected data from those working within the two disciplines including information about their organisation type, areas of speciality, age profile and activity focus as well as qualitative opinions regarding a range of issues affecting their work environment. Part B collected data from an organisational perspective including information about current capacity, future needs, sources of expertise and training perspectives.

In order to maximize responses to the survey the invitation to access the link and complete the survey was distributed to a key contact(s) in the target organisations with a request to forward to the appropriate staff. Target organisations included universities, state and national government entities, commercial industry, grower and industry associations. Approximately 280 invitations were distributed, some organisations having relatively large internal distribution lists, while others having very few or none. At the close of the survey 360 responses had been received. These were checked to ensure that they were correctly completed as valid responses. One response was removed as invalid leaving 359 responses regarded as valid for analysis purposes.

Interviews

In order to improve the qualitative aspects of the survey 15 telephone interviews of respondents were conducted. These interviews further explored the opinions expressed in the survey and provided an opportunity for open-ended input on a range of issues affecting plant pathology and entomology activities within Australia and New Zealand. Survey respondents were invited to voluntarily provide their contact details if willing to be included in these interviews. 49.6% of respondents indicated that they were willing to participate in the interviews. Those ultimately selected for interview were chosen at random and were contacted within 1 month of closing the web-based survey.

Telephone interviews allowed respondents to provide open-ended comment on a range of issues. The interviews were unstructured but primarily focused on asking interviewees to discuss areas of concern, opportunities and risks, positive and negative aspects of their careers, ways to boost student intake and professional development.

Input from these interviews was collated and summarized based on similarities between responses.

3 Capability

Plant pathology and entomology are important fields of science that impact directly on the well-being of society due to their fundamental importance in food and fibre production and in sustaining quality of environment. These scientific disciplines are crucial to the agricultural economies of Australia and New Zealand due to the impact of plant diseases and insect pests on production quality and yields of food crops and commodities derived from agricultural production. Not less important is the contribution of these disciplines to maintenance and sustainability of natural ecosystems that are critical to quality of life and preservation of national heritage.

Capability in any field is concerned with having the appropriate attributes for the required level of performance or accomplishment in the field. In determining the capability of Australia and New Zealand in plant pathology and entomology this study has attempted to identify these attributes in two ways. Firstly, the study reviews the academic standards and accomplishments of practitioners in these disciplines. Secondly, it assesses the availability and location of the relevant skills in order to perform the required services to industry and environment.

An addition to gaining an understanding of the current capability, an important aspect of the study was to make an assessment of how well Australia and New Zealand are positioned to maintain their capability in the context of future industry and environmental needs. In order to do this the study gathered information on perceived future priorities and reviewed a number of issues relating to employment, job satisfaction and training.

Data for the study was obtained from two primary sources. A web-based survey was conducted targeting plant pathologists and entomologists employed in a range of organisations across Australia and New Zealand. The survey provided 359 valid responses. The data was analysed and is presented in summary form in Appendix C. In addition to the survey, 15 telephone interviews were conducted with randomly selected survey respondents in order to gather more qualitative data, primarily on issues impacting employment and the sustainability of their contribution to future capability.

Academic Standard and Accomplishment

Qualification levels of survey respondents indicated a high level of training evident in organisations across Australia and New Zealand. Table 1 shows that 53% of respondents indicated that they hold a PhD degree. A further 12% hold a Master's degree resulting in a total of 65% of respondents qualified with a higher degree. This data indicates a very positive situation in terms of academic accomplishment as an indicator of capability. It is quite evident that both countries have demonstrated an ability to generate a good proportion of well-qualified graduates and postgraduates in these two disciplines.

• **Table 1: Summary of the highest level of training reported (n=333)**

Level	Number	%
Doctorate	175	53
Masters degree (research)	33	10
Masters degree (coursework)	6	2
Graduate diploma	11	3
Undergraduate degree with honours	43	13
Undergraduate degree	48	14
Vocational/TAFE/Diploma	13	4
High school year 12 (or equivalent)	4	1
Total	333	100

It should be noted, however, that the survey drew no response from the under 25 age bracket and very limited response from commercial industry, both areas where it could be expected that there are a number of graduates of generalist courses active in plant pathology or entomology related activities. It is difficult from the current study to identify the reasons for this result but it is possible that many in either of these two categories do not specifically see themselves as accomplished in these disciplines (and therefore did not complete the survey) unless they hold higher degrees.

It was evident in a number of interview responses and some survey results that the major employing organisations place significant importance on postgraduate achievement for entry. It is also known from personal experience in industry that there are substantial numbers of graduates providing plant pathology and entomology extension advice on a regular basis. Many of these hold graduate qualifications in agriculture or environmental studies but would not classify themselves as specialists in either plant pathology or entomology.

This does not, however, detract from the capability of plant pathology and entomology within Australia and New Zealand. In fact it is almost certain that there is significant depth in the practical capability that exists beyond respondents to the survey. What clearly emerges from the data is the challenge of maintaining the high quality capability into the future. There is no indication from trends in agriculture and environment that the current need for specialists will decline. Therefore, maintaining the current high academic profile will require an on-going commitment to adequate training programs focused on building an undergraduate base in these disciplines and providing suitable programs for postgraduate specialisation.

Diversity of Capability

Both plant pathology and entomology are wide-ranging disciplines, each with many speciality areas or sub-disciplines. An important aspect of understanding the capability of the major disciplines is to examine how it is applied to the various sub-discipline areas. This study gathered data on the time allocation as a proportion of fulltime equivalents (FTEs) that respondents committed to a range of sub-discipline areas in each of plant pathology and entomology.

Table 2 illustrates that in plant pathology, mycology is clearly the most widely represented sub-discipline accounting for 45.1% of plant pathology FTEs. Given that fungal pathogens

have such a dominant impact on crop and natural flora it is not surprising that this sub-discipline should be so strongly represented. However, other pathogens are also significant in their impact yet attract substantially less representation. Bacteriology, for example, registered just 4.0% of FTEs in plant pathology. That represents 7 FTEs across Australia and New Zealand. Nematology accounts for 7.1% of FTEs and virology 9.0%. It is not possible to make direct comparisons with, say 5 to 10 years ago, but evidence suggests that these sub-disciplines have declined in representation and are somewhat threatened by limited training opportunities. This view was strongly supported through interviews and discussion.

It does not appear from the survey, however, that the capability in these areas is inadequate to meet current demand. Concerns for sub-disciplines such as nematology, bacteriology and virology are primarily about maintaining the existing capability in order to meet the future requirements of industry and environment. These pathogen groups have major economic impact on primary production and this study highlights the fragile nature of the current capability based on low-level representation. When this current base is linked to the limited opportunities for future specialisation in these fields the concerns would seem to be well founded. If there is not a strengthening of adequate training and retention programs for these sub-disciplines a significant vulnerability is likely to emerge.

• **Table 2: FTEs in plant pathology sub-discipline areas (n=183)**

Plant Pathology Sub-discipline	Number of FTEs	Percentage of FTEs
Bacteriology	7.0	4.0
Molecular Plant Pathology	16.2	9.3
Mycology	78.7	45.1
Nematology	12.4	7.1
Virology	15.8	9.0
No specific sub discipline	28.0	16.0
Other	16.4	9.4
Total	174.5	100.0

Table 3 provides a summary of the diversity of entomology sub-discipline areas. Entomology participants in the survey had much more difficulty identifying their activities with the specific sub-disciplines listed. Therefore, no single sub-discipline area dominates. In fact, close to 50% of entomology survey respondents selected 'other' as their sub-discipline. Analysis of responses indicates that entomologists are far more likely to identify with the application of their discipline rather than a specialty phylogenetic classification as in plant pathology. The survey classifications attempted to recognize this but respondents did not readily identify with the classifications offered. Most strongly represented, at close to 20% of FTEs, was taxonomy/systematics, an area most frequently referred to in survey comments and interviews as lacking in resource allocation both in training and succession planning.

In attempting to categorize the large number of 'other' responses it is clear that there is significant emphasis placed on ecology and integrated pest management. There were 32 'other' responses categorized as ecology related and 31 as integrated pest management. A further 18 indicated general pest management as their primary sub-discipline. These three areas are primarily responsible for the 65.8 FTEs shown as 'other', in Table 3.

As in the case of plant pathology it is not obvious that current capability is inadequate to meet current requirements. However, a similar vulnerability is evident should the issues of specialized training and appropriate knowledge transfer not be addressed through well-structured and targeted programs. Later in this study issues of education and training are reviewed and in that context the apparent adequacy of capability is more closely examined raising concerns that the situation may in fact be weaker than it appears.

• **Table 3: FTEs in entomology sub-discipline areas (n=151)**

Entomology Sub-discipline	Number of FTEs	Percentage of FTEs
Behaviour	9.3	6.9
Biochemistry	1.0	0.7
Genetics	7.0	5.1
Insect pathology	7.7	5.7
Physiology	1.0	0.7
Taxonomy/Systematics	24.8	18.4
No specific sub discipline	18.6	13.8
Other	65.8	48.7
Total	135.1	100.0

Organisational Distribution of Capability

The survey offered 16 different organisation types to respondents in order to minimize ambiguity. For the purpose of this analysis these 16 organisation types have been grouped into the 5 classifications outlined in Table 4. These are broad classifications designed to provide a meaningful analysis and are not intended to rigidly define the roles or activities of organisations within each classification. There is considerable overlap in activity, with universities obviously having research as well as educational activities and Gov1/Gov2 classifications overlapping in the nature of their research and extension activities.

• **Table 4: Organisation type classifications**

Classification	Comments
Gov1	Government organisations with a strong application focus which may include extension, applied research or practical management of agricultural or natural resources: <ul style="list-style-type: none"> • State departments of primary industries, forestry or agriculture. • Ministry of Agriculture and Forestry. • Plant health, quarantine or biosecurity. • Heritage and environment
Gov2	Government organisations with primarily a research focus: <ul style="list-style-type: none"> • CSIRO/ENSIS • Crown Research Institutes • Cooperative Research Centres • Industry research and development organisations
Edu	Organisations in an educational environment <ul style="list-style-type: none"> • Universities and Higher Education. • Vocational
Comm	Organisations having a commercial focus <ul style="list-style-type: none"> • Suppliers and distributors of agricultural inputs including pest and disease management solutions. • Service providers including consultants, advisors and extension services. • R&D start-up companies.
Other	Unclassified including primary producer and grower associations.

Table 5 provides a summary of the survey responses received from each of the classification groups and illustrates the organisational distribution of the plant pathology and entomology capability. 60.4% of total capability is located within the Gov1 organisations, which might suggest a strong practical emphasis. Organisations in this classification have tended to provide the front line services and support to the primary production and natural resource sectors. In addition, this classification includes the defensive support for these sectors in the form of quarantine and biosecurity. Clearly these are all critical areas in which the capability needs to be deployed and the response to the survey indicates a positive distribution of the capability in favour of this organisation classification.

At 20.1% the Edu classification holds a substantial proportion of the capability. This sector, and the activity of those in this sector, plays a vital role in terms of the capacity to meet future needs through adequate training and the provision of future capability. Organisations having a more fundamental research focus, Gov2 classification hold 11.4% of current capability. The actual organisational distribution, however, is not the key issue. Importantly, it must be understood how the capability is deployed within the organisations and this is discussed in the next section of the report.

• **Table 5: Distribution of plant pathology and entomology capability across organisation types**

Organisation type	Plant Pathology (No.)	Entomology (No.)	Administration (No.)	Totals
Gov1	129	77	11	217
Gov2	10	27	4	41
Edu	38	32	2	72
Comm	4	10	5	19
Other	2	5	3	10
Total	183	151	25	359

Application of Capability

While the distribution of capability by organisational classification appears positive it is important to examine, alongside these data, how the capability is applied. The study looks at application in two ways. Firstly it explores the FTE allocation to a range of primary environments and secondly, the allocation to a range of different industries.

Primary Environment

Primary environment in this study is defined in terms of the nature of the activities undertaken by the respondents in carrying out their duties. The survey presented several primary environments and asked respondents to indicate the FTEs allocated to each, where applicable. The primary environments used in the survey and the results obtained are shown in Table 6.

• **Table 6: Primary environment of plant pathologists and entomologists expressed as FTEs and percentage FTEs**

	FTEs	%
Education/Teaching	13.2	4.4
Research – Basic	41.4	13.9
Research – Strategic	34.1	11.5
Research – Applied	120.4	40.4
Extension	14.5	4.9
Support Services	15.9	5.3
Regulatory/Policy	13.6	4.6
Quarantine	28.7	9.6
Commercial – Sales/Marketing	1.7	0.6
Commercial – Technical/Advisory	14.2	4.8
Total	297.7	100

Research – Applied stands out as the most dominant primary environment at 40.4% of FTEs. Combining all research categories the emphasis on research becomes very evident with 65.8% of all FTEs applied in research.

Given the high proportion of respondents in the Gov1 sector it is quite revealing to see such a high percentage of respondents identify research as their primary environment. In the overall survey only 14.5 FTEs or 4.9% were applied to extension and a further 15.9 FTEs or 5.3% in support services. Therefore, only 10.2% of all capability is applied directly in support of primary producers, despite the very high proportion of respondents found in the Gov1 classification. Given the reduction in state government extension services, in Australia, and the shift to a 'user pays' approach to services it would be interesting to compare this data with 5-10 years ago.

It is difficult to obtain definitive data as to whether, at this level, the existing capability is adequate to meet the demands of the primary industries in terms of extension and support services. However, when respondents were asked about their work pressure most responses expressed some level of concern. 52.3% indicated that they were 'very concerned' or 'extremely concerned' which is an indication that they do not feel that they are adequately meeting the demands of their work place.

A more apparent and serious concern is the allocation of FTEs to education/training. Only 13.2 FTEs or 4.4% indicated education/teaching as their primary environment. That would suggest significant pressure on the teaching sector for these disciplines. In contrast to this level reported in the teaching/education environment, 20.5% of FTEs in the survey were from the university sector. While it is not a one-to-one relationship it is evident, therefore, that only about one-fifth of university capability is directly targeted at the education/teaching environment. This figure may not adequately represent post-graduate supervision time, however, it does indicate very strongly that only a small proportion of the university sector regards education/teaching as its primary role.

Available teaching capacity may therefore be an important threat to these disciplines. In the telephone interviews concerns were expressed about the availability of teaching effort, at least, to some of the more traditional and specialist areas. The survey data provides support for these concerns. Current capability levels for insect taxonomy, nematology, bacteriology and virology were discussed above and this low level of direct application to education/training in the higher education sector should offer a clear warning concerning the sustainability of current capability levels.

Primary Focus

The final aspect of current capability addressed by the survey was that of primary focus. In the survey this was defined in terms of the industry or public sector on which the capability primarily concentrates. The sectors identified in the survey and the relative response levels are shown in Table 7.

Plant pathology and entomology not only support the plant production industries, which take many forms, but also biosecurity, preservation of environment, heritage and human health. The major areas of agricultural and horticultural production, however, dominate the utilisation of capability and these will continue to demand the major portion of capability into the future to protect rural production, so important to the economies of Australia and New Zealand.

The capability applied to heritage and natural ecosystems is 11.3% of FTEs (representing about 35 actual FTEs). This includes a range of different sub-disciplines, including mycology, molecular plant pathology and insect pest management. Most capability is supplied by the Gov1 classification and includes substantial input associated with biosecurity and quarantine.

