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Introduction to the Pilbara Biodiversity Survey, 2002–2007

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Abstract – We describe the origins, relevance, aims, specifications and sampling strategy of a six-year biodiversity survey of Western Australia's Pilbara biogeographic region (179,000 km^2). During the project, 422 terrestrial sites were sampled for perennial and annual vascular plants, of which 304 were also sampled for small ground-dwelling mammals, birds, reptiles, frogs, ground-dwelling spiders, ants, beetles and scorpions. Ninety-eight sites on waterbodies were sampled for aquatic invertebrates, macro- and microphytes and the fringing riparian vegetation; 508 boreholes were sampled for stygofauna; 69 sites were sampled for microbats; and mammal bone material from 15 late Holocene deposits was identified. An introduction to literature on the region's physical environments and recent land-use history is provided, along with descriptions of the Pilbara's four sub-regions in terms of their different landforms and vegetations.

BACKGROUND

The Pilbara Region of Western Australia (WA) is important to the economic development of Australia, particularly because of its internationally significant reserves of iron ore and the rapidly expanding resources sector they support. The region comprises ancient and striking landscapes in an arid setting, and its biodiversity has elements of tropical, desert and semi-arid southern rangeland floras and faunas, as well as many local endemic species. It is the location of two major national parks and several other conservation reserves, but their effectiveness in conserving the region's biodiversity has not been properly assessed.

The biota of the Pilbara is still poorly documented, despite a considerable amount of localised survey by government institutions, tertiary institutions, and mining companies or their environmental consultants. Examples include Burbidge (1959), Integrated Environmental Services (1980), Fox and Dunlop (1983), Muir (1983), Dunlop and Porter (1985), Anon. (1991), *ecologia* Environmental Consultants (1997), Eberhard and Humphreys (1999), Trudgen and Casson (1998), van Etten (2000) and Biota Environmental Sciences (2002). Although approximately 800 biological survey reports had been compiled for parts of the region prior to 2005 (Higgs 2005; How and Cowan 2006), only two broad-scale biological studies are available: a vegetation map at 1:1,000,000 scale with explanatory notes (Beard 1975), and a land classification, mapping and pastoral resource evaluation of the region (van Vreeswyk *et al.* 2004). Both focus on patterns in vegetation and dominant flora, rather than floristic composition or fauna. This hampers assessments of the likely environmental impacts of many economically important development projects and pastoral diversification proposals, as well as the development of a comprehensive, adequate and representative reserve system. New species of terrestrial plants and vertebrates, as well as large numbers of terrestrial and aquatic invertebrates, are still being discovered in the Pilbara. For instance, 12 new taxa of wattle (*Acacia*) have recently been described from the Pilbara (Maslin and van Leeuwen 2008), six of which are endemic. Similarly, recent studies have revealed that the region has a rich fauna of subterranean invertebrates (Eberhard *et al*. 2005; Biota Environmental Sciences 2007; Harvey *et al*. 2008), characterised by localised endemism.

Broad-scale exploitation of Australia's natural habitats to meet the economic growth demanded by expanding human populations has resulted in widespread declines in biodiversity, including its composition, biomass and productivity (Woinarski *et al*. 2000). Pilbara landscapes have been modified by pastoral use, mining activities and altered fire regimes for more than a century. During this period, over-grazing and too-frequent wildfires have changed vegetation cover and in many instances stripped the upper layers from soil profiles (Payne and Tille 1992), while a range of exotic animals and plants has been introduced, with detrimental effects on the region's biodiversity. Desktop assessments of the region's rangeland condition (Woinarski *et al*. 2000), environmental health (Morgan 2001) and conservation reserve system (McKenzie *et al*. 2003) have revealed ongoing degrading processes at levels equivalent to the other arid pastoral regions of Australia. Of the original mammal fauna, 15% is now extinct in the region, and 42 of the region's 88 vegetation-types (mapped at 1:250 000 scale) do not occur in conservation estate. Indeed, only 0.8% of the region's Fortescue sub-region is reserved for nature conservation.

Spatially explicit, regional-scale biodiversity models are essential to achieve sustainable development, in which the needs of biodiversity, economic development and human populations are met. Regional biodiversity survey data provide a framework for assessing the environmental impacts of development proposals by providing a quantitative basis for predicting species' occurrences throughout a region. They provide a context for extrapolating the results of localised surveys and explicit inputs for land-use planning, including cost-efficient gap-analysis of a region's conservation reserve system. Without a regional context, intensive localised surveys may exaggerate the conservation importance of a site or of species found there. For example, borefields are being planned in many parts of the Pilbara to extract groundwater for economically important mining and downstream processing projects and to supplement town water supplies. Playford (2001) recommended that regional and site-specific surveys of Pilbara stygofauna were essential to resolve difficulties in assessing, under State and Commonwealth environment legislation, the impact of mine de-watering and/or groundwater extraction on stygofauna. Reliable lists of threatened species and ecological communities compiled at a regional scale underpin cost-effective recovery programs.

The importance of a comprehensive regional biodiversity framework for impact assessment and sustainable natural resource development has been articulated in the advice provided to governments by the Environmental Protection Authority for a number of Pilbara development proposals. For example, in the assessment of the West Angelas Iron Ore Project, the Environmental Protection Authority noted: '*The assessment of developments in the Pilbara is hampered the absence of consolidated information on the regional distribution of terrestrial fauna, subterranean fauna and an adequate database of significant vegetation associations in the region.*' The Authority subsequently recommended: '*a project to consolidate vegetation and fauna data for the Pilbara to facilitate assessment of future proposals should be initiated …*' (Environmental Protection Authority 1999).

Research has demonstrated that a range of plant and animal groups must be surveyed in order to reveal actual biodiversity patterns across the landscape (e.g. Ferrier and Watson 1997; Fleishman *et al*. 2002; McKenzie *et al*. 2004) and thus make conservation programs cost-effective. Regional biodiversity surveys document the distribution and conservation status of biotic components selected to represent diverse mobility, longevity, daily energy and moisture requirements, nutritional roles, biomasses and reproductive strategies.

The Western Australian Department of Environment and Conservation, with the assistance of the Western Australian Museum, has a long-standing commitment to undertaking regional biogeographic surveys of Western Australia. Since the 1970s, there have been major regional surveys of the Eastern Goldfields, Nullarbor, Kimberley rainforests, southern Carnarvon Basin and the Wheatbelt (e.g. McKenzie *et al*. 1991a; Burbidge *et al*. 2000a; Keighery *et al*. 2004). Other major surveys cover parts of the Great Sandy Desert, Gibson Desert, Little Sandy Desert, Dampier Peninsula, southern forests and numerous existing and proposed conservation reserves (e.g. Miles and Burbidge 1975; Burbidge and McKenzie 1983; Keighery *et al.* 2007), though most of these had limited taxonomic scope compared to more recent surveys.

RATIONALE

By 2000, the Pilbara's substantial and economically important mineral industries were expanding rapidly and the Western Australian Government was becoming concerned about environmental issues. The Pilbara Development Commission's draft Regional Policy Statement reported: '*Research and development is a key to a healthy and sustainable future. To maximise the resources available, partnerships will be sought with the private sector, universities and the Commonwealth Government to research regional … environmental issues and opportunities.*' The Premier's Science Council recommended that Government '*Increase the funding available to agencies for strategic biodiversity and taxonomic research ...*' and observed that '*Although CALM …* [Western Australian Department of Conservation and Land Management, now WA Department of Environment and Conservation, DEC] *… is undertaking regional surveys, this effort is not keeping up with the requirements of the Environmental Protection Authority to assess development proposals or the needs of researchers and communities involved in environmental remediation … the high level of biodiversity in the State and the need for comprehensive surveys of biota will place increasing importance on the role of museum staff …* [and] *… funding is required…to enable these researchers … to participate in surveys and conduct taxonomic research.*'

Similar policies were being drafted in a more general context during that period. To '*… Ensure the protection of biodiversity and ecological integrity on a regional scale…*' (Department of Local Government and Regional Development's draft Regional Policy Statement for WA, November 2002); to '*Complete the program of comprehensive bioregional surveys designed to establish an inventory of the State's terrestrial and aquatic biodiversity and to identify areas of significance for nature conservation, and incorporate a CAR* [Comprehensive, Adequate and Representative] *reserve system in … high priority bioregions …*' (Western Australian Government Environment Policy Paper, 'New Directions'); '*Government continues to expand the conservation estate to achieve a* [CAR] *reserve system …*' and will '*Establish and maintain a whole-of-government environmental database that incorporates the results of the ongoing biological survey and monitoring program …*'. (Western Australian Government 2002).

An explicit basis for minimising the impact of resource development and land use on Pilbara biodiversity would require a quantitative, region-wide understanding of biodiversity patterns. To build this context, a program of field sampling was designed for this survey, to:

- Provide systematic baseline data on the current distribution of biota across the region as a regional perspective on nature conservation priorities and a framework for future monitoring of regional-scale trends. To achieve this, the project had to include taxonomic studies of relevant plant and animal groups with poorly resolved phylogenies at the species-level such as lizards and aquatic invertebrates, especially those describing species that define groundwater communities.
- Provide a more detailed understanding of plant and animal distributions: an explicit context for assessing the conservation status and distribution of species and communities and the significance of localised occurrences of species, on which to base management actions and determine the conservation implications of development proposals.
- Include a quantitative assessment of the existing reserve system to identify gaps in its coverage of species and communities and identify areas that efficiently improve its comprehensiveness, adequacy and representativeness. This reserve system is the primary nature conservation strategy, and a basis for promoting and attracting ecotourism to the spectacular and world-class scenery and wilderness values found throughout the Pilbara.
- Make the results of the survey available in a usable form to government, industry and the wider community.

The regional survey to provide these data was first proposed in September 1992 by the Environmental Protection Authority who, in their recommendations to government in the assessment of the Marandoo Mine and Central Pilbara Railway, stated: '*… an integrated biological survey should be carried out to determine the distribution of significant species of flora and fauna and geographically restricted vegetation communities … in the Central Pilbara Region*' and '*Data collection should begin without delay*' (Environmental Protection Authority 1992).

The project's eventual specifications involved surveying the vertebrates and an array of invertebrate groups at 304 terrestrial zoology sites, plants at 422 sites (304 of which were also terrestrial zoological sites), microbats at 69 sites, and invertebrates and flora at 98 surface aquatic sites scattered across the region. It also included a survey of mammal bones from late Holocene deposits located within the region. A stygofauna component was not included in the plan until 2000, when an application to dewater the calcrete aquifer associated with BHP Billiton's 'Ore Body 23', near Newman, was presented to the Environmental Protection Authority. By early 2001, after including a stygofauna survey of 350 ground-water access points in the specification, CALM's policy directorate had decided to proceed with the project, and collaborations with Western Australian Museum and the Commonwealth Government's Natural Heritage Trust were being negotiated. Fieldwork on the stygofaunal component of the survey commenced in July 2002, while other components commenced in March 2003.

AIM

The overall aim was to carry out the first comprehensive biodiversity survey of the Pilbara region. Specific aims were to:

- Provide systematic region-wide site-based survey data on the current distribution of the biota across the region, and a framework for future monitoring of regional-scale trends.
- Sample a range of organisms that, in combination, is wide enough to provide a spatially explicit biodiversity model of the region.
- Analyse these data in relation to the region's physical environments, and interpret them in terms of earlier species records.
- Identify gradients in community composition, and the environmental factors related to these gradients, to provide a better understanding of plant and animal distributions.
- Undertake taxonomic studies where necessary

to define and describe key species that define communities.

- Assess the adequacy of the existing reserve system and identify gaps in its coverage of species and communities.
- Publish the survey results in refereed scientific journals, make the data-bases freely available in convenient formats, and communicate the project's progress, results and implications through relevant media to encourage implementation of the project's recommendations.

THE STUDY AREA

The Pilbara biogeographic region corresponds closely to the Pilbara Craton, and encompasses an area of approximately 179,000 km^2. The mainland component is 178,500 km^2 with the residual area being represented by offshore islands, principally within the Dampier Archipelago. The region extends from 20° to 23°30´S latitude, and 115° to 121°30´E longitude (Figure 1), and is bounded by the Indian Ocean to the north-west, sand deserts to north-east and east, and the Gascoyne and Carnarvon regions to the south and south-west, respectively. For the aquatic survey, the study was extended southwards from the southern boundary of the Hamersley subregion to the main channel of the Ashburton River, and eastwards to the Rudall River.

The Pilbara region as defined by Thackway and Cresswell (1994), and used in the study, is founded on the Fortescue Botanical District as described by Beard (1990). It therefore encompasses the eight physiographic units identified by Beard (1975): Abydos Plain, George Range, Oakover Valley, Chichester Plateau, Fortescue Valley, Hamersley Plateau, Stuart Hills and Onslow Coastal Plain. Within a national physiographic framework, the study area includes the De Grey Lowlands, Nullagine Hills, Chichester Range, Fortescue Valley, Hamersley Plateau and portions of the Onslow Plain and Carnarvon Dunefield sections of the Pilbara and Western Coastlands Provinces as defined by Jennings and Mabbutt (1977). In terms of the contemporary soil-landscape classification for the rangelands and arid interior of Western Australia (Tille 2006), the study area includes all 10 zones of the Fortescue Province and extends into two zones of the Exmouth Province (Cane River and Onslow Plain) and two zones of the Ashburton

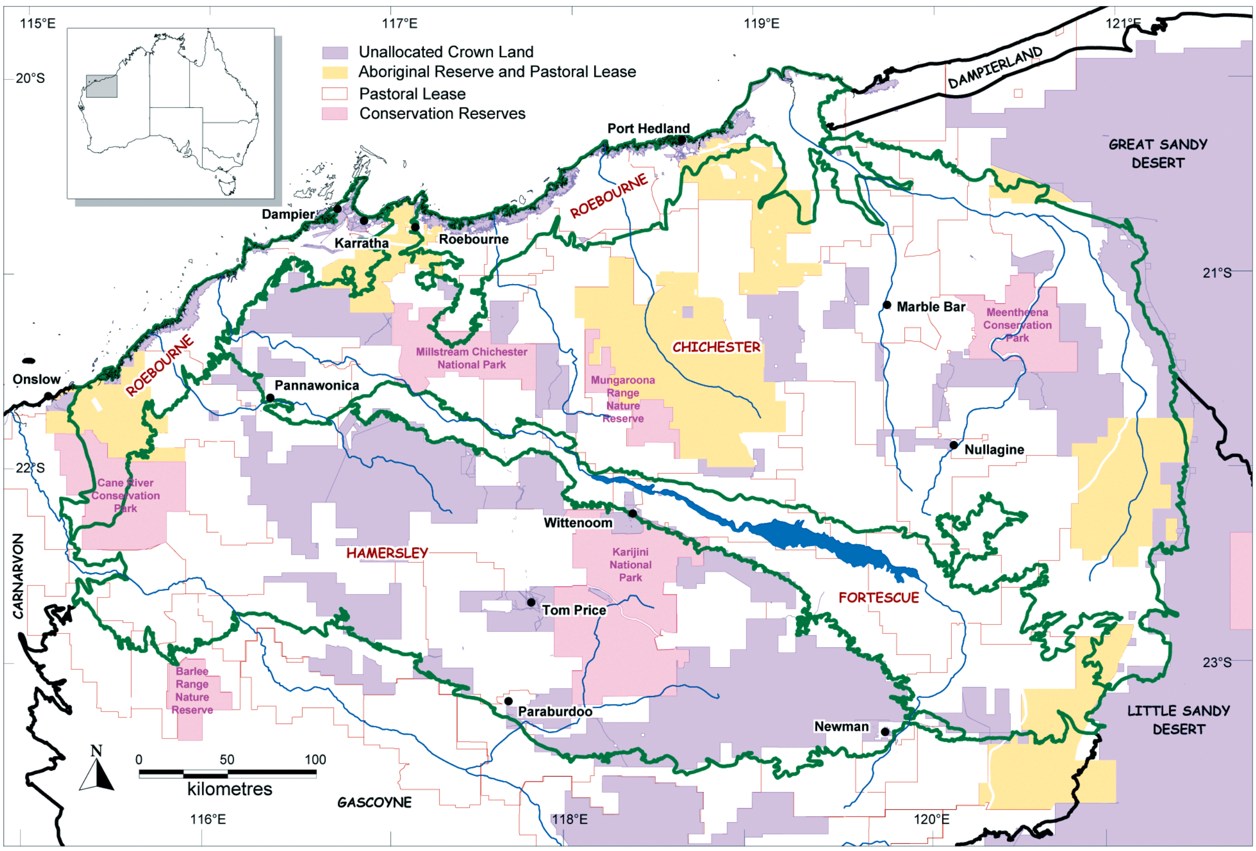

Figure 1 The Pilbara Biogeographic Region (Environment Australia 2000) showing towns, main rivers (blue lines), land tenure, sub-regions (green lines), and surrounding regions (black lines).

Province (Stuart Plains and Hills, and Ashburton Valley). It also intrudes into the periphery of the Eighty Mile Coast, Nita Sandplain and Great Sandy Desert zones of the Canning Province, and the Waroo zone of the Patterson-Yeneena Province.

The region's islands were not sampled during the survey because they are comparatively small and their floras and faunas are relatively well-known in the context of the region as a whole (e.g. WEL 2007).

CLIMATE

An overview of the region's climate was provided by Leighton (2004). Briefly, most rainfall occurs in summer, along with thunderstorms and occasional cyclonic activity. Average annual rainfall is 290 mm, ranging from a monthly average of c. 2 mm in September to 66 mm in February. January, February and March are the wettest months while September and October are the driest (Figure 2). In some years there is rain in early winter. Leighton (2004) commented '*… the slightly bimodal pattern of rain ensures, in good years, that the vegetation growing season is prolonged*.' There is substantial year-to-year variation in rainfall, both locally and regionally. At least one cyclone traverses the region in a normal summer and others pass close by along the coast. They supply half of the annual rainfall. Cyclonic rainfall has occasionally exceeded 700 mm in 24 hours, and more than 1200 mm annually, at particular localities.

The thunderstorm and cyclonic nature of most rainfall events interacts with the rocky slopes of the upper- and mid-catchment topography to generate high run-off volumes and velocities. These events cause widespread sheet erosion in areas denuded by recent bushfires or over-grazing, and the over-bank riverine floods strip riparian zones. The transported material is deposited as bed loads of sand in the river systems, and as clays and silts onto floodplains on the Fortescue and Roebourne Plains and on the seafloor at the mouths of the major rivers. Although there are few extended periods when the entire Pilbara is affected by drought, areas are regularly affected by deficiencies, either serious (lowest 10% of rainfall values recorded for a three-month period) or severe (lowest 5%). On a drought-risk scale of zero to one, the Pilbara has an area-weighted average greater than 0.7 (Colls and Whitaker 1995).

Monthly maximum temperatures range from an average of 25ºC in July to 37ºC in January, and minimum temperatures from an average of 12ºC in July to 25ºC in January (Figure 2). The Pilbara straddles two bioclimatic regions (Beard, 1990). The higher rainfall areas inland (Hamersley Plateau) and the cooler areas near the coast have a semi-desert tropical climate with nine to 11 months of dry weather. The rest has a desert climate characterised by up to 12 months of dry weather and generally higher temperatures. Beard defined dry weather as periods when precipitation is insufficient to sustain growth given the ambient temperatures. The region's broad near-coastal band (Figure 3) has a hot, humid summer with a warm winter, while inland areas experience a hot dry summer and a mild winter. Evaporation is probably the most important factor in water loss in the region, influencing both plants and animals. Throughout the Pilbara, potential evaporation exceeds average annual rainfall by a factor of at least eight, and by up to 20 in its south-east.

Climate change will have a wide range of impacts on biodiversity within the Pilbara. It may impact upon species distributions and abundance, ecosystem processes, the interaction between species and the various threats that currently impinge on biodiversity. Key amongst the emerging climate change threats to Pilbara biodiversity will be the arrival of species (native and exotic) new to the region, further alterations to fire regimes, land use changes and alterations to hydrological regimes (Dunlop and Brown 2008). How Pilbara biodiversity responds to the climate change challenge will to some extent be moderated by a CAR reserves system, the generally good condition of many Pilbara ecosystems and the inherent refugial nature of some habitats (e.g. hill tops, mesic gorges, permanent spring fed pools) (Morton *et al*. 1995).

Current predictions of future climatic conditions across the Pilbara (CSIRO and Bureau of Meteorology 2007; Dunlop and Brown 2008) suggest that:

- the region will become warmer with more hot days and fewer cold nights;
- a small decline in annual rainfall is possible;
- the water deficit will increase as higher evaporation rates reduce runoff;
- droughts will be more frequent and severe;
- extreme storm events will become more common, particularly tropical cyclones;
- there will be greater inundation in coastal areas, associated with storm surge and sea level rises.

Using the agro-climatic zones of Hobbs and McIntyre (2005), Dunlop and Brown (2008) suggested that the key issues for biodiversity resulting from climate change are likely to be:

- changes in fire regime but somewhat moderated by limited growth and grazing;
- arrival of further species from the tropics and additional pasture species as a result of wet season rain.

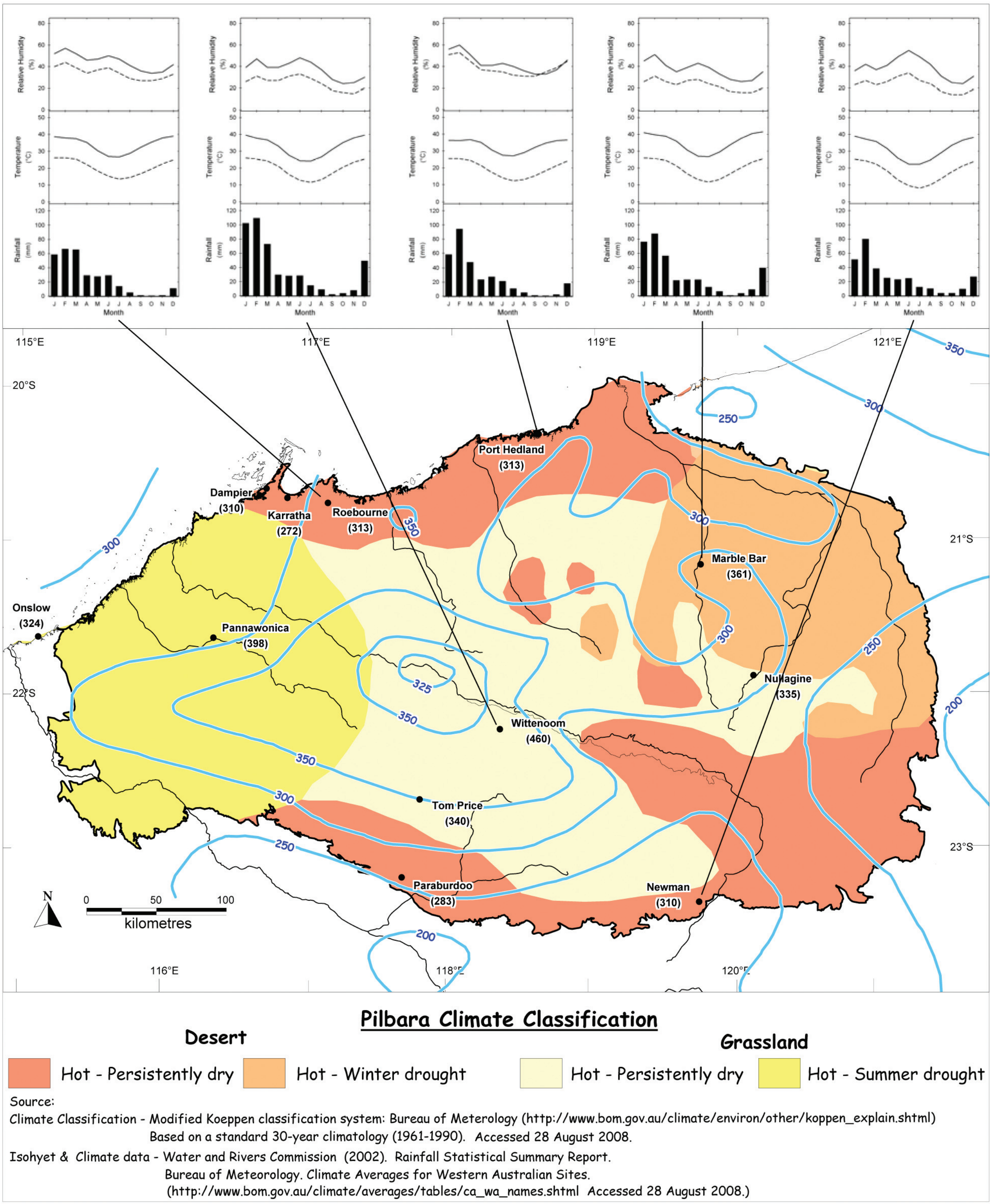

Figure 2 Bioclimatic regions and monthly average rainfall (mm), maximum and minimum temperature (ºC) and 9 am and 3 pm relative humidity values based on a selection of six Bureau of Meterology weather stations scattered throughout the Pilbara.

