SUMMARY OF A
REVIEW OF GRAPEVINE GERMPLASM COLLECTIONS IN AUSTRALIA



SUMMARY REPORT to

GRAPE AND WINE RESEARCH & DEVELOPMENT CORPORATION

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Review of Grapevine Germplasm Collections in Australia

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[1] This summary report is based on the final report prepared by Scholefield Robinson Horticultural Services with detailed confidential material on the collections removed after consultation with the collection custodians and the authors

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ACRONYMS

ACIAR	Australian Centre for International Agricultural Research
AGRF	Australian Genome Research Facility
AHVII	Adelaide Hills Vine Improvement Inc.
APFIP	Australian Pome Fruit Improvement Program
ARM	Agribusiness Research and Management
AVIA	Australian Vine Improvement Association
CDFA	California Department of Food and Agriculture
CEV	Citrus exocortis viroid
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTV	Citrus tristeza virus
DAFWA	Department of Agriculture and Food, Western Australia
DPI	Department of Primary Industries
DUS	Distinctive, Uniform, Stable (tests for Plant Breeder's Rights)
ELISA	Enzyme-linked immune sorbent assay
EMAI	Elizabeth Macarthur Agricultural Institute
ENTAV	Etablissement National Technique pour l'Amelioration de la viticulture
FPS	Foundation Plant Services (California)
FVF	Fruit Variety Foundation
FSAC	Fragmented shoot apex culture
GFKV	Grapevine fleck virus
GWRDC	Grape and Wine Research and Development Corporation
HAL	Horticulture Australia Limited
IAREC	Irrigated Agriculture Research and Extension Center (USA)
IFV	Institut Français de la Vigne et du Vin (France)
INRA	Institut National de la Recherche Agronomique (France)
Kapunda-AGFPS	Australian Grapevine Foundation Planting Scheme (in Kapunda)
MIAVIS	Murrumbidgee Irrigation Area Vine Improvement Society
NGR	National Grape Registry (USA)
NSW DPI	Department of Primary Industries, New South Wales
PCR	Polymerase chain reaction
PIRSA	Primary Industry and Resources South Australia (Department of Agriculture, South Australia)
PORVID	Associação Portuguesa Para A Diversidade Da Videira (Portugal)
PRC	Plant Research Centre (South Australia)
RSPaV	Rupestris stem-pitting associated virus
RVIC	Riverland Vine Improvement Committee Inc.
SA	South Australia
SARDI	South Australian Research and Development Institute
SAVIC	South Australian Vine Improvement Committee
STBA	Southern Tree Breeding Association
UCD, UC Davis	University of California, Davis
UMT	Unité Mixte Technologique Géno-Vigne (France)
USDA	US Department of Agriculture
VAMVVIA	Victoria and Murray Valley Vine Improvement Association
VI	Vine Improvement
Vic DPI	Department of Primary Industries, Victoria
WA	Western Australia

EXECUTIVE SUMMARY

This report has addressed the four main tasks in the Brief and presents the following findings.

Review the status of existing grapevine collections

The project team has collated all available data in current Australian viticultural germplasm collections. This also involved a review and update of the existing germplasm register (not available for public access)[2]. Through this process, the industry's genetic resources were elucidated.

The register has revealed that Australia holds valuable genetic resources of wine, table and dried grape varieties and clones, heritage and alternative varieties, and rootstocks. The total number of different varieties and clones held within Australia's grapevine collections is estimated at close to 900, with multiple clones of some varieties. The project revealed that there is considerable duplication in collections, variation in naming practices, traceability evidence, identity verification and health status.

Resolution of the following data issues would refine the exact quantum of genetic diversity:

- Capture details of all private imports.
- National agreement on accepted synonyms.
- Removal of duplication of varietal and clonal names.
- Accepted methodology for identity verification.
- Agreed guidelines on evidence of traceability.
- Consistent reporting of imposed treatments, eg. hot water, virus elimination.

Deliver information on 'best practice' management of genetic resources

The review of international grapevine repositories and of other perennial repositories in Australia, has provided perspective on various practices undertaken to maintain germplasm resources. All large grapevine collections in Europe and USA are funded by governments at levels ranging from 40-100%. Strong alliances with research institutions are common.

Income earned is derived from sales of cuttings but also specialist services are offered. On entry to most international germplasm repositories, grapevine identity is verified against a reference. However, it should be noted that there is no international agreement of plant type reference standards for grapevine varieties or an agreed method of determination. Many germplasm collections were actually established before standardised visual verification or cross-referencing procedures existed. The level of health status maintenance in international collections often reflects the purpose of the collection and material released.

The Australian citrus industry has always required full testing for endemic and exotic pathogens in post-entry quarantine. It is the leading example of integrated germplasm management and supply amongst perennial crops in Australia, with its germplasm arboreta; breeding and evaluation collections; foundation, high health repositories; and budwood multiplication scheme.

In Australia, less than 7% of grapevine accessions have had their DNA tested. Few have been referenced against international reference databases, however, as noted above, there is no agreed standard. Ampelographers have historically been used for variety identification.

At present the large CSIRO and SARDI germplasm repositories are closed to industry. Several other collections may be financially unstable and the lack of resilience of collections during

[2] The register is not available publically due to confidentiality agreements with the collection custodians.

periods of low demand for planting material has been highly evident in recent years. Total reliance on the sale of cuttings for collection viability is a serious weakness in Australian grapevine collections. There is no requirement for vineyards to be established with specified quality material, and therefore the cost of high health material has contributed further to its low demand. High health collections are expensive to maintain. With the exception of Western Australia's on-going commitment to germplasm and vine improvement activities, government funding of repositories and the provision of specialist services, has declined. The WA industry has benefited from their superior biosecurity and ready access to relevant vine material.

Make recommendations on priority collections

The priority purposes of collections have been ranked in this report, with the highest rankings being:

- Industry supply – high health, for industry development.
- Industry supply – for industry development.
- Germplasm repository – biodiversity, research and breeding.

The perceived collection capabilities have also been ranked. The weightings assigned revealed that the AVIA, CSIRO, RVIC and SARDI collections have the capability to provide the priority services to the Australian industry, at present. As noted previously, not all these collections are currently open to the public.

The project team strongly recommends that the register be maintained, investment in germplasm-related R&D is continued, and that national guidelines on naming, health testing and identity verification, be developed. It should be noted that at the time of preparation of the project report, an Australian Standard for grapevine identity determination is being formulated.

The practical options for germplasm collection management in Australia are limited. There is general agreement that government priorities do not support the funding of germplasm collections. The options presented are to:

Option 1. Do nothing,

Option 2. Secure some government funding to support some collections, or

Option 3. Rationalise the number of collections.

The project team recommends Option 3 be pursued, after completion of a risk assessment, development of a Strategic Plan and formation of a Board of Management.

Discuss potential business models

The business of germplasm management is complex. Until some firm directions for the Australian germplasm collections have been formulated in the Strategic Plan that is recommended by the project team, any work on the development of a formal business plan is premature.

Several other industries are managing their genetic resource 'businesses' successfully and they are models for consideration by the grape industry.

The citrus industry germplasm structure and management are the most advanced of the horticultural industries in Australia. The citrus industry now manages arboreta, high health mother stock in screen houses, some breeding and evaluation collections and a multiplication scheme. Their systems ensure all planting material is managed with skilled oversight of protocols and audits.

The forestry industry has the most commercial germplasm improvement system, but they are working with a small number of tree species and superior lines and have a relatively small number of clients, mainly corporates, across Australia.

Options for future funding of collections could include activation of a biosecurity levy, which would require industry agreement; raising a nursery levy, or expanding the levy payer base of the existing nursery pot levy (to include field nurseries). Biosecurity funding needs to be secured with an industry commitment, as industry members are identified as the major beneficiaries.

1 INTRODUCTION

The nature of genetic resources in the form of *in situ* plantings nationally and internationally, is diverse. The nature of formal collections of plant material is usually an indication of the original purpose of collecting the plants and the value perceived in having the plants maintained in a specific location under particular conditions and operating plans.

The project team was asked to conduct a review of Australia's main grapevine collections. The Brief outlined four main tasks:

- Review the status of existing grapevine collections.
- Deliver information on 'best practice' management of genetic resources.
- Make recommendations on priority collections.
- Discuss potential business models.

A revised and expanded register of grapevine germplasm was produced. To update the previous edition of the National Register (Nicholas, 2006), the team has collated confidential information received from public and private collection managers. It has also reviewed available information on other perennial (grape and non-grape) genetic collections in Australia and overseas. The functions and resources of these collections have been considered in identifying options for Australia and recommended approaches for Australia's future management of grapevine genetic material.

2 REVIEW OF COLLECTIONS

Collection curators provided the data that enabled the update of the 2006 National Register (Nicholas, 2006) by the project team. The composition of collections, number of varieties and clones in each collection, their health status and potential traceability has been documented, and the location of unique varieties has been determined. This information was provided on the basis that it would remain confidential, hence the details are not included in this summary.

2.1 Collection summary

2.1.1 Size of collections

Grapevine collections in Australia include government-supported collections that maintain a large number of accessions, mid-sized vine improvement (VI) collections, and smaller private collections. The government-supported collections analysed for this report included those of CSIRO in Sunraysia, Victoria and SARDI in Nuriootpa, South Australia. The Tasmanian collection has been abandoned. Table grape accessions were removed from the Queensland collection in 2009 and the surviving rootstocks and wine grapes have not been actively managed in the last three years. The number of accessions in these government-supported collections range from about 70 to up to almost 1000.

The Kapunda-AGFPS, RVIC, the Victoria and Murray Valley Vine Improvement (VAMVVIA) and the Adelaide Hills Vine Improvement site were the VI-focussed collections analysed by the project team. The number of accessions in these collections ranges from around 10 to up to 450.

The number of accessions in the private collections of ARM, Brown Brothers, Chalmers[3], Viticlone and Yalumba, ranged from around 10 to up to 120.

The total number of different varieties and clones held within Australia's collections at present cannot be precisely determined. Double entries, spelling variation, name changes and synonyms suggest that the total number in the updated register may be overstated.

[3] This collection is no longer maintained at the original Chalmers site, but has been transferred and most entries retained.

2.1.2 Composition of collections

The majority of rootstock, multi-use and table grape accessions are held within the larger collections. Table grape material is concentrated within the CSIRO and SARDI collections. Private and VI collections have traditionally held wine grape and rootstock material. VAMVVIA however also holds some table grape accessions.

The collections collectively include:

- Common clones of major varieties.
- Old varieties of R&D interest or not in demand.
- Little known varieties never commercialised.
- Major varieties from other countries[4].
- Minor and 'alternative' promising varieties - either recent imports, or old material with identified potential for the future.
- Pre-phylloxera material possibly unique to Australia.

2.1.3 Health status

The data on health status assessed by the review team is that provided by curators. No independent validation has been undertaken. Details are not provided here due to the confidential nature of this information.

The extent of virus testing is variable and appears to reflect a collection's age, size and primary purpose. The samples submitted, frequency of testing, and methodology of testing influence the extent to which virus test results may be relied upon as an indicator of a whole collection's health status. Given the nature of viruses present in Australia and the means by which they are spread, it is our opinion that testing within a year is an indicator of the vine's health only in that year. Past test results are however valuable and should be retained. Positive results usually trigger action within a collection (eg removal, isolation), depending on the nature of the collection. Negative results however indicate that the virus is either not present or at a level too low for detection.

Changes in a collection's schedule or extent of virus testing have occurred for many of the collections reviewed. This is due to questionable result reliability as well as current understanding of the economic impact of several viruses on vine production and growth. Interpretation and reliability of results, as well as cost, were noted as concerns by several custodians. There is no requirement for growers to plant high health vineyards and therefore collections with significant virus testing programmes are unlikely to enjoy financial security if the only income stream is the sale of cuttings.

2.1.4 Identification verification

The data on identification verification are those provided by curators. No independent validation has been undertaken, and, as noted above, there are no agreed international plant type reference standards.