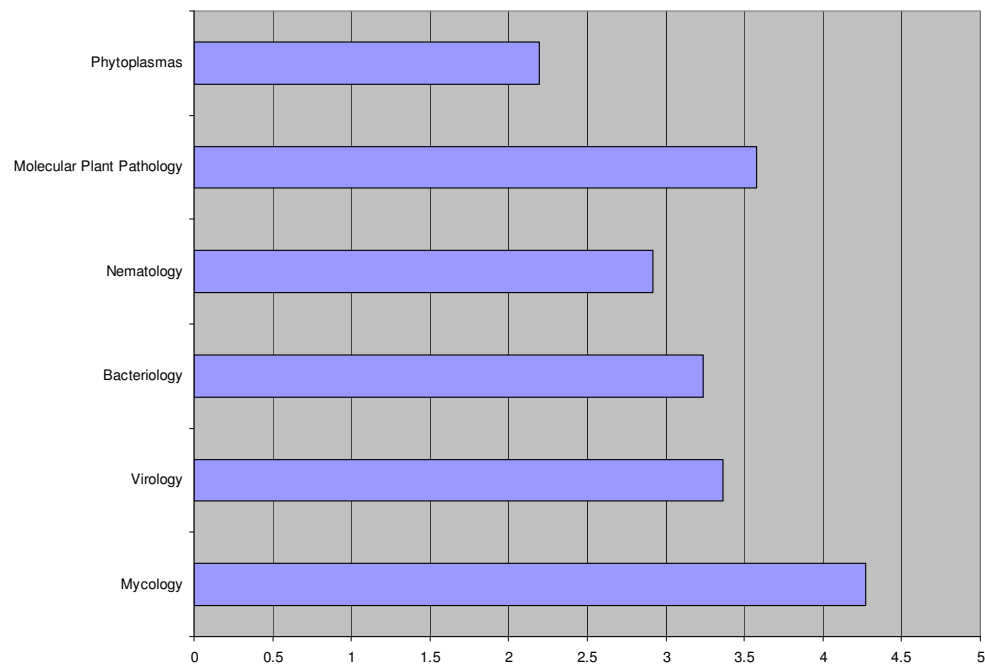
• **Table 7: Primary focus of plant pathologists and entomologists represented as FTEs and a percentage of FTEs (n=334)**

Primary Focus	FTEs	%
Agriculture Production	123.3	40.1
Agriculture Storage	9.0	2.9
Horticulture Production	91.5	29.7
Horticulture Post-harvest	8.3	2.7
Forestry Production	20.2	6.6
Forestry Wood Products	3.6	1.2
Forestry Urban	3.6	1.2
Nursery/Turf Ornamental	13.5	4.4
Heritage	34.9	11.3
Total	307.6	100

Future Demand for Capability

The survey gathered data on how individuals within the targeted organisations identified the current importance of the various sub-discipline areas in plant pathology and entomology. Figure 1 shows the rankings for the various plant pathology sub-disciplines. Rankings are based on a weighted average calculated from a five-point scale where 5 is most important. From a plant pathology perspective, mycology ranks clearly the most important and is then followed up by molecular plant pathology.

• **Figure 1: Ranked importance of plant pathology sub-disciplines**



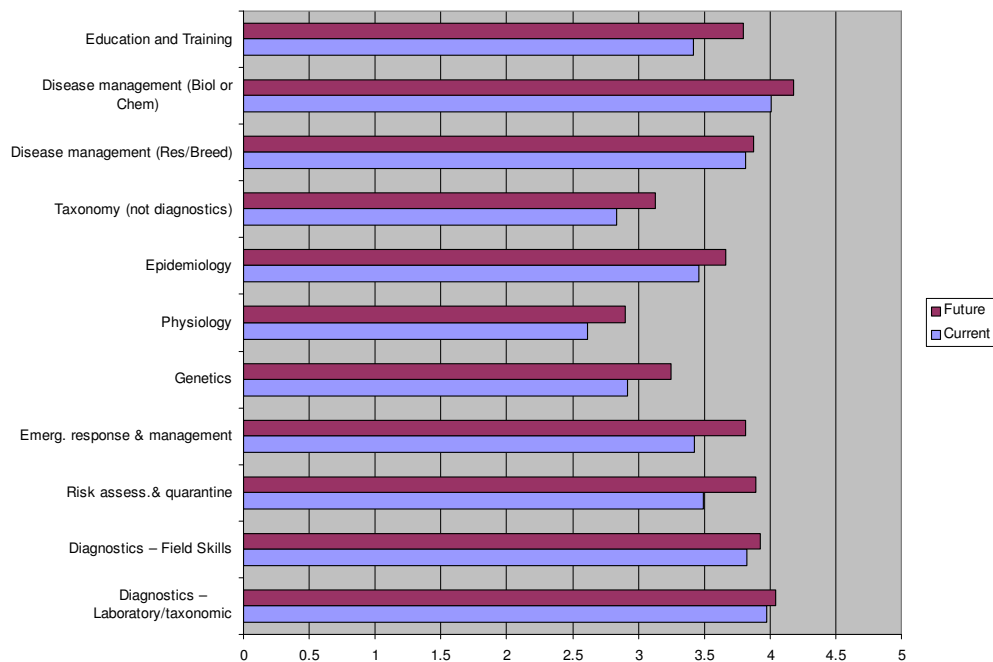
Mycology is and will remain a dominant aspect of plant pathology due to the major economic impact of fungal pathogens, in both agricultural production systems and

environment. The impact of other pathogen groups is not insignificant, however, and all aspects of plant pathology will remain important in managing agricultural and environmental ecosystems. There is no rationale for a reduction in demand for capability in these areas, in fact increasing demand is likely.

Fungal pathogens, for example, have been a major target of the chemical pesticide business. Trends over the last decade have shown a global decline in chemical pesticide use (US EPA data) but this has not been driven by a reduction in pest problems. More importantly it is driven by changes in pest management practices due to increasing concerns over food safety issues and communities demanding more environmentally sensitive approaches. The result has been a shift towards more integrated pest management practices, more targeted chemistry and improved cultural practices. All of these shifts require increased capability in both plant pathology and entomology as they can only be supported by more accurate diagnosis, increased surveillance and monitoring and most importantly a better understanding of both the genetic and ecological basis of host/pathogen relationships.

Figure 2 shows the relative current and future importance of the various plant pathology skills and competencies as ranked by respondents. A similar weighted average calculation is applied.

• **Figure 2: Relative current and future importance of plant pathology skills and competencies.**



The greatest increases in future importance tend to occur in areas related to biosecurity such as emergency response & management and risk assessment & quarantine services. In general there is an increasing emphasis on biosecurity and trade issues so it is not surprising that these areas show an increasing level of importance. Along with these issues, recent incursions have raised the awareness of diagnostic capacity both at the laboratory level and in terms of field skills. The government sector, in particular, has faced significant pressures in these areas in recent years. Therefore, priority is now being placed on ensuring adequate capacity and procedures for diagnostics. It is recognized

that epidemiology and taxonomy (including genetics) underpin diagnostics capacity so these are seen as important priorities. They are critical to correct diagnosis and management of pathogens. Education/training also shows a strong increase in importance in order to meet future needs and is discussed in more detail below.

Figure 3 shows the rankings of current importance for the various entomology sub-disciplines, ranked on the basis of the five-point, weighted average scale. Taxonomy/systematics followed closely by behaviour are most important in terms of current priority sub-disciplines in entomology. Insect pest management practices have also shifted strongly in recent years towards more environmentally sensitive approaches increasing demand for integrated pest management skills which, as with plant pathology, must be supported by diagnostic and monitoring skills as well as understanding of insect behaviour and ecological relationships with their environment.

• **Figure 3: Ranked importance of entomology sub-disciplines**

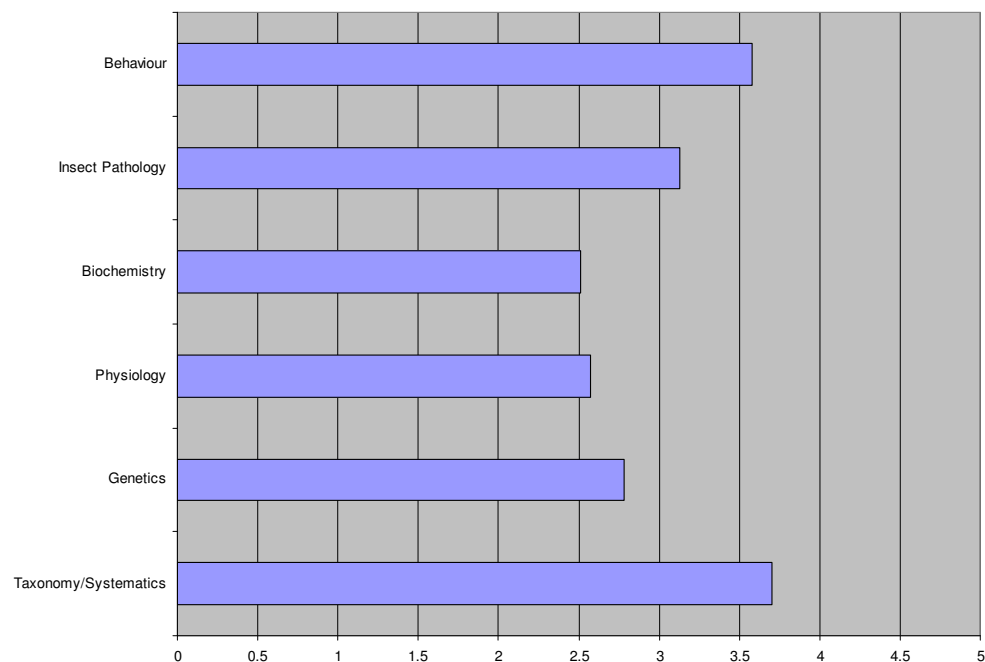
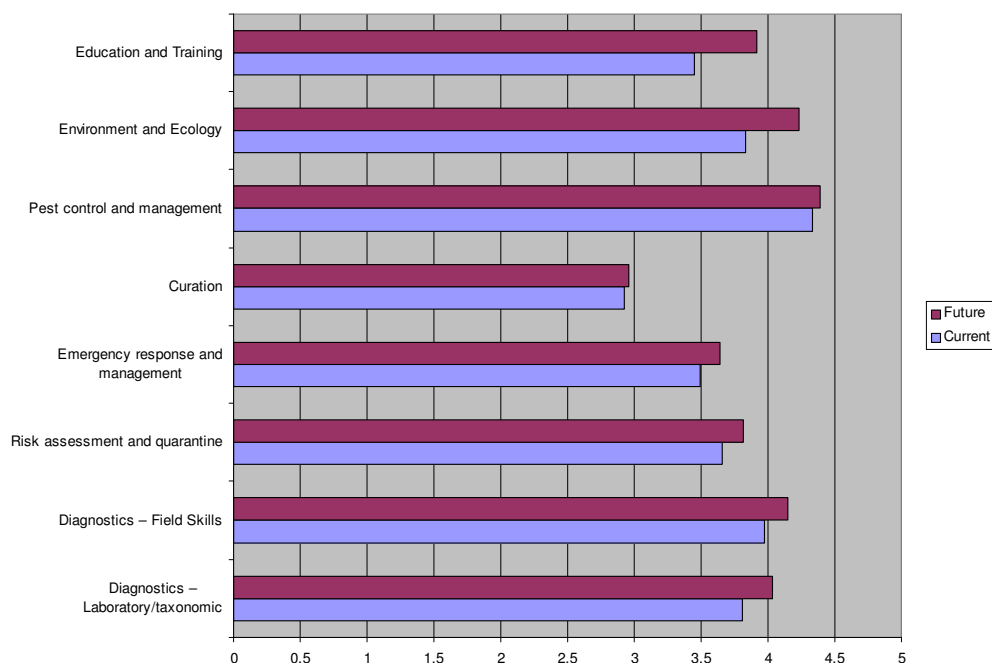


Figure 4 shows the relative current and future importance of the various entomology skills and competencies as ranked by respondents and reported on a weighted average basis. There is a small upward shift in terms of future needs in diagnostics, risk assessment, quarantine and emergency response management but these are not as marked as in plant pathology. However, environment & ecology and once again, the increasing importance of education/training are highlighted. It is not absolutely clear from survey data what is driving the increasing importance of environment & ecology other than a high proportion of respondents noted integrated pest management and ecologically based activities when describing their sub-discipline areas. The issue of education & training is discussed later in the report.

• **Figure 4: Relative current and future importance of entomology skills and competencies.**



There are no obvious changes in direction regarding the capability demands for the future. More apparent is a shift in emphasis of application rather than in the foundational scientific disciplines. Education/training are highlighted primarily because there is a perceived lack of basic and practical skills. These become evident when the application emphasis shifts to areas such as biosecurity where fundamental field taxonomy, symptomatic epidemiology, observation and collection skills are in demand. Therefore, the need to ensure adequate basic skills development in education programs is a priority, yet there is concern that they are neither addressed adequately in current education nor suitably covered through internal knowledge transfer.

Many of these issues were highlighted in a study completed for Plant Health Australia that focused on Australia's diagnostics capabilities (Moran & Muirhead, 2002). The report noted declining support for diagnostics capability in areas such as bacteriology and nematology. It emphasized '...substantial gaps in the taxonomic support for major groups of endemic and exotic insect and mite pests.'

In a submission to the DEST SET audit, the Biodiversity Program, Queensland Museum (Hooper, 2005) expressed strong concern regarding the current status of taxonomic research and skills noting that these are '...badly underdeveloped and cannot provide an adequate basis for understanding our environment. In particular, knowledge of our diverse tropical fauna is still rudimentary...'. In addition, this submission claimed inadequate biodiversity research funding, diminishing expertise and career opportunities as well as virtually non-existent taxonomy training provided by universities. These are strongly expressed concerns that also emerge in many comments made in response to survey questions.

Therefore, references in an earlier section of this report to plant pathology and entomology appearing to be adequate to meet current demands are almost certainly a superficial interpretation. It is difficult to determine whether capability develops in response to

demand or areas of demand adjust to the capability available. If it is the latter then ultimately cracks will begin to appear when unexpected demand creates a draw on resources that the capability cannot respond to. There is evidence that this does occur from time-to-time as in the case of recent incursions. If issues such as those expressed so strongly above in the Queensland Museum submission are therefore not addressed there is real danger of the cracks widening to the point where they are difficult or impossible to cover due to a permanent loss of capability.

4

Age Profile and Service Expectations

Age Profile

An important aspect of the study was to determine the age profile of each of the disciplines. The results are summarized in Table 8. For both disciplines the spread is relatively even across the three spans of 25-24, 35-44 and 45-54, although, in the case of plant pathology the 45-54 bracket is slightly elevated. Overall there is a lower proportion of respondents in the 55+ bracket. Surprisingly, there were no survey respondents that registered less than age 25, although this was an option available. The survey did not target the student sector but this result does reveal a surprising gap in the capability spectrum. There is no firm data in the survey to explain this result, however, when this outcome is linked with the significant percentage of higher degrees in these disciplines there is the possibility that relatively recent graduates of generalized undergraduate programs do not consider themselves as specialists without the completion of further study.

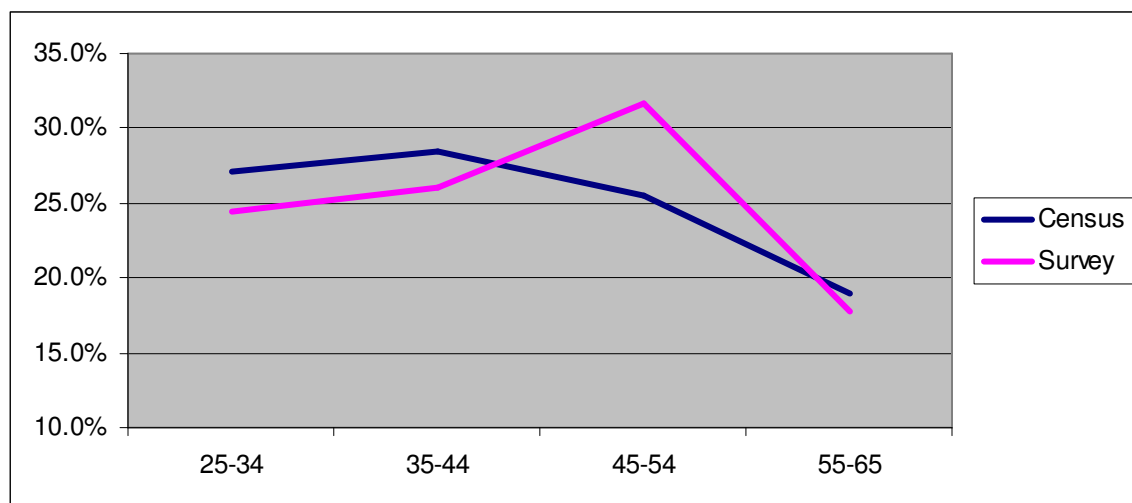
• **Table 8: Age profile for each discipline.**

Discipline	25-34	35-44	45-54	55+	Total
Plant pathology	48	44	60	26	178
Entomology	32	41	43	32	148
Total	80	85	103	58	326
Percentage Overall	24.5	26.1	31.6	17.8	100

From this data, apart from the under 25s, the age distribution appears very positive. With good representation across the age profile and in fact numbers in the over 55 age bracket, potentially within 5-10 years of retirement, substantially lower than the younger age brackets. These results should somewhat allay fears that a high proportion of the capability is close to retirement, a view often informally expressed.

