

USER DOCUMENTATION

INTRODUCTION

A database may be defined as an organized body of related information designed especially for rapid search and retrieval; a collection of related information organized and presented to serve a specific purpose (Woolf, 1977). The Australasian Pollen and Spore Atlas was initially conceived as a support tool, for the enhancement of scientific research in the Australasian region in the field of palaeoclimatic and palaeovegetation reconstruction. A large, growing body of palaeoenvironmental data from all areas within Australasia exists as pollen records from terrestrial as well as marine deposits, for the period starting from the Last Glacial Maximum in particular (~18,000 years before present). As a leading technique, the utilization of pollen can be said to be in response to a need to understand better the regional nature of climate change and to secure more precise knowledge regarding ecosystem response, the nature of past human occupation, and the nature of past human effects on the landscape. Long-term environmental records, to determine the dynamics (including stability) of modern ecosystems, are becoming increasingly pertinent in view of current and predicted future global change. In this respect, the growth of green politics and increased public awareness of the environmental problems facing societies with global warming can be said to have placed increased and additional attention on those research fields concerned with climatic change in particular, propelling pollen analysis even further (*c.f.* Gaillard *et al.*, 1994; Prentice and Webb, 1998).

The accuracy of environmental reconstructions, however, ultimately depends on solid pollen identification and in turn, the degree to which information regarding pollen identification is available and collated. Contemporary pollen sample collection and identification, cross-referenced with plant data, vegetation community information and distributions of current climate, form the basis of fossil pollen sequence interpretation. Modern pollen studies are common precursors to fossil analysis. It follows, therefore, that species-level pollen or spore identification provides the analyst with detailed ecological information, but that a lack of distinction to the species level in fossil pollen studies can render palaeoenvironmental reconstructions under-potential and incomplete. Palynological studies made at the highest possible taxonomic resolution can lead to a more confident characterization and richer view of palaeoenvironmental change (Finkelstein *et al.*, 2006) and ultimately encourage more widespread use of reconstructive data.

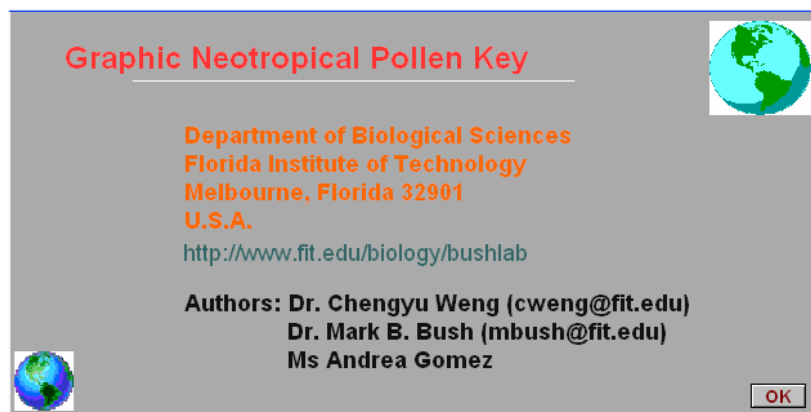
The development of pollen, including modern, databases in the northern hemisphere has been extensive. Whitmore *et al.* (2005) trace the construction history of pollen databases in North America and Greenland in particular, and review the current status of the available modern pollen information network. The North American Pollen Database (Grimm, 2000a) began operation in the late 1980's. The European Pollen Database (Cheddadi, 2002) started shortly thereafter. The North America Pollen Database benefited from being able to incorporate sub-regional, pre-existing datasets consisting of samples from Canada (Gajewski, 2005), Alaska (Anderson and Brubaker, 1986), eastern North America (Webb and Andrews, 1976 quoted in Whitmore *et al.*, 2005) and the southwestern United States (Davis, 1995). Co-operating pollen dataset projects in Europe include the Eastern Mediterranean Database and the Alpine Database (Grimm, 2000a),

PalDat – a palynological dataset based in Austria (Buchner and Weber, 2000) and the more recent Northwest European Pollen Flora (Punt *et al.*, 2003). Continued expansion of both the North American and European Databases initiated the Global Pollen Database (Grimm, 2000b). This Global Database has become more inclusive with contributions from the Africa Pollen Database (Lézine, 1996), the Latin American Pollen Database (Marchant *et al.*, 2002; Grimm, 2000a) and the Neotropical Pollen Database (Bush and Weng, in press) initiatives. The emphasis of the Global Pollen Database is to archive pollen core data; modern pollen data are also included (Whitmore *et al.*, 2005).

The establishment of pollen and spore databases in the northern hemisphere, extending into South America and Africa, teaches us three things. Firstly, that there remains a need for a database spanning the Australasian region, facilitating pollen and spore identification specific to that region. Secondly, that databases may in fact function better along the principle that ‘the whole can be greater than the sum of all the parts’, whereby on collating a number of smaller, individual sub-regional databases the potential exists for a greater collective, for new insights, questions and discussion, increased interdisciplinary application and research support to a degree unlikely to arise from any one given collection (*c.f.* Marchant *et al.*, 2002). Thirdly, that databases serve as an archive of pollen, spore and associated data; as archives of the results of research activities as well as a source of reference for new research programs. Grimm (2000) expresses concern as to the lack of long-term archiving and curation of pollen data, a prime consideration in the creation of the North American and European Pollen Databases. As online archives, databases allow for greater accessibility to any given institution’s ‘hard copy’.

The Australasian Pollen and Spore Atlas is a database constructed and maintained by the Palaeoworks laboratory at the Department of Archaeology and Natural History, Australian National University (Canberra). In the early stages of the project close collaboration developed with the Neotropical Pollen Database (incorporating data from South America, Central America and the Caribbean, see Figure 1, <http://research.fit.edu/bushlab/index.html> and Bush and Weng, in press). As a result of this collaboration the two databases are compatible, designed using the same software and possessing the same file structure with a similar online web-query interface. Such co-operation facilitates scientific exchange and the pooling of pollen and spore knowledge right across the southern Pacific.

Figure 1: The Neotropical Database information window



The Australasian Pollen and Spore Atlas seeks to catalogue the large amount of modern palynological data accumulated by Palaeoworks and the Department of Archaeology and Natural History over many years. The Palaeoworks laboratory holds a collection of modern pollen samples from Australia, southeast Asia and Pacific Oceania, developed through research efforts in palaeoclimatology, palaeoecology, archaeology and aerobiology. Further collections are housed at Monash University (Australian and southeast Asian pollen collections), the University of Newcastle (Australian pollen types), Southern Cross University (pollen, spores and other microfossils from Australia and New Guinea), the Australian Nuclear Science and Technology Organisation (pollen from Australia) and the University of Sydney (pollen and spores from Australian plant species with allergenic properties). Such collections have developed from specific local institutional research needs and have generated information relational databases associated with individual departmental research directions. Importantly, a common characteristic of all collections is that there exists a large, expanding volume of data associated with the pollen and spore taxa represented. The Australasian Pollen and Spore Atlas can only enhance current independent efforts to construct pollen and spore collections by creating a one-stop online query interface and information resource, uniting images and information from existing data sets. The Australian pollen and spore research community has demonstrated a willingness to contribute data, utilize the data and become involved in the wider application and ongoing development of the Australasian Pollen and Spore Atlas. Key contributors met at the Australian National University in December 2005 to resolve certain practicalities involved in starting the database. Discussions centered on the structure of the database, a targeted species list for the initial developmental stage, protocols for contributing information, and appropriate nomenclature. It was considered important that the Australian Pollen and Spore Atlas provide easy access to information and data exchange preventing repetition of works or loss of work. Please note, as an integration of a number of collections within Australia, the Australasian Pollen and Spore Atlas is an on-going project.