No collection has a specific commitment to the verification of identification (trueness-to-type) of all its entries. This reflects the availability of technology at the time many collections were established. Prior to the development and accessibility of DNA technology, importers and custodians relied heavily on the word of their suppliers. Objective DNA testing is replacing expert, ampelographic examination of collections. The shortage of qualified ampelographers is such that none is employed for 'mass' verifications, but they are often utilised when a specific

[4] Old varieties of unknown identity or value are within the large public collections. Some have their origin listed as old vineyards

varietal identity is in question. Yalumba's ENTAV material is still inspected every second year, by the French ampelographer, Laurent Audeguin.

There are no requirements for DNA identity validation for material held in Australian collections, nor guidelines on what may constitute type reference material. Commercial facilities for DNA identification are the IFV, UMT Geno Vigne (in Montpellier) and the Australian Genome Research Facility (AGRF). The Europeans utilise the European *Vitis* database, a common reference point for DNA identification of some varieties. This is the most referenced database available, but as noted above, there is not international agreement that this is the definitive collection for plant type reference standards.

The collections reporting DNA identification in this review have either used the French database or a combination of the French and the Australian databases. The AGRF profile database developed by CSIRO is the basis of the Australian commercial DNA testing service, offered by AGRF.

Less than 7% of grapevine accessions in Australian collections have been verified by DNA testing. CSIRO has DNA profiled many varieties from the old CSIRO collection, but they are yet to be referenced against an agreed international variety type reference database. In collaboration with WA, a DNA-based verification project was undertaken on SARDI and WA material (Tassie *et al.*, 2012). The Kapunda-AGFPS and RVIC collections have a long term plan to verify the identity of all entries and they have utilised AGRF and IFV services.

Despite the difficulty in definitive identification, it appears there are about 900 different varieties and clones held within collection in Australia.

2.1.5 Unique material in collections

A unique accession is defined as a single variety and/or clone contained within only one collection in Australia[5]. Of the approximately 900 different varieties and clones within the collections, 470 are unique. Most of the collections contain at least one unique accession. The largest and oldest collections (CSIRO and SARDI) house the majority of the material identified as unique; about 75% of the unique varieties are held at CSIRO. Of these, 60% are wine grapes and about 25% are table grape accessions.

The limitations of the database for the detection of unique material need to be noted. Incorrect spelling and synonym use may result in classification of the material as unique, eg Peverella and Verdiccio Bianco are potentially synonyms, as are Trincadeira and Tinta Amarella. Clonal naming is inconsistent and the addition/omission of prefixes and suffixes has potentially resulted in the incorrect determination of some material as unique.

2.1.6 Access to material in collections

Australia's two largest collections, CSIRO and SARDI, are closed to the industry at present. This amounts to approximately 50% of germplasm and accessions, and more significantly, up to 80% of unique material being unavailable to industry. Prior to complete closure, clients/applicants could access material from these collections after virus testing had been completed. This was undertaken on the basis of full recovery of the costs of virus testing and packaging and handling. CSIRO also licensed its DNA typing technology to service providers, which was available on request.

There is an increasing local and international interest in a range of material:

- Heritage.

[5] This terminology does not infer that the variety or clone is globally unique.

- Australia's old Riesling and Shiraz clones (by France and Germany – to increase clonal diversity).
- Alternative varieties.
- Varieties bred for drought tolerance to address climate change.

Over the last twenty years, there has been a steady increase of sales of 'alternatives'. The supply of public alternative varieties to nurseries and VI groups (for multiplication) has been affected by the closure of the large collections.

To address shortages, and gain some time advantage, 'private' importers have brought in alternative varieties in recent years. Chalmers, ARM, RVIC and Kapunda-AGFPS have been active importers of interesting proprietary material, but access to it once in their collections, is restricted. The Adelaide Hills Vine Improvement (AHVII) group and private vineyards have collaborated to import new clones, bulk them up and evaluate them in trials on a range of sites.

2.2 Current status and observations of collections

The review of specific collection data has resulted in the revised register of inventory. In addition, some observations have been made and noted below. A questionnaire on management practices and resources in the collections sought a broader view of local activities.

Of the original six governments' state and national collections, Tasmania has been abandoned, Queensland has been mothballed, and two are closed to industry. The trend for collections is a reduction of government involvement.

- It appears that the sustainability of Australia's vine improvement collections is tied to the demand for cuttings, as few have other income streams. VAMVVIA and AVIA are VI plantings on government land (planted in the early 2000s) and AVIA's long term viability is uncertain.
- Partnerships of government and VI groups and/or some private groups have increased in response to financial difficulties. Some remain cost effective.
- Common varieties and clones occupy too many collections.
- High health collections that are too large and house material not in current demand are very expensive to maintain. AVIA, Kapunda-AGFPS and VAMMVIA were reportedly established as high health nuclear collections, but may not be able to be maintained as such.
- Industry has historically not been the driver of collection establishment. The on-going support of industry is needed, but not assured with the current pricing structures for high health material.
- Leadership in germplasm advancement and maintenance has been fragmented in the last 10 years. Progressive private importers and several VI groups are the current leaders, but large collections with government involvement remain the main resource.
- Naming practices have resulted in the loss of traceability for some material and confusion with registered clonal names.
- A national approach to clonal naming and registration is needed.
- Label integrity requirements are expected to increase evidence requirements for traceability.
- National guidelines are needed for vine health testing, traceability and identification verification, and clonal registration.

- Australia has no native, or 'autochthonous' *V. vinifera* and is dependent on international sources for genetic resources. Australia cannot assume it will always be granted access to this material.
- A national body that serves as the agent importing on the Australian industry's behalf, may increase our access to some European material.
- Alternative varieties are of increasing interest and may remain by default in the private import arena, if SARDI and CSIRO are not re-opened to industry.
- International interest has been expressed in our heritage varieties.
- Biodiversity increase and conservation, is the driver behind some international interest in Australia's older material.

3 REVISED REGISTER

3.1 The database

The primary output of this project was to review and update the existing 2006 National Register (Nicholas, 2006). The process revealed new material, material lost from collections, missing entries of older material and name changes. It is the author's view that this is the most current record of germplasm inventory in Australia and is a valuable resource to industry that should be maintained.

The updated register[6] (not available for public access) has confirmed that Australia holds valuable genetic resources of wine, table and dried grape varieties and clones, heritage and alternative varieties, and rootstocks. The total number of different varieties and clones held within Australia's grapevine collections is estimated at close to 900, with multiple clones of some varieties. About half of this material is present in more than one collection: there is in built redundancy.

The database extends beyond varietal, clone and accession details, and also includes product identify, origin, location, end-use and health status.

3.2 Knowledge gaps and data limitations

The updated register reflects current information, however, there is variation in naming practices, traceability evidence, identity verification and health status.

Resolution of the following data issues would refine the exact quantum of genetic diversity:

- Capture details of all private imports.
- Naming guidelines
- National agreement on accepted synonyms.
- Removal of duplication of varietal and clonal names.
- Accepted methodology for identity verification.
- Agreed guidelines on evidence of traceability.
- Consistent reporting of imposed treatments, eg. hot water, virus elimination.

[6] The register is not available publically due to confidentiality agreements with the collection custodians.

4 LOCAL GRAPE GERMPLASM MANAGEMENT AND RESOURCES

Australia has grapevine collections established with different original purposes. Each is maintained by different practices, with differing levels of financial support. Historically, resources supporting germplasm activities have been significant in ensuring on-going industry development. The scope of the review did not extend to the details of the operation or management status of any current collection, but it is evident that today's resources are limited and for several collections, insufficient to ensure on-going viability.

4.1 Background - establishment of collections

The grapevine germplasm collections in Australia were established through three resource bases. The early collections were established by governments recognising the public good in maintaining germplasm. State and Commonwealth governments were active in establishing such resources in the 1960s and 1970s. Other collections were established as integral components of VI organisation activities. They were generally planted in the 1970s and are of variable size. The third basis of current 'collections', is that of private interest and benefit. Individuals and some wineries have seen an opportunity for investment and the potential to gain advantage from importing and housing a small number of specific selections.

Table 1 shows the original basis of a collection's establishment which also reflects the primary funders of each. It is noted that seven of the 16 collections investigated in this review were initially resourced by governments. VI organisations initiated 4 of the 16 collections. VAMVVIA evolved from the Victorian government collection under funding pressure. The remaining 5 collections were established with private funding. The RVIC collection is currently resourced through accumulated funds from its VI activities together with entrepreneurial projects designed to keep each operation solvent.

Table 1 : Collection establishment and original funding

Collection	Code	Government	Vine Improvement	Private
AVIA	A			
AHVII	AH			
WA, ARM	Ar			
Browns	BB			
CSIRO	C			
Chalmers	Ch			
Kapunda	K			
NSW	N			
Queensland	Q			
RVIC	R			
SARDI	S			
Tas	T			
VAMVVIA	V			
Viticlone	Vs			
WA	W			
Yalumba	Y			
	KEY	National	National	Private entities
		State	Regional	
		Funding pressure	Mothballed	Destroyed

4.1.1 Changes in collection resourcing

Government

In the late 1980s, financial pressures on governments initiated broad review of funding needs and priorities in all forms of agriculture, and horticulture in particular. The pressure on horticulture and germplasm collections has not ceased and some collections have been closed; others have changed to new funding arrangements. As shown in Table 1, the Tasmanian collection is now closed and the Queensland collection has been "mothballed". The Queensland table grape entries have been removed and the number of accessions remaining has been reduced.

The insecurity of funding for the Victorian collection was relieved through a partnership with the VAMVVIA. The VAMVVIA plantings occupy NSW government land at Dareton, but the commercial operation is that of the vine improvement organisation. The MIAVIS collection at Griffith (not reviewed) is a collection established from mother vines in the NSW government site.

Changes in resourcing have affected germplasm collections. In Victoria and South Australia, over a period of 25 years the Full Time Equivalent (FTE) resources have decreased from about 25 FTEs in 1986 to between 4 and 5 in 2011. The current FTE level is 3.5. In 1986, the two relevant state Departments of Agriculture and the CSIRO were driving forces for all vine improvement activities. Their activities were focussed on maintenance of germplasm collections, clonal and rootstock importation, viticultural comparative trials, vine breeding and vine health, especially virology.

Since 1986, the Northfield facilities that supported these activities have closed although the Plant Research Centre (PRC) in Adelaide was initially intended as its replacement. Today, neither the PRC nor the Loxton Research Centre, has permanent staff formally assisting germplasm maintenance. The Victorian DPI no longer supports vine improvement activities.

The situation is similar in Tasmania and Queensland, with the state Departments of Agriculture withdrawing all funding for state vine collections. The Western Australian government is the exception. It has continued to support the maintenance of germplasm and vine improvement activity, and in so-doing WA has established itself as a state with superior biosecurity and ready access to vine material of relevance to their industry. In part, WA's particular quarantine restrictions (based initially in downy mildew absence to 1998), have underpinned the commitment of such resources to ensure WA nurseries and growers are not disadvantaged by having no access or delayed access, to material imported through another state. As in other states, private groups like ARM have seen the maintenance of their own collection as a commercial opportunity and benefit.

The CSIRO station at Merbein was supported by the Australian government. It has been closed and CSIRO's significant collection of germplasm has been replanted at CSIRO's Sunraysia site, Victoria. Although funding is still provided, the human resources to support germplasm maintenance and research in related areas, has been reduced.

Vine Improvement

The formation of the AVIA in 1988 followed the success of the South Australian Vine Improvement Committee (SAVIC) which was initiated in 1985. SAVIC was an initiative of the SA Department of Agriculture and chairpersons of the six existing regional vine improvement committees. The funding was achieved through levies on cuttings. AVIA was established with the same model, with the chairs of the state vine improvement organisations representing their members. At the time, state bodies and AVIA benefitted from the considerable support of volunteers, the state departments and CSIRO. While the volunteer ethos continues, supporting resources and income streams are too limited to sustain most bodies through any prolonged planting downturn. The downturn since early 2000 has curbed expenditure on management and development activities and some collections have not been maintained to the level, or kept as relevant, as many desire. Several bodies are not financially viable. The RVIC collection however has addressed the problems more strategically, and remains a dynamic collection that has recently expanded. It has added an income stream by establishing a nursery.