Comparison with Australian population data (Australian Bureau of Statistics, 2001), is shown in Figure 5. The general population data is calculated as a percentage in each age bracket against the total population recorded from age 25 to 65 inclusive. There is a peak in plant pathology and entomology numbers in the 45-54 age bracket when compared with the general population. The younger age brackets are slightly under represented in the comparison. This profile should not be of immediate concern but should be recognised as a significant opportunity for the two disciplines to ensure that capability is maintained well into the future. However, with this opportunity is an unambiguous warning. The capability evident in the 45-54 age bracket must be captured, transferred and most importantly retained down the profile.

• **Figure 5: Age profile compared to the general population.**



The survey also looked at expected years of service and reasons why respondents might leave their employment. Given the age profile evident this emerges as an important consideration. Retirement is by no means the most likely reason for departure. The reasons noted for likely departure prior to retirement present one of the most important threats to plant pathology and entomology revealed in the study.

Service Expectations

Table 9 summarizes the expected years of service indicated by survey respondents. Close to 25% of respondents will potentially leave in each of the time periods, <5 years and 5-10 years. This translates to 49.4% of all respondents indicating that they are likely to leave employment in these disciplines within 10 years. However, only 17.8% of all respondents are in the 55+ age bracket and, therefore, might realistically nominate retirement as the likely reason for departure. This suggests a substantial loss of capability from the younger age profiles, most probably, for reasons other than retirement.

• **Table 9: Expected years of service for each discipline.**

Discipline	<5	5-10	11-15	>15	Total
Plant pathology	46	43	23	71	183
Entomology	37	39	19	56	151
Total	83	82	42	127	334
Percentage overall	24.8	24.6	12.6	38.0	100

In light of these data, if capability is to be maintained, there will be a strong demand for replacement of skills lost. The SET audit (DEST, 2006) indicates that overall 'replacement' demand for SET skills will exceed 'new' demand over the next decade. The audit defines 'new' demand and 'replacement' demand as follows:

'Demand from industry for skilled employees is comprised of two basic components: demand that arises due to economic growth and/or the emergence of new industries and technology leading to the creation of new jobs that did not previously exist, referred to as 'new' demand; and demand that arises from staff turnover, movements and retirement, referred to as 'replacement' demand.'

The audit draws data from a Monash study which projects employment growth over the period 2004-5 to 2012-13 in agriculture & environment related fields of 36.2% and in the natural & physical sciences of 33.3%. Agriculture & environment are projected to show an annual replacement demand of 2.0% and a growth (new) demand of 3.9%. For the natural & physical sciences the projections are 4.5% and -2.3% respectively. Plant pathology and entomology are not specifically addressed but are closely linked to these two categories of SET. The Monash study identifies the 'baby-boomer' retirement effect in these projections but probably does not recognize the high level of early attrition identified in the plant pathology and entomology survey. This result is likely to drive up the replacement demand above that shown in the Monash study and raises important implications for employing organisations with regard to professional development, internal training and succession planning.

In order to gain more insight into the potential loss of capability, the survey, asked those respondents that indicated likely departure from their discipline within the next 15 years to indicate probable reasons for doing so. The responses are summarized in Table 10.

There were 83 responses out of 207 (40.1%) that indicated they are likely to leave employment within 5 years. While 28.9% of those noted retirement as the reason, 34.9% indicated limited tenure or funding constraints and a further 21.7% indicated likely departure within 5 years due to career development (new field of activity). These figures represent significant loss of capability within 5 years due to tenure, funding and new career directions (totalling 56.6% or 47 of the 83 respondents). Quite clearly these are important data that, should be considered very seriously from a human (and skills) resource management perspective.

For those seeing a longer term to departure the reasons swing firmly towards retirement. Those with a horizon of 5-10 years indicate retirement as the most likely reason (67.1%) and an even higher percentage (81.0%) of those with an 11-15 year horizon anticipate retirement as the most likely reason to leave. This indicates that those who feel secure and are likely to remain within the system beyond 5 years have a stronger tendency to see career fulfilment through to retirement. The critical issue, therefore, for retention of capability is to build confidence in short-term security and career fulfilment.

• **Table 10: Relationship between service expectations and likely reasons to leave plant pathology or entomology expressed as a percentage within each bracket of expected years of service (n=207)**

Expected Future Years of Service	n	Likely Reason to Leave					Total
		Career development (new field of activity)	Career development (overseas study or opportunity)	Limited tenure or funding constraints	Retirement	Other	
<5	83	21.7	7.2	34.9	28.9	7.2	100
5-10	82	6.1	8.5	13.4	67.1	4.9	100
11-15	42	9.5	0.0	4.8	81.0	4.8	100
Overall	207	13.0	6.3	20.3	54.6	5.8	100

There were similar views strongly expressed in the telephone interviews conducted as part of the study. Virtually all interviewees emphasized the link between identified areas of concern in the survey and the impact on employment opportunities and risks. The most dominant theme identified was that of the relationship between funding mechanisms and job security. This was expressed in a number of different ways but clearly a widely held concern. Comments referred to lack of permanent status, short tenure related to project timeframes, insecurity, inability to plan career path, minimal or no succession planning and distraction due to the need to generate new project funding. These concerns were overwhelmingly expressed with many interviewees disturbed by the subsequent loss of expertise, lack of safety-net funding to hold valued young talent and limited programs aimed at retaining key researchers and experience.

Particular emphasis was placed on concerns for technical support. Research leaders commented on the pressure placed on their programs by short-term technical appointments. This produced negative impact through the need for increased attention to recruitment, loss of skills and therefore the need for on-going re-training. Similarly those in a technician role felt extremely vulnerable with contract terms frequently no longer than 12-18 months and under constant pressure to identify new opportunities, often in new areas, both professionally and regionally.

5

Education and Training

Training Priorities – Competency and Skills

In order to identify target areas for education and training the survey collected data on the attributes employing organisations would rate most highly when seeking to employ new staff. Respondents familiar with the current and future employment needs of their organisations completed this section of the survey. Most highly regarded are sound research skills followed by communication skills.

Identification of research skills is probably not surprising given the emphasis already placed on research in the organisations targeted by the survey. From results discussed earlier it is evident that all the major organisational classifications, Gov1, Gov2 and Edu, have a strong research focus and recruit most actively for research positions. Field based skills followed by laboratory skills were of highest priority. These are important skills areas that support applied research, as well as the emerging priorities related to biosecurity. Training programs now and into the future need to pay particular attention to these basic skills to ensure that future capability requirements are met.

Education and training programs were explored in the telephone interviews. A concern widely held and expressed by many of those interviewed related to weaknesses in current education programs. Issues such as loss of basic skills (taxonomy frequently referred to), limited specialisation, inadequate practical training and limited cross skilling were typically raised. The outcomes for those recruiting are claimed to be a lack of quality students and difficulty in filling positions with appropriate skills. There was some disagreement as to whether these were weaknesses in undergraduate programs or in postgraduate programs. Overall, however, it was more widely held that undergraduate courses should retain a generalized approach with an emphasis on practical skills, thus, leaving specialisation to postgraduate programs. It should be noted that some interviewees expressed a high level of confidence in the quality of graduates, particularly from some postgraduate programs available in both Australia and New Zealand.

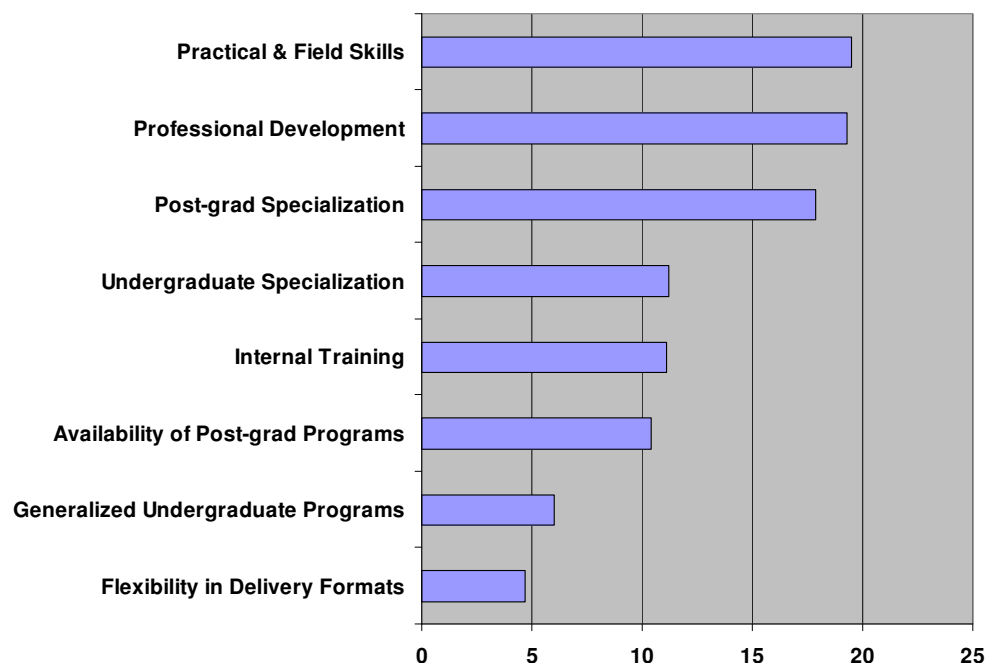
Those aspects of training that were reported as positive commonly related to practical application and participation in industry. Undergraduate programs, in particular, that were considered to be most valuable were those that provided for a high degree of integration with industry. Many variations on the theme were identified, including short-term industry placements; participation of industry personnel in teaching; industry-based scholarships; undergraduate participation in CRCs; utilisation of community resources (eg environmental programs) and industry linked summer schools. Primarily these integrated programs were seen to hold merit on the basis of their effectiveness in developing hands-on, practical experience.

To obtain insight into how best to meet future capability and skills requirements the survey requested information on the most appropriate education and training approaches. Responses to this part of the survey are shown in Figure 6.

It is interesting to note that generalized undergraduate programs did not attract a strong response. The areas that rated most highly were programs involving the development of practical & field skills, professional development and postgraduate specialisation. These three areas stand out quite clearly as the major priorities and provide guidance as to where to place the emphasis in developing education programs for the training and retention of plant pathologists and entomologists.

It is also evident that survey respondents did not see flexibility in delivery formats as a priority area. This may reflect concern regarding loss of traditional programs and perhaps needs further evaluation in light of current higher education funding policies. The reality is that multiple, low enrolment classes are no longer feasible and it is essential to develop innovative approaches for course delivery and curricula if the required level of training is to be achieved.

• **Figure 6: Identification of training priorities as a percentage of all responses (n=160)**



In discussing professional development during interviews it was apparent that many are concerned with the availability of suitable programs. Apart from basic training, professional development and in-service training are vital components of maintaining and building capability in the sciences. Effective programs can ensure the transfer of skills, diversity of expertise and rewarding career progression, all of which improve and enhance capability as well as stability in staffing. Many felt that due to the generalist approach of undergraduate courses and, in some cases, masters degrees, that there is a significant need for in-service basic skills training.

At the same time, it was felt that there are limited opportunities to be trained in highly specialized areas such as taxonomy as these programs are infrequent and often limited only to those currently working within the field. Therefore, opportunities to broaden the skills base or expand cross-skilling within organisations were seen to be generally inadequate. Attendance at conferences is seen as an important aspect of professional development and widely valued. Attendance should be promoted and participation

encouraged. A small number of responses indicated concern that it is often hard to obtain approval for attendance and that there is less than adequate participation in international conferences.

Current Course Availability

Data on university plant pathology course offerings in Australia and New Zealand has been sourced from a recent audit (Ash, 2006). Data for entomology course offerings is only available for Australia and is sourced from the University of Queensland's School of Integrative Biology (SIB) submission (O'Neill, 2005) to the SET audit.

In plant pathology there were 54 different course offerings in 2005-06 at undergraduate level including 4 at level 1, 13 at level 2, 31 at level 3 and 6 at level 4. There were 16 offerings at post-graduate level.

For entomology in 2005 there were 3 offerings at level 2 and 14 at level 3. Information for postgraduate offerings in entomology was not available in the SIB submission.

It is quite difficult to synthesise this data because almost certainly there are components of both of these disciplines in generalized science and biology units, particularly at level 1. However, what is reasonable to conclude from the data and current course structures is that selections in course direction tend to occur at level 3.

What is also evident in reviewing undergraduate course offerings is that the majority are offered as part of a broader course focus, for example as part of a degree in agriculture, viticulture, crop protection or environmental management. Of the 37 plant pathology offerings at levels 3 and 4, 10 could be regarded as plant pathology specialisation. For entomology, the specialisation of offerings is much more apparent with 11 out of 14 level 3 offerings specialized. At the post-graduate level, 5 of the 16 plant pathology offerings would be regarded as specialisation.

There is no suggestion that the undergraduate focus on industry application is not valid. In fact emphasis on applied aspects and an understanding of industry requirements is seen as a positive factor to be exploited. However, the opportunity to undertake the academic study of plant pathology or entomology as a specialist, enabling science and to provide foundational competency is very limited based on current course structures.

It is important to consider this information on current course offerings together with the level of teaching commitment identified in the survey. These issues are interrelated and almost certainly linked with higher education funding policies that tend to channel funding into programs that can generate a high level of student enrolment. A result, not unexpected, is the combining of related subject areas and consolidation into generalized programs having broad appeal. The flow on effect is that staffing priorities have shifted to a requirement for generalist teaching skills and a reduced requirement for specialists, as there is no longer a place for small class sizes with a specialist focus. Specialists have therefore moved out of teaching responsibilities into research or non-training roles. This trend provides for budgetary efficiencies but unfortunately generates a vacuum in the training of specialists, the impact of which will not be felt until the weaknesses are exposed under pressure and specific pest management issues cannot be adequately handled or emergency response demands are not met.

Changes to funding policy, however, are not the only factors that drive the shift from university teaching roles into a research orientation. The BACS SET submission (Mattick,

Keniger and McManus, 2005) is particularly concerned about the lack of integration of teaching and research at Australian Universities. The submission comments:

At present, the three main obstacles to the integration of teaching and research in Australian universities are: (i) academic researchers have little or no formal teacher training in terms of communication skills and presentation strategies that will give the students the best possible learning experience; (ii) reward systems in universities are effectively a disincentive for researchers to devote time to teaching due to a climate of highly competitive research funding and the need to develop research groups and train graduate students and (iii) the frustration of faculty staff with respect to the lack of recognition given to their commitment to teaching, which is often at the expense of research productivity.

These issues, concerning teaching skills, incentives and recognition for teaching commitment are serious drivers and need to be tackled along with course structure if the teaching component of universities is going to be strengthened and students are to be offered a more rewarding and focused program.

As indicated above, generalized programs at the undergraduate level, particularly at levels 1 and 2, are not necessarily considered to be the primary concern. Opportunities to hold students beyond these levels and draw them into the specialist fields of plant pathology and entomology is a far more critical concern. The BACS submission (Mattick et al, 2005) identifies the high level of year 1 and year 2 student attrition from broad based science programs out of science altogether or into professional life science streams. To believe that plant pathology and entomology disciplines can attract student enrolments in sufficient numbers to compete with high profile or popular course offerings is a very risky strategy and demonstrates a significant lack of understanding of the role that these sciences play in our economy and community in general.

There is not a demand for large numbers of plant pathologists and entomologists within Australia and New Zealand. Furthermore, it is not possible to train plant pathologists or entomologists as homogeneous groups. There is a significant range of specialties as indicated in the survey and these need individual focus. But by ignoring them or failing to provide adequate capability across the range of requirements is to risk a certain path to failure of important industries and community well being.

Should we reach a point of crisis in these areas it will not be possible to turn the situation around quickly. The signs of a fragile situation are evident and require attention before further decline. There are two crucial signs that should be noted. Firstly, although there appears to be a level of capability that can meet demands there are strong indications of significant loss of trained personnel from these disciplines, much of which is driven by lack of job security. Secondly, there is an alarmingly low level of education and training resource, not just at industry and professional training levels but also in the university sector itself.