Additional information on the Australian National University Palaeoworks laboratory may be found at <http://palaeoworks.anu.edu.au>. For more information about research and teaching at the Department of Archaeology and Natural History visit the homepage <http://rspas.anu.edu.au/anh>. For details relating to Monash University and research activities within the Centre for Palynology and Palaeoecology visit <http://www.arts.monash.edu.au/ges/research/Cpp/>. An outline of the University of Newcastle pollen collection initiative may be found at <http://www.aqua.org.au/AQUA/Pollen/index.html> and described in Shimeld *et al.* (2000; 2001). Information on the Southern Cross University's Centre for Geoarchaeology and Palaeoenvironmental Research and associated pollen and spore studies may be found at <http://www.scu.edu.au/schools/esm/palaeo/#Home>. For more information about research within the Australian Nuclear Science and Technology Organisation visit the homepage <http://www.ansto.gov.au/>. Finally, palynological research at the University of Sydney is conducted at the Woolcock Institute of Medical Research at <http://www.woolcock.org.au/>. The Airborne Allergens Database is described in Hjelmroos *et al.* (1999).

Over and above a prominent role in palaeoenvironmental investigation, the Australasian Pollen and Spore Atlas is a compelling resource for research in evolutionary and systematic biology, biostratigraphy (oil and gas), airborne allergens and disease, and the forensic sciences. The Australasian Pollen and Spore Atlas seeks to not only assist the professional from such a wide range of disciplines, but to aid students as well as the technical novice involved, or interested in, pollen grain and spore identification.

The Atlas has been designed to be flexible within an individual's operation. It may be browsed according to family, genus or species, or utilized as a multiple access key where the physical attributes of an unknown pollen or spore type can be entered. Any given search may be performed using a graphical key or textually. The Australasian Pollen and Spore Atlas provides comprehensive information on any given pollen or spore type, providing details relating to morphology, quantitative morphometry, plant habitat, growth characteristics and geographical distribution. Each taxon is illustrated via several images; each can be interactively zoomed to allow for visualization at higher resolutions. Instruction on who prepared sample materials, when and in what manner it was prepared, where the sample was recovered and who performed the final identification is also available.

GEOGRAPHICAL COVERAGE

Figure 2 illustrates the geographical area incorporated in the Australasian Pollen and Spore Atlas. As defined here, Australasia is the area that includes Australia, New Zealand, the island of New Guinea, extending west through maritime Southeast Asia, mainland southeast Asia, and as far north as tropical India (the southern India peninsula as well as Sri Lanka), tropical southern China and Taiwan. To the east, Australasia includes the tropical and subtropical Pacific Ocean islands north and south of the equator. For the purpose of the Atlas, and reflecting as close as possible major biogeographical and ecological land classification divisions, Australasia has been divided into 22 floral 'regions' as pictured in Figure 2 and defined below. The relationships of biodiversity within the Australasian realm has been extensively reviewed by Keast (1996; see also Turner *et al.*, 2001; Udvardy, 1975).

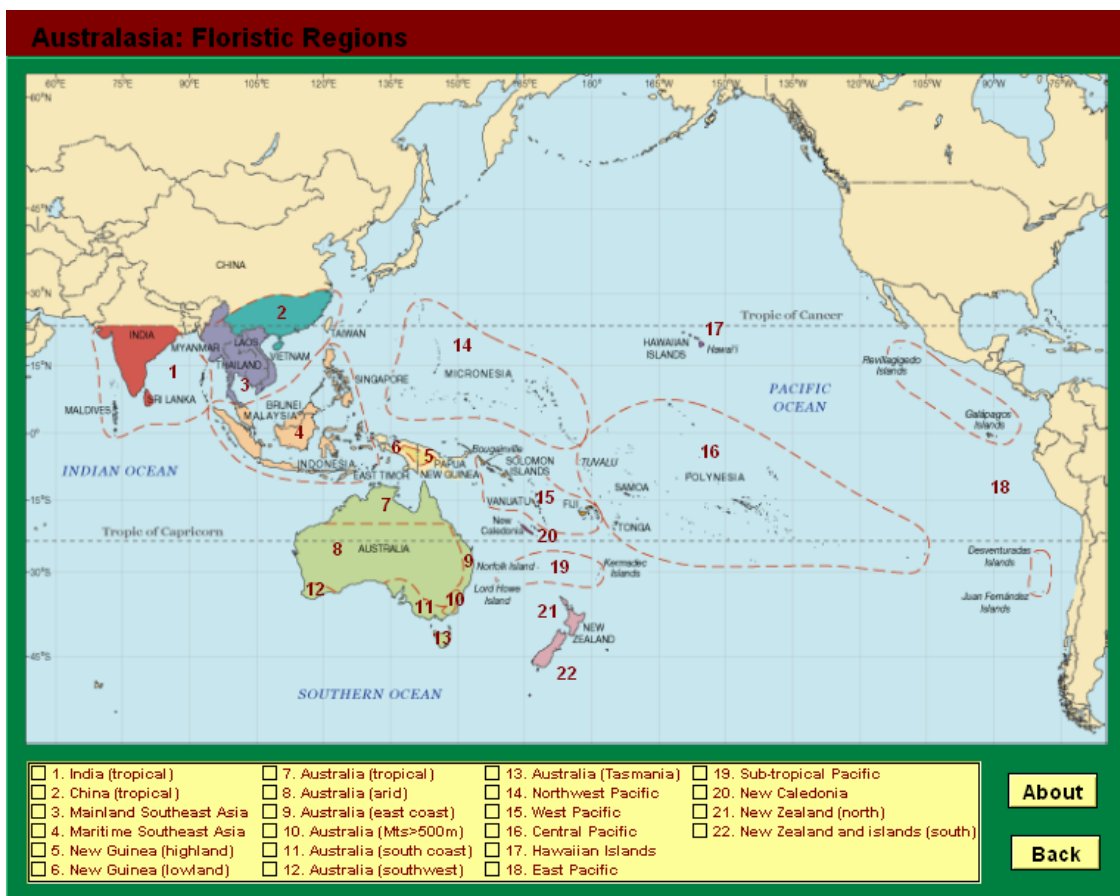


Figure 2: Australasia as defined in the Australasian Pollen and Spore Atlas

India (tropical): Tropical India equates to southern India, roughly south of the Tropic of Cancer (latitude 23° 26'N). The region comprises the whole of peninsula India, south of the Satpura and Vindhya Ranges and Narmada River, almost entirely composed of the Deccan Plateau. For the Australasian Pollen and Spore Atlas tropical India includes the Indian Ocean island states of Sri Lanka and the Maldives, as well as India's Andaman,

Nicobar and Lakshadweep Islands. Southern India's climate is tropical monsoonal, affected by two seasonal winds, the northeast monsoon and the southwest monsoon. Altitude affects temperature to a large extent, with higher elevations within the Deccan Plateau being relatively cool-temperate. India in its entirety hosts a Gondwanan-derived flora with tropical and subtropical dry broadleaf forests prominent in much of the region (Nay, 2003; Punt, 1997).

China (tropical): As a main scheme of division China can be divided into three parts, the northern upland, the central plain, and the southern uplands. The Australian Pollen and Spore Atlas encompasses southern China, as tropical China, and includes those regions south of the Qinling and Nanling mountain ranges, broadly corresponding to eight (People's Republic of China) provinces including Yunnan, Guizhou, Hunan, Jiangxi, Fujian, Zhe-Jiang, Guangdong and Hainan, as well as the autonomous regions of Guangxi-Zhuang and Taiwan. The southern China southwest extension, bordering the South China Sea, is dominated by the Southwest Plateau and is consequently more mountainous than the eastern, East China Sea coastline. The latter includes the extensive lowland Yangtze River Delta and the drainage area of the Zhu Jiang River and its associated network of smaller rivers. The southern tropical to subtropical climate is influenced by the monsoon and a marked summer maximum in precipitation. Much of the remaining natural vegetation cover consists of broad-leaved evergreen forest, incorporating *Cunninghamia* (Tregear, 1980; Liangxing, 1983).