Private funding

In this report on current collections and their future, private collections must be acknowledged despite them not serving as assured resources for industry at-large. Private imports account now for 98% of wine grape entries to Australia, and this is likely to be the same for table grape accessions. Of concern, has been the industry's failure to engage and corral private importers into a national system that accommodates inventory data from all sources, and under agreed industry guidelines that protect privacy, but allow relevant inventory details to be shared.

The essentially private funding and management of collections like those at Yalumba and ARM, demonstrate that proactive importation and responsiveness to industry are worthwhile commercially and apparently viable financially. Neither group functions in isolation. Each has the technical and financial support of a larger organisation underpinning its activities.

4.2 Resources and operations

Australia's current grapevine collections have variable levels of commercial utility. The demand for grapevine material from collections directly affects the maintenance practices and specific testing conducted on the collection entries. At present low demand for material, financial insecurity and/or restrictions on access, are compromising the management of most collections.

4.2.1 Summary of practices and management

- The reported approximate costs of grape collection management ranged from $18,000 to $160,000. It is presumed the latter cost estimate included costs of cutting propagation material which is a commercial, rather than maintenance operation.
- The purpose of the majority of open collections is germplasm maintenance, with some also identifying biodiversity/heritage relevance. 'Industry supply' is the primary purpose of the VI collections with 'high health' also considered important.
- The collections can normally be accessed by public, industry nurseries, growers, corporate and private clients, however the larger collections (CSIRO and SARDI) are at present not accessible to the industry. CSIRO researchers may access CSIRO material.
- Of the collection curators that responded, none reported it was fully meeting the expectations of the intended users, i.e. nurseries and growers.
- The main drivers of success for each collection are similar. All agreed that funding security, industry support, and international recognition would increase their success.
- Insecure funding was the most frequently identified limitation on collection success.
- The supply of cuttings is the only identified source of income noted for collections, but AVIA also acknowledged the voluntary levy paid by VI associations.
- Conditions of entry to collections reflect the primary purpose of the collection.
- Some collections have reported utilising DNA-based verification on some material. All collections have used ampelography at times, especially at time of initial entry. CSIRO profiled a cross section of accessions in their collection to create an initial DNA profiling database. It has not yet been verified against type reference standards because there is no international agreement on what collections hold plant type reference standards for grapevine varieties from which DNA could be obtained for comparative verification purposes.
- Collections generally have accepted material with detectable Grapevine fleck virus (GFKV) and Rupestris stem-pitting associated virus (RSPaV). Such material has not been isolated within any collection.
- Traceability appears to extend to the maintenance of the supplier number, not necessarily the accession number. Individual paper and/or electronic registers exist for most collections.

- Pathogen testing after collection entry is inconsistently undertaken by collections.
- Loss of traceability and identity doubts are given as reasons for vine removal from some collections. Lack of demand for material and duplication of entries do not necessarily result in removal from any collection, which suggests internal collection rationalisation is not occurring.
- Risk management to-date has been achieved through partial or total (AVIA, VAMVIA) duplication of the collections. All collections are planted on 'own roots' so as not to mask pathogens or pests such as phylloxera.
- Collections have different capacities to respond to risk exposure associated with change. Costs rather than expertise limited their capacity in this area.
- Proprietary material is protected in practice (restricted access, coded labels etc.) or legally through the plant breeder's rights (PBR), when included in collections.

5 GERMPLASM MANAGEMENT IN OTHER PERENNIAL HORTICULTURE COLLECTIONS

Task 2 of this project's Brief required a review of several international grape collections and local collections of other (non-grape) perennial, horticultural plant material. Managers of international grape collections and local citrus, almond and grape collections were asked to complete a questionnaire on their management and operational activities and resources.

'Best practices' associated with germplasm collections are neither universally similar nor universally relevant. The best practices appropriate for any collection are those that maximise the potential of the collection to achieve its purpose and to minimise its risk factors. It has been possible to gauge through discussions and questionnaire responses, details of collection purpose, funding and management, if expectations are being met and the relative capacities in addressing challenges in the climate of change. The practices and parameters that underlie the operations of several different collections locally and internationally are discussed below.

5.1 Australia – perennial horticulture collections

Most collections have been established for the purpose of maintaining genetic material in a location that is deemed suitable for the plants' normal growth and maintenance. It is apparent that most of the larger genetic collections in Australia were at one time, located and maintained by governments or institutions that had a relevant research mission and/or industry responsibility.

Specific information on the Australian citrus and almond germplasm collections was provided by Graeme Sanderson, Pat Barkley and Ben Brown. These industry experts have working knowledge of their industry's germplasm collections. Information from the pome and forestry industries was provided through discussions with Garry Langford, Dr. David Boomsma and Peter Cunningham.

5.1.1 Primary function of collections

The main purpose/s and funders of several local perennial plant collections is shown in Table 2.

The primary function and expectations of collections vary. Elite, nuclear or 'high health' collections usually include foundation material (or material with traceability to foundation material) and plants tested routinely for the presence of pathogens. Entries in 'high health' collections are expected to have a known health status (in the year they are tested). The operating costs of these collections are high, and therefore their composition is usually limited to small quantities of in-demand (or promising) material.

Table 2 : Primary function identified - local collections

Commodity	Primary functions	Funding
Grapes	Germplasm repository	Government
	High health elite	Industry – grape grower levies and sales levy
	Supply for industry	Industry - sales of cuttings
Citrus	Germplasm repositories at Auscitrus (Dareton) and EMAI (NSW-DPI, Menangle) + services (health and horticultural testing)	Australian government and Industry (grower levies)
	Arboreta at Dareton and DAFF-Qld Bundaberg	NSW and Qld governments
	Budwood and seed, multiplication	Industry (Auscitrus) - sale of budwood, seed
Almonds	Scion germplasm repository - defined health status	Government + industry – (grower levies)
	Budwood; multiplication	Industry – sale of budwood
Pome Fruit	Germplasm improvement; restricted supply	Government, industry and private
Forestry	Germplasm improvement – breeding and conservation	Industry

5.1.2 Management factors in local perennial collections (other than grapes)

The questionnaire responses of other local perennial germplasm managers are summarised below.

- The majority of other (non-grape) perennial collections are funded by industry funds and government contributions through matched industry levy funds, research grants and in-kind support (land, labour).
- The main drivers of success in the local almond, citrus and pome germplasm schemes/collections were identified as matched funding (from Horticulture Australia Limited – HAL) and industry support through levies and purchase of material.
- Most collection managers suggested government (Australian and/or state) funds were essential to the collection's viability and cost effectiveness.
- The industry demand for planting material influences collection viability because supply of budwood is the only income stream for most. The Dareton citrus arboretum has no identified income stream.
- The limitations on collections were identified as funding (citrus and almond), space (citrus arboretum), and technology to underpin desired collection entry criteria (almonds).
- Conditions of entry to collections reflect the primary purpose of each collection. The citrus germplasm repository requires a defined health status, but the arboretum does not. Almond material may enter the collection if free of exotic pathogens and four endemic viruses.
- Post-entry pathogen testing reflects the primary purpose of the collection, but the testing levels in high health collections have been compromised by the funds available. The almond repository requires 50% of trees to be tested annually for four endemic viruses. The citrus arboretum trees are not tested, but low health trees (visually assessed) are removed. The citrus germplasm collection is tested annually for citrus tristeza virus (CTV) and every three years for specific viroids.
- Each germplasm collection has listed pathogens that trigger removal from a collection if detected.

- Lack of demand for material or duplication of entries does not necessarily result in automatic removal from any collection.
- Risk management to-date in local collections has been achieved through partial duplication of the collection at another location. Proprietary material has been protected generally through restricted access and non-propagation agreements but the citrus industry through Auscitrus, has legal agreements with variety managers that provide greater protection.
- The managers of collections have not clearly identified their perceived risk exposure to changing conditions – regulations, demand for material, disease pressure, climate change, heritage or biodiversity protection, staffing changes. Most collections that carry out health testing believe 'disease pressure' is a manageable risk, but the capacity to respond quickly to exotic or difficult endemic citrus diseases, is noted as 'weak' by arboretum personnel.
- Germplasm collections usually accept visual identity verification but the citrus germplasm repository and pome fruit collection requires confirmed identity (but not through molecular testing) and traceability. The almond repository does not require identity verification but identity doubts may result in removal from the collection.
- Managers of the local citrus, almond and pome collections responded that their collections were meeting expectations of owners and users.

5.1.3 Australian Citrus collections

The Australian citrus industry (through Auscitrus) maintains plant material collections with different purposes – two high health repositories maintained in screenhouses, germplasm conservation sites as arboreta, and sites for horticultural evaluation and budwood and seed multiplication. Auscitrus produces material available to all growers (public scion varieties and rootstock seed) and proprietary line owners, under legal agreement. Private varieties are however held separately to public varieties and are maintained on a cost recovery basis.

The citrus industry believes there should only be one source of high health status (foundation) budwood in Australia (Auscitrus). It manages risk by having two sites where such material is located. The citrus collections are an integral component in a system intended to maintain across industry at all levels, agreed standards for planting material health and horticultural performance. The scheme is maintained with funding contributed by industry (through grower levy funds) and the Australian government (through HAL).

The citrus industry is unique in requiring full testing of commercial and ornamental citrus relatives for endemic and exotic pathogens while in post-entry quarantine (PEQ). The use of a range of biological indicators in PEQ enables the detection of a large complement of graft-transmissible pathogens. The released material therefore has a known health status and is eligible for entry to specific industry collections – foundation repository and budwood scheme. Locally-selected material is tested for graft-transmissible citrus pathogens and undergoes shoot tip grafting *in vitro* before a mother tree is placed in a repository. The testing costs are borne by the importers, but the beneficiaries are the citrus industry members and nurseries, collectively.

Foundation trees are maintained in insect proof screenhouses. They are the "insurance policy" for the citrus industry. Should there be an outbreak of an exotic disease, these would be the source of budwood for the establishment of new budwood multiplication trees. One tree of each variety is held in two locations for 'insurance' purposes. The repositories at Dareton and EMAI include 162 'virus free' clones, some of which are proprietary material. The virus free repository at EMAI fills two screenhouses and fruit from all trees is photographed, with images stored in a database. The repository of more than 80 CTV pre-immunised clones at EMAI is within a controlled environment greenhouse. Dareton houses the larger mother tree repository in an insect-proof screenhouse. The associated nurseries at the two locations are NIASA accredited and the Citrus Pathology and Soil Health technical teams that provide technical and scientific support to Auscitrus for pathogen testing, are ISO 9001:2008 certified.

No DNA testing is undertaken to ensure the validity of varietal names, but annual inspections occur to ensure "trueness to type" and the absence of bud sports. On-going health testing is specifically planned to minimise risk of an undetected infection or contamination through mechanical transmission (eg of viroids) or entry of aphids (eg CTV) and therefore the implemented scientific methodology and testing frequency reflect the identified risk. Since 2010 all viroid re-testing has been undertaken using molecular techniques. High health and pre-immunised repository trees are tested every three years for citrus exocortis viroid (CEV) infection using biological (woody) indexing. Every tree in the high health repositories is tested annually using serological techniques, for CTV – its presence in pre-immunized and its absence in virus-free clones. In the multiplication phase there is recognition that some rootstocks may mask symptoms of citrus tatterleaf virus and therefore some trees on specific rootstocks are tested.