Specialist entomology training in Australia provides very clear evidence of these trends. Within the last 10 years two universities, Adelaide University and the University of Queensland either restructured or downsized their undergraduate programs in entomology to the point that these courses no longer exist in their own right. Previously, these were two universities in Australia offering undergraduate degrees in entomology. In its submission to the SET audit (DEST, 2006) the University of Queensland's School of Integrative Biology (O'Neill, 2005) highlighted this restructuring and claimed the University of Queensland to be the only university in Australia that '...currently offers a broad selection of second and third level insect units.....'. The submission goes on to claim 'It is

possible that within 3 years it will not be possible to obtain a broad training in entomological science in any institution in Australia if current trends continue.’

Plant pathology and entomology as careers

The interviews, conducted as part of this study, paid particular attention to identifying opportunities and strategies to increase student enrolments in plant pathology and entomology. Interviewees felt that there is considerable opportunity to attract students into the plant pathology and entomology disciplines. Emphasis could be placed on many positive aspects of a career based on these enabling sciences. There is significant public good that derives from a career in either plant pathology or entomology, such as food security, preservation of environment, public health and biosecurity. There is a rich diversity of activity, interesting challenges and the stimulation of a discovery environment. Positive views were also expressed regarding the quality of institutional facilities and opportunities to work with highly skilled, world recognized research teams.

With the focus on agriculture and natural ecosystems a career in these disciplines offers a range of life style options, direct industry interaction as well as overseas travel and conference participation. These positive career attributes could be presented in much higher profile at school careers days, through industry promotion and case studies to generate student interest. Given the decision about career direction that emerges at level 3 of undergraduate programs many of these career benefits and opportunities should be strongly promoted during the early stages of the undergraduate degree program in order to target that point of decision.

Views were also expressed regarding the opportunities to ensure that course offerings are more relevant and appealing. Most important in this area is the opportunity to build greater interaction between training institutions and industry, whether research or applied. Where these programs exist there is positive career motivation in addition to improved practical skills development. Capitalizing more fully on such collaboration presents a realistic opportunity for growth yet would not be inconsistent with programs aimed at building the foundational competencies. Strategic programs such as industry based scholarships or cadetships would enhance the development of a higher level of interaction.

Many felt that these positive aspects could be more fully capitalized on in an effort to attract increased student numbers into plant pathology and entomology. It was felt that by emphasizing such benefits through more visible promotion; illustration through career case studies; provision of vacation scholarships and cadetships these disciplines could be promoted as positive career options. With such programs supported by planned mentoring many of the ‘disappearing’ skills could be maintained and developed based on improved student intake and retention.

Most frequently expressed in a negative context were those issues related to lack of job security and inadequate opportunity for planned career development. As previously discussed, many are frustrated by short-term contracts, changing priorities and the reliance on external funding for their programs and feel that these aspects send negative signals to those making career choices. They identify inadequate skills development, lack of succession planning and re-training costs as important consequences both for their own careers and for their employing organisations.

While the science skills, commitment and passion may be identical to other fields such as medical technology; agricultural and environmental sciences are not recognized with similar profile. These fields of science are often seen negatively and providing limited

opportunities. Agriculture is often perceived as boring. Drought and an apparently depressed rural sector suggest a limited future and lack of resources available from industries unable or unwilling to invest due to low returns when compared to the medical sciences. Ultimately many feel somewhat perturbed in industries demanding a high workload yet rewarded with low salaries when compared with peers in other industries.

Industry support for education and training

Training programs require support in a variety of ways. A fundamental requirement for any career oriented training program is that there are attractive employment opportunities available on completion. Support for training programs may also come through specific funding arrangements, for example through the provision of scholarships or cadetships. Funding professional development and in-service training are important aspects of an organisation's support of staff. Support may also be provided through programs offering industry experience or by an organisation providing direct input to the delivery of training programs.

Survey respondents were asked to review a list of different support mechanisms and identify the extent to which their organisation may or may not engage with each. The results are shown in Table 11 with percentage for each of three categories, i) unlikely to support, ii) possibly support or, iii) highly likely to support.

The area receiving the highest percentage response at 70.3% in the highly likely category was employment of postgraduates. Employment of undergraduates attracted a response of 45.6% as highly likely while offering work experience or short term traineeships achieved a 39.2% highly likely response.

Areas receiving a high unlikely response rate included the provision of an annual corporate scholarship (46.8%) and direct sponsorship of a course or speciality unit (56.7%)

• **Table 11: Overall potential for employment and training support (n=158)**

	Percentage of Responses		
	Unlikely %	Possible %	Highly Likely %
An employer of undergraduates	13.3	41.1	45.6
An employer of postgraduates	5.1	24.7	70.3
Provide financial support/ scholarships/cadetships for internal staff	28.5	52.5	19.0
Provide annual corporate scholarship or award on a competitive basis	46.8	43.0	10.1
Offer work experience or short term on the job opportunities for trainees	11.4	49.4	39.2
Provide direct sponsorship for a particular course or specialty unit	56.7	38.2	5.1

These results emphasize again the significance placed on postgraduate achievement, almost certainly driven by the research focus of organisations surveyed. There is a substantial drop to the likely employment of undergraduates and this is an important area for concern. What is evident from this result is an opportunity gap for graduates, meaning that they are driven into postgraduate programs in an effort to improve employment opportunities and therefore do not have the opportunity to build on their undergraduate

degree with workplace experience. It is not surprising that employers identify shortage of practical skills as an issue.

It is also evident from these results that employers are reluctant to contribute in a direct financial way to education and training. All options involving direct financial contribution, including scholarships, cadetships and course sponsorship rate quite strongly in the 'unlikely' category.

In order to encourage graduates into plant pathology and entomology careers, thereby ensuring on-going capability in these fields the major employing organisations need to consider these issues carefully. There is a need to promote the employment of undergraduates, focus on the internal development of the skills base and be more prepared to invest in the specialisation and careers of their people.

6

SWOT Analysis

Strengths	Weaknesses
<ul style="list-style-type: none"> • High level of academic training (PhDs and Masters) • Strong representation in Gov1 sector • Research capability, powerful resource for excellence in research • Well structured age distribution • Willingness to employ postgraduates 	<ul style="list-style-type: none"> • Plant pathology has fragile capability in nematology, bacteriology and virology. • Limited capability applied to education/training • Limited teaching skills of university researchers and poor recognition of teaching commitment • Undergraduate and post-graduate training poorly structured • Undergraduate training unspecialized and mostly incorporated into alternative degree programs such as agriculture, viticulture or environmental science • Lack of job security/tenure and related funding issues • Limited specialisation in the commercial sector • Lack of attention to professional development and internal training • Poor recruitment from undergraduate programs • Low representation in extension and support services • Poor financial commitment to staff development • Ad hoc approach to succession planning
Opportunities	Threats
<ul style="list-style-type: none"> • Resource available in young age groups • Significant potential gains through improved training and retention programs • Establish clear strategies to reduce the disproportionate level of incumbents that have identified early departure from these areas of science. • Development of well-structured curricula to build on the undergraduate base • Enhancement of education/training capability in the university sector • Cultivate current capability to ensure long-term capability is developed • More active and targeted promotion of plant pathology and entomology careers at high school level and years 1 and 2 undergraduate programs 	<ul style="list-style-type: none"> • Poor development of practical skills base through inadequate employment of graduate • Loss of specific industry or sub-discipline skills currently seen as 'fragile' • High loss rate due to lack of job security and transfer to other careers. • Inadequate knowledge and skills transfer • Further decline in university teaching sector including loss of specialist skills • Potential high turnover rate which results in high retraining costs, reduced efficiencies and inadequate succession planning • Potential for significantly reduced output from undergraduate programs • Opportunity gap for graduates due to recruitment focus on postgraduates

7

Conclusion

Australia and New Zealand have a capable resource in the disciplines of plant pathology and entomology. There is particular strength in the academic capability of these disciplines that provides an outstanding resource for excellence in research and leadership in many fields. Australian and New Zealand research in these sciences is world class and internationally competitive.

The largest proportion of those working in plant pathology and entomology are found in the government sector with greater than 50% having a research application. Extension and support services, however, are only represented by about 10% of full time equivalents (FTEs) applied in these disciplines, despite the fact that the agricultural and horticultural production sectors are the primary focus of most practitioners.

The emphasis on research also presents some concerns within the education and training sector in that less than 5% of total FTEs are applied to education and training activities. Even within the education sector only around 20% of FTEs are applied to education and training activities.

The capability is distributed across a wide range of sub-discipline areas although there appears to be some fragility in the fields of bacteriology, nematology, virology and taxonomy. It is possible that capability in these areas is at risk of being inadequate to meet industry and environment needs if immediate attention is not applied to improving availability of specialisation, adequate professional development, more effective knowledge transfer and strategic succession planning.

Industry needs appear to be adequately met at present. However, there is an increasing emphasis on biosecurity issues and the aspects of plant pathology and entomology that underpin biosecurity and quarantine such as epidemiology, taxonomy, diagnostics, risk management and emergency response programs. Over the last decade there has also been a significant shift in pest management practices driven by community concerns related to food safety and demand for environmentally sensitive practices. These trends call for increased capability in both plant pathology and entomology to meet the community's expectations.

These emerging trends do not herald a change in training requirements as much as they draw attention back to basic elements of taxonomy, diagnostics, insect behaviour, recognition of disease symptoms and development as well as practical field experience. These need to be emphasized in future training programs that would benefit from a greater degree of industry integration.

Employers often raise concerns regarding the availability of graduates with appropriate practical and research skills. However, it is evident that there is an emphasis on employment of postgraduates rather than graduates. This may well be driven by the heavy research focus of employing organisations but it does create an opportunity gap for graduates and potentially limits their capacity to develop the required, on the job skills.

Despite this there is a relatively even age distribution across the age range from 25 to 55+. This creates an outstanding resource to ensure the on-going capability in these disciplines. The resource is at risk, however, due to the high potential for those in the younger age brackets to change career direction within 5 to 10 years. There is an urgent need to reduce the potential loss by implementing strategies to improve job security and create more positive career paths. Important factors in this relate to addressing issues of short-term appointments and project funding strategies in addition to the issues of knowledge transfer and succession planning identified above.

University enrolments in the sciences have generally declined over the last decade or so and there is a high level of attrition from years 1 and 2 of undergraduate courses. Much of this loss is towards the professional life sciences and there is more that can be done to ensure that the enabling sciences of plant pathology and entomology are seen to be attractive and offer rewarding careers. In current course structures undergraduate programs tend to be generalized which is largely considered to be appropriate provided that opportunities for specialisation are available at the postgraduate level or through professional development programs.

Therefore, to ensure that capability is retained and suitably developed to meet the on-going requirements of industry and environment the following areas need to be addressed:

- The implementation of strategic programs to improve retention of existing capability. These programs must address the following:
 - lack of job security arising from funding and tenure policies
 - in-service and professional development programs to ensure a broader skills base
 - knowledge transfer, career planning and succession planning in order to capture existing capability and ensure its long term retention
 - retention incentives for valued emerging talent
- Undertake targeted career exposé programs at high school level and during undergraduate programs that promote the positive aspects of plant pathology and entomology careers.
- Develop inspirational curricula that ensure integration with industry during undergraduate programs and provide genuine specialisation at postgraduate levels, ensuring that these programs are supported by increased allocation of education and training capability in the university sector.
- Ensure flexible delivery of specialized postgraduate programs in order to overcome the need to have large enrolments in any one location.
- Encourage industry recruitment of graduates from undergraduate programs, thus enhancing the development of practical skills and closing the opportunity gap currently evident.
- Rebuild the teaching resource within universities to ensure requisite teaching skills, appropriate incentives and professional recognition for teaching commitment.



Acronyms

AERS	Agricultural, Environmental & Related Studies
AFFA	Australian Government Department of Agriculture, Fisheries and Forestry
APPC	Australasian Plant Pathology Curriculum
BACS	The University of Queensland Faculty of Biological and Chemical Sciences,
CRC	Cooperative Research Centre
CRCTPP	Cooperative Research Centre for Tropical Plant Protection
CRI	Crown Research Institute
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEST	Australian Government Department of Education, Science and Training
FTE	Full-time equivalent
GRDC	Grains Research and Development Corporation
NPS	Natural and Physical Sciences
SET	Science, Engineering and Technology



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Appendix A: Statistical Limitations

The survey was distributed as widely as possible with the intention of maximizing the response level rather in order to provide a valid representation of the two disciplines. The data is not statistically analysed but, based on the level of responses, is presented as a valid snapshot of plant pathology and entomology capability, distribution and opinions. Comparisons are made within individual survey questions and relationships between questions are based on a direct one-to-one relationship.

As with any survey there will always be different interpretations of questions. In some cases the opportunity to provide comment was available in order to offer additional clarity.

Some organisations were particularly keen to ensure strong participation of their staff and were therefore diligent in distribution of the survey and promoted its completion with their staff. Some organisations were ambivalent or disinterested resulting in a variable response and therefore there is potential for a small degree of bias in the data.

Note: Abbreviation of Organisation Type

The survey sought to identify the nature of the employing organisation as distinctively as possible. A detailed description of organisation type was provided in order to minimize ambiguity. Differentiation was primarily based on the nature of the various organisation types targeted by the survey. However, for the purpose of the analyses, a number of organisations have been grouped together and abbreviated as shown in Table 12. The organisation detail has not been lost in the raw data and can be analysed separately if required.

• **Table 12: Classification of organisations grouped for analysis purposes.**

Classification	Comments
Gov1	<p>Government organisations with a strong application focus which may include extension, applied research or practical management of agricultural or natural resources:</p> <p>State departments of primary industries, forestry or agriculture. Ministry of Agriculture and Forestry. Plant health, quarantine or biosecurity. Heritage and environment</p>
Gov2	<p>Government organisations with primarily a research focus:</p> <p>CSIRO/ENSIS Crown Research Institutes Cooperative research Centres Industry research and development organisations</p>
Edu	<p>Organisations in an educational environment</p> <p>Universities and Higher Education. Vocational</p>
Comm	<p>Organisations having a commercial focus</p> <p>Suppliers and distributors of agricultural inputs including pest and disease management solutions. Service providers including consultants, advisors and extension services. R&D start-up companies.</p>
Other	<p>Unclassified including primary producer and grower associations.</p>

B

Appendix B: Survey

Introduction

The purpose of this survey is to obtain information about two aspects of plant pathology and entomology in Australia and New Zealand. Part A is designed to capture a snapshot of the current capability in these disciplines, identify the type of organisations where the capability exists and how it is utilized. This information will be profiled against age groupings and expected service, which will be helpful in assessing future capability distribution.

Part B is designed to obtain feedback from various industry levels about current and future industry needs for plant pathology and entomology expertise. This will provide valuable information to assist in planning education and training programs to ensure the availability of specialists to support future industry requirements.

You may wish to complete only Part A or Part B of the survey. For example, if you are a plant pathologist or entomologist with no input on industry needs just complete Part A. If you are not a plant pathologist or entomologist but are engaged in industry in a role that provides you insight into industry requirements in these disciplines just complete Part B. You will be given the option to either complete or skip at the beginning of each of Part A and Part B

Introductory questions for all participants.

- 1) Which of the following best describes the type of organisation in which you are employed, or industry group in which you are involved (select only your primary employer or industry group)?
 - University/Higher education
 - State Department/Ministry of Agriculture, Primary Industries or Forestry
 - Crown Research Institute
 - Commercial Company – supplier
 - Commercial Company – distributor
 - Commercial Company – services
 - Commercial Company – R&D start-up
 - Primary Producer or Grower Association
 - CSIRO/ENSIS
 - Cooperative Research Centre (primary employer)
 - National Plant Health, Quarantine or Biosecurity entity
 - Heritage or Environment (eg Landcare/Museum/National Park/Botanical Garden)

- Vocational (eg Agricultural College/TAFE)
- Industry Research and Development Corporation (eg HAL/GRDC/CRCO/FAR)
- Not currently employed (eg seeking employment or retired)
- Other – please specify

2) If you are associated with a CRC please indicate your percentage in-kind contribution.

 %

3) I am currently located in:

- New Zealand
- Australia
- Other – thank you, you do not need to complete this survey at this time

4) Are you trained or employed in either plant pathology or entomology?

If you answer **YES** you will be directed to **Part A** of the survey (Plant Pathology and Entomology Capability).

If you answer **NO** you will be directed to **Part B** of the survey (Current and Future Industry Needs).

- Yes – go to question 5
- No – go to question 26

Part A – Plant pathology and entomology capability

5) Indicate your highest level of formal training

- High school year 12 (or equivalent)
- Vocational/TAFE/Diploma
- Undergraduate degree
- Undergraduate degree with honours
- Graduate diploma
- Masters degree (coursework)
- Masters degree (research)
- Doctorate

6) What is your age bracket?