Southeast Asia: For the purpose of the Australasian Pollen and Spore Atlas southeast Asia is divided into two regions, namely mainland southeast Asia and maritime southeast Asia. Mainland southeast Asia, variously known as Peninsula southeast Asia, Further India or Indochina, includes all of Myanmar (formally Burma), Thailand, Cambodia, Lao PDR (Laos) and Vietnam. The region lies toward a geological plate intersection, with heavy seismic and volcanic activity. The climate is tropical, incorporating temperate climatic zones at higher altitudes; the flora varies accordingly. Maritime southeast Asia, variously the Malay World or Malay Archipelago, refers to the vast group of islands located between mainland southeast Asia and Australia. These islands constitute Malaysia, Singapore, Brunei, Indonesia, East Timor and the Philippines. Note that Malaysia is here considered an archipelagic nation of maritime southeast Asia. New Guinea, including the Indonesian province, is not included within the Malay Archipelago. Geologically maritime southeast Asia forms an active vulcanological region. Climate throughout the region, owing to its position on the equator, is tropical, incorporating a declining rainfall gradient west to east. The flora is predominantly Asia-derived, encompassing Gondwanian elements including species within the southern conifer families Podocarpaceae and Araucariaceae (Whitmore, 1984; Punt, 1997; Hill and Bray, 1978).

New Guinea: An equatorial land mass to the north of Australia, spanning 800,000 km² in area. 'New Guinea' is a term used in reference to the whole island, incorporating both the eastern Papua New Guinea and western Indonesian province. The dominant feature of the island is the central mountain range (cordillera) stretching west to east. This central range is flanked by extensive alluvial plains. Such geomorphology guides the Australasian Pollen and Spore Atlas's two-fold floristic division – highland New Guinea and lowland New Guinea. In definition therefore, 'highland' refers to the mountains and intermontane

valleys of the central cordillera and 'lowland' refers to the generally low-lying and extensive alluvial plains to the north and south of the New Guinea island. Lowland New Guinea also encompasses those islands directly to the east of the main island: the Bismark Archipelago (New Britain and New Ireland), Manus (largest island of the Admiralty group), Umboi, Long, Madang and Karkar. The boundary between the two broad zones is not sharply defined, lacking a precise altitudinal limit due to variations in local topography and climate. The transition from lowland to highland can be said to coincide with broad changes in the floristics and structure of the rainforest that commonly occurs between 1000m and 1400m altitude. The island of New Guinea experiences a humid tropical climate with moderate to high rainfall and moderate temperatures throughout the year (Paijmans, 1976; van Balgooy, 1976; Mueller-Dombois and Fosberg, 1998).

Australia: The Australian phytogeographic region is defined as including the Australian mainland and Tasmania, subdivided into the northern tropical zone, the arid centre, the temperate zones of the east and southcoast, mountainous regions above 500m in altitude, the southwest province of the state of Western Australia and Tasmania. Division is closely linked with present-day climate, observing also that respective floristics reflect past climatic and geographic conditions (references include Barlow, 1994; Boland *et al.*, 2002; Burbidge, 1960 and Crisp *et al.*, 1999, except where noted). Definitions are as follows,

- Australia (tropical): Tropical Australia extends north of the Tropic of Capricorn, at latitude 23°26'S. The region incorporates a high rainfall, humid-tropical climate along the northeast coastline, influenced by higher altitudes and the southeast trade winds. Much of tropical Australia, however, is low-lying, situated in a western rainshadow experiencing a seasonal-tropical climatic regime with a lower incidence of rainfall dominated by the occurrence of the monsoon. Floristically the region incorporates a strong Indomalayan heritage, most prominent in the wet/humid-tropical rainforests of the northeast, containing canopy species such as *Elaeocarpus* sp., *Ficus* sp., *Agathis* sp. and *Syzygium* sp. Outside of this zone rainforest communities occur as disjunct patches (monsoon forest), largely restricted to topographic fire-proof niches within a vegetation dominated by *Eucalyptus* and *Melaleuca* open-woodland (Webb and Tracey, 1994; Brock, 2001).
- Australia (arid): The arid or eremean zone in Australia is generally defined in relation to the 250mm isohyet. It therefore constitutes over one-third of the Australian land area. The arid zone is crossed by the junction between summer and winter rainfall regimes, although floristically this junction is not strongly marked. Climatically, the arid zone is characterized on the whole by the extreme variability of rainfall, both annually and seasonally. The arid flora is considered a composite flora derived from adjacent, older communities as arid conditions took over the Australian continent (i.e. not a floristic zone in which internal evolutionary radiation has produced its own characteristic flora); open-woodlands and open-shrublands are extensive incorporating *Acacia* and *Chenopodiaceae*, as opposed to *Eucalyptus*. The latter is largely confined to watercourses in the region.
- Australia (east coast): The east coast region of Australia includes southeast Queensland and northeast New South Wales. Within this area tropical and temperate climatic zones overlap; tropical vegetation components (sub-tropical and warm temperate

rainforest) prevail in the moister (protected) habitats of the riparian strips, gullies and on the upper eastern slopes of the Dividing Range, while temperate elements (eucalypt open forests and wet sclerophyll forests) are most developed on the open tablelands and lowlands. Many of the tropical components are to be found in discontinuous areas further south through the southcoast floristic division, but there is no similar pattern of temperate communities to the north. The east coast has a cool to warm temperate or subtropical climate where precipitation is mainly winter in its occurrence except in the northern extension where it may be evenly distributed throughout the year.

- Australia (Mts>500m): Mountainous regions incorporating alpine and subalpine habitats occur over a relatively small area in Australia, confined in the Australasian Pollen and Spore Atlas to the southeast corner of the mainland. The most extensive area of alpine and subalpine vegetation occurs in the Snowy Mountains of New South Wales. The high mountain areas of Victoria have a less continuous distribution. Climate is characterized by relatively low temperatures and relatively heavy precipitation; most precipitation falls as winter snow, normally persisting from June until October. Vegetation consists of a number of structural formations, primarily forest and woodland, heathland, grass(herb)land and bog. Tree growth is limited to areas where the mean temperature of the warmest month is 10°C or greater (Williams and Costin, 1994).
- Australia (southcoast): The southcoast, or ‘coast-to-ranges’ region is a temperate zone roughly south of the 400mm isohyte and where precipitation is concentrated in the winter months. Of the vegetation, the southcoast region of Australia contains many genera found in Tasmania and southwestern Australia, but few of its species occur in the latter. The interchange of plant taxa between southeastern and southwestern Australia is strongest in the state of South Australia, across areas of siliceous sand plains such as the Eyre Peninsula in particular. Broadly, the southcoast division supports *Eucalyptus* open-forest; the wetter limits are marked by tall open-forest; the drier, more fertile limits by herbaceous woodland; the poorer soil regions dominated by shrubs woodlands or ‘mallee’ (Costermans, 1985).
- Australia (southwest): Southwestern Western Australia consists of a broad coastal plain with a wet-winter, dry-summer Mediterranean climate. The vegetation in the region is predominantly woody, including forest, woodlands, shrubland and heathlands, with little herbland. An occurrence of typical nutrient-poor sandy or lateritic soils has encouraged a rich speciation of plants; the region hosts a high number of endemic species, notably among the family Proteaceae. In this respect, this area of Western Australia corresponds to the Southwest Botanic Province where the World Wildlife Fund and Interim Biogeographic Regionalisation for Australia (IBRA) note a number of significant sub-ecoregions (<http://www.biodiversityhotspots.org/xp/Hotspots/australia/>).
- Australia (Tasmania): The state of Tasmania is located at latitude 40°S under the influence of a cool-temperate climate (a rain shadow exists across the state from west to east). Native vegetation is mainly forest and woodland, with relatively small proportions of scrub, heath and grassland when compared to the rest of southern, temperate Australia. At higher elevation Tasmania supports alpine and sub-alpine heath. Tasmania has, notably, the largest area of Australian temperate rainforest. Rainforest predominates in the west and northwest, with significant patches in the south and southwest. In this respect, the vegetation of Tasmania is of interest as it includes relicts from early Tertiary

floras and remnants from the glacial climatic regimes of the Pleistocene (species of *Phyllocladus*, *Nothofagus* and *Tasmania*). Tasmanian flora also demonstrates strong taxonomic affinities with New Zealand and temperate South America (Busby and Brown, 1994).