The annual cost of managing the high health repositories at Dareton and EMAI, including annual pathogen indexing of repository trees is approximately $55,000. It is funded through matched industry contributions and secured in 5-year periods through HAL. The project addresses in part, industry protection against its most serious threat, being incursion by an exotic pathogen, eg huanglongbing, citrus canker. The citrus industry has recognised that further action is also needed to minimise the threat, and mandatory certification and nursery registration schemes have been identified as necessary biosecurity actions.

The citrus arboretum at Dareton is one of two industry arboreta. It occupies two hectares with two trees per species/variety on different rootstocks. Its purpose is germplasm conservation. It is a resource of historical significance. Although the trees are visually examined for obvious virus/viroid symptoms and general health status of the source tree, arboretum trees (and therefore budwood) do not have their health status specifically maintained or tested and therefore no budwood from the arboretum is made available to citrus growers, groups or private individuals.

The survival of this arboretum has largely been the result of local interest and the long-term commitment of the present research officer, and his predecessors at the original arboreta sites. Its future may become more secure if it is agreed to be a suitable site for establishment of mother trees for promising citrus rootstocks obtained from China and Vietnam (under an ACIAR project).

Records are incomplete but those that exist include accession numbers supplied from NSW DPI and CSIRO, PEQ and the old Fruit Variety Foundation (FVF) databases. A card system held at Dareton holds early collection records, varietal names and the date and source of the material in the collection. An old database provides information on source, propagation records etc. Some past records of locally selected variants include only the date and location of where the collection occurred. More recent information is held in Excel spreadsheets and field plans.

Although not the subject of this report, it is interesting to note the citrus industry's activity in multiplication and evaluation. The evaluation of newly imported or locally-selected varieties and clones, is undertaken at Dareton under HAL grower levy funding. The Auscitrus self-funded multiplication of scion varieties as budwood and rootstock seed occurs at two sites. Some rapid nursery multiplication is undertaken by Auscitrus, for newly imported varieties (mostly private) and for public varieties in short supply. Trees are inspected annually by NSW DPI and routinely indexed. The scheme has been operating since 1924 and while NSW DPI has supported it over a long period, it is now operated and owned by Auscitrus.

5.1.4 Australian Almond collection – Monash SA

The most important resource of Australia's almond industry is its germplasm repository and multiplication block at Monash, a property owned and managed by RVIC. A private mother block established with budwood cuttings from Monash (not foundation material), in a cooler, isolated area of central Victoria, has been important at times of high demand, and in 2012 as a

virus-tested alternative source of budwood. A detailed description of the almond repositories is included in McMichael and Barkley (2008).

The almond industry scheme is funded as a 'research' program and it therefore legitimately attracts both industry and government funds. Site management by the Industry Development Officer is funded by HAL as is pathogen testing, but labour (eg budwood cutting) is a commercial operation and at present is unfunded. It is the manager's view that the scheme would become unviable if government funding was removed, unless high volume sales of budwood returned reliably. The annual estimated cost of managing the almond scheme at Monash is given as $40,000. It is unlikely this includes virus testing costs that are a component of the breeding project with University of Adelaide.

The primary aim of the Monash repository is to procure, secure and maintain pathogen-tested public clones of industry-relevant propagation material and to make them available on a basis equitable and advantageous to the national industry. In times of low demand for planting material, the scheme is financially stressed as the operating costs and required maintenance do not decline commensurately. The sale of budwood is the only source of income.

The almond scheme does not include a protected foundation collection, although first generation trees are included within the collection at Monash. The inclusion of imported proprietary clones, other than for breeding purposes, is limited. The collection does not provide a service of horticultural evaluation but regional trials are being initiated by the industry. Collection entries may be rejected on the basis of health status (exotics, four endemic viruses). Similarly, annual testing results of 50% of the collection (as single tree samples) may result in removal from the collection. Identity confirmation is not formally undertaken (DNA) and relies largely on trust in the supplier/exporter.

Almond rootstocks are propagated from seed (local and imported) or cuttings and the rootstock supply to industry is largely outside the almond germplasm scheme and industry control. As a result almond trees in the past have not qualified for certification, especially as it relates to graft-transmissible organisms. Industry is therefore at risk and their scheme is compromised if 'dirty' rootstocks are used.

5.1.5 Australian Pome fruit scheme

The Australian Pome Fruit Improvement Program (APFIP) accommodates and encourages the submission of public- and privately-imported clones that are in the interests of national industry development. The scheme's focus is fruit *improvement* (through attainment of high health status) of a small number (approximately 30) of promising and in-demand cultivars, rather than general maintenance of germplasm or industry supply.

In Tasmania APFIP operates a repository for its certified rootstocks and budwood. The scheme can accommodate privately-imported planting material but there is no obligation for importers to utilise the services of the APFIP repository. The scheme aims to be self-supporting by 2015 with income received from industry through royalty payments on APFIP trademarked material.

The approximate operating cost of the pome fruit improvement scheme is $120,000 annually and funding is received from the government, industry and commercial sources in approximately equal proportions. 'Approved users' of clean cultivars undertake formal evaluation of material according to set guidelines. The data are entered, collated and reported to industry. More information on APFIP material is available at: www.apfip.com.au. See HAL final report AF10000 for more information on APFIP certification and evaluation of pome fruit in Australia.

There is also an example of a privately-owned collection of 850 heritage pome varieties in Tasmania. For more information see http://www.oak.org.au/our-businesses/grove-heritage-nursery/.

5.1.6 Forestry improvement scheme

Two organisations based in Mt Gambier, SA, provide plant *improvement* services to the Australian and NZ forestry industries. The National Genetic Resource Centre manages breeding and conservation of genetic material. The Southern Tree Breeding Association (STBA) was formed in 1983 and consolidated the genetic resources developed by private companies, state and federal governments, resulting in more cost effective breeding and improvement programs. Improved growth rates and superior wood quality are the targets of the improvement program.

STBA manages the improvement programs for Radiata pine (750,000ha) and Blue Gum (450,000ha), the major plantation forestry species in Australia. The STBA also manages evaluation trials across Australia. Their system of genetic evaluation (TREEPLAN®) identifies elite material for mass propagation and release of "mother" material to member companies and Seed Energy Pty Ltd. (Seed Energy). Non-members may also access material subject to payment of royalties to industry. TREEPLAN® is an integrated solution to managing data, and informing industry on breeding values relevant to improved profitability.

Seed Energy was established in 2001 when acquired from STBA. It manages seed orchards to produce commercial quantities of genetically-superior seed for plantation forestry. It is licensed to produce seed from the STBA genetic material, especially Radiata pine, Blue Gum, Shining Gum, Maritime Pine and Dunn's Whit Gum. Seed Energy is committed to sustainable production forestry and more information on its key clients is available from their website at www.seedenergy.com, or from STBA at www.stba.com.au.

5.1.7 Avocado industry plant health scheme

In some other industries, risk management has focussed on curbing the *distribution* of major pathogen threats, rather than maintaining a high health germplasm collection. The avocado industry for example recognises the threat associated with the distribution of trees with avocado sunblotch viroid or roots infected by *Phytophthora* sp. Through third party inspections of nurseries, and tree testing, nurseries earn accreditation and the right to sell 'certified' trees "*free of Phytophthora root rot* and *avocado sunblotch*". The certification in this case is very specific and provides no guarantee of horticultural performance, identity or traceability.

For information on the avocado collection and selections, in California, see
http://www.avocadosource.com/Journals/AUSNZ/AUSNZ_2005/WitneyGuy2005.pdf

5.2 International grapevine collections and schemes

Several researchers have previously reviewed the features of international horticultural and viticultural germplasm and high health schemes (Whiting, 2012; McMichael and Barkley, 2008; Dry, 2005; Constable and Drew, 2004; Nicholas, 2003). Multiplication, certification and distribution components of international schemes are not the subject of this review but comparison of schemes with these purposes was included in Constable and Drew (2004) and McMichael and Barkley (2008) reports.

Key personnel at the main grape collections in Europe (France, Germany and Portugal) and the United States (Washington State and California) were consulted. Private, international collection owners were not consulted. Questionnaire responses have allowed assessment of the current purpose and nature of several international grapevine repositories and of the management resources and practices that underpin them.

Comparative collection information is discussed below.

5.2.1 Purpose

Collection curators were asked to identify their collection's primary purpose. This information is summarized in Table 3. It is noted that the main European and American collections are one of

several in the country; each may have a different purpose. Other collections of note in Italy and Chile were not investigated in this review.

Table 3: Primary purpose of international grapevine collections

Country	Primary functions	Primary funder
Germany - Siebeldingen	Germplasm	Government
Germany - Geisenheim	Germplasm	Government
France – INRA Montpellier	Germplasm, supply, biodiversity, high health; evaluation	Government
France – IFV Vassal	Germplasm, heritage, biodiversity	Government
United States – Washington State	Germplasm, high health	Government
United States – California UC Davis	Germplasm, high health	Government
Portugal – Dois Portos	Germplasm breeding, R&D	Government
Portugal - PORVID	Biodiversity	Industry

5.2.2 Composition of international grapevine germplasm collections - 2012

The composition of collections gained from questionnaire responses and direct contact with some collection managers, is tabulated below.

The size of collections as indicated by the number of accessions range from over 7,500 at Vassal (France), 3,000 table grape, wine grape and/or rootstocks at FPS (California) and at Siebeldingen (Germany), to a total of 323 clones under management at the Clean Plant Center-Northwest (for grapes) in Washington state, USA. Respondents reported a range of 5-100% of material within their collections as being 'unique' to their repository, in their country.

GERMANY

These collections are two of the largest in the country. Regional collections exist and also contain other relevant material.

Julius Kühn-Institut, Institut für Rebenzüchtung Geilweilerhof - 76833 Siebeldingen, Germany

Material within main collection	Wine grapes		Rootstocks		Table grapes	
	Varieties	Clones	Varieties	Clones	Varieties	Clones
Total number of accessions[(a)]	Ca. 2300		Ca. 225		Ca. 850	
Replicates- eg #vines/clone	3		3		3	

[(a)] Accessions without indication of use = 888.

Hochschule Geisenheim Inst., Von-Lade-Str. 1 Geisenheim, Germany

Material within main collection	Wine grapes		Rootstocks		Table grapes	
	Varieties	Clones	Varieties	Clones	Varieties	Clones
Total number of accessions	Ca. 500	Ca. 1200	Ca. 200	Ca. 40		
Replicates- eg #vines/clone						

PORTUGAL

There are a number of government collections in Portugal, and smaller regional collections. The PORVID collection is a recent development and good example of a productive and efficient public/private partnership.

Portuguese Ampelografic Collection (PRT051) - Quinta de Almoínha, 2565-191 Dois Portos, Portugal

Material within main collection	Wine grapes		Rootstocks		Table grapes	
	Varieties	Clones	Varieties	Clones	Varieties	Clones
Total number of accessions	Ca. 675		Ca. 25			
Replicates- eg #vines/clone	7 plants/ accession					
Secondary collection/s	Regional collections					

* The PORVID 'collection' is more correctly a 'set of populations' under collective management.

For more information, see
http://www.ecpgr.cgiar.org/fileadmin/bioversity/publications/pdfs/1293_Report_of_a_Working_group_on_vitis_.pdf#page=101

Associação Portuguesa Para A Diversidade Da Videira – PORVID –Tapada da ajuda, 1349-017 Lisboa, Portugal

Material within main collection	Wine grapes		Rootstocks		Table grapes	
	Varieties	Clones	Varieties	Clones	Varieties	Clones
Total number of accessions	Ca. 60	15,000*	Ca. 25			
Replicates- eg #vines/clone		5 x 3 = 15 plants				
Secondary collection	Yes	Yes				

* Another 5,000 clones are kept in pots pending field grafting.

UNITED STATES OF AMERICA (USA)

The Clean Plant Center Northwest for Grapes - Washington State University (Washington State), and Foundation Plant Services, University of California, Davis California (UC Davis-FPS), are both public grape collections. UC Davis-FPS, with the University of California Agriculture and Natural Resource, and the National Clonal Germplasm Repository of the USDA Agriculture Research Services, coordinates the National Grape Registry (NGR), a comprehensive and impressive database of germplasm available in the USA (ngr.ucdavis.edu/).