- overgrazing from a reduction in productivity commensurate with an increase in moisture deficiency.

SOILS

Soil development throughout the ranges is generally poor, especially toward the highest areas where slope and gravitational forces colluded to redistribute such material down slope. Typically, soils are skeletal, shallow and stony, having been derived *in situ* or deposited as colluvium and alluvium pediments on valley floors. Colours reflect the underlying parent material as does the preponderance of ferruginous pediments. Texturally the soils are stony loams, although clays and silts become prevalent towards the bottom of the catena (Bettenay *et al.* 1967). As a consequence of parent rock geology most soils are of low fertility and slightly acidic, although the clays associated with basalts and those of alluvial and colluvial valley floors tend towards alkaline and are more fertile (CALM 1999; van Etten 2000).

Hennig (2004) identified 21 broad Soil Groups, and interpreted their occurrence according to the region's geomorphology. This interpretation is summarised in the following paragraphs. Shallow stony soils on hills and ranges and sands on sandplains are the most extensive. The red/brown soils of hills and ranges have stony profiles and very stony surfaces with rock outcrops. Red shallow loams/sands are most common on basalt hills, with shallow non-cracking clays in isolated pockets and valleys within these hill systems. Red loamy earths with deeper profiles and stony surfaces occur downslope, along with areas of deep non-cracking clays. Self-mulching cracking clays occur at the lowest landscape levels, with areas of deep non-cracking clays and deep loamy duplex soils.

Granitic landforms comprise red sands, shallow where granite hills outcrop but expressed as gently undulating plains with red sandy earths, deep sands and loamy earths elsewhere. Calcrete areas have shallow calcareous loams. Stony soils dominate hills and mesas on the region's eastern periphery, with stony red loamy earths on plains below the hills and deep red/brown non-cracking clays at the lowest levels in this landscape. Further east is the Great Sandy Desert, characterised by deep red sand surfaces expressed as dunefields with areas of red sandy earth on sandplains and scattered hills with stony soils. The western periphery of the study area has extensive plains of deep red sand and red sandy earths, with stony soils adjacent to hills.

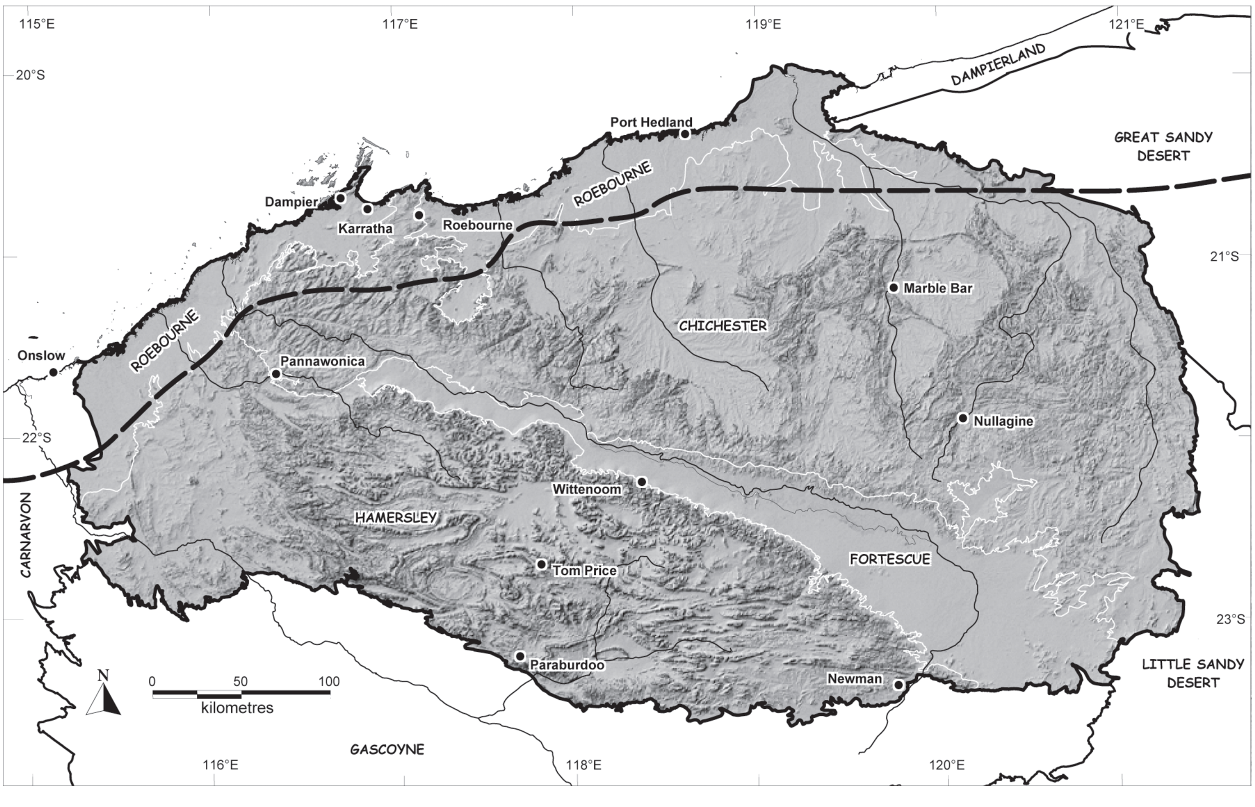

Figure 3 Digital elevation model (from Geoscience Australia GEODATA 3 second DEM version 2), with IBRA version 6 regional and subregional boundaries superimposed as black lines and as white lines, respectively. The boundary between coastal and desert climatic zones is marked as a dashed line.

Alluvial plains of deep red sandy duplex soils and floodplains of red/brown non-cracking clays are associated with major rivers. Alluvial plains of the major rivers further east comprise self-mulching cracking clays, red/brown non-cracking clays and some deep red sandy duplex. These same three soil groups, but in reverse order of extensiveness, form the plains near the Pilbara's north-west coast and the deltas of its rivers. Mostly dry, the river beds and levees have juvenile or poorly developed sandy soils that show sediment layers of coarse loose sand, clayey sand, silty sand and silty clay. The region's coast comprises tidal soils (saline clays and sandy clay loams) with beaches of calcareous deep sands in some areas. Adjacent are plains of deep red or grey sandy or loamy duplex soils, saline red/brown non-cracking clays and deep red sand.

LAND SYSTEMS

The Western Australian Department of Agriculture and Food, in collaboration with the Department of Land Information (now Landgate), have undertaken three rangeland surveys that, together, encompass the Pilbara bioregion. These describe and map the biophysical resources present, and evaluate the condition of the soils and vegetation. Commencing in 1976, the first focused on the Ashburton River catchment (Payne *et al.* 1988). It was followed by the Roebourne

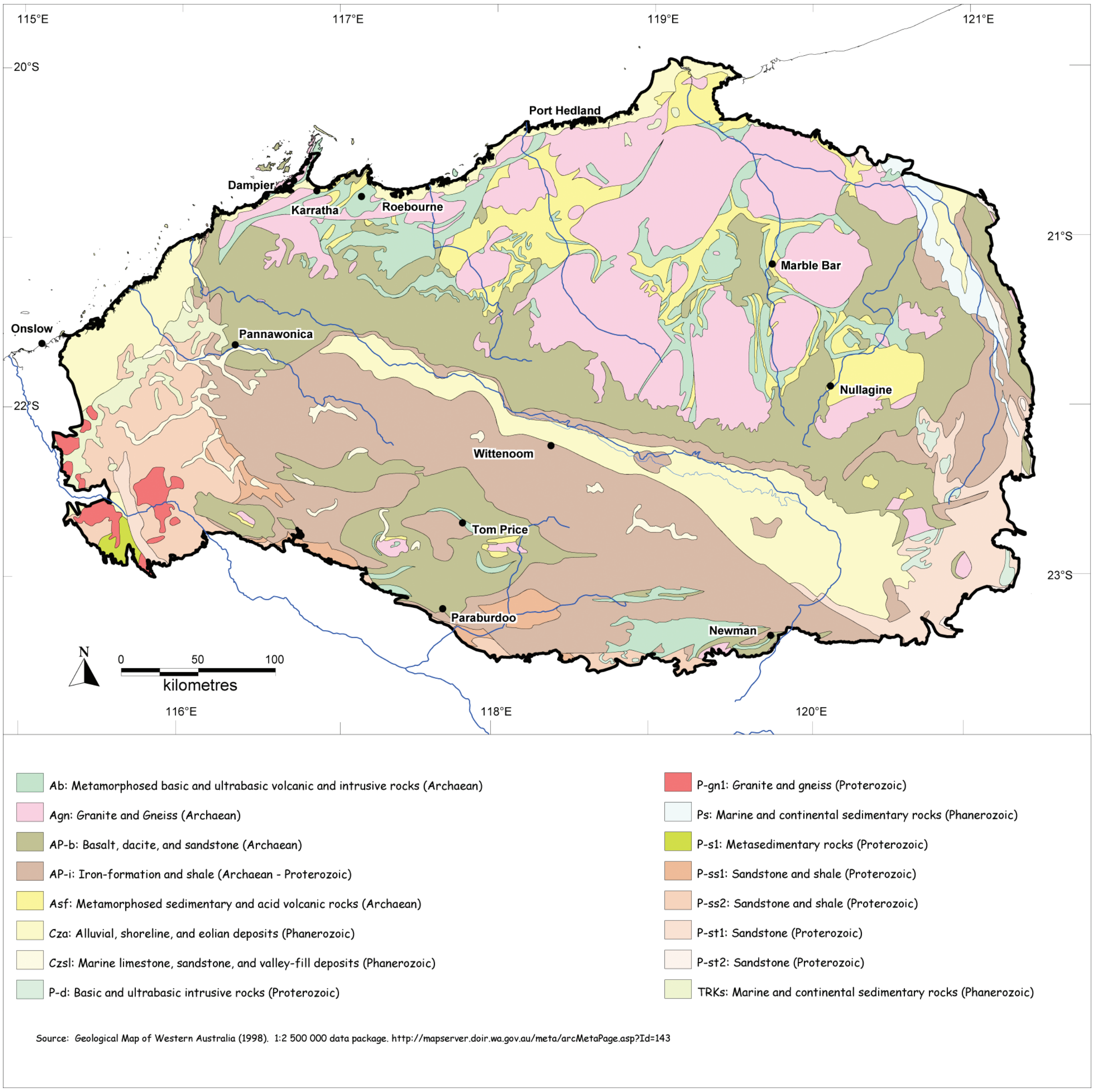

Figure 4 Simplified geological map of the Pilbara.

Plains survey of 1987 (Payne and Tille 1992), and culminated in the Pilbara Ranges survey (van Vreeswyk *et al*. 2004) which commenced in 1995.

Within the bioregion there are 104 land systems (Payne 2004). The area occupied by these land systems varies from approximately 29,000 km^2 for the Rocklea land system to 18 km^2 for the Augustus land system. The five most abundant land systems account for approximately 45% of the bioregion (Rocklea, Newman, Macroy, Uaroo and Capricorn). Forty-five of the land systems are unique to the Pilbara. The largest Pilbara-unique land system is Macroy (13,360 km^2), while the smallest is Tanpool (68 km^2).

Land systems are grouped into land-types according to landforms, soils, drainage patterns and vegetation. Within the Pilbara there are 20 land types with the dominant type, occupying 40% (71,680 km^2) of the bioregion, being described as '… *hills and ranges with spinifex grasslands*' (Payne 2004). The smallest land-type in the region is '… *alluvial plains with halophytic shrublands*' at less than 0.1% of the bioregion. This land type is represented by only one land system (Talawana).

SUBREGIONAL DESCRIPTIONS

The Pilbara Craton is one of Australia's major geological blocks (Trendall 1990). The Craton is characterised by hard rock landscapes that were laid down in Archaean times 2.5 to 3.5 billion years ago, making them some of the oldest rocks on the planet. A simplified geology map is shown in Figure 4. The basement is exposed as granite (domes, nubbins, tors, inselbergs) and greenstone (basic and ultrabasic volcanic rocks) terraine (Thorne and Trendall 2001) in the north, but overlain by rugged sedimentary strata, volcanic flows and lateritised caps in the south. A product of their geoclimatic history, Pilbara landscapes comprise rough ranges, broad plateaux and stony ridges separated by rolling stony plains of alluvial clays, silts, sands and gravels. The uplands are defined by abrupt escarpments and steep scree slopes which are incompletely mantled by shallow skeletal soils. Gorges, picturesque rockholes and grassy floodplains occur along seasonally active, exoreic river systems that drain the uplands. Extensive quaternary alluvial and aeolian coastal flats and floodplains form the region's mangrove-fringed western margin. Because of this history, and its impact on the plants and animals that inhabit these landscapes, the Pilbara is considered to be a natural region both geologically and biologically (Beard 1975, 1990; Thackway and Cresswell 1995).

The region is divided into four geomorphically distinctive subregions (Environment Australia 2008) (Figures 1 and 3).

Roebourne

Abutting the Indian Ocean along the Pilbara's northern and north-western fringe is the Roebourne subregion (PIL4) which covers an area of 18,910 km^2 or approximately 10% of the study area. The subregion is divided into two sections by a coastal extension of the Chichester subregion near Cape Lambert, west of Roebourne. The southern portion of the subregion aligns with the Onslow Coastal Plain physiographic unit as demarcated by Beard (1975), whereas the northern portion of the subregion captures the coastal portion of the Abydos Plain physiographic unit described as 'The grass plains' and 'The coastal complex' by Beard (1975). This subregion comprises mostly Quaternary (< 10 Mya) alluvial and aeolian coastal and sub-coastal plains. These plains, which are traversed by active floodplains adjacent to the larger rivers systems (De Grey, Fortescue, Yule) support sandy to heavy clay substrates and gilgais. They are mostly covered by grassland of mixed bunch grass (*Aristida* spp., *Enneapogon* spp.), tussock grass (*Cenchrus* spp., *Eriachne* spp., *Eragrostis* spp., *Sorghum* spp.) and hummock grass (*Triodia* spp.) and dwarf to open shrubland of snakewood (*Acacia xiphophylla*) and *A. stellaticeps* over soft spinifex, mostly *Triodia pungens* and *T. epactia*. Infrequent emergent Archaean granitic tors and domes, metamorphosed hills of sedimentary rock (banded iron formation) and low ranges of basalt metamorphosed siltstone and granophyre are all covered in dwarf to open shrubland dominated by *Acacia arida* and *A. bivenosa* over hard *Triodia wiseana* hummock grasslands. Ephemeral short drainage features (e.g. Nickol River, Du Boulay Creek), scattered claypans and other drainage foci support open woodlands of western coolibah (*Eucalyptus victrix*) with Pilbara jam (*A. citrinoviridis*) and, in localities with permanent water (e.g. Miaree Pool), forests and closed tall woodlands of silver cadjeput (*Melaleuca argentea*), river red gum (*E. camaldulensis*) and white dragon tree (*Sesbania formosa*). On the larger river deltas, open woodlands of western coolibah and *Bauhinia cunninghamii* are present over dense shrublands of *Sesbania cannabina* and budda pea (*Aeschynomene indica*), although mesquite (*Prosopis* spp.), a weed of national significance, forms impenetrable thickets on the Fortescue River delta. Samphire (*Tecticornia* spp.) dwarf scrublands, *Sporobolus* grasslands, low coastal dunes covered with *Spinifex longifolius*, and low mangrove forests comprising *Avicennia marina*, *Bruguiera exaristata*, *Rhizophora stylosa* and *Ceriops tagal* occur on marine alluvial flats and the smaller river deltas.

Chichester

The Chichester is the largest subregion (PIL1), covering over 47% of the Pilbara (83,700 km^2). Its characteristic feature is the Chichester Range which extends for over 400 km, from west of the Millstream-Chichester National Park to Balfour Downs Station in the east. Other noteworthy ranges include the Gorge Range, Gregory Range, Panorama Ridge, Nimingarra Ridge, Black Range and the Ripon Hills. Northwards and eastwards, its topography becomes more subdued and its landscapes less rugged. The subregion is characterised by undulating Archaean (2500+ Mya) granite and greenstone terrain comprising granitic tors, domes, nubbins, stony granitic plains, some minor sandy plains and significant areas of rugged basaltic and to a less extent sandstone ranges, ridges and dissected plateaux. Significant areas of Archaean greywacke exist (e.g. Mosquito Creek Formation) along with Carboniferous-Permian sandstones in the subregion's east and north-east. Its northern part is relatively flat and undulating, being dominated by large alluvial floodplains associated with the De Grey River system and its tributaries (Oakover, Nullagine, Shaw, Yilgalong). This subregion encompasses all of the gorge ranges, almost all of the Chichester Plateau and Oakover Valley and the largest portion of the Abydos Plain physiographic units as delimited by Beard (1975).

Throughout this subregion, rolling plains and gently undulating hills support a shrubland characterised by wattles, in particular *Acacia inaequilatera*, *A. ancistrocarpa*, *A. tumida* var. *pilbarensis* and *A. orthocarpa/arida*, over hard spinifex (*T. wiseana*, *T. lanigera*, *T. secunda*) hummock grassland. Scattered snappy gums (*Eucalyptus leucophloia*) over open *Acacia* shrublands occur ubiquitously on uplands and ranges. Tablelands of decomposing basalt are a distinguishing feature of the Chichester Plateau along the southern margin of the subregion. These tablelands, described as the Wona Land System (Van Vreeswyk *et al.* 2004), comprise gilgai plains or self-mulching cracking clays supporting tussock grasslands dominated by Mitchell grass (*Astrebla* spp.), sorghum (*Sorghum* spp.) and Roebourne Plain grass (*Eragrostis xerophila*) and/or herbfields of ephemeral Papilionaceae (*Desmodium* spp., *Glycine* spp., *Rhynchosia* spp.), Amaranthaceae (*Ptilotus* spp.) and Convolvulaceae (*Ipomoea* spp., *Operculina* spp.). In the subdued east of the subregion, open Mulga (*Acacia aneura s.l.*) woodlands and shrublands (with *A. subcontorta*) over tussock grasses and soft hummock grasslands (*T. melvillei*, *T. pungens*) are prevalent, especially on hardpans and rocky footslopes. Shrubland dominated by *Acacia* (*A. ancistrocarpa*, *A. fecunda*, *A. synchronicia/robeorum*) with *Grevillea wickhamii* and *Hakea lorea* over hard hummock grasslands (*T. wiseana*, *T. lanigera*) persists on some of the stony pediments. On scree slopes, amongst breakaways, on granitic domes and along many rocky riparian habitats throughout the subregion, figs (*Ficus brachypoda*), the Pilbara kurrajong (*Brachychiton acuminatus*) and wing-nut tree (*Terminalia canescens*) are conspicuous elements of the flora.

The region is drained to the north by numerous river systems including the Maitland, Harding, Sherlock, Yule, Turner, and tributaries of the De Grey. These rivers have a dendritic drainage pattern and most cross extensive flat plains (especially as they traverse the Roebourne subregion). Like the Roebourne subregion, the Chichester's riparian systems typically support a woodland or forest with silver cadjeput, river red gum, western coolibah and white dragon tree. Their understorey is dominated by introduced tussock grasses (e.g. *Cenchrus* spp., *Echinochloa colona*) in most localities. The alluvial plains fronting the De Grey River and its tributaries support soft hummock grasslands (*Triodia pungens*, *T. epactia*) or tussock grasslands (*Eragrostis xerophila*, *Cenchrus ciliaris*, *Chrysopogon fallax*), while gilgai plains support Mitchell grass (*Astrebla* spp.) and swamp grass (*E. benthamii*). Along the escarpment of the Chichester Range in the south of the subregion, drainage is short, parallel and empties onto the alluvial plains of the Fortescue Valley. Open mulga woodlands, snakewood shrublands and hard hummock grasslands with emergent Hamersley bloodwoods (*Corymbia hamersleyana*, *C. semiclara*) or snappy gums occupy these slopes.

The iconic Millstream wetland is located on the southern margin of the subregion, where the Fortescue River has bisected the Chichester Plateau and incised calcareous valley-fill deposits of the Fortescue subregion. A spring-fed riparian system on permanent river pools, Millstream supports a forest or tall closed woodlands of silver cadjeput, river red gum, western coolibah and white dragon tree over thickets of tea tree (*Melaleuca glomerata*, *M. bracteata*) and *Hibiscus austrinus.* It also has a large population of the Millstream fan-palm (*Livistona alfredii*), locally endemic invertebrates such as the damselfly *Nososticta pilbara*, and some unusual introduced plants such as Indian water fern (*Ceratopteris thalictroides*) and water lilies (*Nymphaea* spp.).

Fortescue

The Fortescue subregion (PIL2) corresponds closely to the Fortescue Valley physiographic units as delimited by Beard (1975) and occupies an area of 19 560 km^2 or 11% of the bioregion. The Valley comprises mostly Quaternary alluviums, colluviums, aeolian sand plains and lacustrine deposits overlying Tertiary valley-fill units of the Late Eocene (>41 Mya). These valley-fill deposits are expressed as pisolitic limonites (Robe Pisolite), calcretes and minor silcretes (Thorne and Tyler 1997). The subregion is centred on the Fortescue River.

The northern margin of the Fortescue subregion follows the southern periphery of the Chichester and mostly comprises bajadas (alluvial fan) and outwash plains. The dominant vegetation on these bajadas is open mulga woodland and snakewood shrubland over tussock grasses (*Themeda triandra*, *Chrysopogon fallax*, *Eragrostis* spp.) or open hummock grasses (*Triodia pungens*, *T. wiseana*) although, towards the west, there are woodlands of snappy gum (*E. leucophloia*) and Pilbara bloodwood over *Acacia* and *Senna* shrublands and hummock grasslands (*Triodia* spp.). In some places, the Chichester Range protrudes southwards into the Fortescue valley (e.g. Goodiadarrie Hills, Mt Murray). These isolated hills and ridges comprising Marra Mamba Iron Formation, sandstone or conglomerate landforms and support *Acacia* low shrubland (*A. trachycarpa*, *A. arrecta*) over hummock grasses. The northern slopes of the subregion are drained by mostly short, parallel features, often supporting slightly denser fringing mulga woodland with the occasional western coolibah and whitewood (*Atalaya hemiglauca*).