Northwestern Pacific: A north and western Pacific division of Oceania, north and south of the equator, comprised of approximately 160 islands, atolls or closely associated groups of islands. The northwest Pacific includes the Bonin and Volcano Islands; Marcus and isolated Wake Islands; the Marianas (including Guam) located south of the Bonins; and south of the Marianas the Caroline Islands (incorporating the Belau or Palau group and the Chuuk Islands). East of the Carolines are the Marshall Islands, south of which are the Gilbert Islands. The islands of this Pacific Ocean division range from low coral outcrops, through raised coral islands to volcanic islands. Climate in the eastern and central regions is wet and not strongly seasonal. Westward and more strongly northward, the seasons become more marked. The flora of Micronesia is a tapered Indo-Malaysian assemblage demonstrating relationships both to the west (Philippines and Indonesia) and south (western Pacific, New Guinea and Australia). Indo-Pacific pantropical strand floras are strongly represented (Mueller-Dombois and Fosberg, 1998).

Western Pacific: A western Pacific division of Oceania, south of the equator and consisting of an aggregation of oceanic islands in five major groups: Bougainville and the Solomon Islands west of New Guinea, and extending southeast the Santa Cruz Islands, Vanuatu and Fiji. The Bismark Archipelago is not listed here as part of Melanesia due to the presence of the deep ocean New Britain Trench forming a geological as well as biogeographical boundary. Whitmore (1984, also highlighted in Mueller-Dombois and Fosberg, 1998) marks out the phytogeographic boundary (154°E) grouping the vegetation of the islands nearest to New Guinea (the Bismark Archipelago, Admiralty Islands, the D'Entrecasteaux and Trobriand islands) with that of the Malesian floristic region (including the Malay Peninsula, Indonesia and the Philippines). This boundary excludes the Solomon Islands and Bougainville. The Bismark Archipelago is included as part of the lowland New Guinea floral division. Melanesia is located entirely in the tropics combining a northern uniform climatic zone and a southward gradient of decreasing average annual rainfall and mean annual temperature (Mueller-Dombois and Fosberg, 1998).

Central Pacific: The central division of Pacific Oceania consists of numerous archipelagoes including the equatorial north Line (northern and southern) and Phoenix Islands, the Central Pacific Atolls (Tokelau and Tuvalu Islands), the western Tonga, Samoa and Horne groups, the eastern Cook, Austral, Society, Tuamotu (Gambier and Pitcairn group) and Marquesas Islands, plus remote Easter and Sala y Gomez Islands. This central Pacific Ocean division stretches over an area of tropical and subtropical ocean giving rise to a diverse regional climate. Similar to the west Pacific, the central area is characterized by an increasingly eastward attenuation of Indo-Pacific flora, but with a greater representation of Australian and New Zealand vegetative components. The islands range from low coral atolls through groups of elevated rock to larger elevated limestone deposits and volcanic remnants (Mueller-Dombois and Fosberg, 1998).

Hawaiian Islands: Hawaii consists of a 20-island chain extending over a distance of approximately 2500km. The eight principle high islands, from southeast in order

northwest are, Hawai'i, Maui, Kaho'olawe, Lana'i, Moloka'i, O'ahu, Kaua'i, and Ni'ihau, with a number of islets and rocky outcrops. The leeward chain of twelve small islands continues northwestward, from Ni'ihau. The small islands include Ka'ula and Lehua, Nihoa, the Necker Islands, the French Frigate Shoals, La Perouse Rock, the Gardner Pinnacles, Maro Reef, Laysan and Lisianski Atolls, Pearl and Hermes Atolls, Midway Atoll and Kure Atoll. The eight principle high islands, as well as most of their satellites are volcanic in origin. The majority of Hawaiian plant taxa are endemic, yet demonstrate some tropical American and Indo-Malayan affinities. The climate of Hawaii is atypical for a tropical area and regarded as more subtropical than the latitude might suggest, due to the moderating effect of the surrounding ocean (Sohmer and Gustafson, 1987; Mueller-Dombois and Fosberg, 1998).

East Pacific Islands: The eastern Pacific region encompasses a wide latitudinal range, from 20°N to 35°S, along the west coast of the American continents. To the north are the Revillagigedo Islands (west of Mexico), the three isolated islands Clipperton, Cocos and Malpelo (off central America), and at the equator the Galápagos Islands. These islands positioned to the north lie entirely in the tropics. Further south are the Desventuradas Islands, with San Felix and San Ambrosio, and the Juan Fernandez Islands incorporating the Alejandro Selkirk (Masafuera), Robinson Crusoe (Masatierra) and Santa Clara Islands. Both southern groups are off the coast and politically part of Chile, extending from the subtropics into a south cool-temperate climatic zone. All eastern Pacific islands are oceanic and their floristic relationships are predominantly American, incorporating plant groups of Polynesian or New Zealand origin. Considerable plant endemism exists (Mueller-Dombois and Fosberg, 1998).

Sub-tropical Pacific: The sub-tropical realm of the Pacific incorporates three widely separated island groups, Lord Howe, Norfolk (together with the two satellite islands of Nepean and Phillip) and the Kermadec Islands (a group of 13 small islands of which the largest is Raoul). All islands are volcanic in origin with the Kermadecs currently active. A humid subtropical climate produces strong wind patterns and considerable fluctuation in year-to-year rainfall. Rainfall seasonality is also evident (cool-season wetness). Lord Howe, Norfolk and the Kermadec Islands are floristically related to Australia and the continental islands of New Zealand and New Caledonia. Their isolation, combined with small size, has also resulted in considerable floral endemism. Vegetation community diversity is more restricted on Norfolk than Lord Howe Island. The Kermadec Islands display the simplest vegetation assemblage among this subtropical group (Mueller-Dombois and Fosberg, 1998; Wardle, 1991).

New Caledonia: The continental islands of New Caledonia spans approximately 400km by 50km, positioned between latitudes 20° and 22°S. The main island is surrounded by three satellite islands groups, the Belep Islands to the northwest and the Isle of Pines near New Caledonia's southeast end. The Loyalty Islands, consisting of Uvéa, Lifou and Maré, run parallel to the main island, along the northeast side. New Caledonia sits on the southern-most edge of the tropical zone, thus maintaining a tropical climate influenced by the prevailing easterly air flow (the southeast trade winds). Floristic affinities lie predominantly with Australia and New Guinea; New Caledonia, however, also supports high levels of plant endemism (Stevenson, 1998).

New Zealand: A country of two large and numerous small islands in the southwestern Pacific. For the purpose of the Australasian Pollen and Spore Atlas New Zealand has been divided into two floristic regions, corresponding to the main North Island, and the main South Island and satellite smaller islands (including the Antipodes, Auckland and Bounty Islands, Campbell Island, the Chatham Islands and Stewart Island). The South Island is the largest land mass, and is divided along its length by the Southern Alps (>3000m ASL). Volcanic deposits are especially prominent in the centre and west of the North Island. The north of New Zealand is sub-tropical and the southern region temperate. The southern satellite islands extend the region into the sub-Antarctic. The flora of New Zealand demonstrates a Gondwana-derived heritage, incorporating transoceanic immigrants. A significant proportion of the New Zealand flora is also endemic (Wardle, 1991).