For more information on the National Grape Registry, see
http://ngr.ucdavis.edu/publicnurserylist.cfm?setdisclaimer=yes

Foundation Plant Services One Shields Ave, University of California, Davis CA 95618 USA

The response from UC Davis-FPS was not provided in direct response to the questionnaire, but the details given have been noted. The collection has over 700 varieties of grapes and over 3,000 total clones. A register, categorised by 'end purpose', is not maintained but collection entries include table, wine, and raisin grape scions, rootstocks, and juice and concentrate varieties. Some have multiple uses.

For more information, see http://nationalcleanplantnetwork.org/files/63869.pdf

Clean Plant Center Northwest for Grapes - Washington State University – IAREC, 24106 N Bunn Road, Prosser, Washington 99350 USA

Material within main collection	Wine grapes		Rootstocks		Table grapes	
	Varieties	Clones	Varieties	Clones	Varieties	Clones
Total number of accessions	Ca. 80	Ca. 150	Ca. 10	Ca. 20	Ca. 30	Ca. 30
Replicates-screenhouse	1	1	1	1	1	1
Secondary collection	5	5	5	5	5	5

For more information, see http://wine.wsu.edu/research-extension/nwgfs/info/ and

http://ucanr.edu/sites/NCPNGrapes/Grape_Centers/Prosser/

The **Centre for Viticulture and Small Fruit Research, Florida A&M University** may also have information of value to the industry, but it has not been reviewed in this project.
For more information, see http://ucanr.edu/sites/NCPNGrapes/Grape_Centers/Florida_A-M_University/.

FRANCE

The two main collections in France are the collection at Domaine de Vassal INRA, Montpellier (Vassal) and the collection of Domaine de l'Espiguette IFV (l'Espiguette). Vassal includes internationally-sourced and diverse inter-varietal species, hybrids, rootstocks and *V. vinifera*. L'Espiguette maintains clonal French material (and some foreign cultivars) suitable for propagation. A third tier of repositories in the regions hold specific clonal material, directly relevant to the region.

All French grapevine material is released through, and evaluated by, the Institut Français de la Vigne et du Vin (IFV), previously the Etablissement National Technique pour l'Amelioration de la viticulture (ENTAV). Ten rootstocks service 90% of the wine industry in France.

Domaine de Vassal INRA, Montpellier, France

Material within main collection	Wine grapes		Rootstocks		Table grapes	
	Varieties	Clones	Varieties	Clones	Varieties	Clones
Total number of accessions	Ca. 2,600	Ca. 5,500	Ca. 210	Ca. 480		
Replicates- eg #vines/clone	3					

Plus 60 species of Vitaceae family and 250 accessions

200 *lambrusca V. vinifera* subsp *sylvestris*

400 experimental new varieties, hybrids, rootstocks, breeding lines (populations of segregation)

For more information, see http://www.brg.prd.fr/brg/pages/les_rg_en_france/rgv_vigne_an.php and http://www.ecpgr.cgiar.org/fileadmin/www.ecpgr.cgiar.org/NW_and_WG_UPLOADS/VITIS_2_2012/FRANCE.pdf

Domaine de l'Espiguette IFV, France

Material within main collection	Wine grapes		Rootstocks		Table grapes	
	Varieties	Clones	Varieties	Clones	Varieties	Clones
Total number of accessions	Ca. 400	Ca. 3500	Ca. 40	Ca. 200	Ca. 100	Ca. 500
Replicates- eg #vines/clone		10		5		10
Secondary collections	Vassal and/or local collections	Nurseries	Vassal	Nurseries	Vassal and/or local collections	Nurseries

5.3 International collection comparisons

5.3.1 Purpose

All curators reported their collection was meeting the expectations of owners and industry.

The PORVID 'collection' is more correctly a 'set of populations' built from 30+ years of selection and study. This Portuguese scheme collectively manages close to 100 sites that include 50-100 clones of 260 native varieties. There is a current effort to re-locate all material to one site.

In France the two main collections have distinct purpose and utility that differ from, but support, many regional repositories. They are responsible for germplasm maintenance, biodiversity, research and development, high health attainment, and supply to nurseries and smaller collections where multiplication and regional R&D are carried out. UC Davis operates similarly. The Washington State scheme has an additional role as an importer of public and private material, in response to industry requests.

5.3.2 Entry and rejection criteria

Known identity, health status and traceability are collection entry criteria in international collections. The presence of quarantineable pathogens is a rejection criterion in all collections. Other pathogens may be accepted if they do not pose an economic threat (eg PORVID).

Health status does not restrict entry to the Geisenheim and Dois Portos collections. The PORVID collection accepts pathogen presence if it is not expected to cause economic loss. Other collections screen candidate material for viroids, viruses and phytoplasmas. Washington State requires all selections (public and private) to satisfy the Foundation certification requirements. Viroid presence may be accepted but elimination of specific viruses is required to gain entry to the collection. The cost of therapy and treatments to eliminate viruses and screen for diseases is US $3,500 at Washington State. UC Davis-FPS and Washington State accept material that carries grapevine fleck and RSPaV, but the infected material is isolated until a virus free clone is available. Infected plant material in the Dois Portos collection, is not isolated from higher health accessions.

5.3.3 Funding

Collections in Germany (Siebeldingen), France (Vassal) and Portugal (Dois Portos) appear to be entirely government-funded with annual management cost estimates given as AUD 400,000-450,000 (Siebeldingen), AUD 625,000-650,000 (Vassal). The UC Davis-FPS operations are the most costly, at close to AUD1.5m/pa. The l'Espiguette and UC Davis-FPS collections receive 60% and 40% of their funding from government, respectively. The Washington State collection acknowledges 90% of its funding is from the government and 10% from industry. Only l'Espiguette and UC Davis-FPS reported private sources of funding.

Conservation genetic resource collections have historically had the least secure funding. The ampelographic collection in Portugal however has indicated it runs on a very small annual budget (ca AUD 4,000).

Most international collections have an income stream that results from activity at the collection site. The sale of cuttings is the primary income stream reported. The other income earning activities reported by collection curators include diagnostic, identification, and viticultural acceptability screening; proprietary line care; and distinctness, uniformity and stability (DUS) testing to support plant breeders' rights. It is noted that for several collections these 'services' are in fact costs of management. Income may also be derived from royalty payments, research grants. No collection reported that oenological testing was a source of income (or cost), but several undertake such activity.

Washington State, as an importer of industry-requested material, recovers costs on public selections through sales, grants and nursery assessments. Proprietary material may be imported on behalf of individual 'sponsors' with sponsors responsible for all importing and related operational costs.

5.3.4 Health testing, ampelography and traceability - data management

Most international collections are planted on rootstocks, but the US collections are planted on own roots. In the Pacific north-west, 99% of vineyards are planted on own roots but in high pH soils rootstocks are occasionally used to overcome lime chlorosis (Whiting, 2012).

After acceptance into a collection, health testing may cease or be on-going. Post-entry health testing reflects a collection's primary purpose. At UC Davis-FPS, 20% of the collection is tested each year, thereby achieving a whole collection health status check every five years. The practice is similar at l'Espiguette. The range of tests conducted post-entry usually includes regulated viruses, phytoplasmas, strains of leafroll virus and grapevine fleck (in rootstocks). On-going maintenance of material at Washington State is estimated to be USD150/pa/accession.

To ensure correct identity, the USA and European collections utilise internationally-recognised ampelographers. The European database[7] includes ampelographic descriptors, and has EU agreement on microsatellite markers to be used for verification. It needs be reemphasized, however, that there is no international agreement on which collection or collections holds agreed plant type reference standards for grapevine varieties from which DNA could be obtained for variety verification purposes with the agreed number of microsatelite markers. Australia's use of the European Vitis collection is unknown, but recommended.

The basis of naming/re-naming entries and traceability standards are variable. In some collections the original accession numbers and or donor numbers and breeding codes are retained. In others a unique naming system is applied to material on entry, either as a local name or identification number linked into a national database. UC Davis-FPS and Washington State assign a unique identification number which is linked to the National Grape Register. Recent work has linked this to the original name of the imported clone.

Many European countries have a clonal registration system that ensures some continuity in nomenclature, and maintenance of traceability. At Siebeldingen the accession number and donor number are maintained and breeding codes are kept as synonyms. PORVID has a unique naming system that identifies the original vineyard and mother vine. It is linked to a central database that includes information on the origin, region, and all practices/treatments applied to the vine before entry.

5.3.5 Collection limitations and risk management

Most curators identified money as the limiting factor in operations. The financial status of a collection has an impact on all management activities – expansion, health testing, register/data maintenance, technical staff, long-term planning and technology development etc. The limitations of technology are most pronounced in timeliness and management efficiency. Washington State identified that virus elimination, despite significant advancement in practices, in combination with changing regulations on imports, had delayed access to new clones by interested parties (as for shoot tip grafting as practised by some Australian industries).

Space in which to expand was identified as a limiting factor at one Portuguese collection (Dois Portos). Space is expected to be a limitation at Washington State in the future.

Questions about the resilience of collections and their capacity to adapt to changing circumstances revealed risk exposures in those areas not aligned with a collection's primary purpose. PORVID for example, rated its potential to satisfy heritage and biodiversity demands as 'excellent', whereas Washington State rated their capacity in this area as 'poor'. Washington State however is well-prepared to respond to changing disease pressures. Few collections can reasonably predict their adaptation capacity in a changing climate. Collections with income earning potential beyond the sale of cuttings, are more resilient.

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[7] For more information on the European *Vitis* database, see:
http://www.eu-vitis.de/index.php
http://open-pub.iasma.it/bitstream/10449/20980/1/2012%20Vitis%20Maul%20et%20al.pdf
http://www.cabdirect.org/abstracts/20083299039.html;jsessionid=2E23DE5BDFBEE985AFD1BC7BA2D78E9D?gitCommit=4.13.20-5-ga6ad01a
http://cwrsg.org/ECPGR/workgroups/vitis/Vitis1_WEB.pdf#page=173

5.3.6 Scheme drivers

Managers of international collections identified the drivers of success of their collection. All suggested that funding was a key driver (and also a limitation), while most also suggested industry support was essential to their viability. The UC Davis-FPS curator suggests that expansion will underpin their further success while the authority at PORVID in Portugal believes its international reputation (and consequent demand for heritage material) will continue to contribute to its success. Their reputation for high phytosanitary standards has underpinned Washington State's successful scheme and is expected to drive increased usage.

5.3.7 Summary: International grape collections –resources and management factors

- The international collections are primarily multi-purpose, government-supported resources.
- Most international viticultural collections include wine, table grape and multi-purpose scion material, and rootstocks.
- Most collections identify national government ownership. In the USA, state governments are the acknowledged owners (eg California Department of Food and Agriculture (CDFA) but support is also received from the US Department of Agriculture (USDA), and relevant universities (UC Davis, Washington State University).
- In several European countries, including France and Germany, there is more than one government-owned national collection. Most international collections are partially duplicated in another collection within the same country.
- The collection funding received from governments ranges from 40 -100% of operational costs. Estimated management costs per annum for Vassal, Montpellier is between AUD 625,000-650,000, and Siebeldingen and Washington State both estimate their management costs exceed AUD 400,000. The UC Davis-FPS collection costs are cloes to AUD1.5m/annum.
- Internationally, the multi-purpose repositories list the maintenance of genetic resources as the primary purpose. Portugal's PORVID 'collection' is a scheme of collective clone management, rather than a repository.
- The maintenance of heritage cultivars and increasing/conserving biodiversity are purposes increasingly valued.
- Other identified 'purpose': PORVID's stated purpose is evaluation of inter-varietal diversity, and they do not provide material to growers.
- Washington State, FPS, and France's l'Espiguette collection identify their collections as having high health purpose. The Vassal collection in Montpellier and Germany's Siebeldingen collections are important in supporting research.
- Respondents reported a range of 5-100% of material within their collections as being 'unique' (not in another collection within the country).
- The international schemes generally allow broad access to material by nurseries, growers, and public, private and/or corporate entities. The 'private' access is likely to be for owners of proprietary lines of wine grapes, table grapes and/or rootstocks. Access may reflect obligations of government ownership rather than the stated repository 'purpose'.
- Respondents stated their collection was 'meeting the expectations' of government owners and industry users.
- Reported income streams other than contributed funds, are diverse. The collections that sell cuttings also report other income stream/s from services provided. These include: diagnostics, identification, viticultural acceptability screening, nursery evaluation etc.