The eastern portion of the subregion is very subdued and comprises mostly bajadas, hardpan plains and flood-out zones. The bajadas and hardpan plains are typically covered by low woodlands of mulga and mulga allies (e.g. *Acacia paraneura*, *A. catenulata* subsp. *occidentalis*, *A. ayersiana*) over open shrubs (*Eremophila forrestii*, *E. cuneifolia*, *E. lanceolata*) and scattered hummock grasses, although herbs (e.g. *Ptilotus exaltatus*, *P. auriculifolius*, *P. helipteroides*) are abundant in season. Extensive grove-intergrove mulga communities exist on very gentle bajadas. The flood-out zones, which are mostly restricted to the sluggish dendritic drainage lines and foci of the upper branches of the Fortescue River and its tributaries (e.g. Jigalong and Jimblebar Creeks), support woodlands of western coolibah, western ghost gum (*Corymbia candida*), whitewood, mulga, weeping wire wood (*Acacia coriacea* subsp. *pendens*) and *A. distans* over tussock grasses (*Cenchrus ciliaris*, *Eragrostis benthamii*, *Eulalia aurea*) and herbs (*Calotis multicaulis*, *Ptilotus helipteroides*, *P. gomphrenoides*). Some of these communities are significantly degraded because of unsustainable pastoral activities, with the woody increaser bardi bush (*Acacia synchronicia*) dominating to form impenetrable spinescent thickets over large areas of many flood-out zones, especially at sites where intensive grazing and livestock activity (e.g. around water sources) have excluded all palatable species. Similarly, bardi bush also becomes dominant when the functionality of grove-intergrove and hardpan mulga woodlands on flood-out zones is compromised. Overgrazing and livestock activity promote this dysfunctionality by creating leaky systems (Tongway *et al*. 2001), which are the consequence of alterations to the flow and status of water, nutrients and organic matter in fertile mulga patches. Also, as a result of intensive land revegetation efforts, buffel grass dominates the understorey of some flood-out zones and hardpans, particularly on Ethel Creek station.

Significant areas of aeolian sandplain, occasionally with small (<2 m) dunes, also exist in the east of this subregion as stranded enclaves of the nearby Little Sandy Desert. These sandplains support open mulga, Pilbara box (*Eucalyptus xerothermica*), northwest box (*E. tephrodes*) or desert bloodwood (*Corymbia deserticola*) woodlands with some blue-leafed mallee (*E. gamophylla*) over soft hummock grasses (*Triodia pungens*, *T. melvillei*). Low scrub and heath comprising conspicuous sandy desert floral elements (*Grevillea juncifolia*, *G. eriostachya*, *Kennedia prorepens*, *Leptosema chambersii*, *Diplopeltis stuartii*) persist in the dune areas.

The southern part of the Fortescue Subregion comprises short, parallel drainage features with bajadas abutting the Hamersley escarpment and floodout plains derived from drainage features with steep gradients that arise within the Hamersley Plateau (e.g. Weelumurra Creek, Weeli Wolli Creek, Dales Gorge and Munjina Gorge). Like those bajadas to the north, open mulga woodlands (*Acacia aneura s.l.*, *A. pruinocarpa*) and snakewood shrublands over tussock grasses (*Eragrostis* spp.) or open hummock grasslands (*Triodia wiseana*, *T. melvillei*) predominate, particularly to the east of Wittenoom. West of Wittenoom the woodlands tend to be replaced by *Acacia* shrublands (*A. ancistrocarpa*, *A. tumida* var. *pilbarensis*, *A. cowleana*, *A. atkinsiana*) or open Hamersley bloodwood and Pilbara box woodlands, with some blue-leaved mallee shrublands over hummock grasses (*T. wiseana*, *T. pungens*, *T. melvillei*). The vegetation of drainage features tends to be similar to that on the north side of the valley, although river red gum and white dragon tree persist along the features with greater episodic flows.

The western end of the subregion is represented by the ancient Fortescue River bed and the drainage divide abutting the Robe River valley. This area is relatively flat and mostly supports mixed *Acacia* shrublands (*Acacia ancistrocarpa*, *A. tumida* var. *pilbarensis*, *A. cowleana*, *A. maitlandii*, *A. atkinsiana*) over soft hummock grasses (*Triodia pungens*, *T. melvillei*). At the base of the catenary sequence the calcareous alluvial and gilgai plains support an herbaceous tussock grassland of barley Mitchell grass (*Astrebla pectinata*), kangaroo grass (*Themeda triandra*) and ribbon grass (*Chrysopogon fallax*) with scattered western coolibahs and Pilbara ghost gums.

A significant and dominant feature of this subregion is the Fortescue Marsh. This drainage feature, 100 km long, is effectively the terminus of the upper Fortescue River; the lower Fortescue River arises from streams draining the Chichester and Hamersley Ranges below the Marsh and west of the Goodiadarrie Hills. The Quaternary alluvial and lacustrine deposits of the marsh are dominated by low mulga woodlands over bunch grass (*Aristida* spp., *Enneapogon* spp.) on the non-saline alluvial plains, fringing wattle (*Acacia ampliceps*, *A. sclerosperma* var. *sclerosperma*) shrublands on saline clay banks and calcareous rises, scattered samphire (*Tecticornia* spp.), saltbush (*Atriplex* spp.) and *Eremophila spongiocarpa* shrubs on saline cracking and non-cracking clay flats, and a shrubby grassland of salt water couch (*Sporobolus virginicus*) with false lignum (*Muellerolimon salicorniaceum*) and lignum (*Muehlenbeckia florulenta*) on flood plains. The lakebed and saline floodplains, which may extend for up to 10 km, are dominated by a dense low shrubland or heath of samphires and both lignum and false lignum.

West of the Goodiadarrie Hills, the Fortescue River traverses an extensive active alluvial flood plain where the drainage is meandering and anastomosing until a series of central channels becomes defined near Kanjenjie as the river becomes constrained by the Chichester Plateau and cuts deeply into the calcareous Millstream aquifer.

The vegetation fringing the ephemeral drainage channels along this part of the Fortescue River comprises mixed river red gum, western coolibah and *Acacia* woodlands (*A. distans*, *A. catenulata* subsp. *occidentalis*, *A. aneura s.l.*, *A. xiphophylla)* and tall shrublands over tussock grasslands comprising Roebourne Plains grass, ribbon grass and swamp grass. Heavy cracking clay and gilgai plains are also common and support tussock grasslands dominated by Mitchell grasses, neverfail (*Eragrostis setifolia*), ribbon grass and swamp grass, often with an emergent ephemeral shrub layer of *Sesbania cannabina* and budda pea. Sporadic drainage foci and pools, usually in deep clays or alluvium, support woodlands of western coolibah, *Acacia distans* and *A. aneura s.l.* over lignum and tussock grasses (*Astrebla* spp., *Eriachne* spp., *Themeda* spp.).

Hamersley

The Hamersley subregion (PIL3) occupies the southern part of the Pilbara Craton and encompasses the Hamersley Range *s.l.*, the most prominent mountainous area in Western Australia. The subregion occupies an area of 56,490 km^2 or 32% of the bioregion. The Hamersley Plateau and Stuart Hills (Beard 1975) are encompassed within this subregion. It is a mountainous area of Archaean-Palaeoproterozoic (545–2500 Mya) metamorphosed sedimentary and volcanic ranges and plateaux. The surface geology is dominated by banded ironstone formation sedimentary rocks interlaced to varying degrees with intrusions of chert, dolomite, siltstone and shales. The ancient Archaean granitic and greenstone basement outcrops sporadically throughout the range, predominantly in the south with some isolated exposures along well-eroded drainage lines towards the centre of the subregion (Figure 4). Cainozoic deposits of Robe Pisolite, alluvium and colluvial valley fills derived from sources further up the catena profile form most valley floors (Beard 1975; Tyler *et al.* 1990).

The Hamersley subregion is geomorphologically a series of topographical features (ranges, ridges, hills and plateaux) encompassing isolated and continuous chains of uplands that rise above a plateau surface from a basement of about 250 m above sea level in the west to over 1200 m on the highest peaks which occupy the central Hamersley Plateau. The highest peak, Mt Meharry, is 1245 m above sea level. In the north the subregion is demarcated by an abrupt, precipitous escarpment that is broken in many places by entrenched, incised gorges such as Dales, Hancock, Bee and Yampire Gorge. To the east and south the escarpment is subdued as the topography of the Hamersley Plateau gives way to the broad Ashburton River valley and the low rocky hills of the Bangemall Basin and the Sylvania Inlier (Tyler *et al*. 1990). On the western flank the relief is also somewhat subdued after traversing the western escarpment and entering the raised plains of the Stuart Hills (Beard 1975), although the pisolitic mesas and breakaways of the Robe Valley and sandstones of the Parry Range do confer some relief. The Hamersley Range, which occurs entirely within the subregion, encompasses a number of constituent ranges and ridge massifs, such as the Eastern, Goondoowandoo, Gurinbiddy, Hancock, Jirrpalpur, Lawloit, Ophthalmia, Packsaddle, Werribee and Western Ranges.

Surface water drains into the Fortescue River on the northern and eastern flanks of the subregion, into the Robe and Cane Rivers in the west and into the Ashburton River to the south. Typically, drainage along the northern escarpment is short and abrupt via deeply incised gorges, although some large channels such a Weeli Wolli, Marillana, Western and Weelumurra Creek exist. The small drainages are dominated by emergent Pilbara bloodwoods, Pilbara box, western coolibahs with

Acacia (*A. maitlandii*, *A. monticola*, *A. tumida* var. *pilbarensis*, *A. ancistrocarpa*) shrubland over hard and soft hummock grasses (*Triodia wiseana*, *T. pungens*) and occasional tussock grasses (*Themeda* spp.) depending on landscape position. The large channels contain extensive alluvium and fine depositional deposits and support a fringing riparian open tall woodland of river red gums and western coolibahs over woodlands or tall shrublands of Pilbara jam, slender petalostylis (*Petalostylis labicheoides*) and weeping wire wood over soft hummock grasses (*T. pungens, T. epactia*) and tussock grasses such as buffel grass, kangaroo grass and silky browntop (*Eulalia aurea*). In sites where the drainage is interrupted and the water table rises, extensive silver cadjeput forests with red river gums and western coolibah woodlands over native cotton (*Gossypium* spp.) and sedgelands of stiffleaf sedge (*Cyperus vaginatus*) may exist. Drainage into the Ashburton River is via a series of more elaborate dendritic channels such as Turee and Duck Creeks and the Beasley, Hardey and Angelo Rivers. The vegetation of these drainage lines is akin to that of drainage features elsewhere in the subregion, being dominated by eucalypt woodlands over wattle shrubs, although in the Cave Creek (and to a less extent Duck Creek) systems extensive fringing riparian woodlands support Millstream fan palms when calcareous valley-fill deposits are encountered.

Internal drainage basins are extensive on the Hamersley Plateau. Examples include Lake Robinson, Munjina Claypan and the Mt Bruce, Coondewanna and Wanna Munna Flats. These basins tend to fill following the passage of intense tropical cyclones. The basins are mostly on hardpan or alluvial plains and support extensive tall to low mulga woodland with scattered emergent Pilbara box over bunch grasses (*Aristida* spp., *Eriachne* spp.) on fine textured soils. On very flat pediments, well-developed grove-intergrove mulga woodlands may exist with emergent western gidgee (*Acacia pruinocarpa*) and a suite of mulga allies (*A. paraneura*, *A. ayersiana*, *A. aneura* var. *intermedia*, *A. aneura* var. *macrocarpa*, *A. aneura* var. *pilbarana*). These are also termed banded mulga formations. In areas where the hardpan is close to the surface and soil depth is insufficient to support trees, an open scrub of *Eremophila* (*E. caespitosa*, *E. lanceolata*, *E. lachnocalyx*) and *Senna* (*S. artemisioides* subsp. *helmsii*, *S. artemisioides* subsp. × *sturtii*, *S. sericea*) species may persist with scattered stunted shrubs (*A. subcontorta, Psydrax* spp.). The basement sump of such internal drainage basins is usually dominated by a woodland of western coolibah over tussock grasses (*Themeda triandra*, *Eulalia aurea*, *Eragrostis* spp., *Eriachne* spp., *Chrysopogon fallax*) or lignum and swamp grass.

The permanent pools of the northern gorges support a typically riparian vegetation community dominated by silver cadjeput, river red gum, western coolibah and white dragon tree over sedgelands of stiffleaf sedge along with some relictual tropical elements such as *Clerodendrum floribundum*, *Flueggea virosa* subsp. *melanthesoides*, *Plectranthus intraterraneus*, *Dolichandrone heterophylla* and *Pteris vittata.* The gorges, which are incised through the banded ironstones, are inherently sheer, steep-sided and harbour significant scree and boulder strewn slopes that also provide important fire-avoiding habitats for many relictual floristic elements including figs (*Ficus brachypoda*, *F. virens*), kurrajongs (*Brachychiton acuminata*, *B. gregorii*), native cypress (*Callitris columellaris*) and the wonga wonga vine (*Pandorea pandorana*).

The rolling hills and stony plains of the Plateau support an open woodland of snappy gum over low shrubs (*Acacia bivenosa*, *A. ancistrocarpa*, *A. maitlandii*, *Keraudrenia* spp.) and hard spinifex (*Triodia wiseana*, *T. basedowii*, *T. lanigera*), with drainage features supporting slightly denser vegetation mostly comprising wattle shrubs with some Pilbara bloodwood. Shrub mallee (*Eucalyptus gamophylla*, *E. trivalva*, *E. socialis* subsp. *eucentrica*, *E. striaticalyx*) over tea tree (*Melaleuca eleuterostachya*) and hard hummock grasses (*T. basedowii*, *T. longiceps*, *T. angusta)* are also a common community on stony plains and rolling hills, particularly on calcareous pediments. Run-on, water-gaining slopes and bajadas above detrital banded ironstone deposits and valley-fills support a cover of *Acacia* woodland and shrubland dominated by mulga (*A. aneura s.l.*, *A. ayersiana*, *A. minyura*) over an understorey of open shrubs (*Ptilotus obovatus*, *Rhagodia eremaea*, *Senna glutinosa*) and tussock grasses (*Chrysopogon fallax*, *Eragrostis* spp., *Eriachne* spp.). The composition of the shrub layer in such communities changes with progression south and away from the Hamersley escarpment as there tends to be a reduction in hummock grasses and a concordant increase in *Eremophila* species and other fire-sensitive shrubs. In some situations, particularly on very gentle slopes with a surface mantle of stones which are common in the central and eastern parts of the subregion, a juxtaposition exists where fire-sensitive mulga woodlands and shrublands overlay hummock grasslands.

The ironstone and basalt ridges, ranges and hills of the subregion are dominated by snappy gum woodlands over shrubs (*Acacia hilliana*, *A. adoxa*, *Gompholobium karijini*, *Mirbelia viminalis*), tussock grasses (*Amphipogon carinatus*, *Cymbopogon* spp.) and hard spinifex (*Triodia wiseana*, *T. basedowii*). Blue-leaved mallee, Pilbara bloodwood, Victoria Spring mallee (*Eucalyptus trivalva*) and Pilbara mallee (*E. pilbarensis*) are also common on these slopes. On mountain summits the vegetation is characteristically shrub mallee (*E. kingsmillii*, *E. ewartiana*, *E. lucasii*) with emergent snappy gum or iron bloodwood (*Corymbia ferriticola*) over shrubs (*Acacia arida*, *Gastrolobium grandiflorum*, *Hibbertia glaberrima*, *Daviesia eremaea*) and hard spinifex (*T. brizoides*), although on basaltic hilltops, compared to those on ironstone, Pilbara and desert kurrajongs, Pilbara box and blue-leaved mallee are dominant.

DRAINAGE AND HYDROLOGY

Rivers in the Pilbara consist of broad sandy to gravelly channels that are dry for most of their length soon after floods. They have numerous permanent pools maintained by subsurface inflows and/or springs; there are often downstream bedrock structures. Lower-order creeks are 'flash-flooding', retaining water mostly in rock pools or against cliffs in small gorges. Springs are common, but rivers generally have narrow, well-drained floodplains for most of their length with few off-channel wetlands. Exceptions are the coastal plains, areas above and below Fortescue Marsh, the fringes of the marsh itself and several plains with internal or sluggish drainage on the Hamersley Range, where numerous claypans and clay flats exist.

Five Pilbara wetlands are recognised as being of national significance (ANCA 1996; Environment Australia 2001). All meet several or all of the six criteria for determining important wetlands: (1) examples of wetland types in Australia, (2) having an important ecological or hydrological role in the functioning of a major wetland system/complex, (3) important as a habitat/refuge for animal taxa at a vulnerable stage in their life cycles, (4) supports >1% of the national population of a native plant or animal, (5) supports native species or communities listed as vulnerable or endangered and (6) an outstanding historical or cultural significance. The De Grey River (criteria 1, 2, 3 and 6) is a representative example of a major river system in the region and includes the longest permanent river pools and largest shallow estuary in north-western Australia. The Fortescue Marshes (1, 2, 3 and 6) are a unique wetland landform, an example of an extensive inland floodplain system and have the second largest recorded populations of waterbirds (after Lake Gregory) in Western Australia. The Karijini (Hamersley) Gorges (1 and 6) include magnificent examples of gorge pools and streams. The Leslie (Port Hedland) Saltfield system (all 6 criteria) is a good example of the coastal flats and associated tidal coast in north-western Australia. Millstream Pools (1, 2, 3 and 6) are an outstanding example of a system of permanent river pools and springs in the semi-arid tropics.

Hydrogeology is summarised by Johnson (2004). Briefly, groundwater occurs throughout the region as a water table 'forming a subdued reflection of surface topography' below which all pore spaces are saturated. The Western Australian Department of Water's water information database (WIN) includes information on water levels, depths, yields and salinity for about 6000 bores and wells across the region. They are concentrated near the coast, along main drainage lines, along major roads, around mining operations and near towns. Groundwater is important for both the mining and pastoral industries, although most extraction is for dewatering iron-ore mines and for town water supplies. Generally 'fresh', it occurs in a range of hydrogeological environments. Four main types are recognised:

1. Surficial aquifers in coastal and valley-fill alluvium, including alluvial deposits of the coastal plains, coastal dunefields, and alluvial and colluvial deposits fringing main trunk drainages such as the Fortescue River and in the Hamersley Ranges. The valley-fill deposits often overlay calcrete and limonite.
2. Aquifers in calcrete and pisolitic limonite chemically deposited in Tertiary drainages incised into basement rocks. Both are usually associated with discharge zones such as river pools and springs and/or occur below contemporary drainage channels. Storage is in secondary porosity and karst features. Pisolites can be highly porous.
3. Sedimentary rock aquifers in the western and north-eastern parts of the Pilbara, with the primary porosity providing storage. They can occur in dolomites, banded iron and sandstone formations.
4. Fractured sedimentary and igneous rock aquifers where secondary porosity has developed along bedding joints, and in fractured or weathered zones. These zones are present in mafic volcanic rocks and in granite and greenstone strata. Storage is generally small but may be large locally in solution voids.

Differences in the chemical composition of water samples from six Pilbara aquifers indicate that they represent distinct environments for organisms (see Table 2 in Johnson 2004).

LAND TENURE AND DEMOGRAPHICS

The Pilbara's land area is approximately 60% pastoral lease, 10% conservation reserve, 5% Aboriginal Reserve and 25% unallocated Crown land (Figure 1). It has a resident population of about 40,000 people, mostly living in towns associated with ports along the coast (Dampier, Karratha, Roebourne, Port Hedland and South Hedland). There are six towns inland, all associated with mines (Marble Bar, Nullagine, Newman, Paraburdoo, Tom Price and Pannawonica), the largest being Newman in the region's south-eastern corner, with a resident population of about 5,200. Traditional owners comprise about 10% of the Pilbara population. The Region's population is expected to reach 44,200 by 2010, 48,000 by 2020, and 50,200 by 2031 (Anon. 2006). The Pilbara bioregion includes the Local Governments of the Town of Port Hedland, Shire of Roebourne and large parts of the Shire of Ashburton and Shire of East Pilbara.

The Pilbara is the leading resources sector region in Western Australia, accounting for 63% of the value of the State's mineral and energy production in 2007 (Ruddock 2008). The value of mineral and petroleum sales exceeded $33 billion in 2007. In 2004/05 this figure was b$20.6 with b$8.6 coming from mining alone (Anon. 2006). Tourism contributed b$0.2 to the Pilbara economy (Anon. 2006).

PROCESSES OF LANDSCAPE CHANGE

Aboriginal peoples used and managed land in the Pilbara for thousands of years. While they must have influenced the biota, their affect has not been measured. The most widespread landscape processes modifying Pilbara biodiversity since European settlement are wildfire and alteration of fire regimes. In the 14 years between 1993 and 2006, over 72% (129,000 km^2) of the region was burnt (Figure 5), with upwards of 28% being burnt two or more times in this period. Consequently it took considerable time during 2003 and 2005 to find areas where sets of terrestrial sampling sites could be positioned in habitats that had not been burnt during the previous decade. Between 2002 and 2006, the period of our field sampling program, 39% of the region was burnt. The impacts of these processes on biodiversity have not been quantified across the region, but evidence from the few studies undertaken here (Suijdendorp 1981; Start 1986; Casson and Fox 1987; Casson 1994; van Etten 1998, 2000), and elsewhere in the Australian arid zone (Griffin and Friedel 1984, 1985; Rice and Westoby 1999; Williams 2002; Hodgkinson 2002; Nano and Clarke 2008), suggests that it can be profound. For example, research undertaken by van Leeuwen *et al*. (1995) indicates that the extent of mulga woodland in the Central Hamersley Range is decreasing as a consequence of too-frequent fires.