TERMINOLOGY

Pollen Nomenclature

The terminology used in palynology can be a significant obstacle to those who are not specialists in the subject (Punt *et al.*, 1999). The task then has been to use standardised technical terms facilitating the precise description of pollen and spores, all-the-while in an openly accessible and approachable manner. It is hoped that the provision of illustrations, where appropriate, will help clarify a number of the palynological terms and serve as a practical means for the non-specialist to gain an understanding of pollen nomenclature and become accustomed to their use.

Useful online guides to pollen and spore terminology include,

- Punt, W., Blackmore, S., Nilsson, S. and Le Thomas, A. (1999) *Glossary of Pollen and Spore Terminology*. LPP Foundation, Laboratory of Palaeobotany and Palynology, University of Utrecht, Utrecht (<http://www.bio.uu.nl/~palaeo/glossary/index.htm>)
- Buchner, R. and Weber, M. (2000) *PalDat – a Palynological Database: Descriptions, Illustrations, Identification and Information Retrieval*. Department of Palynology and Structural Botany, Institute of Botany, University of Vienna (<http://www.palдат.org/index.php?page=home>)
- Davis, O. (1999) *Palynology*. Department of GeoSciences, University of Arizona (<http://www.geo.arizona.edu/palynology/>).

The terminology and illustrations presented within the Australasian Pollen and Spore Atlas are based on Punt *et al.* (1999). The many palynological texts should also be consulted. See in particular,

- Moore, P.D. and Webb, J. A. (1978) *An Illustrated Guide to Pollen Analysis*. Hodder and Stoughton, London
- Moore, P. D., Webb, J. A. and Collinson, M. (1991) *Pollen Analysis*. Blackwell, London
- Faegri, K. and Iversen, J. (1989) *Textbook of Pollen Analysis*. John Wiley and Sons, Lichester).

Plant Habit

Plant habit refers to growth form, comprising plant size, shape, texture and stem orientation. The following plant habit descriptors have been adapted from the *Dictionary of Plant Sciences* (Bailey, 1999), further categorized as either terrestrial or aquatic, cultivated or not.

Terrestrial

Herb: a plant which is non-woody or woody at the base only, the above-ground stems usually being ephemeral.

Shrub: a woody plant usually less than 5m high and many-branched without a distinct main stem except at ground level.

Undershrub: subshrub; a small, usually sparsely branched woody shrub less than 1m high.

Tree: a woody plant usually over 5m high and with an unbranched lower axis.

Pteridophyte: a vascular plant which reproduces by spores; the ferns and fern allies.

Liane: a woody climbing or twining plant

Epiphyte: a plant growing on, but not parasitic on, another plant.

Saprophyte: a plant which derives all its nourishment from dead organic matter.

Aquatic

Free-floating: plant species that normally are unattached to any given substrate but float on the water surface

Floating-attached: plant species that are rooted in the substrate but normally have (at least) the mature leaves floating on the water surface.

Submerged: plant species rooted in the substrate or free-floating and submerged below the water surface.

Emergent: plant species rooted in the substrate and whose stems, flowers and most of the mature leaves project above the water surface.

Cultivar

A horticulturally or agriculturally derived variety of plant (i.e. a variety of a plant produced and assisted by humans and not normally found in wild populations) (Bailey, 1999; Woolf, 1977).

The Vegetation Community

Terminology for vegetation community description largely follows that of Specht (1970). Two parameters, projective foliage cover and height or life form of the tallest stratum have been accepted as the main characteristics defining any given plant community (projective foliage cover is defined as the percentage of ground area covered by foliage, typically measured by a vertical point quadrat method).

Closed-forest: Closed-forest possess dense canopies in the upper stratum (70 to 100 per cent projective foliage cover) so that little sunlight penetrates to lower strata. The upper strata may vary in height from 5 to 40m, sometimes with scattered emergents; considerable complexity may be found in the lower strata.

Open-forest: A community dominated by trees where the projective foliage cover of the upper strata is mid-dense, to between 30 and 70 per cent. Height can vary from tall (more

than 30m tall) to low (tree 5-10m tall) open forest with an herbaceous, shrubby or layered understorey.

Woodland: Typically defined as forest with low tree densities. Vegetation in which trees are present but form only a sparse canopy (10 to 30 per cent foliage cover), the intervening areas occupied by shrubs or herbs.

Open-woodland and/or savanna: In comparison with woodland, an open-woodland possesses a very sparse projective foliage cover, less than 10 per cent. Trees may occur singly or in small clumps with large areas of herbaceous ground cover. Within a savanna, greater emphasis is placed on the herbaceous, and particularly graminoid, community component; defined as a closed grass or other predominantly herbaceous vegetation with scattered, widely spaced woody plants.

Shrubland: Woody or herbaceous shrubby vegetation types lacking a dominant tree layer. Projective foliage cover may be sparse (10 to 30 per cent).

Scrub and/or heathland: Heathlands are dominated by shrubs or subshrubs (up to 2m in height) which possess small, evergreen, sclerophyllous leaves and extensive root systems, often arising from lignotubers. An almost tree-less vegetation typically occurring in nutrient poor areas. Annual herbaceous species are rare in the ground stratum. Scrub is also a woody vegetation community, predominantly of shrubs or subshrubs at less than 3m in height. For scrubs, the dominant shrubs are more dense than in shrubland, with a projective foliage cover greater than 30 per cent.

Herbland: A treeless vegetation community dominated by perennial and annual herbaceous plant taxa.

Plant Habitat

Habitat refers to the place or type of site where a plant naturally lives and grows; the environment to which a plant and corresponding vegetation community belong (Bailey, 1999; Brock, 2001). A category list has not been provided for plant habitat, rather the field has been left blank for user entry owing to the number of possibilities associated with Australasia. As an example, where the vegetation community category of ‘closed forest’ has been selected, the user in turn may wish to describe the habitat as ‘montane rainforest’ or as ‘mangrove forest, at the seaward margin’. Alternatively the user may wish to adopt a ‘land-zone’ or simplified geology/substrate-landform approach, describing plant habitat as ‘Quaternary alluvial systems’ and thus including floodplains, alluvial plains, alluvial fans, terraces, levees, swamps, channels and fine textured palaeo-estuarine deposits. Whether or not the principle habitat space is anthropogenic is also an important point to note.

PROTOCOLS FOR THE AUSTRALASIAN POLLEN AND SPORE ATLAS

Contributors

- The Australasian Pollen and Spore Atlas is a freeware initiative. Access to the database collection is unrestricted and all information and images are to be in the public domain with a non-profit motive to encourage widespread use. Contributors are asked to

to provide data in the spirit to which the Australasian Pollen and Spore Atlas was established.

- The Australasian Pollen and Spore Atlas does not uphold compulsory fields of entry. However, the contributor is encouraged to provide as much information as possible in as many fields as possible. Data entry should remain within the descriptive options provided, avoiding the use of outside terms. A consistency in the descriptive terms and phrases facilitates a more accurate search. If a particular term you require is missing, please contact us to have it added to the template for future use.
- A high quality of image entry is to be maintained. As a general guideline, the contributor should provide images of approximately 200 × 200 pixels (preserving aspect ratio, i.e. proportional). Thumbnail images should be in JPEG (.jpeg) format.
- Contributors may not edit pollen or spore images for use in the Australasian Pollen and Spore Atlas. This includes altering contrasts, colours and the removal of blemishes.
- The maximum six pollen or spore photographic angles of view should be governed by the Atlas captions. For consistency, orient your pollen grain or spore along the equatorial plane or polar axis and tailor the scale-bar to suit the feature of interest. The scale-bar should not dominate or intrude, but assist the overall photo.
- Web images are not to be incorporated (including pollen, spore or parent plant images). Reference all other photographs are otherwise to be provided.
- The dimensions of any pollen or spore morphological feature (polar and equatorial diameter, pore size, wall thickness and spine or spinule) is to be an average of at least ten individual measurements – to ensure a representative figure and appropriate guideline.