- Most collection managers identified funding and industry support as the key drivers of their collection's 'success'. The success of the Geisenheim and l'Espiguette collections however was also attributed to legislation. Several collections recognised their success was due to international recognition of the collection as a global resource.
- The limitations of the majority of collections were identified as funding, space and regulations. Regulatory imposts may reflect changing government priorities on entry criteria and/or quarantine requirements.
- The 'number of entries' is a limiting factor in collections that maintain too many cultivars not in demand.
- No collection accepts material with regulated/quarantineable pathogens. Other than this level of assurance, infected planting material may be accepted by collections depending on the collection purpose and the specific pathogen detected.
- Post-entry vine health testing varies with collection purpose. At Geisenheim and Dois Portos, testing occurs only on entry, but high health collections conduct an array of tests, regularly.
- In high health collections, vines are removed on the basis of specific pathogen presence. In other collections, vines are rarely removed on the basis of health status - unless there is an economic consequence of the disease, or it involves an exotic pathogen.
- European schemes rely on the management and technical expertise of highly qualified virologists/plant pathologists, ampelographers, and molecular scientists and are part of a larger organisation Similarly, the UC Davis-FPS and Washington State collections, are strongly linked to university researchers, technology and equipment.
- The practices applied to maintain traceability through identity integrity and records of origin and treatments, are varied but ideally would be uniform within a country.
- The international collections undertake ampelography and DNA testing to confirm trueness-to-type of new entries.
- Most respondents identified 'duplication' as the primary reason for vine removal from collections, but this was qualified by some with perceived heritage and biodiversity value. Loss of traceability and identity doubts were also reasons for removal.
- The collections, other than the two consulted in USA, are planted on rootstocks due mainly to the presence of phylloxera.
- Restriction on access is the main means of protecting private material, although some legal arrangements are also reported.
- Considerable variation exists in the reported capacity of a collection to adapt to/respond to changing situations. Some responses were predictable on the basis of the collection's purpose and composition, with Vassal at Montpellier being most confident in their capacity to sustain or respond to changing regulations, demand, disease pressure, climate change, and to heritage and biodiversity priorities. Washington State predictably rated their capacity in heritage and biodiversity maintenance as 'poor', while PORVID's rating in the same categories, was "excellent".

6 RELEVANCE OF OTHER GERMPLASM SCHEMES TO AUSTRALIAN VITICULTURE

The characteristics of, and influences on, international germplasm collections, warrant consideration by the Australian viticulture industries and those with authority to develop strategies for germplasm research, maintenance and usage that benefits industry.

Australia's main collections cannot at present satisfy industry needs *and* government priorities.

Germplasm repositories require government support.

There is no national coordination of inventory knowledge, management practices, or agreed national standards for testing, health status or identity verification. There is no collaborative resolve that is driving the maintenance of germplasm collections in Australia, to an agreed standard.

High health collections have a different purpose than germplasm collections, and the expected demand for material from each, is different. In practice, and for financial reasons, high health collections need to be smaller and dynamic, maintaining only high health material in-demand (>90% of material demanded[8]). Depending on the resources available, promising alternative varieties (including privately-sponsored imports maintained at full cost recovery) could be accommodated. Successful high health collections should have greater direct use by industry members, than a general germplasm collection.

An informative, formal register/central database of inventory in Australian collections (and all imported material[9]) should be maintained as an industry resource. Entries should adhere to agreed:

- Reporting of private entries.
- Proof of identity and name[10].
- Reporting of imposed treatments - in post-entry quarantine (and health certificate).
- Reporting of treatments on entry to repositories (hot water, virus elimination).
- Registered location of mother vines (potential for an insect proof repository?).

Risk management and collection resilience requires more than simple duplication. Australia cannot rely on any autochthonous varieties as a future resource.

Income streams are too limited for funding Australian grapevine repositories. Services that ensure income in times of industry downturn, need to be offered. Regional, viticultural evaluations could be funded by competitive grants. Central DUS testing (as required by PBR) testing would be welcomed by private importers. Table grapes could derive some income from retail nurseries.

A lack of resilience of several collections during periods of low demand for planting material has been highly visible in Australia. Since 2008, demand for planting material has fallen significantly and no public collection has proven to be self-sustaining, nor sufficiently-funded to allow continued activity at the desired level. Sole reliance on the sale of cuttings (for collection viability) is a serious weakness in Australian vine collections.

Importation by a national body, in response to industry requests and international agency acceptance, is an activity and service Australia has neglected. With efforts to build knowledge of alternative varieties, international agency relationships, and legal protection for proprietary lines, this importing role by a national body, should be resurrected. The potential to create a scheme like that of Washington State exists.

Criteria of entry to collections must be defined. They should reflect the primary purpose of the collection. High health repositories should adhere to agreed testing protocols.

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[8] In 2012, the total of 589,000 cutting sales comprised 48 varieties. In 2010, 90% of the total crush comprised 15 varieties; 80% from eight varieties. In 2002, 20 varieties made up the 590,000 sales. While the interest in and planting of alternative varieties is increasing, they remain a very small percentage of the current vineyard area and crush.

[9] FVF held mother stock of approved virus-tested varieties associated with certain state departments of agriculture until 1991.

[10] Currently new clones may be named in Australia with no frame of reference as to uniqueness or eligibility for clonal (rather than selection), status. The Australian system compares poorly with the European registry system and will continue to suffer inefficiencies due to unnecessary duplication and loss of inventory knowledge.

Technical services are more freely available in Europe, due to proximity, industry structure, funding priorities, and training priorities. The case for a central testing facility for Australian perennial crops is warranted and would allow for the development and more affordable provision of specialist services and technology. Decline in services by most state departments has made this option more viable.

Standards for health status and testing, specifications of wine grape and table grape planting material and labelling are needed. Unlike the citrus industry, viticultural industries have not demanded testing for endemic pathogens in quarantine. Unless further testing before entry to collections is required, there is risk that endemic pathogens will spread within collections and subsequently through the distribution of propagation material.

Access to material and technical services will be critical in the future. There are strong indications that Australia may not have ready access to several overseas collections in the future. The Australian grapevine industry is notably fragmented in its importing efforts. With several European collections limiting their export of heritage material and reluctance to work through individual rather than national bodies, the Australian industry is at risk of having limited access to material at a time when alternative varieties are underpinning most vineyard activity[11].

The response capacity of local collections to an exotic disease outbreak is highly variable. The vulnerability of vine germplasm resources to eradication during an incursion by an exotic pest should not be discounted[12].

Traceback and forward knowledge from nurseries during an incursion would be incomplete in the absence of inventory records, and an up-to-date vineyard registry and nursery registration scheme. Accuracy of the industry data is important for industry biosecurity and for future planning, resource use and market access decisions. At present it is lacking due to the limited ability of the industry to undertake rigorous data gathering under agreed guidelines.

It is essential to have a process, supported by legislation, that ensures the addresses and contact details of those involved in vineyard and nursery industries, are known and accurate.

Australia's inventory of grapevine accessions has not been systematically reviewed – either as a database, or in terms of identity confirmation against European collections. Industry is currently unable to access the main collections due to unconfirmed identity and health status of entries.

7 COMPARISON OF COLLECTIONS WITH RESPECT TO FUTURE PRIORITIES

7.1 Collection types

There are several types of collections that have the potential to serve the different priorities and needs of the various components of the viticulture industry. They are briefly described in Table 4. The features, beneficiaries and ownership of different collections are noted, as are the barriers to meeting their intended industry objectives.

[11] Germany is reluctant to export to a party other than a national body for vine improvement; current restrictions on wine from Australia due to naming, eg Prosecco, Montepulciano varieties; access to ampelographic expertise is limited due to demands on such services within Europe.

[12] The 2005 experiences in Florida with huanglongbing and canker serve as a reminder that healthy perennial sources may be removed in eradication efforts. The challenge for the nursery industry in Florida was to overcome critical shortages of citrus budwood after the loss of two budwood repositories. The extensive Citrus Variety Collection at UC Riverside is at risk as hunaglongbing moves westerly in the USA. CVC has two trees each of more than 1000 different citrus types, and is one of the premier citrus germplasm collections in the world and a valuable university resource. For information on US citrus certification programs and repositories see (from p 26): http://www.citrusresearch.org/wp-content/uploads/CitrographMay-June.pdf

Decisions on the collection types needed for the future must include consideration of risk, inventory knowledge, biosecurity and climate change. To achieve biosecurity Australia needs to have a genetic resource from which material in demand can be readily accessed and multiplied. A source of high health material that is true to type is needed to protect the Australian industry from exotic and endemic graft-transmissible diseases. Only with the availability and use of pest and disease-free nursery stock will biosecurity in nurseries and vineyards be manageable. An industry repository with favoured, promising and clean varieties can best serve this purpose. In the event of a large scale replanting, duplicated resources may be beneficial and these may be in vine improvement or regional plantings.

Germplasm resources are useful to the industry and researchers engaged in breeding and climate change adaptation. Rather than being undefined plantings, germplasm collections are irreplaceable gene banks and are particularly valuable if associated with an up-to-date database. Climate change researchers are evaluating grapevine material for its suitability to warming environments. Researchers have continued access to the large germplasm repositories and are likely to retain this access even if the SARDI and CSIRO repositories do not open up to the industry.

Table 4 : The features of different genetic collection types

Collection type	Main features	Beneficiaries/benefits	Preferable ownership	Barriers to meeting expectations
Germplasm repository General industry access to public material	Library of varieties of unknown health (until released) and often unverified identity, but traceable. Unlikely duplication of content or site. Basis of industry inventory records and knowledge.	Diversity of germplasm – for industry; researchers, breeders. International resource esp. if native material, heritage, biodiversity value established. Research institutions benefit from close proximity to collections. Industry - naming, traceability, maintained. Source of material for international requests.	National – government; or government/industry.	Funds to maintain - size, too many entries; rarely rationalised once established. Limited income potential. Lack of perceived value - by industry or government. Low 'public good' value. Risk of disease spread. Legal implications of material released.
Industry repository Relevant in-demand and promising clones Core, heritage, alternatives Clients - nurseries; VI groups	Dynamic, high percentage relevant and promising clones. High health - optional or obligatory. National importer - on behalf of industry. Potential to isolate incoming material of unknown health. R&D potential - evaluation trials – tolerance, resistance, regional suitability. Income potential – cuttings, R&D, member services – trials, performance records, proprietary line care.	Nurseries and VI groups Industry – through good quality material for nurseries and VI groups Industry - more responsive to industry than germplasm repository. Industry can drive entry and removal - to keep relevant Added value for members. Industry as a whole – a means of engaging private importers.	Industry – membership rewarded with access. Partnerships with government (encouraged).	Funding. Incomplete record keeping. Private importers outside system – imports, naming, record keeping etc. Size - too many clones; high health clones maintained without commensurate demand. Lack of facilities – testing, trials, isolation etc. Private importers with import rights that preclude industry at-large importing, restricted access to international clones of interest.
Scientific resource Addressing R&D	Utilised for R&D - by researchers, breeders eg climate change, disease, drought, salinity, compatibility etc.	Same as for germplasm repository.	Government + institution. Should not duplicate germplasm repository.	Unnecessary cost if overlap with germplasm repository in purpose and composition.
Multi-purpose repository Any combination of the above	Germplasm collection with potential to value-add, house incoming material, utilise collection for R&D; and/or supply nurseries etc.	Industry as a whole.	Partnership- industry and government.	Funds. Loss of relevance; mixed objectives. Record-keeping.
Vine integrity collection	Entries have identity verified by DNA testing (noting current lack of	Industry, researchers, peak marketing bodies (label integrity	Government with support from	Few entries likely to be suitable for