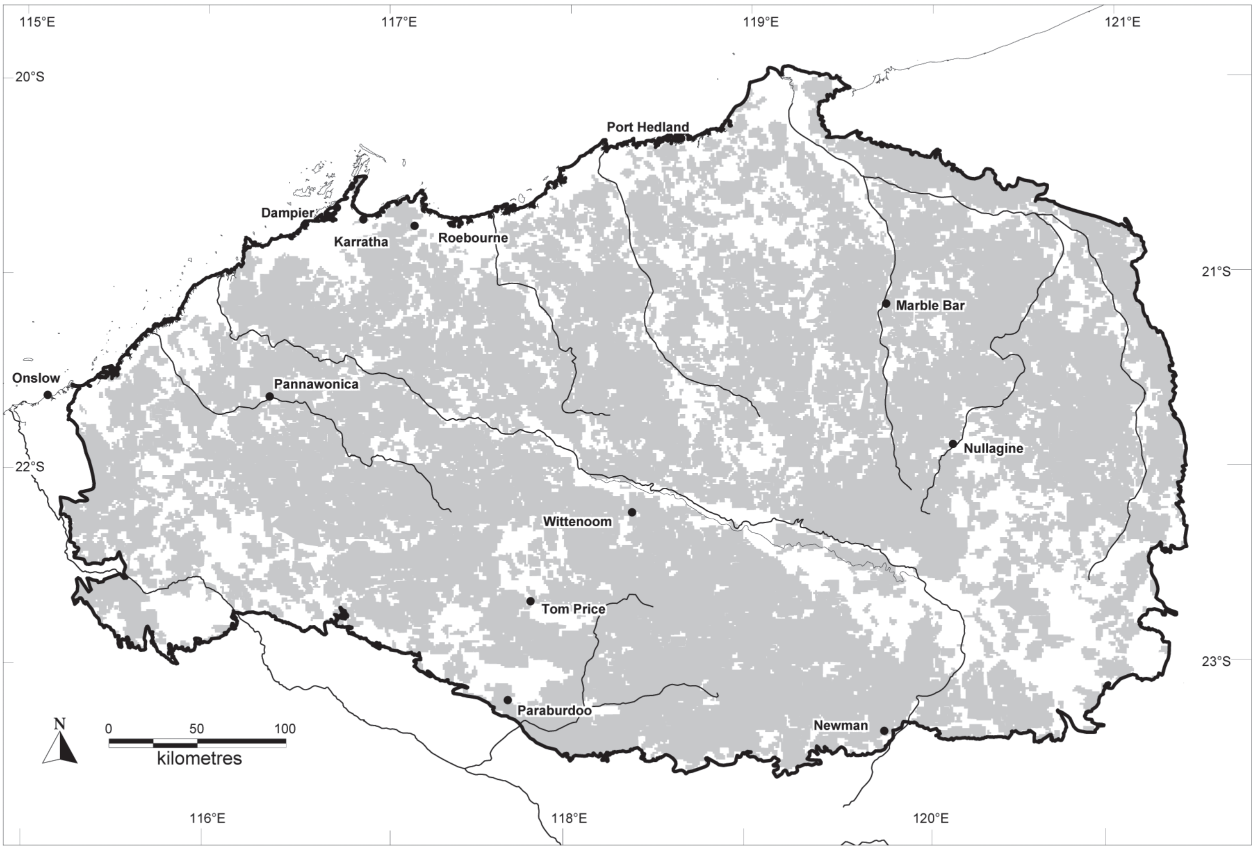

Figure 5 The pattern of fires over the last decade. From 'Landgate (2007). Fire Scars: Department of Land Information, Floreat: Western Australia.' http://www.rss.dola.wa.gov.au/newsite/apps/firescarmap.html (accessed 5 September 2007).

These woodlands support assemblages of species that do not persist in the spinifex scrublands that are replacing the mulga.

Other important processes modifying biodiversity relate to the region's land-use history. In 1863, the first pastoral leases were established on the Roebourne Plains, near the mouths of the Harding and De Grey Rivers. Within a few years, several other properties were established on these plains and, by 1868, 24,000 km^2 of land supported 38,000 sheep, and 300 bales of wool had been produced (Hennig 2004). Pastoral land-use rapidly spread eastwards and, by the end of the century, more than 50% of the region was under pastoral lease. Only the rugged range country was spared. The large properties carried up to 70,000 sheep. A series of droughts at the beginning of the 20th century reduced overall sheep and cattle numbers from 800,000 (in 1890) to 500,000 (official figures, Australian Bureau of Statistics and the Pastoral Lease Information System) but, by 1935, numbers had increased to 1,300,000 (>98% sheep).

Livestock grazing had depleted the native grass cover along the main river channels by the 1920s, resulting in increasingly occluded drainage systems with substantial bed loads. During the same period, an introduced perennial grass (buffel, *Cenchrus ciliaris*) was rapidly colonising alluvial surfaces throughout the region via these river systems. Allelopathic, it has displaced indigenous shrub and grass cover from the variety of Pilbara environments that it now pervades, including some scree slopes, but offers some protection from soil erosion. Sheep numbers have declined since 1930, sharply during long droughts in the 1930s and 1970s. The development of oil-based synthetic fibres during the 1960s reduced the market for wool, so the pastoral industry increased cattle numbers. Unfortunately, sheep numbers were maintained until the mid-1970s, effectively imposing a net grazing pressure equivalent to the 1930s peak (see figure 4 in Hennig 2004). After the mid-1970s, sheep grazing was effectively abandoned so that, by 2002, the region supported about 250,000 cattle but fewer than 20,000 sheep. Cattle have a severe impact on many river pools, especially late in the dry season; they trample and graze riparian zones and defecate in and around the pools with consequent eutrophication (the water essentially becomes a pool of cattle feces).

Degradation caused by increased fire frequencies, buffel grass and/or overgrazing is overt throughout the region. Rangeland surveys of the Roebourne Plains and Pilbara Ranges identify 357 km^2 as severely degraded and eroded land (Payne and Tille 1992; van Vreeswyk *et al*. 2004). The land systems that exhibit most of this degradation and erosion are 'run-on alluvial' or 'river plains' low in the landscape with soil surfaces protected by stony mantles and supporting preferentially grazed vegetation, typically tussock grasslands and chenopod shrublands.

Rich copper and lead deposits were found near Roebourne in the early 1870s and, by 1890, gold was being mined from the eastern Pilbara, near Marble Bar and Nullagine, and areas rich in iron ore were being reported. During the 1960s, massive tonnages of iron ore were being mined near Newman and Goldsworthy, and subsequently from other centres including Tom Price, Pannawonica and Paraburdoo. Extensive evaporative salt plants were also developed on the coastal flats near Port Hedland and Dampier, and gas-processing facilities have now been built on the Burrup Peninsula.

Introduced feral species are among the threats to biodiversity enumerated for the region in the National Land and Water Resources' biodiversity audit (McKenzie *et al*. 2003). A great range of plants and animals has been introduced, including unmanaged livestock and invertebrates such as the feral bee. Particularly significant among the introduced plants are three weeds of 'National Significance': mesquite (*Prosopis* spp.), parkinsonia (*Parkinsonia aculeata*) and athel pine (*Tamarix aphylla*), as well as several 'Environmental Weeds' including calotropis (*Calotropis procera*), kapok (*Ceiba pentandra*), coffee bush (*Leucaena leucocephala*), ruby dock (*Acetosa vesicaria*), date palm (*Phoenix dactylifera*), Chinese apple (*Ziziphus mauritiana*), buffel grass (*Cenchrus ciliaris*), birdwood grass (*C. setiger*) and numerous other grasses. The effect of buffel was described in an earlier paragraph; most of the other species are similarly invasive, but form dense impenetrable thickets that shade out other plants.

Twelve introduced mammals occur in the Pilbara (McKenzie and Burbidge 2002). Besides cattle (*Bos taurus*) and sheep (*Ovis aries*) discussed earlier, house mice (*Mus domesticus*) are ubiquitous on fine-textured soils across the region, black rats (*Rattus rattus*) are confined to mangrove communities and coastal towns, feral domestic dogs and dingo hybrids (*Canis familiaris*) are widespread but most common around towns, red fox (*Vulpes vulpes*) have been found on many pastoral leases, cats (*Felis catus*) are common throughout the region, European rabbits (*Oryctolagus cuniculus*) favour clayey soils low in the landscape and riparian zones, brumbies (*Equus caballus*) and feral donkeys (*Equus asinus*) are found on most pastoral leases, feral pigs (*Sus scrofa*) occur along the De Grey River from Warrawagine Station to the coast, and camels (*Camelus dromedarius*) are widespread but most common in eastern parts of the study area. All compete with and/or prey on indigenous species.

Hives of feral bees are common in tree hollows along watercourses throughout the Pilbara, presumably displacing a range of hollow-dwelling vertebrates, and competing with indigenous pollination vectors (Paton 1996; Paini 2004).

In summary, European activities, including pastoralism, the introduction of exotic plants, and mining, have modified Pilbara vegetation and landscapes, although their effects have been mitigated by the large areas of rugged upland with low pastoral value. More than 100 years of over-grazing and too-frequent bushfires have reduced vegetation cover and stripped soils of their organic and mineral-A layers, thereby reducing their water-holding capacities. The heavy bed loads of sand now carried by most of the region's major river systems are a direct consequence of excessive run-off volumes and velocities in substantial areas of catchments.

THREATENED COMMUNITIES

One threatened ecological community (TEC) and 16 priority ecological communities (PEC) are currently listed for the Pilbara (http://www.dec.wa.gov.au/management-and-protection/threatened-species/wa-s-threatened-ecological-communities.html). The TEC comprises grasslands on cracking clay plains of the Hamersley pastoral lease, dominated by the perennial kangaroo grass (*Themeda*) and many annual herbs and grasses. The PECs comprise the West Angelas cracking clay community, Weeli Wolli Spring community, Burrup Peninsula rock pool communities, Burrup Peninsula rock pile communities, Roebourne Plains coastal grasslands, stony chenopod associations of the Roebourne Plains, subterranean invertebrate communities of pisolitic hills in the Robe Valley, Peedamulla Marsh vegetation complex, *Astrebla lappacea* grasslands, Robe Valley sandsheet vegetation, Mingah Springs calcrete groundwater invertebrate assemblage, Wona land system plant assemblages, *Eucalyptus victrix* over *Muehlenbeckia florulenta* community of clay flats, Erawallana Spring type invertebrate assemblages on Coolawanya Station, Nyeetbury Pool type invertebrate assemblages, and stygofauna communities of the Millstream freshwater aquifer.

SURVEY SAMPLING STRATEGY

Scale, complexity and patchiness must be taken into account in sampling the biota of a study area to describe the diversity of its patterns (Braithwaite 1984; Bowers 1997). Various factors can distort the results, including:

- The sampling regime – land-class sampling regimes presume that species all respond to the same environmental factors in the same way, whereas site-based strategies allow the relationships to be investigated (Austin *et al*. 1984; McKenzie *et al*. 1991b, 2000a; Margules and Austin 1994; Oliver *et al*. 2004).
- Geographical and seasonal sampling bias (Braithwaite 1984; Weins 1985; Rosenzweig and Abramski 1986).
- Historic extinctions and introductions (McKenzie *et al*. 2006), and storage effects that allow some organisms to persist through periods when conditions prevent recruitment (Warner and Chesson 1985).
- Limitations in scale (Dale 1983; Whitmore 1984; Bowers 1997; MacNally and Quinn 1997; Huston 2002).
- Inefficient sampling methods (Hobbs *et al*. 1984; Rolfe and McKenzie 2000), including the analytical implications of unreliable 'absence' data in the presence-absence matrix (Margules and Austin 1994).
- The assumption that guilds follow taxonomic boundaries (Adams 1985; McKenzie and Rolfe 1986; Bowers 1997). In this context, we define a guild as a community of species that partitions the same resource axis.
- Uneven taxonomic resolution (McKenzie *et al*. 2000b; Bortolus 2008).
- Strongly localised patterns of endemism (Solem and McKenzie 1991).
- Patterns of land use. For example, almost 60% of the Pilbara study area is pastoral lease, with a strong bias towards productive soils.

Aspects of the survey's design offset some of these problems, as follows:

- The study area was large enough to encompass significant sections of both the geographical and environmental ranges of the species sampled (Austin and Heyligers 1989).
- Site-based sampling was applied, in which data were collected as biophysical attributes measured at the same place in the same time frame, so that co-occurrences between species and environmental parameters could be exposed through analysis. The climatic variables were based on long-term averages.
- The site-size (*ca*. 1 ha for most zoological groups, enclosing a 0.25 ha plant quadrat) was large enough to encompass the assemblages of the organisms being sampled (considering their mobility, longevity and bodysize in the context of their density, productivity and standing biomass in the study area). At the same time, the quadrats were small enough to allow the assumption that there was a reasonable level

of internal homogeneity, and that there was syntopy between all biophysical attributes recorded within each quadrat (McKenzie *et al*. 1991b).

- The environmental attributes measured for each site were biologically relevant to the organisms being sampled and reflected processes operating at both regional and local scales.
- To better represent ecosystem complexity, we sampled a range of organisms with very different life history strategies and ecological roles to achieve organism-based view of biodiversity patterns. Terrestrial sites were sampled for perennial and annual vascular plants, small ground-dwelling mammals, birds, reptiles, frogs, ground-dwelling spiders, ants, beetles and scorpions. Additional sites were sampled for microbats and others for mammal bones from late Holocene deposits. Sites on water bodies were sampled for aquatic invertebrates, macro- and microphytes and the fringing riparian vegetation. Boreholes were sampled for stygofauna.
- Tested sampling methods were applied by experienced field survey ecologists, and species were included in the analysis only if they were reliably captured by the sampling methods (see Burbidge *et al*. 2000b; Rolfe and McKenzie 2000) and confidently identified, so that the problems of unreliable 'absence' data in the presence-absence matrix were minimised.
- Undescribed species were studied by taxonomists familiar with the relevant group in Western Australia (see also Oliver and Beattie 1996).
- Sampling was carried out during an integrated program; all terrestrial and aquatic sites were sampled in two seasons, while subterranean water bores were sampled at least twice during the survey. In each case, sites were positioned across the geographical extent of the region, and selected to represent the diversity of the major physical environments in the Pilbara, as detailed below.

IMPLEMENTATION

The survey was divided into sub-projects that reflected the different sampling methods

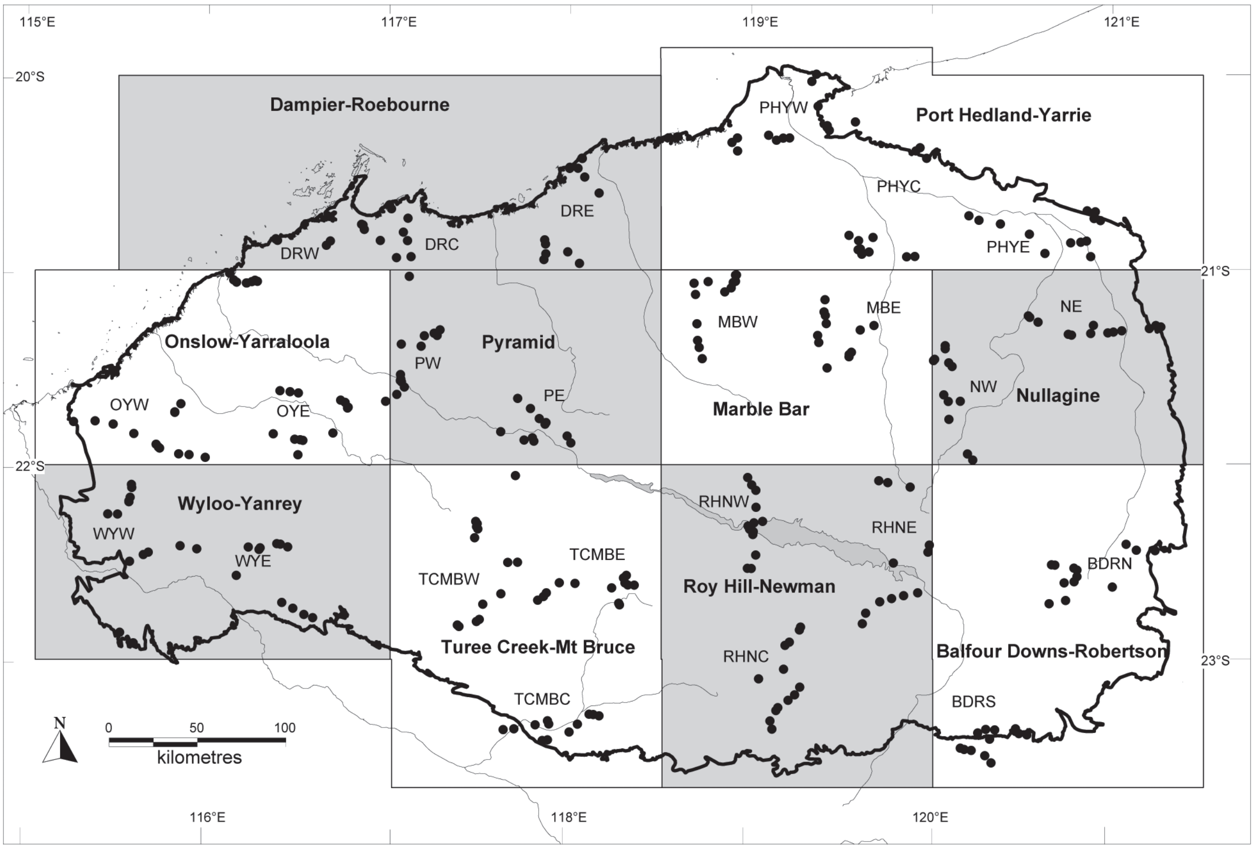

Figure 6 The 304 sites sampled for terrestrial biodiversity in the Pilbara. The stratification framework comprised 10 grid cells and 24 survey areas. For instance, the western-most of the three survey areas in the Dampier-Roebourne (DR) cell was coded DRW. There was also a (C)entral and an (E)astern survey area in this cell. Sites in cells shaded grey were sampled in 2004–05, while those in the 'white' cells were sampled in 2005–06.

Table 1 Terrestrial site environmental attribute codes.

Code	Attribute	Code	Attribute
Tann	Annual mean temperature (°C)	EC	Electrical conductivity (mS/m)
Tdir	Temperature diurnal range (°C)	pH	pH
isoT	Isothermality	Sand	Sand (%)
Tsea	Temperature seasonality	Silt	Silt (%)
mxTwP	Warmest period maximum temperature (°C)	Clay	Clay (%)
mnTcP	Coldest period minimum temperature (°C)	orgC	Organic carbon (%)
Tar	Temperature annual range (°C)	totN	Total nitrogen (%)
TweQ	Wettest quarter mean temperature (°C)	totP	Total phosphorus (mg/kg)
TdrQ	Wettest quarter mean temperature (°C)	totK	Total potassium (%)
TwmQ	Warmest quarter mean temperature (°C)	P	Available (HCO3) phosphorus (mg/kg)
TcoQ	Coldest quarter mean temperature (°C)	exCa	Exchangeable calcium (me%)
Pann	Annual mean precipitation (mm)	exMg	Exchangeable magnesium (me%)
PweP	Wettest period precipitation (mm)	exNa	Exchangeable sodium (me%)
Psea	Precipitation seasonality	exK	Exchangeable potassium (me%)
PweQ	Wettest quarter precipitation (mm)	Subs	Sandy, clayey or rocky substrate
PwmQ	Warmest quarter precipitation (mm)	soilD	Soil depth (cm)
PcoQ	Coldest quarter precipitation (mm)	gm7	Geomorphic unit (in 7 categories)
Long	Longitude (°E)	gm10	Geomorphic unit (in 10 categories)
Lat	Latitude (°S)	gm13	Geomorphic unit (in 13 categories)
Elev	Elevation (m)	Fabu	Surface fragment abundance
Sun	Sun index	Fmax	Maximum surface rock size
Slp	Slope	Outcrp	Outcrop extent
Asp	Aspect	Riv	Distance to major drainage line (km)
Cst	Distance to the coast (km)	Gcov	Total ground vegetation cover
Rug500	Topographic ruggedness; standard deviation in elevation in a 500 m radius		

and team expertise required: terrestrial fauna, terrestrial flora, surface aquatic fauna and flora, and stygofauna.

Terrestrial biota

The terrestrial sample sites were sited across the region in a stratified array to include the major geological formations, landform types, soils, climate and vegetation types. To achieve geographic coverage, the study area was divided into 10 grid cells based on 1:250,000 map sheet coverage of the Pilbara, for a total of 24 survey areas, arrayed in a roughly checker-board pattern. Two or three survey areas were selected in each cell, according to cell size, so that sampling was evenly dispersed across the study area's spatial extent (Figure 6). Finally, 11, 12 or 13 sample sites were selected in each survey area to represent its geomorphic profile (i.e. combination of geology and topographic position). Initial planning was based on maps of vegetation (Beard 1975), land surface (van Vreeswyk *et al*. 2004), geology (Hickman 1983; Trendall 1990; Thorne and Trendall 2001) and surface lithology (e.g. Hickman 1978, 1983; Hickman *et al.* 1983). Actual sites on the ground were selected by N.L. McKenzie and S. van Leeuwen during field traverses by vehicle, with assistance from A.H. Burbidge, L.A. Gibson or P.G. Kendrick in some areas.

As far as possible, sites were pseudo-replicated between survey areas and some sites were pseudo-replicated in the more extensive geomorphic units of each survey area. The pseudo-replication was to allow for the internal heterogeneity of the stratification units (hypothesised scalars) and to minimise any analytical circularity introduced by the stratification (Taylor and Friend 1984; McKenzie *et al*. 1989, 1991b; Gaston and Blackburn 1999). The sites chosen were the least disturbed examples that could be found, to minimise the effect that the uneven probability of disturbance among landform units would have on the survey design, an unavoidable source of variance. However, all possible sites on some landform and geological units were significantly infested by buffel grass. In total, 304 sites were selected for soils, animals and plants. An additional 118 sites were added subsequently to provide additional resolution on floristic patterns.

The 304 terrestrial biodiversity sites were established and sampled in two phases. This reduced biases from year-to-year variations in climate, and loss of sites to wildfires. Sites in the first five grid cells (the grey rectangles in the conceptual 'checker board', Figure 6) were established in mid-2003, while those in the other five cells (the clear rectangles) were established in mid-2005. Installation of two fenced pit trap lines (each with five pits), five invertebrate pits and the 50 m x 50 m flora quadrat at each sample site was undertaken by field teams led by J.K. Rolfe that included R. Bromilow, P. Cullen, T. Farmer, D. Kamien, B. Muir, C. Parker and R. Whitelaw in 2003, and J. Dunlop, T. Farmer, A. Lang, W. Manson, J. Nolthenius and T. Smith in 2005. General logistical support to these teams was provided by S. van Leeuwen in 2003 and by R. Bromilow, M. Hughes, T. Smith and S. van Leeuwen in 2005.

Soil samples from the top 10 cm of the soil profile taken at ten sampling points across the diagonal of each flora quadrat were obtained and bulked for later analysis by the Chemistry Centre of Western Australia. The soil samples were all obtained by R. Bromilow in April 2004 and May 2006. The analyses included electrical conductivity, pH, organic carbon, total nitrogen, total phosphorous, available phosphorus, total potassium and the concentrations of exchangeable cations, namely calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na). The textural attributes assessed were the fractions of sand, silt and clay present.