- <25
- 25-34
- 35-44

45-54

>55

7) Do you anticipate leaving your work in the Australian/NZ Plant Pathology or Entomology fields within the next:

<5 years

5-10 years

11-15 years

No plans to leave within the above time frame – go to question 9

8) Please identify the likely reason for leaving employment in Australian/NZ plant pathology or entomology from the options below:

Retirement

Career development (new field of activity)

Career development (overseas study or overseas opportunity)

Limited tenure/funding constraints

Other – please specify

9) How concerned are you about each of the following issues associated with **your** employment in plant pathology or entomology in Australia/NZ?

	Not concerned at all	Concerned	Very concerned	Extremely concerned
Employment opportunities in your field	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prospects for career progression	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Emphasis on provision of services in commercial context	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tenure or funding constraints	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Work pressure demands	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Are there other issues that concern you? Please specify	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

10) How concerned are you about each of the following issues associated with the future requirements within **your** area of plant pathology or entomology in Australia/NZ?

	Not concerned at all	Concerned	Very concerned	Extremely concerned
General capacity to meet demands for services	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Impact of emergency response requirements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Availability of key staff in critical activity areas	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Access to graduates in specialty disciplines	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Standard of graduate skills base	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Movement of staff to overseas positions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Anticipated retirement of key personnel	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Are there other issues that concern you? Please specify in the comments section	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Comment:

11) What is your primary discipline?

- Plant pathology – go to question 12
- Entomology – go to question 16

12) Plant pathology – What is your sub-discipline?

- Mycology
- Virology
- Bacteriology
- Nematology
- Molecular Plant Pathology
- Phytoplasmas
- No specific sub-discipline
- Other (please specify)

13) If you have a focus on a particular systematic group (eg Fusarium, Phytophthora etc) please record that here.

14) In what capacity do you work in your sub-discipline area? What percentage of your time do you devote to each area checked? For each of the 'capacities' checked indicate the primary environment that best fits your program.

Capacity	% allocation	Primary environment options (select one for each capacity checked)
<input type="checkbox"/> Diagnostics – Laboratory	<input type="text"/>	
<input type="checkbox"/> Diagnostics – Field	<input type="text"/>	

<input type="checkbox"/> Emergency response and management	%	Education/Teaching
<input type="checkbox"/> Genetics	%	Research - Basic
<input type="checkbox"/> Physiology	%	Research - Strategic
<input type="checkbox"/> Epidemiology	%	Research - Applied
<input type="checkbox"/> Taxonomy	%	Extension
<input type="checkbox"/> Disease control and management (Resistance/Breeding)	%	Regulatory/Policy
<input type="checkbox"/> Disease control and management (Biological or Chemical inputs & practices)	%	Quarantine
<input type="checkbox"/> Administration	%	Commercial - Sales/Marketing
<input type="checkbox"/> If 'Other' – please specify in the comments box	%	Commercial - Technical/ Advisory

15) Comments:

You have completed the specific plant pathology questions now go to question 20.

16) Entomology – What is your sub-discipline?

- Taxonomy/Systematics
- Genetics
- Physiology
- Biochemistry
- Insect pathology
- Behaviour
- No specific sub-discipline
- Other – please specify

17) If you have a focus on a particular systematic group (eg Lepidoptera, Diptera; Arachnids, other invertebrates etc) please record that here.

18) In what capacity do you work in your sub-discipline area? What percentage of your time do you devote to each area checked? For each of the 'capacities' checked indicate the primary environment that best fits your program.

Capacity	% allocation	Primary environment options (select one for each capacity checked)
<input type="checkbox"/> Diagnostics - Laboratory	<input type="text"/> %	

<input type="checkbox"/> Diagnostics - Field	%	Education/Teaching
<input type="checkbox"/> Emergency response and management	%	Research - Basic
<input type="checkbox"/> Population studies	%	Research - Strategic
<input type="checkbox"/> Quarantine	%	Research - Applied
<input type="checkbox"/> Pest control and management (including IPM)	%	Extension
<input type="checkbox"/> Environmental	%	Regulatory/Policy
<input type="checkbox"/> Administration	%	Quarantine
<input type="checkbox"/> If 'Other' – please specify in the comments box	%	Commercial - Sales/Marketing
		Commercial - Technical/
		Advisory

19) Comments:

20) Indicate the industry focus that best fits your program. You may select more than one and estimate percentage time allocated.

Primary Focus	% allocation
<input type="checkbox"/> Agriculture – Production	%
<input type="checkbox"/> Agriculture – Storage	%
<input type="checkbox"/> Horticulture – Production	%
<input type="checkbox"/> Horticulture – Post-harvest	%
<input type="checkbox"/> Forestry - Production	%
<input type="checkbox"/> Forestry – Wood Products	%
<input type="checkbox"/> Forestry - Urban	%
<input type="checkbox"/> Nursery/Turf/Ornamental	%
<input type="checkbox"/> Heritage/Natural Ecosystems	%

21) Do you anticipate undertaking further study in plant pathology or entomology in the future?

- Yes – in Australia/NZ
- Yes – overseas
- No – Go to question 24

22) How soon do you plan to commence further study?

- <5 years
- >5 years

23) Please indicate the expected level of your next study program.

- High school year 12 (or equivalent)

- TAFE Diploma
- Undergraduate degree
- Masters degree (coursework)
- Masters degree (research)
- Doctorate
- Postdoctorate
- Unsure

24) Have you registered on the Plant Health Australia Expertise Register?

- Yes
- No

25) We would like to conduct a small number of short interviews with respondents to this **Part A** of the survey. Would you be willing to participate in a telephone interview? If **yes** please provide your contact details below.

First Name	
Last Name	
Contact Phone Number	
Email	

26) Are you in a position that allows you to comment on current and future industry needs? This includes plant pathologists, entomologists or administrators who have insight to industry needs.

If you answer **YES** you will be directed to **Part B** of the survey (Current and Future Industry Needs).

If you answer **NO** you will be directed to the end of the survey.

- Yes – go to question 27
- No – go to the end of the survey and 'submit'

Part B – Current and future industry needs

27) Are you currently involved in the appointment of plant pathology or entomology staff within your organisation?

- Yes
- No

28) Are you familiar with the plant pathology requirements of your organisation?

- Yes – go to question 29
- No – go to question 35

29) Rate the following sub-disciplines in terms of their **current importance** to your organisation. *Where 1= 'not very important' and 5= 'very important'.*

	1 - Not				5 - very
Mycology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Virology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bacteriology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Nematology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Molecular Plant Pathology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Phytoplasmas	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Additional comment:

30) Rate the following skills and competencies in terms of their **current importance** to your organisation. *Where 1= 'not very important' and 5= 'very important'.*

	1 - Not				5 - very
Diagnostics – Laboratory/taxonomic	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Diagnostics – Field Skills	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Risk assessment and quarantine services	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Emergency response and management	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Genetics	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Physiology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Epidemiology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Taxonomy (other than for diagnostics)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Disease control and management (Resistance Breeding)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Disease control and management (Biological or Chemical inputs & practices)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Education and Training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

31) Indicate your **three** main sources of the skills and competencies required:

- Internal
- University/Higher education
- State Department/Ministry of Agriculture or Forestry
- Commercial Agronomist/Service Provider/Consultant
- Grower or Industry Association
- CSIRO/ENSIS

- Cooperative Research Centre
- National Plant Health, Quarantine or Biosecurity entity
- Rural Industry Research and Development Corporation (eg HAL/GRDC/CRDC/FAR)
- Other – please specify

32) How well would you rate the accessibility of support for the required skills and competencies? 1 = 'not accessible', 5= 'very accessible':

1 - Not					5 - very
○	○	○	○	○	○

33) How well would you rate the quality of the skills and competencies available to your organisation? 1 = 'poor quality', 5= 'great quality'.

1 - Not					5 - very
○	○	○	○	○	○

34) Rate the following skills and competencies in terms of their **future importance** to your organisation. Where 1= 'not very important' and 5= 'very important'.

	1 - Not				5 - very
Diagnostics – Laboratory/taxonomic	○	○	○	○	○
Diagnostics – Field Skills	○	○	○	○	○
Risk assessment and quarantine services	○	○	○	○	○
Emergency response and management	○	○	○	○	○
Genetics	○	○	○	○	○
Physiology	○	○	○	○	○
Epidemiology	○	○	○	○	○
Taxonomy (other than for diagnostics)	○	○	○	○	○
Disease control and management (Resistance Breeding)	○	○	○	○	○
Disease control and management (Biological or Chemical inputs & practices)	○	○	○	○	○
Education and Training	○	○	○	○	○

35) Are you familiar with the entomology requirements of your organisation?

- Yes – Go to question 36
- No – Go to question 42

36) Rate the following sub-disciplines in terms of their **current importance** to your organisation. Where 1= 'not very important' and 5= 'very important'.

	1 - Not			5 - very	
Taxonomy/Systematics	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Genetics	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Physiology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Biochemistry	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Insect Pathology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Behaviour	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

37) Rate the following skills and competencies in terms of their **current importance** to your organisation. *Where 1= 'not very important' and 5= 'very important'.*

	1 - Not			5 - very	
Diagnostics – Laboratory/taxonomic	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Diagnostics – Field Skills	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Risk assessment and quarantine services	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Emergency response and management	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Curation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pest control and management	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Environment and Ecology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Education and Training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

38) Indicate your **three** main sources of support for the skills and competencies required:

- Internal
- University/Higher education
- State Department/Ministry of Agriculture or Forestry
- Commercial Agronomist/Service Provider/Consultant
- Grower or Industry Association
- CSIRO/ENSIS
- Cooperative Research Centre
- National Plant Health, Quarantine or Biosecurity entity
- Rural Industry Research and Development Corporation (eg HAL/GRDC/CRDC/FAR)
- Other – please specify

39) How well would you rate the accessibility of support for the required skills and competencies? 1 = 'poor', 5= 'excellent':

1
poor

5
excellent

40) How well would you rate the quality of the skills and competencies available to your organisation? 1 = 'poor', 5= 'excellent'.

1
poor

5
excellent

41) Rate the following skills and competencies in terms of their **future importance** to your organisation. Where 1= 'not very important' and 5= 'very important'.

	1 - Not				5 - very
Diagnostics – Laboratory/taxonomic	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Diagnostics – Field Skills	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Risk assessment and quarantine services	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Emergency response and management	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Curation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pest control and management	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Environment and Ecology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Education and Training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

42) Rate the following attributes in terms of importance to the people your organisation will employ in the future? Where 1= 'not very important' and 5= 'very important'.

	1 - Not				5 - very
Training or teaching skills	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Laboratory skills	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Field based skills	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Communication skills	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Research skills (Basic, Strategic or Applied)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Commercial or advisory skills	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

43) In order to meet the future needs of your organisation on which three of the following programs (**in order of priority 1-3**) would you place the greatest emphasis?

- Internal training programs
- Generalized undergraduate program

- Undergraduate specialisation
- Development of practical/field based skills
- Postgraduate specialisation
- Availability of postgraduate programs
- Professional development opportunities
- Flexibility in delivery formats

44) There are many ways in which your organisation might support an enhanced curriculum for the training of plant pathologists and entomologists. For each of the following indicate the likely level of your organisation's support. If **'Other'**, please provide comments.

	unlikely	possible	highly likely
An employer of undergraduates	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
An employer of postgraduates	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Provide financial support/scholarships/cadetships for internal staff	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Provide annual corporate scholarship or award on a competitive basis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Offer work experience or short term on the job opportunities for trainees	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Provide direct sponsorship for a particular course or specialty unit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Contribute skills to on-line or distance training programs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Additional comments:

45) We would like to conduct a small number of short interviews with respondents to this **Part B** of the survey. Would you be willing to participate in a telephone interview? If **yes** please provide your contact details below.

First Name	<input style="width: 550px; height: 15px;" type="text"/>
Last Name	<input style="width: 550px; height: 15px;" type="text"/>
Contact Phone Number	<input style="width: 550px; height: 15px;" type="text"/>
Email	<input style="width: 550px; height: 15px;" type="text"/>

46) Please add any further comment regarding future plant pathology or entomology training needs for your organisation.



Appendix C: Survey Results

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Survey Results

The survey was distributed widely to and through organisations considered to be likely or possible employers of plant pathology and entomology staff, as well as industry organisations likely to have requirements for access to expertise from these disciplines.

At its close there had been 359 responses to the survey that were checked and considered to be suitable for inclusion in the analysis. There were 329 responses from Australia and 30 from New Zealand. Of the 359 responses 183 (51%) completed Part A, plant pathology section, 151 (42%) completed Part A, entomology section and 160 (45%) completed Part B on future needs. Some completed both Part A and Part B.

Part A: Plant Pathology and Entomology Capacity

Part A was completed by 334 respondents representing 93% of survey returns.

Distribution of Capability

An important objective of the survey was to determine the distribution of plant pathology and entomology capability throughout Australia and New Zealand. Question 1 asked respondents to identify the type of organisation that best described where they were employed.

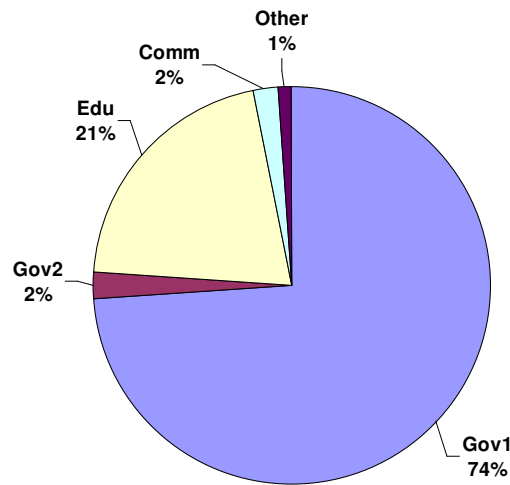
Plant Pathologists

Figure 7 and Figure 8 illustrate the distribution of plant pathologists across the various organisation types in Australia and New Zealand respectively.

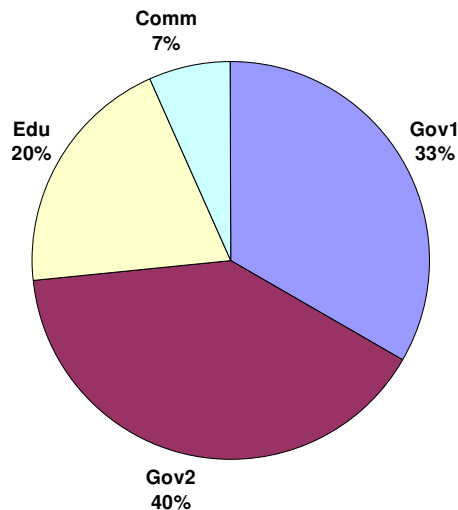
In Australia the largest group of plant pathologists are in the Gov1 classification (74%), followed by the Edu classification (21%). Gov2 and commercial in Australia each accounts for 2% of plant pathologists.

In New Zealand the spread of plant pathologists is across the Gov2 classification (40%), Gov1 (primarily the Ministry of Agriculture and Forestry) at 33% and Edu at 20%. Only one other group was represented in New Zealand, that being commercial at 7%

• **Figure 7: National Distribution of Plant Pathology Capability by Organisation – Australia (n=168)**



• **Figure 8: National Distribution of Plant Pathology Capability by Organisation – New Zealand (n=15)**



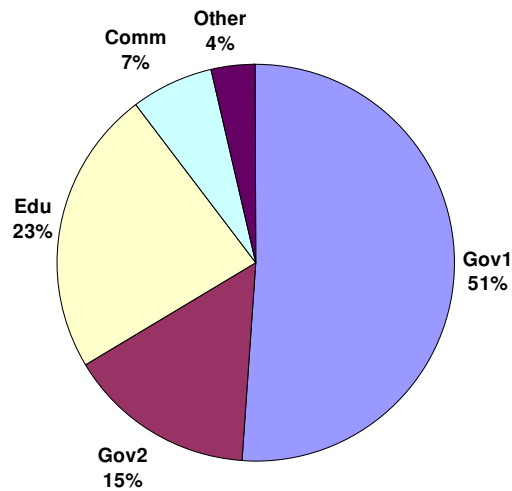
Entomologists

Figure 9 and Figure 10 illustrate the distribution of entomologists across the various organisation types in each country respectively. The Gov1 classification makes up the largest percentage of Entomologists (51%). Edu classification (23%) followed by Gov2

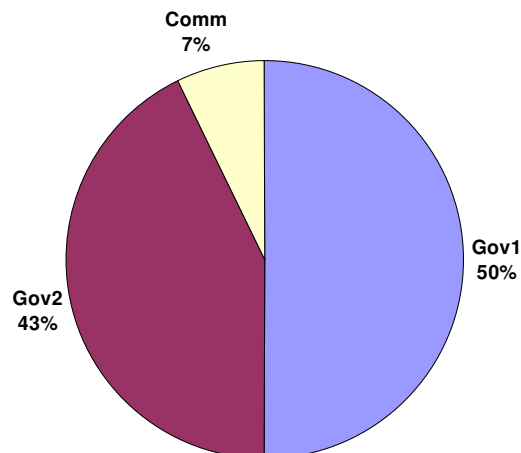
(14%) contribute the next largest percentages. Commercial contributes 7% and others, 4%.