Collection type	Main features	Beneficiaries/benefits	Preferable ownership	Barriers to meeting expectations
Addressing biosecurity, traceability	international agreement on plant type reference standards for grapevine varieties). 1-3 vines confirmed against international reference + complete origin and identity history. Potential storage alternatives, eg *in vitro* collection - cryopreservation.	program managers).	industry (eg marketing components).	entry (30 to-date). *In vitro* storage potentially not sufficiently explored. No established national standards, guidelines. Cost to industry. (if DNA identity required on imports, cost transferred to importer/exporter) Technology important, expensive.
High health repository Addressing biosecurity, industry response	Repository for vines with defined health status – field and/or screen house (mother vines). Virus elimination services Addresses some biosecurity threats. Records of all treatments – linked to database. Adheres to naming protocols.	Nurseries, VI groups doing multiplication. Industry – but at growers cost unless mandated/contracted use of high health clones and endemic and exotic testing in post-entry quarantine. Potential for certification scheme	Industry – with technical support in-kind from eg a national facility for perennial vine /plant testing (proposed).	Funds. Lack of nursery contributions Keeping too many clones in high health state (especially if demand is low). Purchase price doesn't cover testing/treatment costs and grower resistance to pay. Absence of leadership in directing the planting of high health material.
Private repositories	Small, dynamic, relevant. Restricted access to material. Exclusive rights. Legal protection.	Private owners and importers – early adoption benefits Industry – if proprietary line inventory added into central database.	Private- but merit in partnerships – eg other perennials, VI groups.	Costs/risk not shared. Private entries can 'tie-up' agency agreements that deny access for national industry (to import). Hidden inventory – loss of national inventory knowledge.

***** The larger the collection, the greater the cost is a constant across all categories

7.2 Comparison of collections with respect to future priorities

The review team have made a subjective assessment and ranking of the collections and their organisation's capacity to meet the needs of the grape industry. The ranking was based on much of the confidential data gathered in this project, and thus the details cannot be provided in this summary report.

Eight priority purposes (or needs) for the collections of grape germplasm were identified:

- A germplasm repository for biodiversity, research and breeding.
- Planting material superior to the existing standard for industry development.
- Planting material of the highest health standard.
- A supply to industry of new or alternative varieties.
- A germplasm repository for heritage varieties that warrant preservation.
- A germplasm repository of unique varieties that may not be found elsewhere in the world.
- A germplasm collection that includes wine grapes but also table and dried grape varieties.
- A supply of appropriate rootstock material for current and future industry needs.

The ranking for the purpose of the collections was assigned by the consultant team taking into account our view of industry priorities combined with a broader view of what we considered to be best for the industry.

Each of the nine collections[13] was given a ranking for their capacity to satisfy the priority purposes. It should be noted that the CSIRO and SARDI collections are currently not available to supply germplasm material to industry but our ranking has presumed that this position will not be permanent. The ranking of the capacity of these two collections was made on the basis of them being available to service industry's needs in the future. The Western Australian collection provides high level service to the WA industry, but does not at present provide material to other parts of the national industry.

Some of the priority purposes are covered by a high proportion of collections; for example, industry rootstock supply and alternative varieties. However other priority purposes are covered by a low proportion of collections; for example, germplasm repository, unique and heritage collections. Within the collections covering any one priority purpose there is also a very wide range of capability of the collections to satisfy the priority purpose.

Given the assigned priorities, the outcome of the subjective weightings show that AVIA, CSIRO, RVIC and SARDI are the collections with the highest weighting for capability to meet the priority purposes. These collections/organisations are those that have played leading roles in providing varietal resources to the industry in various ways in the past.

The top priority purposes are the core purposes of repositories for research/breeding, high health status, availability of quality scion and rootstock varieties for industry and new alternative varieties.

Some of the lower priority purposes are still very important to industry but they cannot compete with the higher priority purposes, and an industry cannot sustain itself on these priorities.

For example:

- Table and dried grape germplasm is critical to these industries. Table grape varieties are well supplied with varieties from overseas breeders and CSIRO. Dried grape varieties are

[13] Main public collections. Despite its supply limitations, the NSW collection rather than MIAVIS was included because it houses the mother vines.

also supplied from overseas breeders and CSIRO, albeit to a very small market. The R&D funding of the table grape and dried grape industries is through Horticulture Australia Limited and not within the responsibility of GWRDC.

- Unique and heritage germplasm repositories are very important and must be included in at least one collection. However because of the low numbers of these varieties, they have been given a low weighting compared with the other priority areas. Nevertheless, Australia has a responsibility to maintain these varieties, which may only be present in Australia, on behalf of the international grape industry as they are a key global resource to provide genes for future breeding programs.

The rankings and weightings used for this assessment were subjective and present the collective view of the consultant team, even though we did not individually rank or weight things exactly the same. Readers of this summary report may use their own rankings and weightings to compare our view with theirs. We anticipate that there will still be a range of very different views within the complex grape collections and vine improvement sectors of the grape industry.

8 FUTURE OPTIONS

In providing options for future grape genetic resources and future investment in germplasm research, the project team recognises a full risk assessment has not been undertaken, that their review of other schemes has been extensive but not exhaustive, and that our view of the priorities for the wine grape industry are likely to differ from those of the table grape industry.

Ultimately the industry will identify the value they place on genetic resources through their demand for material and support for collections, but industry leadership at the national level must allow time and provide resources for the development of risk-based guidelines that ensure the industry in times of low demand, do not relinquish/abandon resources that will be required to underpin subsequent growth in demand.

The project team has considered the 'ideal' genetic resource/s for Australian viticulture. The ideal scenarios assume no encumbrances.

8.1 Some ideal scenarios for germplasm management

The ideal genetic material resource for Australian viticulture serves two purposes, and is best provided as two separate collections. One is a resource to serve national viticultural interests; the other primarily serves the grape growing industry.

The ideal genetic resource for *national viticultural interests* is a collection comprised of.

- Accessions with confirmed identity (DNA tested against agreed international standards).
- Accessions of known health status, subject to on-going testing that meets industry-agreed standards.
- Accessions from environmentally-diverse regions.
- Mainstream varieties and clones.
- Promising varieties and alternative varieties, be they of heritage or unique interest.

The collection ideally would have:

- An enviable international reputation.
- A system by which the database of inventory of vine material was maintained, was accessible (nationally and internationally) and was considered a valuable global resource.
- A close association with a research and development facility, that housed professional resources in plant pathology (virology, mycology, bacteriology), entomology, molecular biology, and ampelography.
- Government ownership.
- Industry support through demand for material at fair prices, and demand for services (eg. central coordination of imports and exports).

The ideal genetic resource for the Australian *wine grape industry* would include:

- Accessions with verified identity.
- Accessions in-demand, improved and/or identified as having demand in the near future.
- Accessions with high health status.
- A database that includes health status, and follows nationally-agreed nomenclature conventions.
- Dynamic and responsive links to industry and international intelligence on trends.
- Accredited nurseries (including approved VI bodies) as clients.

- Co-operation with the national repository on import requests on behalf of industry (private and public) material, to reduce duplication and loss of traceability.
- Industry support and fees for service that provide an income stream.

Australia is unlikely to achieve the 'ideal' situation for its genetic resources, but the team recognises that two complementary repositories can serve the Australian viticultural industries well. They should have most of the features of the 'ideal' scenario. Some are considered 'essential'; others 'beneficial' for the Australian germplasm context. The essential components are:

- Accessions with confirmed identity (DNA tested on entry).
- Accessions of high health status (known prior to release for propagation).
- An appropriate range of varieties and clones.
- To be resourced to allow regular database maintenance.
- Associated with a professional support facility.
- Resourced effectively to provide stability and maintain cash flow with government partnerships.

In addition to the above, the 'beneficial' features in the Australian repositories are:

- Coordination of industry importing.
- Potential for self-sufficiency.

9 WHAT ACTION IS NEEDED?

Three options are presented for consideration by industry. Ultimately the industry will have to conduct a full risk assessment in order to justify the chosen course of action. A strategic plan will also be necessary to guide decision-making on genetic resources.

The options are:

1. No action

Leave collections in the current state. Allow market forces to dictate the survival of VI resources, and government to dictate the future of their resources without industry engagement or consideration. It appears it will not be possible to maintain the *status quo* because the reported financial constraints are such that industry could anticipate:

- The closure of several collections.
- A decline in health and number of genetic resources the industry can access.
- An increase in private importations (legal and illegal) outside any industry system.
- The loss of inventory details and intelligence on existing and in-coming plant material.

The potential outcomes of this option are that:

- Industry will not advance. It will lose pace against respected international industries.
- Industry will not be responsive to new trends.
- Planting of clones with unknown confirmed health and identity will increase.
- Response to new trends for varieties and clones will be slow.
- Industry will not be assured adequate supply of good quality rootstocks or mainstream scion material when vineyard development again becomes popular.
- R&D and germplasm development will decline and industry is unlikely to see appropriate returns on their investment of $500,000 per annum of levy funds for the past 20 years.

2. Provide funding

It is not expected that funding to rescue or maintain all collections is either likely or warranted. However the injection of some funds, directly or with the assistance of a levy activation or levy base increase, would allow time to develop, with an engaged industry, a process for the management of grape genetic resources and adjustment for the future. In the absence of financial support, Option 1 is likely the only real option.

With the provision of industry funds, collection managers and a guiding management body would have the opportunity to conduct a risk assessment, and develop a strategic plan that should direct decision making. Some industry funds may be warranted now to maintain key resources in the short term, but would be contingent on some effort to investigate alliance and re-structuring potential.

With the provision of government funding, the CSIRO and SARDI collections have the potential to return as active, accessible collections with more identity-verified accessions. In the absence of this, it is likely these collections will become research collections only. This has industry-wide consequences as these two collections hold a significant number of accessions held nowhere else in Australia.

Potential outcomes of this option:

- The CSIRO and SARDI collections remain as industry resources (if vine identity investment resolves outstanding issues).
- VI partnerships may be strengthened.
- AVIA, RVIC and VAMVVIA survive[14].
- WA collection remains active as a WA industry resource.
- NSW collection may be able to remove virus-infected material and increase its use by industry.
- Private collections are unaffected.

3. Rationalise collections

This review has confirmed that Australia has valuable grapevine genetic resources. It has also confirmed that different segments of the industry may have different priorities, and no collection meets all industry priority purposes. There is significant duplication in the composition of collections, and few non-government collections are financially viable and stable.

To retain necessary industry germplasm resources, there is justification for rationalisation of collections, primarily between similarly funded bodies, eg between the two government-owned germplasm repositories, and between the leading VI groups.

Government funds may increase the partnership potential for the advanced VI groups that house valuable plant material; allow them to rationalise and reduce the duplication across collections to become more relevant and dynamic industry resources.

Potential outcomes of this option are budget dependent, but include:

- CSIRO and SARDI collections maintained, as a risk management strategy.
- Amalgamation of the CSIRO and SARDI collections to one site (new or existing), minimising duplication.
- Consolidation of viable VI groups, to ensure states are effectively served, and biosecurity is considered, by

[14] RVIC and VAMVVIA are the most viable, industry-relevant collections at present amongst the VI groups. Both have income streams in addition to sales of cuttings. RVIC has a commercial nursery and initiatives with other horticultural crop germplasm programs.

either *Selecting two physical collections*, eg. SA – rationalise RVIC and Kapunda; Victoria – rationalise AVIA and VAMVVIA,

or *Uniting to form one collection* that has assured industry and professional support (near a university or other research facility) or best complements the government repository and close working relationship.