Site latitude, longitude, geological unit and thumbnail descriptions of the 304 terrestrial biodiversity sites are provided in Appendix A. Latitude and longitude coordinates were determined using a hand-held GPS accurate to +/- 10 m and with the datum set to WGS84. Forty-seven climate, soil, geomorphic and vegetation attributes were determined for each terrestrial site (Table 1). The 17 climatic attributes comprised annual and seasonal average and range values for temperature and precipitation (Appendix B), and were derived

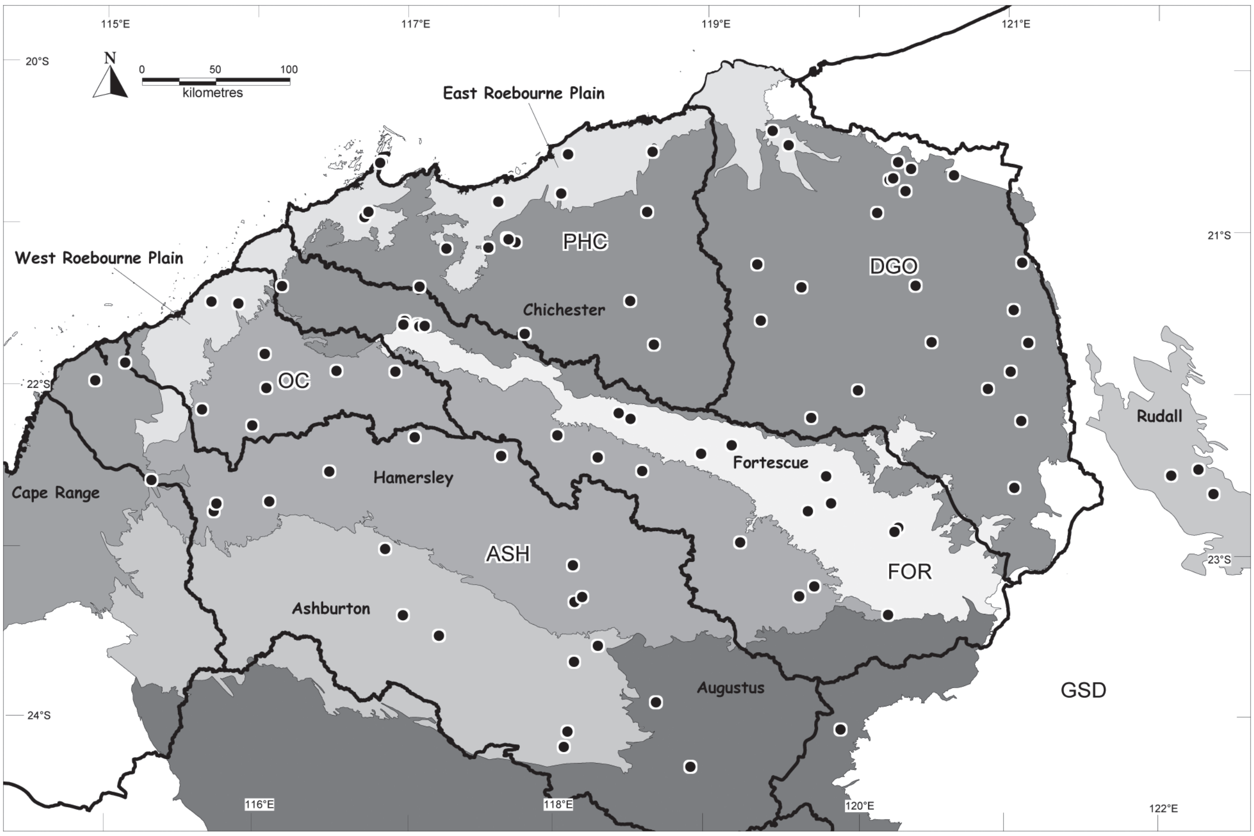

Figure 7 Surface water localities sampled. Drainage basins are bounded by heavy black lines and labelled as follows, ASH: Ashburton; DGO: De Grey Oakover; FOR: Fortescue; GSD: Great Sandy Desert; OC: Onslow Coast; PHC: Port Hedland Coast. IBRA subregions are shaded and labelled on the map.

using the BIOCLIM module of ANUCLIM (Houlder *et al*. 2000). The 14 soil chemical and texture values obtained for each site are listed in Appendix C.

Sixteen geomorphological attributes of the 304 sites are provided in Appendix D. They comprise soil depth, main substrate type (sand, clay or rock), geomorphic categorisation (into 7, 10 and 13 classes), distance to the coast (Cst) and to a river (Riv), extent of rock outcrop, surface stoniness (coarse fragment abundance and maximum size), topography (slope, elevation, sun index and landscape ruggedness) and vegetation cover (Gcov). The topographical variables (Slp, Asp, Elev and Rug500) were derived from a 90-m resolution digital elevation model. Aspect (Asp) was further transformed to give north-west and south-east as the extremes. Sun index was calculated as cos(aspect) × tan(slope) × 100. Distances to the coast (Cst) and to major drainage lines (Riv) were generated from digitised hydrology information available from DEC Corporate GIS dataset. Vegetation cover (Gcov) is an index of total ground cover (i.e. shrubs < 2 m, grasses and sedges) that was estimated visually. The variables maximum fragment size (Fmax), fragment abundance (Fabu) and extent of rock outcrop (Outcrp) were estimated visually and categorised following McDonald *et al.* (1984). Because surface geology (from 1:250,000 maps, see Appendix A) was used to position the quadrats in each survey area, it could not also be used as an attribute in modelling species assemblages. Equivalent and additional data for the 118 flora-only sites are provided as an appendix to the relevant paper.

Surface aquatic biota

Ninety-eight wetlands were chosen by M.N. Lyons and A.M. Pinder (Figure 7). To assist with an even geographic spread of sites:

- the coastal rivers near Port Hedland were divided into Roebourne Plain and Chichester sections,
- the Ashburton and Fortescue Rivers were divided into upper, middle and lower sections, and
- the De Grey River was divided into the Oakover/Nullagine and Coongan/Shaw subcatchments.

Within each catchment section, an attempt was made to select representatives of all the broad wetland types present (especially claypans, river

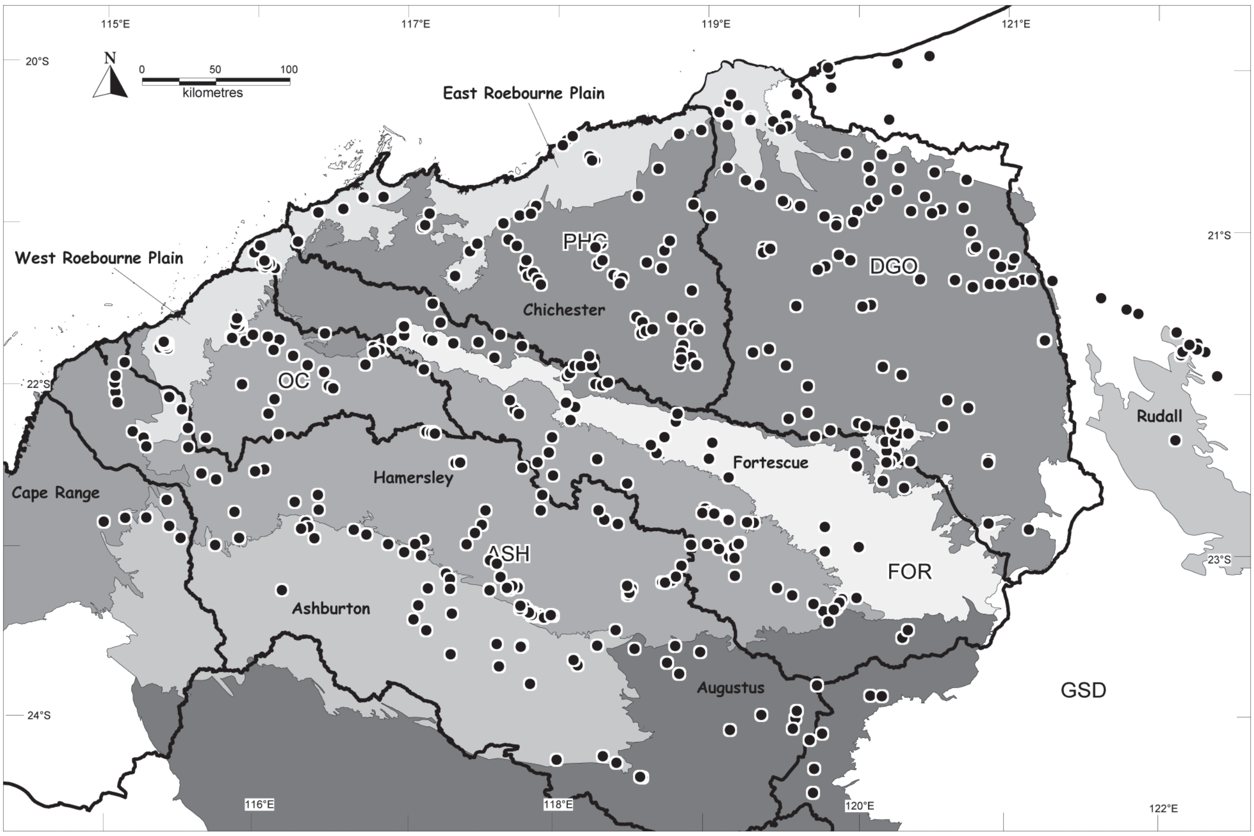

Figure 8 Water bores sampled for stygofauna. Drainage basins are bounded by heavy black lines and labelled as follows, ASH: Ashburton; DGO: De Grey Oakover; FOR: Fortescue; GSD: Great Sandy Desert; OC: Onslow Coast; PHC: Port Hedland Coast. IBRA subregions are shaded and labelled on the map.

pools within a variety of stream orders and springs). Generally one 'site' within each wetland was sampled, with the exception of Fortescue Marsh where the western and eastern ends were sampled separately. Wetlands were selected following consultation with local experts (including landholders and regional DEC staff), use of topographic maps, a reconnaissance trip and aerial surveys along the De Grey/Oakover, Fortescue and Ashburton Rivers. Eleven ephemeral sites were sampled only once (in spring, summer or autumn) but other wetlands were sampled in both spring and autumn (85 wetlands) or in spring and summer (3 wetlands). All riparian quadrats were sampled twice.

The locations of sampling sites were determined by GPS using the GDA94 datum. Aquatic invertebrates, aquatic vascular plants, benthic diatoms, charophytes, filamentous algae, planktonic algae and riparian plants were sampled at each site, and waterbirds were surveyed within a portion or all of the wetland. During the first sampling trip (spring 2003), only 13 of the 29 wetlands were sampled for diatoms, and planktonic algae were not sampled at all. These 29 sites were sampled for all aquatic plant groups (and re-sampled for water chemistry) in spring 2006. On each sampling occasion:

- water chemistry variables were measured and water samples were taken for laboratory analysis,
- submerged macrophyte biomass and cover were estimated,
- emergent macrophyte cover was estimated,
- sediment particle size distribution was estimated for fractions greater than gravel and measured for fine sediments (as silt+clay, sand and gravel), and
- soil samples within riparian vegetation quadrats were taken for laboratory chemical and physical analyses during the first wetland visit.

The following aquatic physico-chemistry variables were measured: maximum flow rate, water temperature, total dissolved solids, pH, turbidity, colour, total filterable nitrogen and phosphorus, iron, silica, alkalinity, hardness and composition of the major ions. Strahler stream order was calculated using 1:250,000 topographic maps, and distance to coast was measured as a straight line using ArcGIS and the Western Australian coastline in the DEC Corporate dataset 2007. Because they are single-paper specific, these data will be provided as appendices to the relevant paper.

Stygofauna

Stygofauna were sampled in bores and wells, principally drilled for groundwater extraction or groundwater monitoring. The study area was divided into 12 sub-regions based on the major river catchments and distance from the coast

Table 2 Personnel involved in sampling for terrestrial vertebrates.

Session	Personnel
October 2004	Reptiles and Mammals: C. Baker-Sadler[d], P. Doughty[b], B.J. Durrant[a], L.A. Gibson[a], N.A. Guthrie[a], P.G. Kendrick[a], N.L. McKenzie[a], K.D. Morris[a], D.J. Pearson[a], M. Pepper[d], D. Rabosky[d], J.K. Rolfe[a], T.A. Smith[d] and N. Thomas[a]. Birds: A.H. Burbidge[a], N. Hamilton[a], R.E. Johnstone[b], L.A. Smith[b] and P. Stone[b].
May 2005	Reptiles and Mammals: P. Doughty, K. Edwards[d], K. George[d], L.A. Gibson, K. Himbeck, M. Hughes, B. Johnson, P.G. Kendrick, N.L. McKenzie, P. Oliver[d], M. Pepper and J.K. Rolfe. Birds: A.H. Burbidge, R. Davis, N. Hamilton, D.J. Pearson, W. Rutherford[c] and L.A. Smith
October 2005	Reptiles and Mammals: L. Beasley[d], P. Cullen[d], P. Doughty, L.A. Gibson, B. Johnson, P.G. Kendrick, K.D. Morris, J.K. Rolfe and N. Thomas. Birds: A.H. Burbidge, N. Hamilton, R.E. Johnstone, B. Rutherford, C. Stevenson[b] and P. Stone.
May 2006	Reptiles and Mammals: P. Doughty, S. Fleischer[d], K. George, L.A. Gibson, P.G. Kendrick, N.L. McKenzie, J.K. Rolfe and C. Sorokine[d]. Birds: A.H. Burbidge, R.E. Johnstone, D.J. Pearson, C. Stevenson and P. Stone
October 2006[e]	Reptiles and Mammals: J.K. Rolfe and T. Limantachai[d]. Birds: A.H. Burbidge

[a] Department of Environment and Conservation
[b] Western Australian Museum
[c] Ornithological Technical Services
[d] Volunteer
[e] Selected sites at PHYC, PHYE and NE

Table 3 Personnel involved in sampling for terrestrial flora.

Personnel	Agency Affiliation	Sampling Year													
		2004			2005		2006								
		Apr	May	Aug-Sep	Jul	Aug	Feb	Apr-May	May	May-Jun	Jun	Jun	Jun	Aug	Sep
Survey Team															
Stephen van Leeuwen	DEC	√	√	√	√	√		√	√	√	√	√	√	√	√
Neil Gibson	DEC	√		√				√		√				√	√
Greg Keighery	DEC	√		√		√		√		√					
Sue Patrick	DEC	√		√		√									
Bob Bromilow	DEC	√	√				√	√		√	√			√	√
Margaret Langley	DEC					√		√		√				√	√
Bill Muir	DEC	√								√					√
Collaborators															
Kate Brown	Volunteer									√					
Margaret Byrne	DEC														√
David Coates	DEC									√					
Doug Cook	DEC							√							
Rowan Dawson	DEC			√											
Daphne Edinger	Volunteer													√	
Jodie Fraser	Rio Tinto														√
Regina Flugge	Volunteer				√				√			√	√		
Gilbert Marsh	Volunteer													√	
Julie Morthy	DEC						√								
Yvonne Muller	DEC			√											
Emil Thoma	Rio Tinto									√					
Visiting Botanists															
David Albrecht	NT			√											
Bill Barker	AD									√					
Tony Bean	BRI							√							
Bob Chinnock	AD			√						√					
Lyn Craven	CANB							√							
Rob Davis	PERTH			√						√					
Richard Fairman	PERTH													√	
David Halford	BRI														√
Wayne Harris	BRI			√						√					
Brendan Lepschi	CANB							√							
David Mallinson	CANB														√
Bruce Maslin	PERTH													√	
Frank Obbens	PERTH									√					
Jo Palmer	CANB									√					
Leigh Sage	PERTH			√						√					
Neville Walsh	MEL														√
Carol Wilkins	UWA														√
Karen Wilson	NSW							√							
Peter Wilson	NSW									√					

Table 4 Personnel involved in sampling for aquatic flora and fauna.

Session	Personnel	Sampling
August–September 2003	A.M. Pinder[a], J.M. McRae[a], M.N. Lyons[a], S.D. Lyons[a]	29 wetlands (only 13 for diatoms, no planktonic algae sampling)
May–June 2004	A.M. Pinder, H. Barron[a], M.N. Lyons, D.A. Mickle[a]	26 wetlands
August–September 2004	A.M. Pinder, L. Grant[b], N. Gibson[a], D.A. Mickle	29 wetlands
April–May 2005	A.M. Pinder, J.M. McRae, M.N. Lyons, D.A. Mickle	38 wetlands
August–September 2005	A.M. Pinder, J.M. McRae, M.N. Lyons, D.A. Mickle	28 wetlands
January–February 2006	A.M. Pinder, J.M. McRae, M.N. Lyons, S.D. Lyons	8 wetlands
April–May 2006	A.M. Pinder, J.M. McRae, D.A. Mickle, N.Y. Huang[a] and J.A. Dunlop[a]	26 wetlands
August–September 2006	S.A. Halse[a], J. Powling[c], M.N. Lyons, M.T. Casanova[d] and D.A. Mickle	4 wetlands for all taxonomic groups (29 for all aquatic plant groups)

[a] Department of Environment and Conservation
[b] James Cook University
[c] The University of Melbourne
[d] Royal Botanic Gardens Melbourne

and, insofar as possible, all were sampled with similar effort. An attempt was made to sample all geologies of the Pilbara, although the reliance on existing bores meant that there was bias towards transmissive aquifers (e.g. alluvium, calcrete). A total of 508 bores was sampled (Figure 8), mostly twice, though with a few only sampled once and a small subset sampled up to seven times to investigate the importance of sampling effort for determining aquifer species richness. In all, 1084 samples were collected.

Each time a bore was sampled, a range of water chemistry variables was recorded, water samples were collected for laboratory analyses and stygofaunal invertebrates were sampled using weighted conical nets. The following aquatic physico-chemistry variables were measured: water temperature, oxygen, redox, total dissolved solids, pH, total soluble nitrogen and phosphorus, iron, strontium, silica, alkalinity, hardness and concentrations of the major ions. Details of bore construction, dimensions and depth were collected in the field and from various databases. In many cases little information was available. These data are provided as an appendix to the stygofauna paper.

Milestones

Terrestrial fauna

The first 151 sampling sites were selected during July 2003, and trap systems for invertebrates and vertebrates installed between July and late-September 2003. Invertebrate sampling commenced at these sites in November 2003 and was completed by June 2005, while vertebrates were sampled in October 2004 and re-sampled in May 2005 (Table 2). The second set of sites (153) was selected by September 2005, and trap systems installed by late September 2005. They were sampled for invertebrates from September 2005 until June 2006, and for vertebrates during October 2005 with re-sampling in May 2006. The invertebrate sampling was carried out by B.J. Durrant and N.A. Guthrie, with assistance from other team members.

Two or three sites in each of the 24 survey areas (Figure 6) were sampled for microbats (echolocation recordings) during the vertebrate trapping program. During separate field trips in August 2004, February 2006, May 2007 and November 2007, the echolocation calls, flight capabilities and foraging niches of all microbat species represented in the Pilbara fauna were documented by N.L. McKenzie with assistance from T.A. Smith, R.D. Bullen, M.H. McKenzie and A.N. Start, respectively.

In August 2004, T.A. Smith, M.C. McDowell and A. Baynes searched rock shelters and overhangs across the Pilbara for mammal bones. These were cleaned, sorted and identified, along with all previously collected material from the region held by the Western Australian Museum, including material from a sinkhole in the Ripon Hills collected by P.G. Kendrick and G.J. Angus.

By June 2008, all terrestrial fauna records were identified, the data compiled and analysis and written interpretation commenced for separate papers reporting the spider, scorpion, beetle, ant, reptile and frog, small ground-dwelling mammal, microbat, original mammal fauna and bird data-sets.

Terrestrial flora

Flora sampling at the 304 terrestrial sites and an additional 118 flora-only sites commenced in April 2004 (first 151 terrestrial and 60 flora-only sites) and, for the second 153 terrestrial and 58 flora-only sites, in April 2006, with at least two visits to each site in different seasons, depending on rainfall patterns (Table 3). Two cyclones in early 2004, following an unusually dry year in 2003, delayed the program, but 2005 brought good dry-season then wet-season rains that allowed the flora sampling to be completed at all sites by September 2006. Specimen curation, identification and data-entry of the 80,000 voucher specimens commenced in November 2004 and are expected to be completed by December 2009, when analysis and interpretation can begin.

In addition to the core survey team of seven personnel from the Department of Environment and Conservation, a further 31 people were involved in the field program (Table 3). Most of these were botanists, ecologists and volunteers affiliated with the Western Australian Herbarium or herbaria in eastern and northern Australia. The three-year field program involved 180 days of fieldwork, a total of 1,260 person days of collecting and close to 128,000 km of vehicle travel.

Surface aquatic biota

Following a site selection trip in June/July 2003, sampling of the first 29 wetlands commenced in August and September 2003 (Table 4). Between 26 and 38 wetlands were sampled on each subsequent trip – at the beginning and end of the 2004 and 2005 wet seasons, and at the end of the 2006 wet season. Eight ephemeral wetlands were sampled towards the end of the 2006 wet season, following cyclone Clare, and four wetlands were sampled towards the end of the 2006 dry season. All invertebrate specimens were identified by April 2007 and aquatic flora specimens by February 2008, with analysis and writing of separate papers on aquatic invertebrates and aquatic flora commencing thereafter.

Stygofauna

In the first year of fieldwork (2002), bores on mine leases were the focus of sampling. As the survey progressed, emphasis shifted to Western Australian Departments of Water and Main Roads bores and then pastoral-lease bores. Fieldwork was conducted during most dry season months between October 2002 and August 2006 by M. Scanlon, J. Cocking and H. Barron, with assistance from S.A. Halse, J.M. McRae, S. Eberhard and A. MacIntosh. Sampling methods were refined during a preliminary fieldtrip by S.A. Halse, M. Scanlon, J. Cocking, J. Bradbury and R. Shiel (Adelaide University) and R. Leijs (South Australian Museum). A review of sampling methods was undertaken with P. De Deckker (Australian National University).

Wet season months were spent sorting stygofauna samples and either undertaking identifications or processing specimens for identification by relevant morphological and molecular taxonomists. A considerable amount of taxonomic work was commissioned or facilitated, including work on ostracods (Ivana Karanovic, Western Australian

Table 5 Year-to-year comparison of bi-monthly rainfall (mm), averaged across the Pilbara. Table values are from Bureau of Meteorology weather stations as represented in Figure 2: Port Hedland (004032), Roebourne (004035), Marble Bar (004020), Wittenoom (005026) and Newman (007151). The period of the stygofauna survey is outlined; the period of the terrestrial zoology survey is shaded grey; the period of the botanical sampling is underlined; and the period of the surface aquatic survey is shown in bold.

	Bi-monthly rainfall (mm)						
Year	Dec & Jan	Feb & Mar	Apr & May	Jun & July	Aug & Sep	Oct & Nov	Annual (mm)
2001	164	13	12	19	1	0	418
2002	40	12	30	**0**	**1**	**21**	207
2003	**112**	**48**	**15**	**4**	**0**	**3**	319
2004	**90**	**92**	**5**	**3**	**1**	**4**	390
2005	**10**	**5**	**18**	**44**	**0**	**33**	222
2006	**200**	**160**	**1**	**0**	**12**	8	614
Long-term average	78	42	24	10	2	18	348

Museum), copepods (Tom Karanovic, Western Australian Museum; Danny Tang, University of Western Australia), isopods (Buz Wilson and Stephen Keable, Australian Museum; Niel Bruce, Museum of Tropical Queensland) and water mites (Mark Harvey, Western Australian Museum). Identifications were completed by January 2007, except for some continuing taxonomic refinements, and data analysis began in June 2008.

Integration of information

Papers integrating the survey results (including manuscripts on species/community distributions, environmental patterns and reserve recommendations) will be prepared as soon as all datasets become available. As papers are completed, all records will be stored in accessible archives, and all specimens lodged in relevant State natural history collections along with relevant databases.

Conditions at the time of sampling

Rainfall averages across the Pilbara were unusually dry during 2002 and 2005, although there was above-average dry season rainfall in 2005 that resulted in minor flood events across most of the Pilbara (Table 5). Tropical cyclones Monty and Fay in early 2004 caused widespread inundation and severe floods in all major Pilbara river systems. Tropical cyclones Clare and Glenda in early 2006 also caused widespread inundation, and resulted in severe floods in the Ashburton, Robe, Fortescue and Port Hedland coastal rivers but only minor flooding in the De Grey/Oakover system. No cyclones affected the Pilbara in the 2004/5 wet season.

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APPENDIX A

Brief description of the 304 terrestrial biodiversity sites sampled for plants and animals during the Pilbara biological survey. Each entry consists of site label that comprises the survey area code (**Fig. 1**) concatenated with the site number, then the site's latitude, longitude, 1:250,000 map sheet surface geology code assessed by two of the authors on the site (NMcK & SvL), followed by a description of the site's surface and/or vegetation. The final columns are the stratigraphic and regolith units, determined by intersecting the site coordinates with the Department of Minerals and Energy (Geological Survey) geographical information system, including a photo interpretation of the site (R. Langford, personal communication). Latitudes & longitudes were determined by GPS using the Australian Geodetic Datum 1984; precision was about 10 m. Bedrock and regolith codes are explained below the tabulation.