Users

- All palynological data held within the Australasian Pollen and Spore Atlas has been generated during the course of scientific research and should be cited appropriately. Users should cite the Australasian Pollen and Spore Atlas in any publication to which it contributed. See below for guidelines.
- When making use of the Australasian Pollen and Spore Atlas for the identification of an unknown pollen grain or spore, the user is reminded not to automatically impose a species level of identification, particularly when the unknown is of fossil origin. The user is advised to take note of genus level characteristics in morphology, via multiple records.
- User registration is not required for the Australasian Pollen and Spore Atlas.
- The Australasian Pollen and Spore Atlas is available free through unrestricted web access; users are asked not externally distribute/circulate the Australasian Pollen and Spore Atlas via CD or any other format.

Citation

- APSA Members* (2007) The Australasian Pollen and Spore Atlas V1.0. Australian National University, Canberra. <http://apsa.anu.edu.au/>

WORKING WITHIN THE AUSTRALASIAN POLLEN AND SPORE ATLAS

Filemaker Basics

The Australasian Pollen and Spore Atlas is built on a Filemaker Pro 7 platform. As a database managing system Filemaker Pro was chosen for its ease of use, and twin ability to act as a program for end users (a productivity application) and as a program conducive to building a product (a development tool). The Australasian Pollen and Spore Atlas seeks to be 'in use' as it also evolves as a creation.

The working principle of Filemaker follows that each database file contains one or more tables which in turn are a collection of like records. Fields hold and also identify the type of information found in each record, meaning that a field is a basic unit or category of data entry within a record. The information placed into a field is its value and such entry may be text or pictorial. In the Australasian Pollen and Spore Atlas therefore, as a database of pollen and spore types, each record represents an individual pollen grain or spore and the fields are the attributes specific to each pollen or spore. In FileMaker Pro you will be working with one specific individual record at a time and will be searching for and/or storing information from that record's fields.

For Filemaker Pro 7 and the Australasian Pollen and Spore Atlas it is important to note the following,

- Work within Filemaker is conducted in one of four modes (Browse, Find, Layout and Preview). For the user, data entry and editing is carried out in Browse mode. A search for particular records that match a criteria set is performed in Find mode. How the data will appear before printing may be examined in Preview mode. Layout mode determines how the information is presented. It is recommended the layout found within the Australasian Pollen and Spore Atlas not be changed; layout access has been restricted to prevent users from modifying database presentation.
- Unlike most word processing or spreadsheet programs, Filemaker saves work automatically, including deletions.
- Filemaker Pro 7 converts files from the following previous versions: Filemaker Pro 5.x/6, Filemaker Pro 4.x and Filemaker Pro 3.x. A single file or multiple files may be converted at once.
- Filemaker Pro supports many common, open standards for data exchange. Filemaker Pro 7 can import the following file formats: BASIC (.bas), comma-separated text (.csv or .txt), , tab-separated text (.tab or .txt), dBaseIII and IVDBF (.dbf), DIF (.dif), HTML table (.html), Lotus 1-2-3 WK1/WKS (.wki or .wks), Excel (.xls) and XML (.xml) format.

For more information on Filemaker Pro basic concepts, see Lane *et al.* (2004) *Special Edition: Using Filemaker 7*. You can also find specific information about working within Filemaker Pro in the Filemaker Pro program help.

To access Filemaker Pro help:

Choose Help Menu>Filemaker Pro Help

To see an overview of Filemaker Help topics:

Choose Help Menu>Contents and Index.

A number of websites which provide a support-base on using Filemaker Pro and should also be consulted, including,

- FileMaker Pro Advisor: <http://filemakeradvisor.com/>
- Database Pros: <http://www.databasepros.com/index.html>
- FileMaker TechInfo database: <http://www.filemaker.com/support/techinfo.html>

Start Up

From the **main database window** (Figure 3) you can navigate to each component of the Australasian Pollen and Spore Atlas.



Figure 3: The main database (introductory) window

To identify an unknown pollen grain or spore type, or to access information on a particular taxa contained within the database select the **Search** option. The **main database window** will be replaced by a new layout where pollen or spore morphology information, or the appropriate family, genus and species name, may be inserted and researched. Matches to any given record search can be viewed via the **Show** button.

If you have material to contribute to the Australasian Pollen and Spore Atlas select the **Edit** option.

The **Exit** button will unload the Australasian Pollen and Spore Atlas and return your computer to the standard operating setting.

Information, including contact information, regarding each contributing institution can be viewed from the main database window by clicking on the representative logo. For ongoing guidance in relation to the Australasian Pollen and Spore Atlas, including its foundation, navigation and instruction, glossary information and references, select the button labeled **About**.

Search: Pollen grain and spore morphology

The **search window** (Figure 4) will help you select the characteristics that match the description of your unknown pollen grain or spore. Note that the Australasian Pollen and Spore Atlas allows for more than one value to be selected in each field. If, for example, it is unclear whether the given pollen grain is circular or elliptic in polar view, both values may be chosen. Similarly, the Australasian Pollen and Spore Atlas can run on incomplete or sporadic data. Not all fields have to be filled in, though naturally increased selections will reduce the final number of potential matches on offer. The aim is to reduce the final number of potential species in the listing to a single possibility, or at least a small collection of possibilities. It is recommended that a search begin with broad key structures such as grain arrangement, morphology and shape followed by narrow or more specific features such as pore or colpi attributes. A search can always be refined or changed later by altering the field selections.

The screenshot shows the search interface for the Australasian Pollen and Spore Atlas. It features a blue header with three tabs: 'Search' (active), 'Ecology & Geography', and 'Collection'. Below the header are input fields for 'Family', 'Genus', and 'Species'. The main search area is divided into several sections: 'Grain arrangement' and 'Pollen / Spore' with dropdown menus; 'Aperture #' and 'Morphologic Type' with dropdown menus; 'Grain Shape' with 'Polar' and 'Equatorial' sub-sections, each having two dropdown menus; 'Size' with two dropdown menus; 'Surface Pattern', 'wall Evenness', 'Pore Shape', 'Pore Section', 'Colpus Length', and 'Colpus Margin' with dropdown menus; 'Exine Type', 'Wall thickness', 'Columella', 'Pore Size', 'Pore Position', 'colpi_width', and 'Pore-colpus' with dropdown menus and vertical scroll arrows; 'Tetrads or Polyads' with 'Total size', 'Arrangement', and 'Pollen number' dropdown menus; and 'Reticulate surface' with 'Murus Formation', 'Murus complexity', 'Homogeneity', 'Size Trend', 'Shape', and 'murus number / 10 um' dropdown menus. At the bottom left is a 'Main' button with a left-pointing arrow. At the bottom center are 'Reset', 'Cancel', 'Search', and 'About' buttons.

Figure 4: The Australasian Pollen and Spore Atlas search window

The **search window** has three main sections: a selection area pertaining to taxonomic rank, providing access to family, genus and species name as included within the Australasian Pollen and Spore Atlas; the morphological key feature selection area occupying the majority of the window; and, toward the base of the window, a set of database and record navigation buttons.

You can return to the database main window by pressing the **Main** button at any time.

You can also refer to the user documentation file at any stage by selecting the **About** button.