In New Zealand the Gov1 classification contributes the largest proportion of entomologists at 50% while Gov2 contributes 43%. Commercial entities were represented with 7% of respondents.

• **Figure 9: National Distribution of Entomology Capability by Organisation – Australia (n=137)**



• **Figure 10: National Distribution of Entomology Capability by Organisation – New Zealand (n=14)**



Regional Distribution

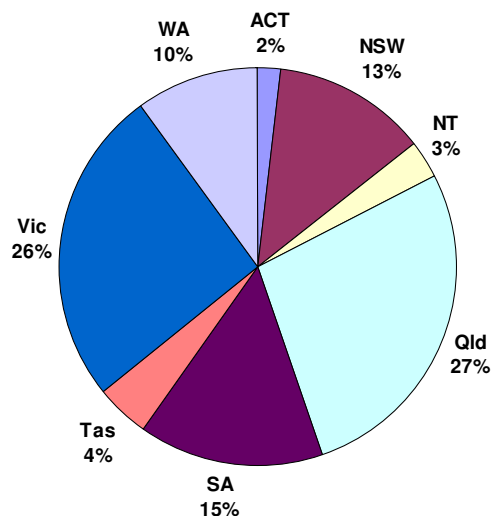
The survey did not request any regional identification from New Zealand and of Australian responses a small percentage of surveys failed to provide sufficient information to identify clearly the source state. There were 30 responses in total from New Zealand and out of 329 Australian responses 295 could be linked to specific states.

Figure 11 illustrates the regional distribution of plant pathologists in Australia while Figure 12 illustrates the regional distribution of entomologists.

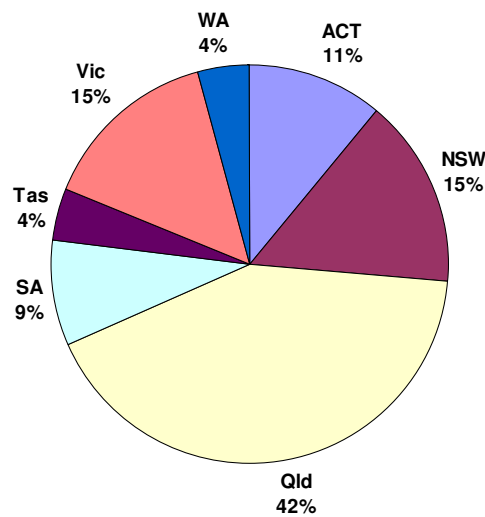
Of 168 responses from Australian based plant pathologists, 159 could be identified with a state location. Queensland and Victoria revealed the highest percentages of plant pathologists at 27% and 26% percent respectively.

Of 137 responses from Australian based entomologists, 117 could be identified with a state location. Queensland reported a much larger percentage of entomologists than other states at 42% of state based responses. NSW and Victoria followed, each at 15%.

• **Figure 11: Regional Distribution of Plant Pathology Capability – Australia (n=159)**



• **Figure 12: Regional Distribution of Entomology Capability – Australia (n=117)**



Qualification Levels

Question 5 asked respondents to indicate the highest level of formal training completed. A total of 333 responses were received to this question and Table 13 summarizes this data. The results show a high percentage of practitioners in the plant pathology and entomology disciplines are qualified at the doctorate level (53%) followed by undergraduates (14%), undergraduates with honours (13%) and then masters degree (research) (10%).

This data is then cross-tabulated with employing organisations (Table 14) to show the distribution of these qualifications across organisation type. Edu, Gov1 and Gov2 are well represented with doctorates. Of all Edu respondents 76% held PhDs; Gov2, 51% and Gov1 reported a 47% level of PhDs. The Gov1 sector is clearly the strongest employer of those holding masters degrees, 11% of Gov1 respondents, and undergraduates at 30% of Gov1 respondents.

• **Table 13: Highest level of training reported (n=333)**

Level	Number	%
Doctorate	175	53
Masters degree (research)	33	10
Masters degree (coursework)	6	2
Graduate diploma	11	3
Undergraduate degree with honours	43	13
Undergraduate degree	48	14
Vocational/TAFE/Diploma	13	4
High school year 12 (or equivalent)	4	1
Total	333	100

• **Table 14: Qualifications reported by organisation type, actual numbers (n=333)**

Level	Organisation				
	Gov1	Gov2	Edu	Comm	Other
Doctorate	96	19	53	3	4
Masters degree (research)	22	6	3	0	2
Masters degree (coursework)	1	1	1	2	1
Graduate diploma	9	0	0	2	0
Undergraduate degree with honours	28	3	10	2	0
Undergraduate degree	33	8	2	5	0
Vocational/TAFE/Diploma	13	0	0	0	0
High school year 12 (or equivalent)	3	0	1	0	0
Total	205	37	70	14	7
Overall %	61.6	11.1	21.0	4.2	2.1

Age Profile and Service Expectations

An important aspect of the study was to determine the age profile of each of the disciplines. Separate analyses have been made for plant pathologists and entomologists with the results shown in Table 15 and Table 17 respectively. These tables cross-tabulate the age profiles across organisation types. In addition to requesting information on respondents' age bracket the survey also sought information on service expectations in order to gain some insight into risk factors that might impact the future availability of plant pathologists and entomologists to meet industry needs. These data are presented for each discipline in Table 16 and Table 18 respectively with the combined data in Table 19.

Plant Pathology

Overall just over 50% of plant pathologists are under 45 with only 14.6% 55 or over. This profile is driven largely by the Gov1 and Edu sectors having produced the largest number of respondents. Although an option on the survey there were no responses from the under 25 age bracket.

• **Table 15: Age profile by organisation – plant pathology (n=178)**

	Number of Respondents in Age Bracket				Total
	25-34	35-44	45-54	55+	
Gov1	31	35	45	16	127
Gov2	5	1	1	2	9
Edu	9	7	14	6	36
Comm	2	1	0	1	4
Other	1	0	0	1	2
Total	48	44	60	26	178
Overall %	27.0	24.7	33.7	14.6	100

Based on the survey data, Table 16 reveals that 25.1% of plant pathologists expect to leave service under 5 years with a further 23.5% within 10 years. Close to 40% have an expectation in excess of 15 years.

• **Table 16: Service Expectations by organisation – plant pathology (n=183)**

	Expected Future Years of Service				Total
	<5	5-10	11-15	>15	
Gov1	38	28	15	48	129
Gov2	2	4	0	4	10
Edu	6	9	8	15	38
Comm	0	1	0	3	4
Other	0	1	0	1	2
Total	46	43	23	71	183
Overall %	25.1	23.5	12.6	38.8	100

Entomology

In the case of entomology the distribution across the age profile is relatively even with only a slight elevation in the two brackets, 35–45 and 45–54. Once again the Gov1 and Edu sectors dominate the age distribution numbers. However, Gov2 and Commercial organisations are well represented, demonstrating a profile tending towards the younger age brackets. There were no responses in the under 25 age bracket.

• **Table 17: Age profile by organisation – entomology (n=148)**

	Number of Respondents in Age Bracket				Total
	25-34	35-44	45-54	55+	
Gov1	12	19	27	17	75
Gov2	10	7	4	6	27
Edu	5	11	10	6	32
Comm	4	3	1	1	9
Other	1	1	1	2	5
Total	32	41	43	32	148
Overall %	21.6	27.7	29.1	21.6	100

Results shown in Table 18 for entomology are very similar to those for plant pathologists with around 50% expecting to serve 10 years or less. The greatest exposure in this area is Gov2 with 81.5% of respondents from this classification indicating a potential departure within 10 years.

• **Table 18: Service Expectations by organisation – entomology (n=151)**

	Expected Future Years of Service				Total
	<5	5-10	11-15	>15	
Gov1	16	21	13	27	77
Gov2	11	11	0	5	27
Edu	8	4	5	15	32
Comm	2	1	1	6	10
Other	0	2	0	3	5
Total	37	39	19	56	151
Overall %	24.5	25.8	12.6	37.1	100

Table 19 summarizes the combined results for both plant pathology and entomology. Close to 25% of respondents will potentially leave in each of the time periods, <5 years and 5-10 years. Thirty-eight percent expect to remain in excess of 15 years.

• **Table 19: Number of respondents for each period of expected years of service for plant pathologists and entomologists, Australia and New Zealand (n=334)**

Discipline	<5	5-10	11-15	>15	Total
Plant pathology	46	43	23	71	183
Entomology	37	39	19	56	151
Total	83	82	42	127	334
Overall %	24.8	24.6	12.6	38.0	100

Likely Reasons to Leave Plant Pathology or Entomology

Those respondents that anticipated leaving their employment in Australia/NZ in the time frames up to 15 years were asked to complete Question 8 identifying likely reasons for

their departure. Table 20 combines the service expectations data for plant pathologists and entomologists and cross tabulates the 207 responses to provide a relationship between the expected years of service and likely reasons for departure. For those expecting to leave within 5 years 28.9% indicate retirement as the likely reason and 34.9% indicate issues around limited tenure or funding constraints. Career development (new field of activity) is also important in the case of short horizon (<5 years) respondents (21.7%). Career Development (overseas study or opportunity) is indicated by 6.3% overall.

Those with a longer horizon of 5-10 years indicate retirement as the most likely reason (67.1%) and an even higher percentage (81.0%) of those with an 11-15 year horizon anticipate retirement as the most likely reason to leave.

• **Table 20: Relationship between service expectations and likely reasons to leave plant pathology or entomology (n=207)**

Reason to Leave	Expected future years of service			Total	%
	<5	5-10	10-15		
Retirement	24	55	34	113	54.5
Career development (new field of activity)	18	5	4	27	13.0
Career development (overseas study or overseas opportunity)	6	7	0	13	6.3
Limited tenure/funding constraints	29	11	2	42	20.3
Other	6	4	2	12	5.8
Total	83	82	42	207	100
Overall %	40.1	39.6	20.3	100	

Sub-Discipline Capability

Both plant pathology and entomology are relatively broad disciplines, each with a range of speciality or sub-discipline areas. It was important in this study to identify how the various sub-discipline areas are resourced. A series of questions was designed in the survey to capture information, not only on the sub-disciplines in each of plant pathology and entomology but also to understand

- In what capacity (field of application) the sub-disciplines are applied,
- the fulltime equivalent (FTE) allocation to each capacity, and
- the primary environment in which each capacity is applied.

Table 21 summarizes the focus of the various questions in this section while Table 22 defines the terms 'sub-discipline', 'capacity' and 'primary environment' as used in the survey. The full detail of these questions can be found in the complete survey attached as Appendix D.

- **Table 21: Focus of survey questions relating to sub-discipline resource allocation, capacities in which applied and primary environment of application.**

Focus of Question	Numbering in Survey (Plant Pathology)	Numbering in Survey (Entomology)
Identify primary discipline	11	11
Identify sub-discipline	12	16
Identify specialty focus within sub-discipline	13	17
Identify application area, FTE allocation and primary environment in which applied	14	18

- **Table 22: Explanation of terms sub-discipline, capacity and primary environment as used in the survey**

Primary Discipline	Sub-discipline Areas	Capacities	Primary Environment
Plant Pathology	Mycology Virology Bacteriology Nematology Molecular plant pathology Phytoplasmas No specific sub-discipline Other	Diagnostics – laboratory Diagnostics – field Emergency response & management Genetics Physiology Epidemiology Taxonomy Disease management (resistance/breeding) Disease management (Inputs/practices) Administration Other	Education/Teaching Research – Basic Research – Strategic Research – Applied Extension Regulatory/Policy Quarantine Commercial – Sales/Marketing Commercial – Technical/Advisory
Entomology	Taxonomy/Systematics Genetics Physiology Biochemistry Insect pathology Behaviour No specific sub-discipline Other	Diagnostics – laboratory Diagnostics – field Emergency response & management Population studies Curation Pest control & management Environmental Administration Other	Education/Teaching Research – Basic Research – Strategic Research – Applied Extension Regulatory/Policy Quarantine Commercial – Sales/Marketing Commercial – Technical/Advisory

Sub-discipline areas of Plant Pathologists

Part A, plant pathology, of the survey was completed by 183 respondents reporting a total of 174.3 FTEs across the various sub-disciplines as shown in Table 23. Mycology is the strongest sub-discipline represented at 45.1% of all FTEs reported. No specific sub-discipline, representing generalist plant pathologists, accounted for 16.0% of FTEs. Remaining FTEs were molecular plant pathology (9.3%), virology (9.0%), nematology (7.1%) and bacteriology (4.0%). There were no responses identifying phytoplasmas as a specific sub-discipline. However, phytoplasmas were reported in association with bacteriology and/or virology sub-disciplines.

Table 23 also cross tabulates the sub-disciplines with organisation types but apart from Gov1 and Edu overall FTEs are relatively modest. but the emphasis on mycology and molecular plant pathology tends to be evident.

• **Table 23: FTEs for plant pathology sub-discipline areas within organisations (n=183)**

	Plant Pathology Sub-discipline							Total
	Bacteriology	Molecular Plant Pathology	Mycology	Nematology	No specific sub discipline	Virology	Other	
Gov1	6.0	4.0	54.3	10.5	22.0	14.3	12.6	123.6
Gov2	0.0	4.0	1.8	0.0	2.0	0.0	2.0	9.8
Edu	1.0	8.2	19.5	1.0	2.0	1.5	1.7	34.9
Comm	0.0	0.0	2.0	0.0	2.0	0.0	0.0	4.0
Other	0.0	0.0	1.0	1.0	0.0	0.0	0.0	2.0
Total	7.0	16.2	78.6	12.5	28.0	15.8	16.3	174.3
Overall %	4.0	9.3	45.1	7.1	16.0	9.0	9.4	100

Sub-discipline areas of Entomologists

Part A, entomology, of the survey was completed by 151 respondents reporting a total of 135.1 FTEs across the various sub-disciplines as shown in Table 24. Taxonomy/systematics is the strongest sub-discipline represented at 18.4% of all FTEs reported. No specific sub-discipline, representing generalist entomologists, accounted for 13.8% of FTEs. Remaining FTEs were behaviour (6.9%), insect pathology (5.7%), genetics (5.1%) with biochemistry and physiology each (0.7%). Almost 50% of entomologists selected 'other' for sub-discipline indicating that the survey sub-discipline categories were not closely aligned with how a large proportion of entomologists define the focus of their training. Table 25 provides a selection of responses recorded in 'other' in the context of sub-discipline. Control and management activities tend to dominate in these responses.

• **Table 24: FTEs for entomology sub-discipline areas within organisations (n=151)**

	Entomology Sub-discipline								Total
	Behaviour	Biochemistry	Genetics	Insect pathology	No specific sub discipline	Physiology	Taxonomy /Systematics	Other	
Gov1	3.0	0.0	1.0	3.0	7.8	1.0	20.0	33.1	68.9
Gov2	1.0	1.0	2.0	1.0	4.8	0.0	1.0	13.9	24.6
Edu	4.0	0.0	4.0	2.9	4.0	0.0	2.9	10.9	28.6
Comm	1.0	0.0	0.0	0.0	2.0	0.0	0.0	6.0	9.0
Other	0.4	0.0	0.0	0.8	0.0	0.0	1.0	2.0	4.1
Total	9.3	1.0	7.0	7.7	18.6	1.0	24.8	65.8	135.1
Overall %	6.9	0.7	5.1	5.7	13.8	0.7	18.4	48.7	100

• **Table 25: A selection of sub-discipline areas identified by entomologists that selected 'other' in response to question 16.**

Insect rearing	Insect-plant interactions
Integrated pest management	Medical Entomology
Biological control & biodiversity & ecology	Biocontrol of weeds, pest management
Ecology - Pest Management	Forest entomology
Chemical ecology and IPM	Spray Application Technology
Multiple: Behaviour; Physiology: Structure and Function	Development & Extension in Stored grain pests

Primary Environment of Plant Pathology and Entomology Capacity

Respondents were asked to identify the primary environment that best fits their program for each of the capacities reported. Table 26 provides a summary of the FTEs for each of the primary environments identified in the survey. Research – Applied stands out as the primary environment for both plant pathologists and entomologists at 39.4% and 41.9% of FTEs respectively. Combining all research categories the emphasis on research becomes very evident with 64.1% of plant pathology FTEs applied in research while 68.1% of entomology FTEs are similarly engaged.