Site	Lat S	Long E	Habitat Description (by site selection team)	Bedrock	Regolith	Photo Interpretation
BDRN01	22.4443	121.2320	Qs. Red sand dune of Little Sandy Desert. Deep red sand.	P_-MN-s	Qs	Sand dune
BDRN02	22.4417	121.1290	Qw. Depressions in undulating upland. Stony clay to less than 30 cm over duricrust. Mixed pebbles and gravel in profile and as surface strew. Mulga.	AP_-_pj-ccx	Qw	Rock; proximal colluvium
BDRN03	22.4118	121.0720	Tb. Undulating upland. Discontinuous shallow stony clay over massive sheet caprock. Surface covered in coarse Tertiary gravel.	AP_-_pj-ccx	Tb	Siliceous lag
BDRN04	22.6308	120.9960	Qe. Quaternary elluvial plain. Brown sandy clay to 20 cm with stones in profile & surface strew. Over ?rock hardpan. Low open woodland of mulga.	P_-MN-s	Qe	Rock; proximal colluvium
BDRN05	22.6038	120.7840	Czc. Rolling country. Tertiary colluvium (Tc). Deep clay (red-brown) with surface cover of ironstone gravel & rocks. *Acacia* shrubland.	AP_-_pj-ccx	Tc	Ferruginous gravel; colluvium or lag
BDRN06	22.5781	120.8000	dd'. Steep Davis Dolerite hillside. Stony clay with surface cover of broken rock to 20 cm over massive rock.	P_-od		Rock; proximal colluvium
BDRN07	22.5442	120.8000	MNb. Undulating valley side-slope (gentle) & floor. Deep sandy clay with varnished gravel & pebble surface cover. Balfour Manganese Formation.	P_-MN-s		Ferruginous gravel; colluvium or lag
BDRN08	22.5344	120.7830	Czk. Undulating calcrete plain. Pale calcareous fine loamy clay with surface of calcrete & ironstone gravel & pebbles. *Eucalyptus socialis* mallee.	AP_-_pj-ccx	Czk	Mixed calcrete and ferruginous gravel
BDRN09	22.6098	120.7290	Fn. Steep Nymerina basalt hillside. Boulder scree below breakaway. Brown clay to depth with rocks & fragments in profile & as surface cover between boulders. Mulga.	A-FOm-b-HAE		Ferruginous duricrust; weathered rock
BDRN10	22.5186	120.6780	Tl. Tertiary laterite rise (?=Czl Tb Czp). Fine loamy light brown sand with laterite fragments & gravel to 20 cm over pavement. Surface strew of rocks, pebbles & gravel.	A-FOm-b-HAE		Ferruginized rock; proximal colluvium
BDRN11	22.5169	120.6590	Ft. Low stony mudstone & basalt rise in valley of undulating upland. Shallow brown clay packed with broken rocks to 15 cm over massive basalt rock outcrop. Soil surface mostly covered by stones & rocks.	A-FOt-xb-k-HAE		Rock; proximal colluvium
BDRN12	22.7177	120.6460	Agb. Granitoid hillside. Massive outcrop. Shallow pockets & crevices of sandy granite grit with quartzite fragments & decaying granite rocks.	A-g-PCN		Rock rise adjacent sand sheet

Site	Lat S	Long E	Habitat Description (by site selection team)	Bedrock	Regolith	Photo Interpretation
BDRN13	22.7011	120.7370	Fk. Undulating upland valley floor unit of Kylena basalt. Heavy red-brown clay (with stones & gravel in profile & as surface cover) as 20 cm thick veneer over massive rock.	A-FOk-b-HAE		Rock; proximal colluvium
BDRS01	23.3913	120.5230	Qc. Gently sloping plain of colluvial clay with rock fragments & buckshot in profile to depth (Little Sandy Desert vegetation).	P_-HAj-xci-od	Qc	Colluvium; colluvial fan
BDRS02	23.3840	120.4790	Qa. Plain of heavy alluvial clay. Scattered *Eucalyptus victrix* & *Corymbia*.	P_-HAj-xci-od	Qa	Alluvium on floodplain
BDRS03	23.3595	120.4600	MNs(c). Rocky scree & outcrop slope & hill top. Quartz sandstone interbedded with conglomerate. Shallow skeletal soil in pockets & crevices—fine brown clayey sand.	P_-MN-s		Siliceous bedrock slopes
BDRS04	23.3725	120.4590	Ql. Alluvial sandy clay plain incised by very narrow creek bed with river sand bed. *Eucalyptus victrix*.	P_-HAo-cib	Qa	Sandy drainage channel in alluvial flood plain
BDRS05	23.3653	120.3450	Qs. Quaternary aeolian sandplain. Firm red clayey sand to depth (Little Sandy Desert vegetation).	P_-HAj-xci-od	Qs	Aeolian sand plain
BDRS06	23.3627	120.2950	Qw. Plain below banded iron hills with surface strew of banded iron pebbles in places. Firm sandy clay to depth.	P_-HAb-cib	Czc	Rock; proximal colluvium
BDRS07	23.3807	120.2510	Hb. Steep banded iron hillside & top. Sheet outcrop, scree, rock strew & shallow skeletal clay in pockets, crevices etc.	P_-HAb-cib		Ferruginized rock; proximal colluvium
BDRS08	23.4588	120.1550	Ab. Steep basalt hillside. Outcrop & rock-strewn slope. Discontinuous, shallow clay soils packed with rock fragments & stones.	A-og-PSY		Rock; proximal colluvium
BDRS09	23.4659	120.1760	Aua. Schist hillside. Outcrop & rock-strewn slope under rock wall, with discontinuous shallow clay soils packed wth rock fragments.	A-u-PSY		Ferruginized rock; proximal colluvium
BDRS10	23.4703	120.2150	Czc. Cenozoic colluvial plain with surface strew of quartzite pebbles & other rock fragments on firm red sandy clay. Groves of mulga.	A-u-PSY	Czc	Colluvium
BDRS11	23.4982	120.2900	Czc. Plain of fine sandy clay with quartz & calcrete fragments in profile & on surface as pebbles & decaying rocks.	A-g-PSY		Proximal colluvium
BDRS12	23.5352	120.3250	Ag. Undulating granite plain with scattered outcrops & shallow sheets & pockets of friable brown gritty clay mantling decaying granite outcrop.	A-g-PSY		Distal colluvium or alluvial gravel
BDRS13	23.4128	120.3170	Qw. Light brown fine-textured clay to depth. Mulga woodland.	A-g-PSY	Qw	Distal colluvium or alluvial gravel
DRC01	20.7680	116.8420	Arwb?. Low stony hills; small trees scattered/*Triodia*.	A-ROr-xb-u		Rock; proximal colluvium
DRC02	20.7716	116.8500	Ql. Heaving clay plain with Roebourne Plains grassland.	A-CEkr-gg	Qwb	Distal colluvial or sheet-flood fan
DRC03	20.7945	116.8570	Qw. Snakewood/*Triodia*; outwash plain; sandy clay with quartzite surface strew.	A-CEkr-gg	Qwb	Distal colluvial or sheet-flood fan
DRC04	20.8521	116.9450	Ql. *Eucalyptus victrix* over tussock grass & *Acacia* shrubs on floodplain/river bank alluvium.	A-ROn-xca-f	Qaa	Alluvial channel and overbank deposits on floodplain

DRC05	20.9399	117.0350	Ab. *Triodia* with scattered eucalypts & *Acacia* shrubs; stony undulating hilly country; Bradley basalt.	A-WHb-b		Rock; proximal colluvium
DRC06	21.0364	117.1060	Afdc. True Pilbara hilltop; Cooya Pooya dolerite; top of massive mesa. Bare black boulder scree. Stony crevice soil with *Triodia* & scattered shrubs.	A-FOh-xs-f-HAW		Rock; proximal colluvium
DRC07	20.9346	117.1150	Qc. *Acacia* & *Grevillea/Triodia*; stony valley floor.	A-FOr-b-HAW	Qc	Colluvium in lower slopes and fans
DRC08	20.8526	117.0960	Aao. Granitoid hills with bare boulders on slopes with shrubs & *Triodia*.	A-OPan-xo-a		Bedrock outcrop
DRC09	20.8080	117.0730	Qw. Sheetwash deposits on lower slopes to hills.	A-ROr-xb-u	Qc	Sheet-flood fan or colluvial footslopes
DRC10	20.7364	117.0990	ACi. Rocky hills slope & top with *Triodia* & scattered *Acacia* in gullies.	A-GCe-ca		Rock; proximal colluvium
DRC11	20.6884	117.0070	AFr. Rock hills with scree & *Triodia*.	A-_re-b		Rock; proximal colluvium
DRC12	20.6676	116.9970	Qhm. Un-sampled for fauna. Inter-tidal mud sheet behind mangrove.	A-GCe-ca	Qhmu	Supratidal flats
DRE01	20.4806	117.9940	Qhm. Samphire.	A-MR-gm	Qhm	Supratidal mud flats
DRE02	20.4756	117.9950	Qpmb. Beach sand dune.	A-MR-gm	Qpmb	Coastal sand dunes
DRE03	20.4302	118.0640	Qhm. Limestone coastal ridges.	A-MR-gm	Qpmb	Calcarenite rubble
DRE04	20.4286	118.0620	0. Tussock grass flat; deep non-saline clay.	A-MR-gm	Qhm	Supratidal mud flats
DRE05	20.4804	118.0400	Qx. Spinifex flat; orange loamy sand.	A-MR-gm	Qhms	Supratidal mud flats
DRE06	20.5256	118.0770	Qa. Floodplain; Coolibah, *Acacia*, Buffel Grass.	A-MR-gm	Qao	Alluvial silt and clay in floodplain
DRE07	20.6074	118.1570	Acf. *Corymbia/Acacia/Triodia*.	A-STpt-gf	Qao	Alluvial silt and clay in floodplain
DRE08	20.8485	117.8550	Adm. Steep slope of range; *Triodia* with scattered shrubs on scree & outcrop.	A-WCr-f		Bedrock outcrop
DRE09	20.8699	117.8590	Afr. scattered shrubs over *Triodia* on gentle slope.	A-CDm-s	Qc	Colluvium in lower slopes and fans
DRE10	20.9198	117.8610	As. scattered shrubs over *Triodia*; flat.	A-CDm-s		Thin sand and colluvium
DRE11	20.9499	117.8500	Qx. *Eucalyptus/Owenia/Acacia/Triodia*; flat red sandy loam with ?calcrete in profile.	A-CDm-s	Qwb	Sheet-flood fan
DRE12	20.9101	117.9830	Czk. *Eucalyptu*s low open woodland over *Triodia*.	A-CDm-s	Qao	Alluvial silt and clay in floodplain
DRE13	20.9696	118.0480	Ag. Plain with scattered outcrops; red loamy clay plain; sparse low trees & sparse shrubs over *Triodia*.	A-STpe-gi		Thin sand and colluvium
DRW01	20.8429	116.3670	Qsc. Coastal sand dunes; *Acacia coriacea*; buffel & spinifex.	A-MRer-gm	Qhms	Sand dune or foredune
DRW02	20.8446	116.3670	Qhm. Coastal limestone ridge; spinifex & buffel.	A-MRer-gm	Qhms	Broad swale behind foredune
DRW03	20.8514	116.3770	Qhm. Coastal samphire & buffel; *Triodia* sandplain.	A-MRer-gm	Qhms	Low coastal dune

Site	Lat S	Long E	Habitat Description (by site selection team)	Bedrock	Regolith	Photo Interpretation
DRW04	20.8761	116.6470	Ql. River frontage; riverine.	A-MRwh-ggp	Qaa	Alluvium in river channels and overbank deposits
DRW05	20.8539	116.6690	Arnc. Scree slope of narrow abrupt range.	A-ROn-xca-f		Rock and proximal colluvium
DRW06	21.0619	116.2650	Qlx. Snakewood on plain.	A-MRer-gm	Qp	Floodplain or distal colluvial fans; channelled
DRW07	21.0557	116.2520	Qx. Qx sandy clay mantling; Ag expressed as plain with scattered flat outcrops; *Acacia* & eucalypts (scattered) over *Triodia*.	A-MRer-gm		Colluvium with calcrete
DRW08	21.0633	116.2340	Qw. Elluvial & outwash plain mantling Ag with quartzite strew on surface as outwash plain; sandy clay; *Acacia* shrubs over *Triodia*.	A-MRer-gm	Qb	Colluvial footslopes
DRW09	21.0699	116.2070	Qw. Kylena volcanic outwash slope; sandy clay; tall *Acacia* shrub thicket over *Triodia*.	A-FOm-b-HAW		Colluvial footslopes
DRW10	21.0699	116.2040	Pfm. Kylena volcanic spur; rocky ridge of spur with *Triodia* & scattered shrubs.	A-FOm-b-HAW		Proximal colluvium
DRW11	21.0655	116.1500	Phb. Scree, boulder & outcrop slope with shallow pockets of soil.	P_-HAb-cib		Rock and proximal colluvium
DRW12	21.0539	116.1340	Qx. Gentle Qx slope; clay & crab holes; Snakewood & saltbush & tussock grass.	P_-HAb-cib		Colluvium in lower slopes and fans
DRW13	21.0197	116.1110	Qhm. Coastal samphire flat behind mangal.	P_-HAb-cib	Ql	Alluvial channel and overbank deposits on floodplain
MBE01	21.2882	119.6770	Qc. Undulating plain of Quaternary colluvium with calcrete rises. Pale brown sandy clay with calcrete & basalt pebbles as well as varnished gravel in profile & as surface strew.	A-FOh-xs-f-HAM		Distal colluvium in outwash fans
MBE02	21.3116	119.6010	Pk. Kylena Basalt undulating upland & rolling hills. Outcrop & rocks with thin veneer of brown sandy clay & surface strew of stones, rocks, pebbles & quartz.	A-FOh-xs-f-HAM		Colluvial footslopes
MBE03	21.4255	119.5520	Ag. Granitoid plain. Coarse gritty plain over massive granite at 50 cm depth.	A-g-PS		Sheet-flood fan or distal colluvium in outwash fans
MBE04	21.4376	119.5400	Ql. Riverine levee bank & bed of coarse river sand. River gums & paperbarks.	A-g-PS	Qa	Alluvial channel
MBE05	21.4490	119.5390	Pd. Massive bare black dolorite scree & boulders as top & sides of abrupt range. Fine brown sandy silt in crevices between boulders.	A-g-PS		Proximal colluvial footslopes
MBE06	21.5062	119.4180	Ag. Massive granitoid hill with scree & sheet outcrop. Brown silty grit in crevices.	A-SR-g		Granite bedrock
MBE07	21.3759	119.3720	Qa. Alluvial plain of light brown gritty clay. Heavily grazed.	A-g-PS	Czcg	Sand and silt in outwash fan

MBE08	21.3393	119.3660	Qb. Heaving clay plain with rocks in profile; gilgai.	A-WA-xb-f	Qw	Distal colluvium in outwash fans
MBE09	21.2790	119.4130	Phr. Massive basalt scree slope of range with skeletal soil in crevices.	A-FOr-b-HAM		Ferruginised bedrock ridge
MBE11	21.2365	119.4080	Ab. Gentle basalt hill slope & top. Massive outcropping basalt; brown sandy loam with rocks in profile.	A-WA-xb-f		Colluvial footslopes below bedrock outcrop
MBE12	21.2184	119.4010	Ab. Small valley in massive basalt ranges with scree, brown sandy clay with stones in profile & surface strew.	A-WA-xb-f		Colluvial footslopes
MBE13	21.1563	119.4060	Czk. Cenozoic calcrete rises. Pale sandy clay with calcrete fravel as surface strew & in profile.	A-WA-xb-f	Czrk	Calcrete mound
MBW01	21.0296	118.9110	Au. Ultramafic ridge. Massive rock outcrop & surface with skeletal soil in crevices.	A-WA-xb-f		Bedrock and proximal colluvium
MBW02	21.0288	118.9170	Ab. Lower slope of massive basalt hill with patches of brown sandy loam with rocks in profile & as surface cover but mainly massive basalt outcrop.	A-WA-xb-f		Bedrock and proximal colluvial footslopes
MBW03	21.0613	118.9110	Ab. Side of massive basalt hill with rocks, outcrop & areas of sandy clay with rock fragments in profile & as surface strew.	A-WA-xb-f		Colluvial footslopes
MBW04	21.0673	118.8990	Au. Massive outcrops & rock-sheets as tilted strata forming ultramafic hillside. Skeletal brown sandy clay in gaps with rocks in profile & surface strew.	A-WA-xb-f		Bedrock
MBW05	21.0950	118.8870	Czk. Slopes & low hills of Cenozoic calcrete. Sheet & rubble calcrete. Pale brown sandy rubble in profile with stony surface strew.	A-g-PY	Czag	Calcrete rubble and colluvium in distal slopes
MBW06	21.1156	118.8520	Qg. Quaternary gravelly sandplain. Deep firm pale brown sand with surface of varnished gravel & scattered pebbles.	A-g-PY	Czag	Distal colluvium in outwash fans
MBW07	21.0633	118.7600	Ql. Riverine levee of alluvial sand with river stones through profile in channels, river gums etc.	A-g-PL	Qao	Alluvial stream bed and banks
MBW08	21.0711	118.6820	Qs. Quaternary sand sheet. Firm red clayey sand.	A-g-PL	Qao	Alluvial floodplain
MBW09	21.1288	118.6900	Qeg. Quaternary elluvial gravel. Firm gravelly sand over hardpan at 35 cm. Gravel & quartzite pebbles on surface.	A-g-PL	Qc	Distal colluvium in outwash fans
MBW10	21.2793	118.6980	Agb. Granite outcrop hill with profile of grit & decomposing granite as pockets in hollows on top of outcrop.	A-SRnu-gmp	Qrg	Granitic bedrock and proximal colluvium
MBW11	21.3651	118.7010	Agc. Grit & decaying granite fragments as profile to 30 cm in depression on bare granite hills. Massive boulders & sheet outcrop on one side.	A-SRnu-gmp		Granitic bedrock and proximal colluvium
MBW12	21.4007	118.7100	Agc. Granitoid plain of deep granite grit containing gravel, quartzite pebbles in profile & as surface strew over sheet granite at 30 cm.	A-SRnu-gmp		Colluvial gravel or lag
MBW13	21.4589	118.7270	Agm. Granite plain of red gritty sandy clay to 30 cm then solid. Surface strew of quartz & decomposing granite.	A-g-PY		Colluvial gravel or lag
NE01	21.2389	120.5310	AFk. Kylena basalt undulating hill country; karst clay & rock profile.	A-FOk-b-HAE		Proximal colluvial footslopes

Site	Lat S	Long E	Habitat Description (by site selection team)	Bedrock	Regolith	Photo Interpretation
NE02	21.2462	120.5390	Pftc. Banded carbonate scree slope; massive rocks & scree with small areas shallow skeletal soils in cracks & crevices.	A-FOk-b-HAE		Bedrock and proximal colluvium
NE03	21.2716	120.5850	Pftt. Mingah Tuff Member of the Tumbiana Formation as terrace; profile deep stony clay with surface strew.	A-FOk-b-HAE		Thin colluvium or lag over bedrock
NE04	21.3337	120.7520	Phc. Carawine dolomite hill slope; massive stone & stone fragment profile.	A-FOm-b-HAE		Bedrock and proximal colluvium
NE05	21.3377	120.7700	PH. Lewin shale; deep stony clay with outcrops of sheet shale.	A-FOm-b-HAE		Distal colluvium in outwash fans
NE06	21.3299	120.8760	Qc. Quaternary colluvial outwash plain; deep sandy clay with pebbles in profile.	A-HAc-kds	R1tpa	Colluvial gravel
NE07	21.2879	120.8910	Qb. Heaving clay plain with tussock grass.	CP-_pa-sepg-CA	A1fcb	Alluvial floodplain
NE08	21.3263	120.9710	Qp. Quaternary sandy clay cenozoic gravel & quartz surface strew.	CP-_pa-sepg-CA	C1	Distal colluvium in outwash fans
NE09	21.3219	121.0020	To. Duricrust top of mesa.	CP-_pa-sepg-CA	Czos	Colluvium; calcrete rubble
NE10	21.3160	121.0480	Qa. Riparian deep clay.	CP-_pa-sepg-CA	Qa	Alluvial channels and floodplain
NE11	21.3044	121.2000	Ph. Koongaling Volcanics (Afk); undulating stony hill country with rocky clay surface/rock.	A-FOk-b-HAE		Colluvial gravel or lag
NE12	21.2884	121.2370	Agr. Granite boulder hills; massive outcrops & boulders.	A-GR-g		Colluvial footslopes
NE13	21.2957	121.2640	Qx. Great Sandy Desert dune-interdune; deep sand profile.	A-GR-g	Qs	Sand plain and dunes
NW01	21.9794	120.2240	Agf. Granitoid undulating hills with outcrops & gritty profile of decomposing rock & clay.	A-mg-PK		Granitic bedrock and proximal colluvium
NW02	21.9478	120.1940	As. Mosquito Creek Formation greywacke etc. undulating hill country rock scree (decomposing rock) on massive outcrop.	A-NUq-mh		Colluvial footslopes
NW03	21.7703	120.0920	Afh. Quartz Porphory (Pp) etc.; boulder slope to range.	A-FOh-xs-f-HAE		Bedrock and proximal colluvium in footslopes
NW04	21.6785	120.0880	Phr. Mount Roe Basalt; massive basalt as undulating hill country stony clay profile over massive outcrop.	A-FOr-b-HAE		Colluvial footslopes
NW05	21.6773	120.1550	Aav. Agglomerate, hard clay plain with surface strew of small stones.	A-WAp-f		Silt, sand and gravel on distal colluvial footslopes
NW06	21.6442	120.0630	PHg. Hardy Sandstone hillside.	A-FOh-xs-f-HAE		Bedrock and proximal colluvium
NW07	21.4992	120.1090	Ab. Outwash foot slope-Archaean basalt, profile is surface strew of decomposing basalt over massive basalt.	A-KEw-xf-s		Colluvial footslopes
NW08	21.4799	120.0910	Ab. Archaean basalt & ardersite.	A-WA-xb-f		Colluvial footslopes