The Australasian Pollen and Spore Atlas provides **Note Fields** for typing in general information that the user considers relevant and otherwise not catered for in the field design of the database.

The selection options for key pollen and spore attributes are loosely grouped into structural organisation and feature characteristics. General structure incorporates the field categories of arrangement, morphology, aperture number and overall shape, as well as the question as to whether the particle you are trying to identify is in fact a pollen grain or spore. Feature characteristics allow you to refine your identification by addressing surface pattern, wall structure, pore and colpi properties. Identification may also be improved through the use of dimensional data. Measured values from your unknown particle, including polar and equatorial diameter, wall thickness and pore size, may be entered. Ranges of numerical information are also a possibility.

By clicking on each field of entry a drop-down menu will appear and the appropriate descriptor can be selected. Click on the blue triangle next to each field to be offered a visual cue. Example images will be displayed in a new window to assist you with your field value entry. Simply click the image or check-box name. Pressing the **Select** button will record your choice and return you to the **search window**.

Should you decide that your choice is not appropriate press the **Reset** button to clear and select again.

In the case of grain arrangement, four different options of pollen composition are presented, Monad, Dyad, Tetrad and Polyad. Each of these four options are illustrated via the blue triangle. If your unknown particle has four or more cells to its structure you can further refine your grain arrangement selection through the Tetrad or Polyad field group as shown below (Figure 5). Here, you can specify the number, arrangement and collective size of the cells.

Selection of the reticulate surface sculpture under the surface pattern field follows a similar sub-window principle (Figure 6). In the case where your unknown presents a

mesh-like pattern (incorporating the muri or the ridge, and the lumina or the space) you can specify the shape, size and uniformity of that pattern.

Figure 5: Search window: the Tetrad and Polyad field group

Figure 6: The search window reticulate field group

On performing a search Filemaker Pro examines all records in a table, comparing the criteria you specify with the data in the table. Records with data matching the criteria become the ‘found set’ which is an activated sub-list of all the records being browsed. Records that don’t match are excluded. You can then narrow or extend the found set as described below.

When you have finished selecting field values hit the **Search** button and a series of matches will be shown (Figure 7). By clicking on the blue triangle next to any given match, or the **Details** triangle at the base of the results list, you will be transferred to the **show window**, presented with a full descriptive record and offered different views of the pollen grain or spore. To scroll through all search results; utilize the **First-Prev-Next-Last** buttons. A higher resolution version of the thumbnail image may be accessed via the triangle button at the base of the image of interest.

Initially, the **show window** displays the front-tab pollen morphological data. Additional information pertaining to your match can be obtained by clicking on the **Ecology and Geography** tab (parent-plant, ecological and distributional information) and **Collection** tab (personnel, sample field collection and laboratory preparation). You can return to the **results-list window** at any time by selecting the **To List** button.

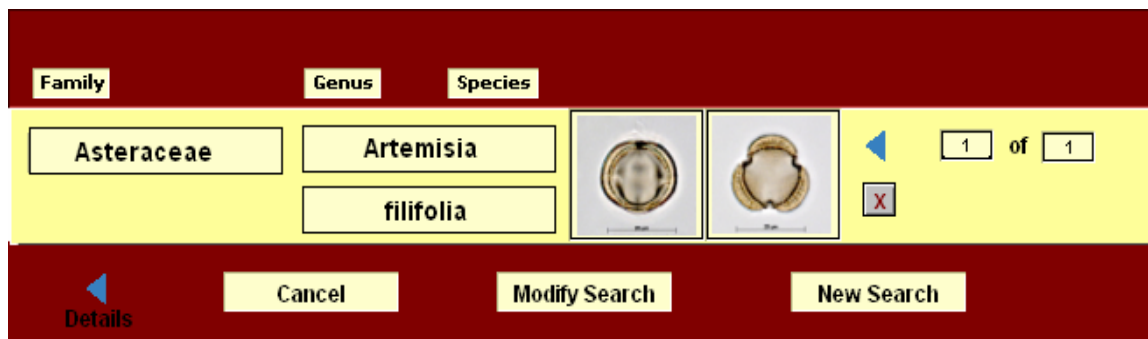


Figure 7: Results-list window

After performing a search you can omit inappropriate individual records from the resultant list. Choose Records Menu>Omit Record or alternatively click on the corresponding red-cross button. Your original search may be amended, or if you wish to re-start the identification process on a new unidentified particle, select the **Modify Search** and **New Search** buttons respectively.

Printing is straight-forward. Choose File Menu>Print. You have the choice to print your results-list, a single selected record or a blank window showing field names only. To print-preview use Preview mode; choose View Menu>Preview. Select the window from which you want to print and change to Preview mode.

Search: Parent plant name, ecology and distribution

In addition to identification based on pollen or spore morphology, the **search window** allows for enquiry based on taxon name or individual plant characteristics such as growth habit, associated vegetation community and geographical distribution.

Select **Search** from the Australasian Pollen and Spore Atlas **main window** and the identification key and Search interface will be loaded. Click on the **Ecology and Geography** tab.

The **ecology and geography window** has four main sections (Figure 8): name entry, including common name; plant species descriptor selection area; and, a set of navigation buttons at the base of the window that allow you to move between records and different Atlas components. At the right window side is a section reserved for the insertion of plant and vegetation images. The ecology and geography tab includes **Note Fields** reserved for including an account of plant habitat and other information considered significant by the user.


Figure 8: the database ecology and geography window

A search within the **ecology and geography window** is conducted in an equivalent manner to that based on pollen morphology; a series of entries encapsulating criteria for performing a search. Utilising name, click on the field of entry and on the pull-down menu to select the family, genus and species title to be researched. The option to select a listed generic name will only appear once a family has been chosen. Alternatively, double-click the field space and type in the desired genus followed by the specific epithet. Based on life-form, plant community and geographical extent, click on the field of entry and select the appropriate descriptor from the pull-down menu. Select the relevant check-box button(s) for the vegetation community, or communities plural, in which the plant in question is best associated. By clicking on the blue triangle connected

to regional distribution you will be offered a map of Australasia and the 22 floristic divisions to help guide your choice. The check-box list allows for multiple value selection. Use the **Back** button to return to the ecology and geography window where the field will record your choice. For definitions and information relating to each floristic region select the button labeled **About**.

When you have finished selecting field values hit the **Search** button and a series of matches will be shown as your found-set. By clicking on the blue triangle next to any given match you will be transferred to the **show window**, presented with a full descriptive record over the three tab-pages and offered different views of the pollen grain or spore. A higher resolution version of any given thumbnail image may be accessed via the triangle button at the base of the image.

You can return to the **results-list window** at any time by selecting the **To List** button.

After performing a search you can choose to omit inappropriate individual records from the found-set. Choose **Records Menu>Omit Record** or alternatively click on the corresponding red-cross button. 

Modify Search is a useful button if you want to continue on to amend a particularly long results-list, or seek to perform a series of similar searches. Alternatively chose **Records Menu>Modify Last Find**.

To replace the current search and resulting found-set, click on **New Search**.

You can return to the database main window by pressing the **Main** button at any time.

Printing is straight-forward. Choose **File Menu>Print**. You have the choice to print your results-list, a single selected record or a blank layout showing field names only. To print-preview use **Preview mode**; choose **View Menu>Preview**. Select the window from which you want to print and change to **Preview mode**.

Search: Collection Information

Select **Search** from the Australasian Pollen and Spore Atlas **main window** and the identification key and search interface will be loaded. Click on the **Collection** tab.

An information and identification search can be performed based on sample collection and preparation field categories (Figure 9). A search may be founded, for example, on a known collector, a particular institution's research collection or whether the sample was derived from herbarium material. You select or type data into fields just as you would for a search based on pollen morphology or plant ecology, serving as a means of matching your unknown data. Such a search, however, is not recommended as the number of potential species matches in your found-set would be substantial. Specific field information will reduce the final number of potential matches on offer. Remember, the aim is to reduce the final species found-set to a single or small number of possibilities.