These alternatives would each benefit from an association with a government program, directly (eg in partnership with funding) or indirectly (with R&D institution and/or university). Comparable arrangements internationally all have some government support.

Rationalisation of collections will require time and some immediate resourcing. A timeframe for review of progress should be a requirement, if this option is pursued.

4. Recommendations

The project team's assessment of the options:

Option 1 is not an option that is acceptable to industry.

Option 2 with government funding is preferred, but full government underwriting of germplasm repositories is unlikely, when the public good is unclear.

Option 3 has most potential to satisfy industry needs in the future. This is supported by the analysis conducted on priority purposes and collection capabilities.

The project team recommends that Option 3 be pursued.

To progress the further assessment of Options 2 or 3, the industry will require a Risk Assessment, Strategic Plan and the formation of a skilled management committee.

10 OTHER RELATED MATTERS

In order to progress the broader issues identified for vine collections, there is a need for a Risk Assessment, the development of a Strategic Plan, and for appointment of a Board of Management. Further requirements are the forming of alliances with more institutions, other perennial industries, and vine improvement groups, and to combine these elements into a strategy for vine collections.

10.1 Risk Assessment

A risk assessment that identifies perceived threats to the industry related to the future of planting material is essential. The threats are likely to be at both the organisational level and vineyard level. A thorough risk evaluation would clearly identify risk, its potential impact, and the necessary actions to avoid, transfer or eliminate both risk and impact.

It may reasonably be predicted that a risk assessment on Australian vine germplasm resources would identify risks associated with: financial viability of collections, material access, diagnostic standards and inconsistency, loss of traceability, loss of professional specialist services, loss of germplasm inventory knowledge, and loss of international access to material. Of particular importance in determining future options is the likely impact of each threat: loss of access to genetic material for example, may trigger a damaging industry response, eg increase in illegal importations, planting of diseased material, poor industry stakeholder relations etc. The distribution and planting of mis-identified germplasm has been experienced and in the absence of national protocols and plant standards, variable database referencing, and industry supply and acceptance of variable quality planting material, we can assume the potential remains for this to occur again.

In the event of an incursion of exotic disease, subsequent re-planting needs must not be met with common stock. Collections therefore are essential industry assets and the impact of threats to their existence must be identified and factored into decisions on germplasm resources.

It is important that the risks to the Australian germplasm resources are know and the responses required are identified and understood.

10.2 Strategic plan

WFA and WGGA have agreed in principle that germplasm resources are important for the future performance of the wine sector. An agreed strategic plan is required to determine industry priorities and on-going funding. It may incorporate a biosecurity plan. Essential to the development of these plans, is industry engagement and commitment to the agreed outcome.

A strategic plan for the industry may identify the most advantageous balance of purpose priority and size of collections, against available funds and the returns to industry. The strategic plan would also recognise that not all collections provide a financial return to industry (eg. germplasm repository) and would therefore guide a strategy for securing government support and re-structuring of collections, together with a vision for self-sufficiency in the longer term.

The absence of funding from nurseries (and nursery registration) is a barrier that should be addressed. Nurseries are a beneficiary of collections and the associated best practice activities, but they do not contribute to the funding of them, other than in the price paid for cuttings. Nursery levies are relevant to potted plants, rather than field nurseries. The pot levies are paid into HAL and table grapes and dried grapes may be a potential beneficiary of them, but it is unlikely. The strategic plan may identify a means by which nursery industry contributions could be directed to collection maintenance, or a nursery levy could be raised and collected on field plantings.

10.3 Management Board

A Management Board to oversee the Australian vine germplasm resources will require a strong independent chair to ensure that the core organisations (CSIRO, SARDI, AVIA, and the relevant VI groups) complete a strategic plan and commence its implementation in an agreed timeframe. The management board may also guide the process by which CSIRO and SARDI germplasm collections can meet the industry priorities in the strategic plan.

10.4 Alliances with other perennial crop industries

Alliance with other organisations to reduce net costs for collection maintenance and servicing would be a useful strategy. In preparing this review it is apparent that other Australian horticultural collections are having similar problems with funding and maintenance of collections and there is a requirement to establish partnerships in this environment. However, with so many common interests, the sharing of ideas and resources really need to be seriously explored.

Detailed examples from other industries are presented in Section 5 of this report and are the basis of the following comments.

The citrus industry's management of the health and quality of their collections and the supply of superior planting material to their growers is the most developed of the horticultural/viticultural industries in Australia. Their practices and funding arrangements should be further investigated for their relevance to the grape industry.

Some cooperation between the citrus and grape collections occurred when Auscitrus, NSW DPI and VAMVVIA were partners in the development of the resource block at Dareton, NSW in 2010.

The pome fruit group is well-organised. It limits its activities to cleaning up varieties in demand, or those that are newly imported. They add value for members, by providing exclusive access initially and coordinating evaluation trials.

The almond collection has been actively maintained at Monash in the SA Riverland under arrangement with RVIC. The almond industry plans to review its activities and biosecurity and is likely to establish a new mother block in the near future.

Several perennial, horticultural industries have expressed support for a central facility for professional support services (pathology, molecular biology, indexing) relevant to germplasm maintenance and industry development. The economies of scale and the assurance of on-going specialist services would be valuable to all industries. Other cross-industry activities that may deliver cost reductions through alliances include: a nursery registration scheme, development of national guidelines for germplasm database management, legal protection agreements for proprietary material, and investigation of joint *in vitro* repositories, eg. cryopreservation.

In the forestry industries, the Southern Tree Breeding Association has managed an improvement program since 1983. It is recommended that the Management Board examine this program for elements that may be applied to a vine improvement model that also addresses germplasm maintenance in the long term.

The other important alliances that are often taken for granted are those with universities and research institutions that have the capacity to provide specialist pathology and DNA testing services, and germplasm evaluation. Without access to these specialist services, the monitoring and quality control essential for the guarantee of germplasm quality will not be possible.

11 POTENTIAL BUSINESS MODELS

The business of germplasm management is complex. Until some firm directions for the Australian germplasm collections have been formulated in the Strategic Plan, any work on the development of a formal business plan is premature.

The examples in Section 5 of this report explain how other industries are managing their genetic resource "businesses" and they are models for consideration by the grape industry.

The citrus industry germplasm structure and management are the most advanced of the horticultural industries in Australia. The citrus industry manages arboreta, high health mother stock in screen houses, breeding and evaluation collections and multiplication schemes. Their systems ensure all planting material is managed with skilled oversight of protocols and audits. They accommodate proprietary lines imported by commercial variety managers, who pay a fee to gain access to the valued Auscitrus label and horticultural evaluation.

The forestry industry has the most commercial germplasm management system, but they are working with a small number of tree species and superior lines and have a relatively small number of clients, mainly corporates, across Australia.

The international germplasm resource schemes in Europe and California are supporting larger industries than those in Australia and they appear to have a strong government funding base and access to associated technical expertise from research and university agencies.

None of the examples will exactly fit the requirements and politics of the complex collection arrangements found in the Australian grape industry.

11.1 Current funding

The viability of commercial collections at present relies on sale of cuttings. This is not sustainable in times of low demand and any business model must include consideration of income streams. The different skills and focus of some VI groups suggest this is already being

considered. Some VI groups do not maintain collections but source their material from other VI bodies and focus activity on multiplication in source blocks. Some VI groups maintain collections beyond the needs of industry. The specialisation of VI groups through rationalisation will likely present some cost mitigation opportunities and reduce the non-competitive pricing for high health material, and competition for the same income stream. It is also expected that VI groups will consider a fee structure for sales to nurseries, especially retail nurseries (eg for table grapes) in times of low vineyard demand.

Government funding at present is restricted to the government collections, and research stations. Indirectly they are supporting some non-government collections through the sharing of space and some services.

11.2 Other avenues for funding

The viticulture industry has several options to economically advance the status of their genetic resources beyond those dependent on collection management and funding. If DNA-based identity evidence were required on entry to Australia, it would relieve the industry and collection managers of this cost. Registration in the database could be immediate. Similarly, it is incumbent on the industry and especially private importers, to ensure that endemic pathogens do not enter the vine collections so the industry should increase alliances with private importers and quarantine services within DAFF to increase post-entry quarantine indexing for endemic as well as exotic pathogens (as for citrus and citrus relatives). Importers rather than the industry would incur the additional cost, but material released would have a known health status, and be immediately suitable for propagation or entry into a foundation mother block.

Options for funding may include activation of a biosecurity levy, which would require industry agreement; raising a nursery levy, or expanding the levy payer base of the existing nursery pot levy (to include field nurseries). Biosecurity funding needs to be secured with an industry commitment, as industry members are identified as the major beneficiaries. The EPPR (Biosecurity) levy has been set at zero for the grape industries that are signatories to the Deed. Under the biosecurity requirements this may be activated in the event of an incursion, or set at a positive rate to build up a fund. It is the latter option that may be used to support the industry plan for the germplasm collections, in the interest of biosecurity.

12 SUMMARY AND RECOMMENDATIONS

This review recommends actions to be taken to optimize Australia's germplasm resources, their management and usefulness to the viticulture industries and allied interests. This will assist the Australian wine industry to reach an international, competitive standard with respect to knowledge of, and access to extensive genetic resources that can provide options to address future environmental and marketplace challenges.

The project has resulted in a revised register of germplasm in Australian grapevine collections. The project team strongly recommends that the register be maintained, regularly updated, and refined, in association with the development of national guidelines on naming, health testing and identity verification. A focus on identification verification against international reference databases, is recommended.

The project team recommends that investment in germplasm-related R&D continue and that some funds be directed to management of the register and collection management, as inventory knowledge and the germplasm plantings underpin much of the relevant R&D.

The practical options for germplasm collection management in Australia, are limited. The options presented are to:

Option 1. Do nothing,

Option 2. Secure some government funding to support some collections, or

Option 3. Rationalise the number of collections.

The project team recognizes that government priorities do not generally support the funding of germplasm collections, and therefore it recommends Option 3 be pursued. It is recommended that support be provided to first undertake a risk assessment, develop a Strategic Plan and form a Board of Management.

It is recommended that the Management Board examine the activities, funding and business structures of other perennial industries (eg. citrus, forestry) to identify elements that may be applied to germplasm management and/or vine improvement models, requiring long term relevance.

It is recommended the industry pursue closer alliances with other perennial industries and with authorities in post-entry quarantine services.

13 REFERENCES

Constable, F. and C. Drew. 2004. Review of vine health parameters, implementation priorities and capabilities for vine improvement groups and accredited nurseries. Final Report GWRDC NVH03/01.

Dry, N. 2005. *Grapevine Rootstock evaluation and breeding in Germany, France and California*. PGIBSA Final Report to GWRDC. PGI 05/01.

McMichael, P. and P. Barkley. 2008. *Review of Almond Budwood and Seed Multiplication and Recommendations for Accreditation Scheme*. HAL Final Report AL06006.

Nicholas, P. 2003. *Standardised protocols for conducting grapevine improvement trials in Australia*. Final Report GWRDC Project SAR99-6. 26 pp.

Nicholas, P.(ed). 2006. *National Register of Grapevine Varieties and Clones.* AVIA, Irymple, Australia.

Nitschke, D. 2013. *Alternative varieties, planting material and RVIC approach.* in Central Region Alternative Varieties Workshop – Successes, Opportunities and Cautions. Feb 2013. GWRDC Grassroots funding.

Tassie, E., Henschke, P. and D. Coleman. 2012. *Ensuring Trueness to Type of some Alternative Varieties.* GWRDC Project GWR IN1007.

Walker, R., Thomas, M., Clingeleffer, P., Davis, H and M. McCarthy 2009 *The future of Dual purpose Grapevine Germplasm Collections in Australia*. (component of Project GWR 1112 Brief).

Whiting, J. 2012. *Rootstock Breeding and associated R&D in viticulture and wine industry*. GWRDC Review – Final Report GWR 1009. August 2012.

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