NW09	21.4619	120.0130	Agp. Plain of deep gritty clay.	A-g-PO		Thin sand and colluvium over bedrock
NW10	21.4684	120.0070	Qeg. Undulating plain of decomposing elluvial granite soils with sandy, gritty & stony profile.	A-g-PO		Thin sand and colluvium
NW11	21.4077	120.0710	Agm. Granitoirite undulating plains country deep sandy & gritty clay profile with decomposing granite rocks in profile.	A-g-PE		Colluvial gravel or lag
NW12	21.3923	120.0710	Agm. Large granite boulders emerging through surface of clay gritty to depth with decomposing granite; bedrock at 21 cm average.	A-g-PE		Bedrock rise with boulders and thin proximal colluvium
OYE01	21.6230	116.3900	Qp. Heaving clay upland plain on Fm basalt. Herbs & annual grasses.	A-FOm-b-HAW		Bedrock and proximal colluvium
OYE02	21.6283	116.4460	Fm. Basalt upland. Fine sand with minor clay & stones in profile, scattered basalt boulders outcropping.	A-FOm-b-HAW		Bedrock, including corestones, and proximal colluvium
OYE03	21.6343	116.4920	Fm. Basalt upland. Fine clayey sand with rocks in profile & as surface strew.	A-FOm-b-HAW		Colluvial footslopes
OYE04	21.6714	116.7260	Qg. Quaternary valley alluvium among Fm basalt hills. Brown clayey sand to depth.	A-FOm-b-HAW		Alluvial valley floor
OYE05	21.6835	116.7510	Fjo. Massive mudstone hill slope thinly mantled in light sandy-clay packed with stones.	A-FOj-xs-b-HAW	Qg	Colluvium and bedrock debris
OYE06	21.7074	116.7670	Ql. Riverine channel through Czk with tall river gums etc. Gritty alluvial silt & clay of levee bank.	A-HAm-cib-HAW	Qr	Alluvial stream channel
OYE07	21.7118	116.7640	Czk. Cenozoic calcrete—massive outcrop thinly mantled (incompletely) in calcrete fragments & brown silt.	A-HAm-cib-HAW	Czk	Calcrete mound
OYE08	21.8401	116.6830	Czc. Cenozoic colluvium. Light sandy brown clay compacted with stones as undulating Cenozoic rises in main valley. Surface strew of buckshot gravel & pebbles.	A-HAd-kd-HAW	Czc	Sheet-flood fan or distal colluvium in outwash fans
OYE09	21.8776	116.5170	Hd. Massive Hamersley Dolomite outcrop as small hill with discontinuous thin patches of red clay & rock fragments as surface cover.	A-HAd-kd-HAW		Bedrock
OYE10	21.8748	116.5020	Qg. Quaternary plain of firm red sandy clay with pebbles in profile as broad valley floor.	A-HAd-kd-HAW	Qg	Distal colluvium or alluvial gravel
OYE11	21.8724	116.4720	Tp. Tertiary pisolite breakaway scarp & slope—massive Tp outcrop & scree slope. Tp rocks & gravel in matrix of clay on slope.	A-HAd-kd-HAW	Qg	Colluvial footslopes below bedrock outcrop
OYE12	21.8439	116.3530	Qp. Quaternary valley floor—outwash plain of heavy clay with pebbles in profile.	A-HAm-cib-HAW	Qp	Alluvial silt and sand
OYE13	21.9518	116.4890	Hr. Massive rock, scree & rock fragments with clay in crevices.	P_-HAb-cib	Tp	Colluvial footslopes below bedrock outcrop
OYW01	21.9655	115.9770	Qg. Flat colluvial sand sheet with some clay content & pisolite stones in profile.	K-_ny-sp	Qg	Distal colluvium in lower slopes and fans

Site	Lat S	Long E	Habitat Description (by site selection team)	Bedrock	Regolith	Photo Interpretation
OYW02	21.9509	115.8870	Ql. Colluvial clay valley floor with hardpan in places.	P_-WYU-xs-k	Ql	Alluvial floodplain silt and clay
OYW03	21.9471	115.8300	Wa. Gentle rises & footslopes around foot of Tp hills. 2 cm of quartz pebbles on 60 cm of light clay over massive mudstone.	K-_ny-sp	Qpt	Distal colluvium in lower slopes and fans
OYW04	21.9171	115.7240	Qg. Gentle gravelly slope of firm clay to depth.	P_-WYU-xs-k	Qpt	Colluvial footslopes
OYW05	21.9127	115.7180	Kn. Gently upland slopes. Stony surface of rocks & pebbles over firm clay packed with conglomerate.	P_-WYU-xs-k		Distal colluvium or alluvial gravel
OYW06	21.8980	115.7050	Czl. Undulating plateau. Red gravelly clay over massive ferricrete.	K-WN-sfl-WC		Colluvial gravel or lag on bedrock rise
OYW07	21.7340	115.8080	Ql. Riverine levee—gritty sandy alluvium mixed with river stones.	K-WN-sfl-WC	Ql	Alluvial stream channel gravel and sand
OYW08	21.7316	115.8080	Kn. Massive Kn breakaway scree of conglomerate cemented into ferruginous laterite. Skeletal clay & stones over massive duricrust on top of mesa.	K-WN-sfl-WC	Ql	Cemented alluvial gravels in old terrace
OYW09	21.6896	115.8420	Tp. Lateritic upland. Gravelly clay to depth with buckshot surface.	P_-WYU-xs-k	Tp	Drainage channel with gravelly silt and clay, over ferruginous rise
OYW10	21.8425	115.5820	Qa. Massive alluvial clay to depth with ?hardpan—floodway.	K-WN-sfl-WC	Ql	Floodplain silt and clay
OYW11	21.7937	115.4670	Qc/Czc. Colluvial plain of clay with shallow veneer of red sandy clay.	K-WN-sfl-WC	Czc	Floodplain silt and clay
OYW12	21.7776	115.3670	Qs/Czp. Low dunefield associated with claypans. Red sand with massive clay at 60 cm exposed in blow-outs between lunettes.	K-WN-sfl-WC	Czp	Floodplain
OYW13	21.7808	115.2480	Qs/Czc. Residual plain of deep red sand.	K-WN-sfl-WC	Czc	Floodplain silt and clay
PE01	21.8647	117.7870	Qr. Alluvial plain with grassland.	A-HAm-cib-HAW	Qaa	Alluvial silt and clay on floodplain
PE02	21.8822	117.7950	Qg. *Acacia*/*Triodia* on stony plain of sandy clay.	A-HAd-kd-HAW	Qw	Lower slopes of sheet-flood fan; distal colluvium
PE03	21.8764	117.7410	Qr. Cracking clay plain with grassland.	A-HAm-cib-HAW	Qwc	Alluvial silt and clay on floodplain
PE04	21.7950	117.8570	Pfjw. Mallee/spinifex.	A-FOj-xs-b-HAW		Proximal footslope colluvium; subrounded to subangular bedrock debris
PE05	21.8915	118.0000	Qpg. Snakewood/tussock grass on river alluvium.	A-HAm-cib-HAW	Qao	Alluvial or distal colluvial gravel; relict valley fill
PE06	21.8562	117.9800	Qpt. Mulga/*Triodia* buckshot; red sandy clay plain.	A-HAm-cib-HAW	Qw	Upper slopes of sheet-flood fan; distal colluvium

PE07	21.7868	117.8620	Ptjd. *Triodia* hilltop with scattered Eucalypts; Woodjana Sandstone member.	A-FOj-xs-b-HAW		Colluvium and bedrock debris
PE08	21.7665	117.8250	Ptjd. Scree slope under scarp.	A-FOj-xs-b-HAW		Colluvial footslopes below bedrock outcrop
PE09	21.7141	117.7760	Pfm. *Triodia* & scattered Eucalypts; termite mounds; hard stony soil profile.	A-FOm-b-HAW		Colluvial slopes and bedrock debris
PE10	21.6625	117.7050	Czt (Qpx). Cracking clay tableland-grassland.	A-FOm-b-HAW	Czcb	Dissected distal colluvial footslopes of sheet-flood fan; gravelly silt and clay
PE11	21.8336	117.6110	Phm. *Grevillea* & *Acacia* shrubs/*Triodia* on ridge.	A-HAm-cib-HAW		Bedrock debris and proximal colluvial gravel on low hill
PE12	22.0592	117.6930	Phd. Shrubs/*Triodia*.	A-HAd-kd-HAW		Colluvial slopes and bedrock debris
PHYC01	20.3751	119.9320	Qs. Broad interdune sandplain. Firm red sand with minor clay to depth.	K-_ca-sp	Qs	Aeolian sand plain
PHYC02	20.3911	119.9090	Agp. Granitoid plain. Decaying granite & quartz pebbles as surface strew on firm gritty clay profile to depth.	K-_ca-sp	Czc	Colluvial gravel with bedrock in dissected sheet or fan; some claypans
PHYC03	20.4296	119.9690	Agp. Hollow in top of granite outcrop hill. Decaying granite in matrix of grit as deposit on sheet granite at foot of granite scree.	A-g-PM		Granitic bedrock outcrop; sheets, domes and corestones
PHYC04	20.9337	119.9030	Ql. Riparian levee banks of sandy clay supporting buffel grass, separated by dry water course of coarse gritty sand lined with river gums.	A-WAd-f	Qaas	Alluvial stream bed and banks; adjacent overbank deposits
PHYC05	20.9359	119.8580	Aav. Agglomerate flat in small valley between low basalt hills (Ab). Deep clay profile with areas of basalt gravel on surface in patches. Massive *Triodia*.	A-WAd-f	Qao	Alluvial gravel; reworked colluvium; in small valley floor
PHYC06	20.8356	119.6720	Qf. Quaternary (old) plain of re-worked sandy clay. Deep profile.	A-g-PM	Qw	Silty sand in distal fans or relict alluvial floodplain
PHYC07	20.9110	119.6500	Ab. Steep outcrop & scree on lower slope at end of basalt ridge. Broken & decaying rock in shallow clay matrix incompletely mantling slope.	A-GC-xca-b		Bedrock ridge and adjacent colluvial footslopes, with boulders
PHYC08	20.9229	119.6100	Pfk. Kylena basalt outcrop as gentle slopes, rises & low ridges. Broken rocks & stones in shallow clay matrix incompletely mantling the outcrop surface by filling crevices & covering it in shallow sheets.	A-FOh-xs-f-HAM		Bedrock and proximal colluvium in footslopes
PHYC09	20.8952	119.6020	Qk. Calcrete rises of old, undulating & partially stripped Cenozoic valley floor. Sheet calcrete with superficial mantle of decaying calcrete gravel.	A-GC-xca-b	Czrk	Distal colluvial gravel in lower slopes and fans; includes calcrete rubble

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PHYC10	20.8996	119.5900	Qg. Valley floor plain. Deep Quaternary alluvial clay with surface cover of basalt, calcrete & quartz pebbles.	A-GC-xca-b	Qc	Colluvial footslope gravel; minor calcrete
PHYC11	20.8526	119.5920	Ast. Archaean siltstone & sandstone. Steep outcrop & scree slope below scarp with decaying siltstone fragments in skeletal thin sandy silt matrix incompletely mantling slope.	A-GC-xca-b	Czaz	Colluvial footslopes below ferruginised and cemented alluvium
PHYC12	20.8245	119.5390	Qb. Heavy cracking clay plain with sink-holes rather than heaves, but effectively the same without the stones.	A-WA-xb-f	Qwb	Sheet-flood fan of gravelly silt and clay with gilgai surface
PHYE01	20.6988	120.8570	Qs. Dune crest. Red desert sand to depth.	CP-_pa-sepg-CA	Qs	Aeolian sand plain
PHYE02	20.7039	120.9020	Qs. Interdune sandplain. Red desert sand to depth.	CP-_pa-sepg-CA	Qsf	Aeolian sand dune
PHYE03	20.7487	120.9300	Czoc. Mesas of Cenozoic opaline silica, mudstone & minor calcareous mudstone (similar in appearance to calcrete). Tops of mesas are massive sheet exposures thinly mantled by pebbles in matrix of fine clay filling crevices & depressions.	CP-_pa-sepg-CA	Czos	Silicified carbonate debris and outcrop
PHYE04	20.7388	120.8950	Czc. Undulating Cenozoic calcrete plain. Red sand thinly & incompletely mantling pale brown clayey sand containing calcrete & opaline pebbles & ironstone gravel over calcrete.	CP-_pa-sepg-CA	Qaa	Alluvial or colluvial gravel; some carbonate gravel; eroded terrace or valley floor
PHYE05	20.8549	120.8530	Ql. Riverine frontage of Oakover River. Sandy alluvial clay of levee bank. River Gums etc.	CP-_pa-sepg-CA	Qaas	Silt, sand and clay in alluvial channel
PHYE06	20.8613	120.8210	Qc. Quaternary colluvium—gentle calcrete slope version, pale loamy clay with calcrete stones & gravel in profile & as surface strew.	CP-_pa-sepg-CA	Qc	Distal colluvial gravel in outwash fans
PHYE07	20.9347	120.8760	Qep. Quaternary elluvial plain. Sandy clay with surface strew of gravel & pebbles.	CP-_pa-sepg-CA	Czag	Alluvial floodplain or terrace gravels
PHYE08	20.8645	120.7660	Qb. Heaving clay plain of cracking clays with quartz fragments in profile.	CP-_pa-sepg-CA	Qaob	Alluvial plain of gravelly silt and clay with gilgai surface
PHYE09	20.9181	120.6230	Afk. Kylena basalt hill. Low rounded hills with occasional boulders. Hiils have mantle of sandy clay with stones & broken rock in profile.	A-FOk-b-HAE	Qc	Colluvial gravel in distal footslopes or fans
PHYE10	20.8193	120.5370	Qc/Ag. Granitoid colluvial plain—orange-brown gritty clay over hard clay at 30 cm.	A-g-PW	Qaa	Alluvial silt and clay on flat in valley
PHYE11	20.7660	120.3770	Qeg. Quaternary alluvial gravel. Orange-brown gritty clay to depth with definite surface skin of encrusting organisms.	A-g-PW	Qwg	Gravelly silt and sand in sheet-flood fan
PHYE12	20.7471	120.2580	Aci. Archaean Chert range. Massive outcrop on steep slope with massive scree slopes. Skeletal loamy sand & rock fragments in crevices & depressions.	A-GC-xci-s		Bedrock and proximal colluvium
PHYE13	20.7242	120.2020	Pfh. Hadley Sandstone hillside. Steep slope of light scree & rubble. Skeletal sandy soil & rock fragments in crevices.	A-WA-xb-f		Colluvial footslopes below bedrock outcrop

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PHYW01	19.9976	119.3590	Qcd. Unconsolidated ridge of calcareous beach sand with some clay (hence termite mounds). *Spinifex longifolius* & buffel, heavily grazed.	A-g-PI	B1b	Aeolian sand in coastal dune
PHYW02	20.0343	119.3340	Qcs. Heavy cracking clay of sub-coastal flats—Roebourne Plains equivalent.	A-g-PI	Qas	Alluvial floodplain; silty clay
PHYW03	20.1623	119.3680	Qa. Plain of deep sandy clay—very firm at depth.	K-_ca-sp	Qao	Floodplain; alluvial silt and sand
PHYW04	20.2616	119.4190	Qs. Pindan sand—40 cm of red sand mantling clay.	A-PI-xb-s	Qs	Aeolian sand dune
PHYW05	20.2852	119.4300	Qb. Heavy, seasonally inundated clay plain.	A-PI-xb-s	Qaoc	Floodplain or lacustrine silty clay
PHYW06	20.2425	119.5750	Qs. Pindan sand. Firm red sand with some clay content.	K-_ca-sp	Qs	Aeolian sand plain
PHYW07	20.3246	119.2110	Ql. Riverine. Sandy clay levee bank with areas of river stone & gravel.	A-WC-f	Qaa	Alluvial valley flat or floodplain
PHYW08	20.3259	119.1750	Ac. Steep banded iron over chert outcrop & scree slope with rock fragments in shallow gritty clay matrix filling gaps & crevices.	A-PI-xb-s	Qc	Colluvial footslopes below siliceous bedrock outcrop
PHYW09	20.3359	119.1380	Acf. Steep plateau edge, chert-ironstone breakaway & scree slope with rock fragments in shallow gritty clay matrix filling gaps & crevices.	A-GC-xci-s		Colluvial footslopes below siliceous bedrock outcrop
PHYW10	20.3111	119.0950	Qf. Plain of alluvium. Reworked red gritty sand with clay at surface & through profile. Sand dominates mix to at least 60 cm.	A-GC-xci-s	Qao	Floodplain silt and sand
PHYW11	20.3251	118.9220	Qf. Plain of reworked alluvial gritty granitic soil with some surface clay. Termite mounds.	A-g-PI	A1c	Floodplain silt and sand
PHYW12	20.3914	118.9230	Qeg. Granitoid plain of gritty clayey sand with thin clay on surface.	A-g-PI		Colluvial fan or distal footslopes
PHYW13	20.3478	118.8920	Qa. Plain of Quaternary alluvium. Reworked gritty granitic sand with clay at surface.	A-g-PI	A1c	Floodplain or overbank silt and sand adjacent to river channel
PW01	21.3397	117.2600	Pdc. Slopes of dolerite boulder hills—bare tops with *Triodia* on slopes.	A-FOcp-od		Bedrock, dominated by corestones, and proximal colluvium
PW02	21.3280	117.2430	Pfk. *Acacia* shrubs/*Triodia* on boulder field; Kyalene basalt scree slope.	A-FOk-b-HAW		Colluvial footslopes
PW03	21.3413	117.1890	Pfp. Undulating upland with scattered sparse trees over *Triodia* in stony hill country.	A-FOt-xb-k-HAW		Bedrock and proximal colluvium in footslopes
PW04	21.3949	117.1710	Qpx. Heaving clay plain with rock strew on surface.	A-FOm-b-HAW	Czcb	Colluvium and bedrock debris
PW05	21.5773	117.0620	Qa. Paperbarks, sedges etc. of swamp.	A-HAm-cib-HAW	Qaa	River channels and overbank sediments
PW06	21.6772	116.9750	Qc. *Acacia/Triodia*; buckshot plain.	A-HAd-kd-HAW	Ql	Sheet flood fan; silt and clay

PW07	21.6424	117.0370	Qc. Snakewood/*Acacia*/tussock grass.	A-HAd-kd-HAW	Qaa	Floodplain; calcrete debris on edge of terrace
PW08	21.6042	117.0780	Czk. Eucalypts over spinifex; calcreted sand.	A-HAm-cib-HAW	Czm	Valley flat; silty alluvium
PW09	21.5713	117.0560	Qa. River gum and Cajeput near pipeline crossing.	A-FOj-xs-b-HAW	Qaa	Floodplain or overbank adjacent to river channels
PW10	21.5634	117.0590	Pfjw. Snappy gum/*Triodia*; stony ground.	A-FOj-xs-b-HAW		Bedrock debris and proximal colluvial gravel on low hill
PW11	21.5402	117.0570	Pfjd. Eucalypts over *Acacia* over *Triodia* on stony ground.	A-FOj-xs-b-HAW		Colluvial gravel or lag on bedrock rise
PW12	21.3841	117.0610	Pfm. *Triodia* and scattered *Hakea* on stony sand.	A-FOm-b-HAW	Czc	Colluvial gravel or lag on bedrock rise
PW13	21.3104	117.2760	Ql. Fluvitide plains; tall open *Acacia* shrubs over *Triodia*.	A-FOh-xs-f-HAW	Qaa	Alluvial valley flat or floodplain
RHNC01	23.3611	119.1120	Czl. Cenozoic duricrust.	A-FO-od-HAS	Czr	Colluvial gravel in footslopes
RHNC02	23.3195	119.1020	Czk. Cenozoic calcrete.	A-FO-od-HAS	Czk	Calcrete mound
RHNC03	23.2662	119.1340	Qw. Red sandy clay over sheet, hard pan at <10cm of cap over clay.	A-HAm-cib-HAS	Qw	Sheet-flood fan or distal colluvium in outwash fans
RHNC04	23.2509	119.1450	PHb. Lower scree slope & outcrop of range.	A-HAs-xsl-ci		Colluvial footslopes below bedrock outcrop
RHNC05	23.2136	119.2020	Qa. Deep red clay.	A-HAd-kd-HAS	Qw	Alluvial silt and clay on valley flat
RHNC06	23.1852	119.2380	Qx. Valley floor deep red clay with surface pebbles strew.	A-HAd-kd-HAS	Qw	Distal colluvial gravel in lower slopes and fans
RHNC07	23.1460	119.2660	Ahm′. Hillside; massive rock outcrops & rocky clay (shallow) profile.	A-HAm-cib-HAS	Czc	Colluvial footslope gravel
RHNC08	23.1032	119.0390	AFd. Undulating hill country with rock outcrops & stony clay profile (shallow).	A-FO-od-HAS		Bedrock debris and proximal colluvial gravel on low hill
RHNC09	23.0538	119.1770	AHb. Wittenoom dolomite (mudstone) on foot slopes to PHb mesa; soil with rock scree over massive dolomite.	A-HAd-kd-HAS		Colluvial footslopes below bedrock outcrop
RHNC10	22.9312	119.1850	Qa. Riparian deep clay & rock profile with cobbles etc. over Czk basement. Hard digging on fences.	A-HAs-xsl-ci	Qa	Floodplain or overbank adjacent to river channels
RHNC11	22.9146	119.2090	PHb. Brockman Iron Formation.	P_-HAj-xci-od		Colluvial footslopes
RHNC12	22.8524	119.2650	PHj. Weeli Wolli Formation; rock profile with skeletal soils over massive rock with outcrops.	P_-HAj-xci-od		Colluvial slopes and ferruginised bedrock debris
RHNC13	22.8372	119.2710	Qa. Alluvial clay with colluvial grit, cobbles & river sand; drop off of Cenozoic surface (Czk) onto river flat (Qa). Hard digging on fences.	P_-HAj-xci-od	Czk	Floodplain or overbank adjacent to river channels

RHNE01	22.8201	119.6130	Qs. Red sand dune on Qx.	A-HAd-kd-HAE	Qs	Red aeolian sand in dunes and sand plain
RHNE02	22.7661	119.6310	Qw. Gentle wash slope, brown clay with pebbles on surface & in profile.	A-HAd-kd-HAE	Qw	Distal colluvial gravel in outwash fans
RHNE03	22.7073	119.7090	Qx. Mulga on Qx.	A-HAd-kd-HAE	Qw	Alluvial channels and floodplain
RHNE04	22.6907	119.7750	Qx. Quaternary plain-brown sandy clay.	A-HAd-kd-HAE	Qw	Alluvial plain or distal sheet flood fan
RHNE05	22.6757	119.8410	Czk. Calcrete & snakewood; deep red-brown gritty clay with calcrete.	A-HAd-kd-HAE	Qw	Alluvial sand and gravel on floodplain
RHNE06	22.6611	119.9190	Czk. Calcrete.	A-HAd-kd-HAE	Qw	Alluvial plain; possible calcrete debris
RHNE07	22.5082	119.7840	Qa (saline). Deep saline clay profile; samphire of Fortescue Marsh.	A-HAd-kd-HAE	Qa	Alluvial silt and clay on floodplain
RHNE08	22.4518	119.9760	AHm. Banded ironstone Nerra Mamba Formation; massive rock with skeletal surface soil.	A-HAm-cib-HAE		Colluvial footslopes with ferruginous gravel and rock debris
RHNE09	22.4154	119.9840	AFjc. Jeerinah Formation pelite & thin bedded metadolomite; stony profile/ massive metadolomite.	A-FOj-xs-b-HAE		Colluvial gravel or lag on bedrock rise
RHNE10	22.1178	119.8770	Czp. Cenozoic pisolite plain with surface of laterite gravel with desert varnish; deep gravelly clay profile.	A-FOm-b-HAE	Enrb-cip	Ferruginous gravel; colluvium or lag
RHNE11	22.0947	119.7530	AFk. Kylena Basalt; red-brown hard stony clay profile.	A-FOk-b-HAE		Colluvial footslopes to bedrock rises
RHNE12	22.0853	119.7040	Agsm. Shallow brown gritty clay over decomposing granite sheet; granitoid undulating plain.	A-g-PS		Colluvium and bedrock debris
RHNW01	22.5350	118.9770	Phb. Phb slope with massive sheet banded iron formation with surface strew & skeletal soil in thin discontinuous surface.	P_-HAb-cib		Colluvium and bedrock debris on upper slopes of ridge
RHNW02	22.5358	118.9980	Czr. Czr haematite; Goethite deposits on banded iron formation & adjacent scree deposits; sheet rock & pebbles; snappy gum, open *Grevillea*, *Acacia*, *Triodia*.	A-HAs-xsl-ci	Czr	Colluvium and bedrock debris on upper slopes of ridge
RHNW03	22.4665	119.0230	Qx. plain sandy clay with rock fragments in profile.	A-HAd-kd-HAE	C1f	Sheet-flood fan or distal colluvium in outwash fans
RHNW04	22.3346	118.9890	Qa. Coolibah open woodland to 15 m, *Acacia* and *Hakea*.	A-HAd-kd-HAE	Qa	Alluvial valley flat or floodplain
Site	**Lat S**	**Long E**	**Habitat Description (by site selection team)**	**Bedrock**	**Regolith**	**Photo Interpretation**
RHNW05	22.3175	118.9800	Qa. Cracking clay Qa flat with tussock grass of *Eriachne benthamii*.	A-HAd-kd-HAE	Qa	Alluvial silt and clay in floodplain