The screenshot displays a software interface for a database. At the top, there are three tabs: "Show / Edit" (blue), "Ecology & Geography" (green), and "Collection" (grey). The "Collection" tab is active. The interface is divided into several sections:

- Top Section:** Fields for "Family", "Serial Number", "Genus", and "Species". An "About" button is located to the right of the "Serial Number" field.
- Collector Information:** Fields for "Collector" and "Collection Date".
- Institution:** Fields for "Institution" and "Institution Link".
- Sample Collection Location:** A section containing fields for "Country", "Site Name", "Lat/Long.", and "Altitude".
- Collection Method:** Fields for "Method of Sample Collection" and "Herbarium Sample".
- Herbarium Details:** A large text area for "Herbarium Details".
- Preparation and Publication:** Fields for "Method of Sample Preparation", "Date of Preparation", and "Microscopic Instrument". A "Publication Information" section with a text area is also present.
- Notes:** A large text area for "Notes".
- Navigation and Control:** A bottom bar containing a "Main" button, a "Show All" button, a "New" button, navigation buttons for "To: First", "Prev", "Next", "Last", a "Search" button, and a "To List" button.

Figure 9: The database collections window

Data Entry: field entry

Select the **Edit** button and the Australasian Pollen and Spore **main window** will be replaced by a new interface permitting the entry of new data, including images (Figure 10).

The act of contributing data consists of three category steps, corresponding to the three tab-pages addressing (1) pollen and spore morphology and measurement (2) the parent plant including description, distribution and ecology, and (3) pollen or spore sample collection and preparation. The front-tab **edit window** itself relates to pollen and spore description and is similar to the **search window**, sharing three main areas: family, genus and species name entry; a key characteristic features selection area; and, a set of record and database navigation buttons, only with an additional area allocated to image insertion.

The **ecology and geography** tab-page window accommodates graphics as they relate to the parent plant and associated environment, along with a record of taxon name, including common name, plant habit, vegetation community and general distribution within the Australasian region. Habitat forms a separate notes entry field.

The **collection window** consists of five sections: family, genus and species name entry, personnel information and affiliation; sample properties and collection information area;

The screenshot shows a software interface for data entry. The top bar has three tabs: 'Show / Edit' (blue), 'Ecology & Geography' (green), and 'Collection' (grey). The 'Ecology & Geography' tab is selected. Below the tabs, there are input fields for 'Family', 'Serial Number', 'About', 'Genus', and 'Species'. A large yellow area contains various morphological parameters: 'Grain arrangement' (with a dropdown for 'Tetrads/Polyads'), 'Pollen / Spore', 'Aperture #' (with a dropdown), and 'Morphologic Type'. Below these are 'Grain Shape' and 'Size' sections, each with 'Polar' and 'Equatorial' sub-sections containing range and average input fields. Further down are 'Surface Pattern' (with a dropdown for 'Reticulate'), 'Wall_evenness', 'Exine Type', 'Wall Thickness', 'Columella', 'Pore Shape', 'Pore Size', 'Pore Section', 'Pore Position', 'Colpus Length', 'colpi_width', 'Colpus Margin', and 'Pore-colpus'. A 'Notes' field is located below the morphological parameters. At the bottom, there are navigation buttons: 'Main', 'New', 'Show All', 'To List', and 'Search', along with a 'Notes' field. The right side of the window features a 'Plates' section with an 'insert' button and six empty photo slots labeled 'Polar View', 'Equatorial view', 'Aperture photo', 'Surface photo', 'Wall structure', and 'Unique feature'.

Figure 10: The edit window facilitating data entry

a section pertaining to the laboratory preparation of the sample; and, a set of navigation buttons at the base of the window. Additional information may be accommodated in the Notes Field and Publications field. The majority of fields are formatted for standard keyboard entry. The collection window has been included within the Australasian Pollen and Spore Atlas from the point of view of data validation. Data integrity, or more specifically identification integrity, is a matter of concern for the developers of the Australasian Pollen and Spore Atlas, not to mention the user. The collection window allows for each record to be traced and for different laboratory procedures and microscope models to be taken into account when observing the pollen or spore results-record. There may be some variability between any given unknown particle and the record entry, based on the number of visible features, the nature of the sample, the age of the sample and how it was prepared, and these need to be understood.

You can return to the database main window by pressing the **Main** button at any time.

You can also refer to the user documentation file at any stage by selecting the **About** button.

The Australasian Pollen and Spore Atlas provides **Note Fields** for typing in general information that the user considers relevant and not otherwise catered for in the field design of the database.

When entering data into the Australasian Pollen and Spore Atlas you are creating a record. Establishing a record within the Australasian Pollen and Spore Atlas and Filemaker Pro is simple:

Choose Records Menu> New Record.

The family, genus and species names must be entered first!

You enter data into fields just as you would in search mode. Fill in as many of the pollen attributes as you can; a more detailed record will result in a more specific user result. By clicking on each field of entry a drop-down menu will appear and the appropriate descriptor can be selected. Click on the blue triangle next to each field and you will be offered a visual cue. Example images will be displayed in a new window to assist you with your field value entry. Simply click the image or check-box name. You will be returned to the **search window** following the **Select** button where the field will record your choice.

That the family, genus and species names are to be entered first underpins the data entry process. The system will prompt you with a reminder notice should this not be the case. Upon completion of name entry in the **edit window** the equivalent fields will automatically be entered in the **ecology and geography** and **collection** tab-page windows as you move through these data entry categories.

When entering data into the field of grain arrangement, should you describe the pollen grain as a Tetrad or Polyad an additional button on the **edit window** will be activated, facilitating the provision of more information with respect to the multi-celled structure. Click on the blue triangle labeled **Tetrads/Polads**.

Entering 'Tetrad' or 'Polyad' into the field of grain arrangement will activate the blue triangle button labeled **Tetrads/Polyads** on the **edit window**. Press this button to enter more information about the multi-celled structure.

Although there is an Undo command in the Edit Menu, it does not function at the record level. After a record is committed, it is part of the Australasian Pollen and Spore Atlas. Once a record is deleted, it cannot be retrieved. If you are entering data and creating a record and need to undo the field entry, use Records Menu>Revert Record. Alternatively, should you decide that your descriptor choice at the visual prompt is not appropriate press the **Reset** button to clear and select again.

A record is saved (committed) automatically when you click outside a field for the first time, when you change windows or press the Enter key. Filemaker Pro uses the term 'commit' to indicate when your record is saved within the database.

When you have finished entering field values hit the **New** button to contribute a fresh record.

Data Entry: Inserting Graphics

Filemaker Pro stores and displays images in a field category known as ‘container fields’. A number of container fields have been constructed within the **edit window** and **ecology and geography window**. Container fields cannot be used for searching or for the purpose of sorting records.

Data entry for container fields is slightly different from other types. You need to either paste a file or image into the container field or use the insert menu:

Click the destination container field to activate it

Insert Menu>Picture

In the dialog-box select the graphics file

Click open.

If you select ‘store only a reference to the file’ Filemaker Pro does not import the graphics file, it only keeps track of where it is on your hard-drive. If you ever move or delete the file, Filemaker Pro will not be able to display the image.

To delete the image from the container field:

Click the respective container field to activate it

Press Backspace or Delete.

You can also drag and drop the image into the Recycle Bin (Windows) or Trash (Mac OS).

Filemaker Pro supports a number image formats. The Australasian Pollen and Spore Atlas requests high quality JPEG (.jpg) picture formats. For more information on the criterion for image entry see the Protocols for the Australasian Pollen and Spore Atlas, as above.

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