Only 3.9% of plant pathology FTEs and 5.1% of entomology FTEs were recorded against education/teaching as the primary environment of respondents. In plant pathology, support services (9.6%), quarantine (7.2%) and extension (6.8%) all exceed 5% of FTEs. For entomology, quarantine at 12.8% captures the most FTEs after research activities.

• **Table 26: Plant pathology and entomology capacity expressed as FTEs and percentage FTEs as applied in a range of environments (n=334)**

	Plant Pathology		Entomology	
	FTEs	%	FTEs	%
Education/Teaching	6.5	3.9	6.7	5.1
Research – Basic	24.0	14.6	17.4	13.1
Research – Strategic	16.7	10.1	17.4	13.1
Research – Applied	64.9	39.4	55.5	41.9
Extension	11.2	6.8	3.3	2.5
Support Services	15.9	9.6	0	0
Regulatory/Policy	6.8	4.1	6.8	5.1
Quarantine	11.8	7.2	16.9	12.8
Commercial – Sales/Marketing	0.1	0.1	1.6	1.2
Commercial – Technical/Advisory	7.2	4.4	7.0	5.3
Total	164.9	100.0	132.5	100.0

Primary focus of Plant Pathologists and Entomologists

In order to achieve a better understanding of how the plant pathology and entomology resources are applied in Australia/NZ it is important to determine the context in which they are applied, that is to identify the primary focus. Often the particular skills are applied across a range of activities so respondents were given the opportunity to select more than one area of primary focus but provide an estimate of the percentage of their time allocation to each area. This provided the data shown in Table 27, which shows the percentage FTEs applied in the various areas of primary focus. The data is cross tabulated with organisation classification to provide some insight into how the resource is allocated by organisation.

From a total of 334 responses the survey collected data on areas of primary focus equating to a total of 307.6 FTEs. Agricultural production accounted for 40.1% of those FTEs while horticultural production accounted for 29.7%. Heritage and natural ecosystems capture 11.3% of FTEs and forestry production 6.6%. All other areas are under 5% of FTEs.

• **Table 27: Primary focus of plant pathologists and entomologists within organisations represented as FTEs (n=334)**

	Area of Primary Focus									
	Agriculture Production	Agriculture Storage	Horticulture Production	Horticulture Post-harvest	Forestry Production	Forestry Wood Products	Forestry Urban	Nursery/Turf Ornamental	Heritage	Total
Gov1	83.2	6.8	61.5	6.9	6.2	1.9	1.4	9.9	14.0	191.6
Gov2	13.1	1.0	2.8	0.1	7.6	1.1	1.5	0.7	6.1	33.9
Edu	20.6	1.1	19.3	0.8	5.0	0.6	0.3	0.9	14.2	62.6
Comm	3.7	0.1	6.1	0.6	0.5	0.0	0.4	2.0	0.1	13.5
Other	2.7	0.0	1.8	0.0	1.0	0.0	0.0	0.0	0.6	6.0
Total	123.3	9.0	91.5	8.3	20.2	3.6	3.6	13.5	34.9	307.6
Overall %	40.1	2.9	29.7	2.7	6.6	1.2	1.2	4.4	11.3	100

In addition to how plant pathology and entomology resources are applied across organisation types the survey also provided data on the areas of primary focus for the various sub-disciplines. Table 28 provides a cross tabulation with the plant pathology sub-disciplines while Table 29 shows the relationship with entomology sub-disciplines.

Bacteriology resource is applied primarily in production support with horticultural production the greatest utilisation followed by agricultural production and forestry production. Molecular plant pathology is similarly production focused but has an important application (22.5% of MPP FTEs) in the heritage/natural ecosystems area. Mycology and nematology have a strong agricultural production focus while virology is more strongly aligned with horticultural production.

• **Table 28: Primary focus of plant pathologists within sub-discipline areas represented as FTEs (n=183)**

	Area of Primary Focus									
	Agriculture Production	Agriculture Storage	Horticulture Production	Horticulture Post-harvest	Forestry Production	Forestry Wood Products	Forestry Urban	Nursery Turf Ornamentals	Heritage	Total
Bacteriology	2.8	0.1	3.9	0.2	1.7	0.3	0.2	0.2	0.1	9.2
Molecular Plant Pathology	6.6	0.4	2.6	0.0	2.6	0.3	0.6	0.1	3.8	16.9
Mycology	41.3	0.0	20.9	2.5	0.0	0.0	0.0	4.1	8.2	76.8
Nematology	8.8	0.2	2.8	0.0	0.8	0.2	0.2	0.6	0.9	14.4
Virology	4.8	0.0	7.4	0.4	0.0	0.0	0.0	0.6	0.9	13.9
No specific sub-discipline	8.0	0.1	12.9	1.0	1.5	0.2	0.3	2.5	0.6	26.9
Other	5.2	0.0	6.5	1.3	0.0	0.1	0.0	0.9	1.3	15.2
Total	77.2	0.8	56.9	5.3	6.6	1.0	1.2	8.8	15.6	173.3
Overall %	44.6	0.5	32.8	3.0	3.8	0.6	0.7	5.1	9.0	100

Entomology resources are also applied largely to the production areas. Insect behaviour has a strong allocation (19.7% of behaviour FTEs) into heritage/natural ecosystems and genetics has a strong component (19.4% of genetics FTEs) in storage. While taxonomy is production focused it has a more extensive spread across areas of primary focus as is the case with the generalised areas of no specific sub-discipline and 'other'.

• **Table 29: Primary focus of entomologists within sub-discipline areas represented as a percentage of FTEs (n=151)**

	Area of Primary Focus									
	Agriculture Production	Agriculture Storage	Horticulture Production	Horticulture Post-harvest	Forestry Production	Forestry Wood Products	Forestry Urban	Nursery/Turf Ornamentals	Heritage	Total
Behaviour	3.0	0.0	3.0	0.0	1.8	0.0	0.0	0.2	2.0	9.9
Genetics	3.7	1.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	5.2
Insect pathology	3.2	0.0	3.3	0.0	1.0	0.0	0.0	0.0	0.6	8.0
No specific sub-discipline	5.5	1.2	3.8	0.2	2.6	0.1	1.3	0.3	1.7	16.6
Other	22.9	2.3	19.9	1.0	5.7	1.3	1.0	2.5	10.1	66.5
Physiology	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
Taxonomy/Systematics	6.0	1.7	2.4	1.8	1.5	1.2	0.2	1.4	3.2	19.2
Total	45.2	6.2	32.8	3.0	12.4	2.6	2.4	4.3	17.5	126.3
Overall %	35.7	4.9	26.0	2.4	9.8	2.1	1.9	3.4	13.8	100

Issues of Concern to Plant Pathologists and Entomologists

An important objective of the study was to identify opportunities and threats. Questions 9 and 10 of the survey were designed to obtain information on areas that concern those employed in the fields of plant pathology and entomology. Question 9 focused on areas of concern associated with individual employment and job security, while Question 10 explored issues associated with organisational structure and resources, in particular the skills base.

These qualitative issues were explored further through the telephone interviews, the results of which will be discussed in the body of this report.

Employment Issues

Table 30 shows the percentage responses across a number of aspects relating to employment in the plant pathology and entomology disciplines. Respondents were asked to indicate their concerns on four levels:

- Not concerned at all
- Concerned
- Very concerned
- Extremely concerned

On the issue of employment opportunities in their field, only 15.6% were not concerned at all. 46.8% were either very concerned or extremely concerned.

Responses to the issue of prospects for career progress were very similar to those above.

There was less concern expressed on the issue of shifting emphasis towards provision of commercial services. 41.3% are concerned but only 9.9% extremely concerned and 25.6% not concerned at all.

Tenure or funding constraints elicited the strongest expression of concern with 36.4% extremely concerned, 30.4% very concerned and only 11.4% not concerned at all.

Work pressure demands also rated high on the scale with over 50% either very concerned or extremely concerned.

A number of other issues were identified in open responses and a summary of these is provided in Table 31.

• **Table 30: Level of concern expressed across a range of issues relating to employment**

	Percentage of Responses			
	Not Concerned at all %	Concerned %	Very Concerned %	Extremely Concerned %
Employment opportunities in the field	15.6	37.7	24.9	21.9
Prospects for career progression	16.1	37.4	26.1	20.4
Emphasis on provision of services in commercial context	25.6	41.3	23.2	9.9
Tenure or funding constraints	11.4	21.7	30.4	36.4
Work pressure demands	13.9	33.8	29.6	22.7
Other	35.1	13.2	16.7	35.1

• **Table 31: A selection of concerns noted when respondents selected 'other'.**

Administrative time now takes up time that could be devoted to research, etc	Gradual [loss] of expertise and not [placing] any importance on training in the fields for future.
Entire period of employment within Entomology has been contractual based on external funding. This not only creates a situation of insecurity, but requires moving from one area of speciality to another within relatively short time frames	Pay structure for plant sciences is not equivalent to that of other specialist disciplines in science. People will leave, or not consider it as a career; to move onto better paying, better funded jobs (business management etc) or not consider it at all
The extreme time requirements in the New Zealand science system for applications for funding and reporting/accountability dominate work time for senior scientists, drastically reducing the potential for innovation and new knowledge creation	Apparent lack of concern by Government and management for loss of expertise and experience taking place and looming to a greater extent in the near future.
Too much bureaucracy	Succession planning
A low paid career considering the qualifications required	Lack of public awareness of the importance of insects and plant pathogens
Continual restructuring and relocation - very disruptive to work output and meeting deadlines	Supermarket destroying horticulture

Issues Related to Organisational Structures and Resources

Organisational capability is, to some extent measured by such things as, capacity to meet the demand for services, staff availability, competency of staff and access to a suitable skills base. The latter is influenced by training of new staff and the potential for skills to be lost through relocation, resignation or retirement. The survey asked respondents to identify their levels of concern in a number of these areas and the results are summarized in Table 32.

General capacity to meet demands rated primarily as concerned or very concerned with 73.0% of responses for these two levels combined.

Impact of emergency response requirements was considered of extreme concern to 18.4% with the bulk of responses (75.4%) again falling into concerned or very concerned categories.

Availability of key staff in critical activity areas registered 26.0% responses at the extremely concerned level. This was followed by 36.5% very concerned and 29.0% concerned. These responses rate this as one of the major areas of concern.

Access to graduates in specialty disciplines and the standard of graduates each drew highest responses in the concerned or very concerned categories.

Movement of staff overseas did not emerge as a priority issue of concern, rating 45.8% not concerned at all and only 4.2% extremely concerned.

Anticipated retirement of key personnel was rated of extreme concern by the highest number of respondents at 29.8%, with 30.4% very concerned and 28.0% concerned.

Just under 50% of respondents also indicated 'other' areas of concern, some of which are summarized in Table 33.

• **Table 32: Level of concern expressed across a range of issues relating to future requirements within each discipline**

	Percentage of Responses			
	Not Concerned at all %	Concerned %	Very Concerned %	Extremely Concerned %
General capacity to meet demands for services	12.0	41.6	31.4	15.0
Impact of emergency response requirements	17.2	34.9	39.5	18.4
Availability of key staff in critical activity areas	8.4	29.0	36.5	26.0
Access to graduates in specialty disciplines	14.8	36.7	31.3	17.2
Standard of graduate skills base	18.3	39.6	26.4	15.6
Movement of staff to overseas positions	45.8	37.0	13.0	4.2
Anticipated retirement of key personnel	11.7	28.0	30.4	29.8
Other	51.5	10.6	18.2	19.7

• **Table 33: A selection of concerns noted when respondents selected 'other'**

Corporatisation, increased bureaucracy, emphasis away from research and scholarship and towards showmanship	With reducing teaching pathologists there has been an overemphasis on fungal pathology and de-emphasis on other aspects of the discipline
Entomology in Australia may become history	Lack of well trained, experienced field plant pathologists
Lack of development and recognition of technical expertise and the "disposable" attitude to technicians	Reiterate impact of retirement and loss for other reasons of experienced personnel.
Depletion of university course in the field of entomology and plant pathology	Erosion of diagnostic experience and quality
Lack of core funded positions for trained young staff in 25-35 age group	Appears most state Ag Dept not replacing lost staff - reduction in expertise
Standard of some 'expert' staff	Skilled staff are retiring but not replaced

Part B: Current and Future Needs

Part B was completed by 160 respondents representing 45% of survey responses. Respondents were asked if they were familiar with the needs of their organisation in the fields of plant pathology or entomology. If they were not familiar with an area the questions for that section were skipped. It was therefore possible for some to complete responses for either plant pathology or entomology individually or both. Both sections were completed by 41 respondents, 56 completed plant pathology only and 63 completed entomology only.

This section of the survey was structured so as to assess the current importance of various aspects of the two disciplines and then to explore these same areas in terms of future importance so as to determine possible changes in emphasis. The areas rated in the survey were firstly the current importance of the knowledge areas (sub-disciplines) and secondly both current and future importance of the skills and competencies areas. A rating scale of 1 to 5 was provided where 1 was 'not important' and 5 was 'very important'.

Also in this section of the survey respondents were asked to identify their primary sources of knowledge, skills and competencies and to rate the accessibility and quality of what was available to them.

The survey then requested information on the attributes they would require when making future decisions to employ staff and to identify what they perceived as the priority areas for training.

Finally, respondents were asked to indicate how their organisation might support curriculum development and implementation in these disciplines from simply employing graduates through to financial support (sponsorship or scholarships) or direct contribution of knowledge and skills.

Information gathered in Part B of the survey is intended to provide guidance on industry and organisational priorities in knowledge, skills and competencies so as to guide curriculum development and to most effectively target training to meet future needs.

Plant Pathology

Importance of Plant Pathology Sub-discipline Areas

Respondents were asked to rate the current importance to their organisation of each of the sub-discipline areas. Responses are shown in Table 34.

Mycology peaks at rating 5 indicating the high level of importance of this sub-discipline to most organisations and the fact that this sub-discipline is strongly represented in survey responses overall. In 80.4% of responses this sub-discipline is rated at 4 or 5.

Virology also rates highly peaking at 4 and with 57.8% of responses rating it at 4 or 5.

Nematology peaks at 2 but still retains a rating of 4 or 5 in approximately one-third of responses.

Molecular plant pathology peaks at rating 4 and is rated 4 or 5 by 57.8% of respondents.

Finally the specialty area of phytoplasmas does not rate highly across the range of organisations but is clearly of high importance in a small number of cases.

• **Table 34: Ranking of current importance of plant pathology sub-discipline (n=97)**

	Percentage of Responses for Each Ranking (1=Not important:5=Very important)				
	1	2	3	4	5
Mycology	0.0	7.6	12.0	26.1	54.3
Virology	17.8	11.1	13.3	32.2	25.6
Bacteriology	13.0	16.3	27.2	20.7	22.8
Nematology	13.5	28.1	24.7	20.2	13.5
Molecular Plant Pathology	6.7	13.3	22.2	31.1	26.7
Phytoplasmas	33.3	27.6	29.9	4.6	4.6

Importance of Plant Pathology Skills and Competencies

A range of skills and competency areas was similarly rated based in current importance and the results presented in Table 35.

Diagnostics, both laboratory/taxonomic and field skills are rated highly by a large proportion of respondents. Also rating above 50% when ratings for 4 and 5 are combined are risk assessment and quarantine services; emergency response and management; epidemiology; disease control and management (resistance/breeding) and disease control and management (biological or chemical inputs & practices).

Genetics peaks at a rating of 2 and 3 but remains very important for 12.2% of responses. Taxonomy (other than for diagnostics) rates very important for 13.2% of respondents while physiology rates very high for only a small percentage (3.3%) of cases.

Education and training peaks at rating 3 and has a combined 4 and 5 rating of 47.3%.

• **Table 35: Ranking of current importance of plant pathology skills and competencies (n=97)**

	Percentage of Responses for Each Ranking (1=Not important:5=Very important)				
	1	2	3	4	5
Diagnostics – Laboratory/taxonomic	3.2	11.8	16.1	21.5	47.3
Diagnostics – Field Skills	6.4	10.6	20.2	20.2	42.6
Risk assessment and quarantine services	7.4	19.1	21.3	20.2	31.9
Emergency response and management	13.8	17.0	14.9	21.3	33.0
Genetics	11.1	28.9	28.9	18.9	12.2
Physiology	14.3	35.2	28.6	18.7	3.3
Epidemiology	2.2	21.1	23.3	35.6	17.8
Taxonomy (other than for diagnostics)	15.4	31.9	19.8	19.8	13.2
Disease control and management (Resistance/Breeding)	3.3	12.1	22.0	25.3	37.4
Disease control and management (Biological or Chemical inputs & practices)	1.1	10.5	15.8	31.6	41.1
Education and Training	7.5	16.1	29.0	21.5	25.8

The rating of future requirements in the skills and competency areas provides some insight into perceptions of future needs. Table 36 provides a summary of the ranking of future requirements in the skills and competency areas. Comparison with current requirements (Table 35), while not statistically interpreted offers a view on possible trends and directions for future training programs.

Laboratory based diagnostics retains importance but reveals little change, while there is a slight upward shift evident in the field aspects of diagnostics. Risk assessment and quarantine services show a strong upward shift, particularly into the 4 rating. A similar shift is noted for both emergency response and management and genetics.

Physiology, epidemiology and taxonomy (other than for diagnostics) all show an upward shift but in these cases the shift is relatively strong right through to the 5 rating. This is also evident in the case of education and training where the combined 4 and 5 rating becomes 60.9% compared to 47.3% on the current rating.

Disease control and management (resistance/breeding) remains relatively unchanged while there is a modest upward shift in the case of disease control and management (biological or chemical inputs and practices).

• **Table 36: Ranking of future importance of plant pathology skills and competencies (n=97)**

	Percentage of Responses for Each Ranking (1=Not important:5=Very important)				
	1	2	3	4	5
Diagnostics – Laboratory/taxonomic	3.2	10.5	11.6	28.4	46.3
Diagnostics – Field Skills	3.2	11.6	15.8	28.4	41.1
Risk assessment and quarantine services	2.1	15.8	12.6	29.5	40.0
Emergency response and management	3.2	13.8	19.1	25.5	38.3
Genetics	8.6	17.2	30.1	29.0	15.1
Physiology	11.8	26.9	30.1	21.5	9.7
Epidemiology	4.3	9.7	25.8	35.5	24.7
Taxonomy (other than for diagnostics)	8.5	28.7	24.5	18.1	20.2
Disease control and management (Resistance/Breeding)	3.2	11.7	18.1	28.7	38.3
Disease control and management (Biological or Chemical inputs & practices)	2.1	2.1	19.1	28.7	47.9
Education and Training	3.3	8.7	27.2	27.2	33.7

Entomology

Importance of Entomology Sub-discipline Areas

Respondents were asked to rate the current importance to their organisation of each of the sub-discipline areas. Responses are shown in Table 37.

Taxonomy/systematics peaks at rating 5 and is obviously highly important to a majority of organisations. When ratings 4 and 5 are combined there is a 60.1% response rate.

Of the other disciplines listed only behaviour attracts a response in excess of 50% for the combined 4 and 5 ratings.

Genetics, physiology and biochemistry each peak at rating 2 and while these areas still rate as very important to some organisations their requirement is less widespread.

Insect pathology rates a little higher than the above for more organisations, peaking at rating 3 and when ratings 4 and 5 are combined this discipline achieves a 42.2% response from participants.

• **Table 37: Ranking of current importance of entomology sub-disciplines (n=104)**

	Percentage of Responses for Each Ranking (1=Not important:5=Very important)				
	1	2	3	4	5
Taxonomy/Systematics	7.8	14.4	16.7	22.2	38.9
Genetics	23.0	27.6	16.1	14.9	18.4
Physiology	21.1	30.0	25.6	17.8	5.6
Biochemistry	25.0	34.1	18.2	10.2	12.5
Insect Pathology	14.4	20.0	23.3	22.2	20.0
Behaviour	4.4	16.5	22.0	31.9	25.3

Importance of Entomology Skills and Competencies

Respondents were asked to rate the current importance of a range of entomology related skills and competencies and the results are shown in Table 38.

Pest control and management drew the strongest response at the 4 and 5 rating levels with a combined result of 81.1% of responses.

Diagnostics (laboratory/taxonomic) and diagnostics (field skills) both exceeded 65% responses at the combined 4 and 5 rating.

Risk assessment and quarantine, emergency response and management, environment and ecology, education and training all attracted in excess of 50% response when the 4 and 5 ratings were combined.

Curation rated high to very high importance for the lowest percentage of respondents but still recorded one-third of responses at these levels.

• **Table 38: Ranking of current importance of entomology skills and competencies (n=104)**

	Percentage of Responses for Each Ranking (1=Not important:5=Very important)				
	1	2	3	4	5
Diagnostics – Laboratory/taxonomic	3.4	19.1	12.4	23.6	41.6
Diagnostics – Field Skills	4.4	11.1	13.3	24.4	46.7
Risk assessment and quarantine	10.0	10.0	20.0	24.4	35.6
Emergency response and management	9.0	14.6	22.5	25.8	28.1
Curation	14.8	26.1	26.1	17.0	15.9
Pest control and management	1.1	4.4	13.3	22.2	58.9
Environment and Ecology	1.1	13.5	23.6	24.7	37.1
Education and Training	9.3	18.6	17.4	26.7	27.9

As with the plant pathology skills and competency areas many of those applicable to entomology showed a potential increase in future importance to organisations. Results are presented in Table 39.

Most areas, including both aspects of diagnostics, risk assessment and quarantine, emergency response and management showed a small shift to the 4/5 end of the rating scale.

Curation showed a rise in rating 4 but a decline at rating 5, while pest control and management remained relatively static at an already high level.

Two areas showed a very strong shift towards the 5 end of the scale. These were environment and ecology and education and training. Each of these showed close to 15% points rise at the level 5 rating.

• **Table 39: Ranking of future importance of entomology skills and competencies (n=104)**

	Percentage of Responses for Each Ranking (1=Not important:5=Very important)				
	1	2	3	4	5
Diagnostics – Laboratory/taxonomic	1.1	12.1	16.5	23.1	47.3
Diagnostics – Field Skills	2.2	5.5	14.3	31.9	46.2
Risk assessment and quarantine	5.6	14.4	14.4	23.3	42.2
Emergency response and management	5.6	18.9	14.4	27.8	33.3
Curation	14.6	22.5	25.8	25.8	11.2
Pest control and management	1.1	4.4	11.0	22.2	61.5
Environment and Ecology	1.1	4.4	15.6	27.8	51.1
Education and Training	5.6	5.6	21.3	25.8	41.6

Training Issues

Importance of General Staff Skills for Future Appointments

In addition to the skills and competencies related to specific disciplines as reported above the survey also collected data on the more individual specific skills that organisations might consider in making future staff appointments. These are important in considering overall training programs to ensure that not only the knowledge based skills and competencies are adequately developed but also the skills related to practice and individual performance.

Respondents were asked to rate, on a five-point scale, the importance of a number of such skills and the results are presented in Table 40. A response of 1 represents 'not important' while a response of 5 represents 'very important'.

Achieving the strongest response at rating 5 were research skills (66.0%). Next, at 47.5% at rating 5 were communication skills, followed by field-based skills at 38.4% and laboratory skills at 35.3%.

Combining the 4 and 5 ratings, research skills and communication skills each attracted 85.5% of all responses, while field-based skills resulted in 76.8% and laboratory skills at 69.3%.

Training/teaching skills and commercial/advisory skills did not rate strongly at rating 5 but each achieved in excess of 50% response over the combined 3 and 4 ratings.

• **Table 40: Overall ranking of importance of attributes in future staff appointments (n=104)**

	Percentage of Responses for Each Ranking (1=Not important:5=Very important)				
	1	2	3	4	5
Training or teaching skills	7.1	19.9	31.4	25.6	16.0
Laboratory skills	4.5	10.3	16.0	34.0	35.3
Field based skills	3.8	5.7	13.8	38.4	38.4
Communication skills	0.0	0.6	13.9	38.0	47.5
Research skills (Basic, Strategic or Applied)	0.6	4.4	9.4	19.5	66.0
Commercial or advisory skills	3.8	18.5	28.7	34.4	14.6

Training Priorities

In order to meet the future needs of industry and target training programs effectively the survey gathered data on what respondents perceived to be the training priorities for future plant pathologists and entomologists.

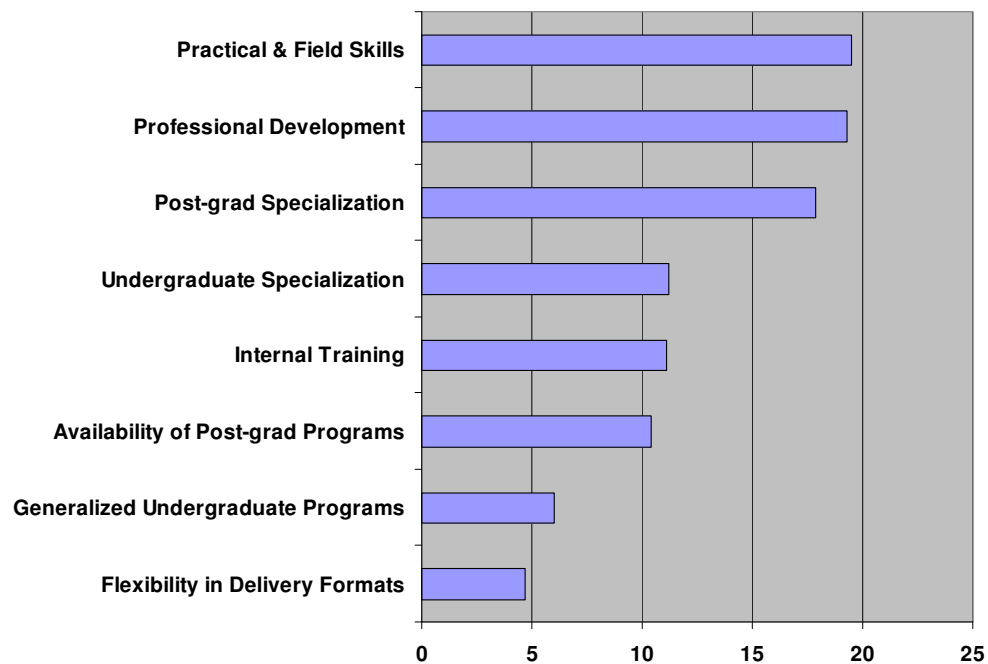
Respondents were asked to identify their top three training priorities. In the analysis of data these were evenly weighted and combined into the graph shown in Figure 13.

Training in practical & field skills rated highest, closely followed by professional development then post-graduate specialisation.

There is then a step downwards to undergraduate specialisation, internal training and availability of post-graduate programs.

There is a further step downwards to generalized undergraduate programs and finally flexible delivery formats.

• **Figure 13: Identification of training priorities as a percentage of all responses (n=160)**



Support for training programs

Training programs require support in a variety of ways. A fundamental requirement for any career oriented training program is that there are attractive employment opportunities available on completion. Support for training programs may also come through funding arrangements, for example through the provision of scholarships or cadetships. Funding professional development and in-service training are important aspects of organisation support of staff. Programs may also be supported through programs offering industry experience or by an organisation providing direct input to the delivery of training programs.

Survey respondents were asked to review a list of different support mechanisms and identify the extent to which their organisation may or may not engage with each. The results are shown in Table 41 with percentage for each category, unlikely to support, possibly support or highly likely to support.

The area receiving the highest percentage response at 70.3% in the highly likely category was employment of post-graduates. Employment of undergraduates attracted a response of 45.6% as highly likely while offering work experience or short term traineeships achieved a 39.2% highly likely response.

Areas receiving a high unlikely response rate included the provision of an annual corporate scholarship (46.8%) and direct sponsorship of a course or speciality unit (56.7%)

Rating high as possible support options included employment of undergraduate (41.1%), financial support/scholarships/cadetships for internal staff (52.5%), annual corporate scholarship (43.0%) and work experience or short-term traineeship (49.4%).

• **Table 41: Overall potential for employment and training support (n=160)**

	Percentage of Responses		
	Unlikely %	Possible %	Highly Likely %
An employer of undergraduates	13.3	41.1	45.6
An employer of postgraduates	5.1	24.7	70.3
Provide financial support/ scholarships/cadetships for internal staff	28.5	52.5	19.0
Provide annual corporate scholarship or award on a competitive basis	46.8	43.0	10.1
Offer work experience or short term on the job opportunities for trainees	11.4	49.4	39.2
Provide direct sponsorship for a particular course or specialty unit	56.7	38.2	5.1

Sources of Support for Plant Pathology and Entomology Services

The survey asked respondents to indicate the three primary sources of support for plant pathology and entomology services. Table 42 shows the percentage of responses that identified the various organisations as a primary source of support.

Edu and Gov1 classifications rate most highly along with internal support for most organisations.

• **Table 42: Sources of support by organisation (n=160)**

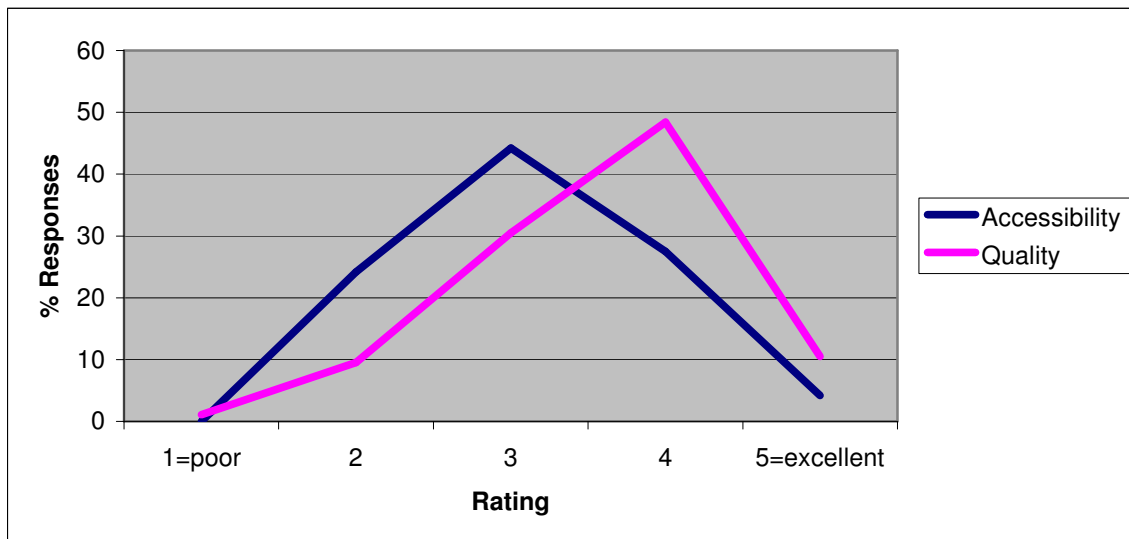
Source	Plant Pathology %	Entomology %
Gov1	18.8	15.5
Gov2	20.8	22.7
Edu	15.8	15.0
Comm	2.8	2.8
Internal	13.9	14.1
Other	4.5	4.7

In addition to identifying sources of support respondents were asked to rate both the accessibility of support services and the quality of support available. In each case a 5-point scale was used where 1 represents poor accessibility or quality and 5 represents excellent. Responses from plant pathologists and entomologists have been presented separately in Figure 14 and Figure 15 respectively.

In the case of plant pathology, accessibility rating ranges between 2 and 5, with a strong peak in the middle of the range at 3.

In terms of quality of plant pathology support the curve peaks positively at a rating of 4.

• **Figure 14: Accessibility and quality of plant pathology support (n=95)**



In the case of entomology accessibility peaks at rating 4 but both the 2 and 3 ratings are well represented. However, as in the case of plant pathology the quality of support peaks strongly at rating 4.

• **Figure 15: Accessibility and quality of entomology support (n=91)**