RHNW06	22.3018	119.0130	Qa. Clay with surface strew; Snakewood, *Ptilotus*, tussock grass.	A-HAd-kd-HAE	C1f	Colluvial and alluvial gravels in fan or floodplain
RHNW07	22.2217	119.0250	AHm. Marra Mamba banded iron formation on low rolling hills with stony soil; shallow cover.	A-HAm-cib-HAE		Alluvial valley floor with some boulders
RHNW08	22.1068	119.0010	Czc. Chichester Tablelands cracking & heaving clay with tussock grassland.	A-FOm-b-HAE	R2CbVb	Alluvial or distal colluvial gravel; relict valley fill
RHNW09	22.0688	118.9790	AFtc. Bedded dolomite & pelite; undulating uplands of Chichester Range; red clayey & rocky strata with outcrops.	A-FOm-b-HAE		Bedrock rise with thin proximal colluvium
RHNW10	22.1347	119.0240	AFm. upper scree slope.	A-FOj-xs-b-HAE		Colluvium and bedrock debris
RHNW11	22.2941	119.0610	Qa. Mulga grove on Qa-collapsing clay with some snakewood.	A-HAd-kd-HAE	C1f	Sheet-flood fan or distal colluvium in outwash fans
RHNW12	22.3469	119.0100	Qa. Saline clay with samphire.	A-HAd-kd-HAE	W1	Floodplain; alluvial silt and sand
RHNW13	22.3614	119.0070	Czk. Caliche Land System.	A-HAd-kd-HAE	C1	Colluvial footslope gravel
TCMBC01	23.3638	117.6250	Qs. Plain of firm pale sand with some clay in profile. Strew of fine buckshot on surface in places. Ashburton Region.	P_-WYU-xs-k	Qa	Alluvial floodplain and overbank deposits
TCMBC02	23.3600	117.6840	Czc. Small rise in gibber plain among gently rolling hills of Ashburton Region. Deep clay profile with stony surface strew & some boulders. Scattered mulga over snakewood.	P_-WYU-xs-k	Czc	Colluvial gravel or lag on bedrock rise
TCMBC03	23.3392	117.8020	Czk. Slope of rolling calcrete hills & mesas. Calcareous clay soil with some hard siliceous calcrete through profile & surface strew of calcrete, basalt & ironstone pebbles. Re-worked.	P_-WYU-xs-k	Czc	Colluvial footslopes to calcrete rises
TCMBC04	23.3347	117.8770	Czc. Gentle slope below Brockman Iron (Hb) hill. Deep clay with grit & ironstone through profile & surface strew of ironstones, cobbles & gibber with some large boulders.	P_-WYU-xs-k	Czc	Sheet-flood or colluvial fan; gravel
TCMBC05	23.3183	117.8700	Hb. Brockman Iron ridge-top & steep upper slope. Skeletal red clay in pockets & depressions between massive banded iron scree & outcrops. Rocky strew on surface.	P_-HAb-cib		Colluvial gravel or lag on bedrock rise
TCMBC06	23.4193	117.8410	Wb. Cheela Spring Basalt. Steep scree slope with massive outcrops & skeletal gritty red-brown soil with rock in profile in crevices & shallow pockets with surface strew of basalt fragments.	P_-WYU-xs-k		Colluvial slopes and bedrock debris
TCMBC07	23.4161	117.8700	Qa. Plain of Quaternary alluvial clay soil. Deep clay with pebbles through profile. Surface covered in pebbles in run-off areas.	P_-WYL-xs-b	Qa	Alluvial silt and clay in valley flat
TCMBC08	23.3758	117.9900	Czc. Red clay slope over hardpan or duricrust. Stones, cobbles & rocks through profile.	P_-HAj-xci-od	Czc	Sheet-flood or colluvial fan; gravel; distal or reworked

Site	Lat S	Long E	Habitat Description (by site selection team)	Bedrock	Regolith	Photo Interpretation
TCMBC09	23.3361	118.0360	Hj. Moderately steep slope on side of Weeli Wolli ironstone hill. Red-brown clay profile containing rocks & mantle of banded iron rocks & boulders, overlying massive ironstone.	P_-HAj-xci-od		Bedrock debris and proximal colluvial gravel on low hill
TCMBC10	23.2848	118.1010	Ql. Riverine coarse gritty sand alluvium with calcrete & calcareous conglomerate as cobbles & pebbles, & massive calcrete at depth. River Gums etc.	P_-TK-s	Qa	Alluvial channel and overbank deposits
TCMBC11	23.2869	118.1240	Czk. Massive sheet calcrete superficially mantled by decomposing calcrete fragments, rocks, boulders & gibber in light brown clay matrix. Opaline fragments on surface.	P_-TK-s	Czk	Calcrete gravel and colluvium
TCMBC12	23.2934	118.1560	Qw. Flat plain of gritty red clay with surface strew of rocks & pebbles. Stones in profile & hardpan at 20–30 cm.	P_-TK-s	Czc	Distal colluvial gravel in sheet-flood fans
TCMBE01	22.5713	118.3070	Czc. Undulating stony valley floor of incised Cenozoic colluvium. Rock fragments & fine gravel in a red clay matrix with gravelly & stony surface cover.	P_-HAb-cib	Czc	Colluvial gravel in footslopes to low hills
TCMBE02	22.5839	118.2910	Qw. Gentle footslope outwash of Quaternary colluvium & alluvium—red-brown sandy clay with rock fragments in profile & as surface strew.	A-HAs-xsl-ci	Qw	Colluvial gravel in footslopes
TCMBE03	22.6215	118.3510	PHj. Gentle footslope below a low banded iron ridge. Red clay profile containing rock fragments with small angular rock fragments as surface strew.	P_-HAj-xci-od		Colluvial gravel in footslopes
TCMBE04	22.6207	118.3150	Qw. Plain of Quaternary alluvium & colluvium; outwash from Phb hills. Sandy red clay with small rock fragments in profile & as surface strew.	P_-HAj-xci-od	Qw	Distal colluvial gravel in lower slopes and fans
TCMBE05	22.6099	118.2990	Phb. Steep hill slope of Brockman banded iron formation. Massive rock outcrop & boulders with broken decaying rock in shallow clay matrix incompletely mantling slope.	P_-HAb-cib		Bedrock outcrops and proximal colluvial gravel on low hill
TCMBE06	22.6356	118.2260	Qa. Mount Bruce flats. Clayplain with hardpan of ironstone at 20 cm.	A-HAd-kd-HAS	Qa	Alluvial plain; gravelly silt and clay
TCMBE07	22.7148	118.2650	Czk. Cenozoic calcrete valley fill on undulating plain with incised drainage. Decaying calcrete fragments & coarse ironstone gravel (angular) in deep clay matrix overlying decaying calcrete sheet over deep clay.	A-HAm-cib-HAS	Czk	Calcrete rubble and ferruginous colluvium
TCMBE08	22.7230	118.2690	Ql. Riverine alluvial deposit of Turee Creek. Coarse alluvial grit & river stones as low levee bank in bed of river.	A-HAm-cib-HAS	Qa	Alluvium in stream channel and overbank deposits
TCMBE09	22.6123	118.0230	AHm. Hillslope of massive banded iron outcrop with decaying rock in shallow clay matrix.	A-HAm-cib-HAS	Czc	Colluvial gravel or lag in footslopes
TCMBE10	22.6087	117.9360	Qb. Heaving clay. Cracking & heaving clay profile to depth with rocks & stones.	A-FOu-bbo	Czc	Rocky ridge with lag or proximal colluvium
TCMBE11	22.6606	117.8640	Afu. Gentle lower slope with stony surface & deep stony clay profile.	A-FOu-bbo		Colluvial gravel or lag on bedrock rise

TCMBE12	22.6800	117.8480	Afu. Hilltop and massive scree upper slope & sheet outcrop (volcanic flow) with decaying rock in a shallow clay matrix.	A-FOu-bbo		Bedrock ridge
TCMBE13	22.6991	117.8160	Ab. Massive scree slope (steep) of basalt with areas of decomposing basalt in shallow clay matrix.	A-FO-od-HAS		Bedrock, including corestones
TCMBW01	22.8267	117.3710	Agm. Granitoid slope with elluvial soil profile of gritty sand granitic soil, decomposing granite & massive granite sheet outcrops.	A-mgn-PRK		Bedrock; sand and gravel in proximal colluvial footslopes
TCMBW02	22.8344	117.3800	Agm. Granitoid plain of red sand soil with some clay in profile & small gravel fragments on surface.	A-mgn-PRK		Colluvial footslopes to bedrock rises; sand and minor gravel
TCMBW03	22.8084	117.4770	Czp. Pisolitic duricrust. (similar to CzL) Skeletal red-brown gritty clay over massive lateritised ironstone which is exposed as surface capping in places. Soil surface covered in rocks & gravel.	A-FOh-xs-b-HAS	Czp	Ferruginous bedrock debris and proximal colluvial gravel on rises
TCMBW04	22.7979	117.4930	Afo. Upper slope & top of a metabasaltic hill. Shallow skeletal gritty clay incompletely mantling massive basalt surface of scree, rocks & boulders.	A-FOo-bbo		Colluvial footslopes to rise; siliceous rock debris; adjacent to alluvial channel
TCMBW05	22.7197	117.5120	Czk. Calcrete ridge & slope of decomposing white/brown clay over massive calcrete at 20 cm depth. Calcrete & quartzite fragments & gravel on surface with some ironstone.	P_-HAw-fr	Czk	Calcrete mound
TCMBW06	22.6661	117.6120	Hb. Banded Iron ridge. Steep outcrop slopes & scree. Skeletal grit in crevices & pockets between rocks & boulders on steep slope with outcrops.	P_-HAb-cib		Colluvial footslopes below bedrock outcrop
TCMBW07	22.5045	117.6500	Qc. Gentle red clay slope with surface strew of buckshot, gravel & large ironstone rock fragments.	A-FOp-bs	Qw	Distal gravely colluvium in sheet-flood fan
TCMBW08	22.5037	117.7040	Qw. Flat plain of cracking & mulching gilgai clay with surface strew of large basalt rocks & gravel. Snakewood etc.	A-FOp-bs	Qa	Alluvial floodplain or terrace gravels
TCMBW09	22.3783	117.4670	Czc. Colluvial slopes below ironstone. Red clay with stones in profile & surface strew of stones, gravel & buckshot.	A-FOu-bbo	Czc	Distal colluvial gravel in sheet-flood fan; eroded by recent drainage channels
TCMBW10	22.3326	117.4850	Qa. Alluvial flat with Mulga. Heavy red clay to depth with some surface strew of buckshot.	A-HAd-kd-HAS	Qw	Distal colluvium in sheet-flood fan
TCMBW11	22.3209	117.4780	AHm. Massive sheet outcrop of banded ironstone with some soil in pockets & surface strew of rocks & gravel.	A-HAm-cib-HAS		Rocky rise with lag or proximal colluvium
TCMBW12	22.3056	117.4810	Qa. Heavy alluvial clay, cracking with crabholes & surface strew of pebbles & gravel, a mix of quartzite, calcrete & ironstone.	A-HAd-kd-HAS	Qa	Floodplain silt and clay
TCMBW13	22.2942	117.4730	Qw. Alluvial & colluvial outwash plain from banded iron hills. Skeletal gritty red clay with ironstone rock fragments & boulders through profile & surface strew of rocks & pebbles.	A-HAd-kd-HAS	Qw	Distal colluvial gravel in sheet-flood fan

WYE01	22.7892	116.5710	Hb. Brockman Iron slope of range with rock scree on massive outcrop.	A-HAd-kd-HAS		Colluvial footslopes below bedrock outcrop
WYE02	22.7727	116.5220	Qc. Deep clay with stony surface.	A-FO-bb-HAS	Qc	Calcrete mound; calcareous rubble and ferruginous colluvium
WYE03	22.7402	116.4610	AFr. Mount Roe Basalt hillside; stony scree over massive basalt.	A-FOr-bbg-HAS		Colluvial footslopes below bedrock outcrop
WYE04	22.7112	116.4000	Qa. Crabhole heaving clay of valley floor; deep clay with surface strew.	A-FOr-bbg-HAS	Qa	Alluvial floodplain or terrace gravels
WYE05	22.5714	116.1480	Fb. Mount Jope Volcanics (basalt) hillside; rocky scree/massive outcrop.	A-FO-bb-HAS		Colluvial footslope gravel
WYE06	22.4348	115.9300	Qs. Quaternary Sand sheet associated with granitoid surfaces; deep sandy-clay profile.	P_-WYU-xs-k	Qc	Distal colluvium
WYE07	22.4193	115.8380	Pgbr. Granitoid plain with outcrop; gritty clay profile with quartzite & decomposing granite fragments in profile & many outcropping boulders etc.	P_-MO-mg	Qc	Granitic bedrock rise, including corestones and proximal colluvium
WYE08	22.4253	116.2150	Wai. Wyloo Group; Ashburton Formation; ferruginate mudstone & banded iron formation; stones/massive rock, ie gibber scree surface.	P_-WYU-xs-k		Bedrock outcrops and colluvial gravel on low hill
WYE09	22.4376	116.2740	Wd. Duck Creek dolomite of the Wyloo Group; stony surface over dolomite & mudstone outcrop.	P_-WYU-xs-k		Bedrock outcrops and thin colluvial gravel on low hill
WYE10	22.4300	116.2800	Tp. Tertiary pisolite low hills & breakaway sheet pisolite at top of abrupt rise.	P_-WYU-xs-k		Colluvial gravel or lag on bedrock rise
WYE11	22.4080	116.3720	Wm. Wyloo Group Mount McGrath Formation; boulder scree on clay with stones in profile.	P_-WYL-xs-b	Qc	Bedrock ridge and adjacent colluvial footslopes, with boulders
WYE12	22.4107	116.3920	Wb. Wyloo Group Cheela Springs Basalt; low hill top loose stone over massive sheet basalt.	P_-WYL-xs-b		Colluvial gravel or lag on bedrock rise
WYE13	22.4249	116.4330	Wg. Yyloro Group Beasley River quartzite; rock scree/massive 'quartzite' outcrop.	P_-WYL-xs-b		Colluvial footslope gravel below bedrock outcrop
WYW01	22.1041	115.5680	Ia. Mount Waramboo Minnie Group, sandstone thin bedded arenite; thin layer of rock pebbles & clay over massive stone.	P_-MM-s		Bedrock debris and proximal colluvial gravel on rise
WYW02	22.1201	115.5700	Wa. Wyloo Group Ashburton Formation; steeply inclined ?mudstone; pebble strew quartzite etc over massive rock with near-vertical strikes.	P_-WYU-xs-k		Bedrock rise or low hill, dominated by outcrop, with minor proximal colluvial debris or lag
WYW03	22.1697	115.5610	Qc. Snakewood colluvial clay plain; deep clay with surface strew of gibber.	P_-MM-s	Qc	Distal colluvial and alluvial gravels in large fan or floodplain

Site	Lat S	Long E	Habitat Description (by site selection team)	Bedrock	Regolith	Photo Interpretation
WYW04	22.1886	115.5540	Qs. Dune; red sand dune; deep red sand.	P_-MM-s	Qs	Aeolian sand plain
WYW05	22.1933	115.5540	Ib. Mount Brodagee Minnie Group; (arenite & conglomerate); stony surface on massive rock.	P_-MM-s		Colluvial footslopes below bedrock outcrop
WYW06	22.2560	115.4910	Kn. Lower Cretaceous Winning Group, Nanutarra Sandstone & siltstone tidal & supra tidal; sandy claystone at 30 cm over sheet rock.	K-_na-ss	Czc	Distal colluvial and alluvial gravels in large fan or floodplain; quartz gravel and sand
WYW07	22.2554	115.4370	Qs. Sheet over with late Cenozoic calcrete (Czk) with deep sand mantle; deep red sand.	P_-MO-mg	Czk	Alluvial plain or distal sheet flood fan; silty sand
WYW08	22.4984	115.5580	Qs. 'Sandplain'; deep red sand.	P_-MR-xmd-mk	Qc	Aeolian sand plain
WYW09	22.4640	115.6340	Miw. Bangemall Group Wongida dolomite; stony surface on massive outcrop.	P_-MEP1-kt		Bedrock outcrops and proximal colluvial gravel on low hill or rise
WYW10	22.4523	115.6610	Mia. Bangemall Group Irregully Sandstone; stony clay on hill upper slope.	P_-MEP1-kt		Colluvial footslope gravel and lag on bedrock rises
WYW11	22.8635	115.5030	Qc. Quaternary colluvium; deep clay.	P_-MR-xmd-mk	Qc	Alluvial channels and floodplain; silty sand
WYW12	22.9179	115.5780	np?. Morrissy metamorphic suit of microgneiss & schist as low rolling hills; stony outcrop on top of hill.	P_-MR-xmd-mk		Bedrock outcrops and proximal colluvial gravel on rise

BEDROCK CODE	NAME	LITHOLOGY
A-_re-b	REGAL FORMATION	Massive and pillowed basalt, with local komatiitic peridotite; minor chert; metamorphosed
A-CDm-s	MALLINA FORMATION	Interbedded shale, siltstone, sandstone, and medium- to fine-grained wacke; metamorphosed
A-CEkr-gg	KARRATHA GRANODIORITE	Granodiorite and tonalite; foliated with local compositional banding; metamorphosed
A-FO-bb-HAS	FORTESCUE GROUP	Unassigned basalt
A-FOcp-od	COOYA POOYA DOLERITE	Fine- to medium-grained dolerite sill; locally forms dykes within HARDEY FORMATION
A-FOh-xs-b-HAS	HARDEY FORMATION	Sandstone; mudstone; siltstone; conglomerate; felsic and mafic volcanic sandstone and conglomerate; and basaltic flows and breccia; metamorphosed
A-FOh-xs-f-HAE	HARDEY FORMATION	Sedimentary and felsic volcanic rocks; local intrusive rocks
A-FOh-xs-f-HAM	HARDEY FORMATION	Sedimentary and felsic volcanic rocks; local intrusive rocks
A-FOh-xs-f-HAW	HARDEY FORMATION	Sedimentary and felsic volcanic rocks; local intrusive rocks
A-FOj-xs-b-HAE	JEERINAH FORMATION	Mudstone; siltstone; sandstone; chert; massive basaltic flows; basaltic pillow lava; basaltic breccia; and minor felsic volcaniclastic rock; intruded by numerous dolerite sills; metamorphosed

A-FOj-xs-b-HAW	JEERINAH FORMATION	Mudstone; siltstone; sandstone; chert; massive basaltic flows; basaltic pillow lava; basaltic breccia; and minor felsic volcaniclastic rock; intruded by numerous dolerite sills; metamorphosed
A-FOk-b-HAE	KYLENA FORMATION	Massive, amygdaloidal, or vesicular basalt and basaltic andesite; local komatiitic basalt, dacite and rhyolite
A-FOk-b-HAW	KYLENA FORMATION	Massive, amygdaloidal, or vesicular basalt and basaltic andesite; local komatiitic basalt, dacite and rhyolite
A-FOm-b-HAE	MADDINA FORMATION	Massive, amygdaloidal, or vesicular basalt and basaltic andesite; local komatiitic basalt, dacite and rhyolite
A-FOm-b-HAW	MADDINA FORMATION	Massive, amygdaloidal, or vesicular basalt and basaltic andesite; local komatiitic basalt, dacite and rhyolite
A-FOo-bbo	BOONGAL FORMATION	Pillowed and massive basaltic flows; basaltic breccia; siltstone; mudstone; minor chert; metamorphosed
A-FO-od-HAS	FORTESCUE GROUP	Dolerite dyke or sill
A-FOp-bs	PYRADIE FORMATION	Pyroxene spinifex-textured basaltic flows and pillow lava; mafic volcaniclastic rock; minor chert; local komatiite; metamorphosed
A-FOr-bbg-HAS	MOUNT ROE BASALT	Amygdaloidal basaltic flows and breccia; and basaltic volcaniclastic sandstone; metamorphosed
A-FOr-b-HAE	MOUNT ROE BASALT	Amygdaloidal basaltic flows and breccia; and basaltic volcaniclastic sandstone; metamorphosed
A-FOr-b-HAM	MOUNT ROE BASALT	Amygdaloidal basaltic flows and breccia; and basaltic volcaniclastic sandstone; metamorphosed
A-FOr-b-HAW	MOUNT ROE BASALT	Amygdaloidal basaltic flows and breccia; and basaltic volcaniclastic sandstone; metamorphosed
A-FOt-xb-k-HAE	TUMBIANA FORMATION	Basaltic volcanic rocks and carbonate rocks
A-FOt-xb-k-HAW	TUMBIANA FORMATION	Basaltic volcanic rocks and carbonate rocks
A-FOu-bbo	BUNJINAH FORMATION	Pillowed and massive basaltic flows; basaltic breccia; and basaltic volcanic sandstone; minor chert; amygdaloidal basalt flows occur in upper parts of formation; metamorphosed
A-GCe-ca	CLEAVERVILLE FORMATION	Chert and banded iron-formation; minor felsic volcaniclastic rock; metamorphosed
A-GC-xca-b	GORGE CREEK GROUP	Banded iron formation, chert, siliciclastic sedimentary rocks, and mafic volcanic rocks; metamorphosed
A-GC-xci-s	GORGE CREEK GROUP	Banded iron-formation and siliciclastic sedimentary rock; metamorphosed
A-g-PCN	COONINIA INLIER	Granite to granodiorite; variably foliated
A-g-PE	MOUNT EDGAR GRANITIC COMPLEX	Undivided granitoid rock; metamorphosed
A-g-PL	CARLINDI GRANITIC COMPLEX	Undivided granitoid rock; metamorphosed
A-g-PM	MUCCAN GRANITIC COMPLEX	Undivided granitoid rock; metamorphosed
A-g-PO	CORUNNA DOWNS GRANITIC COMPLEX	Undivided granitoid rock; metamorphosed
A-g-PS	SHAW GRANITIC COMPLEX	Granitic rock; metamorphosed
A-g-PSY	SYLVANIA INLIER	Granite to granodiorite; variably foliated
A-g-PW	WARRAWAGINE GRANITIC COMPLEX	Undivided granitoid rock; metamorphosed
A-g-PY	YULE GRANITIC COMPLEX	Granitic rock; metamorphosed

BEDROCK CODE	NAME	LITHOLOGY
A-GR-g	GREGORY RANGE SUITE	Syenogranite and granophyre ; well foliated, gneissic, or sheared
A-HAc-kds	CARAWINE DOLOMITE	Massive- to well-bedded, recrystallised dolomite, and stromatolitic dolomite; minor chert
A-HAd-kd-HAE	WITTENOOM FORMATION	Thin- to medium-bedded dolomite, dolomitic mudstone, chert, and felsic to mafic volcanic sandstone; metamorphosed
A-HAd-kd-HAS	WITTENOOM FORMATION	Thin- to medium-bedded dolomite, dolomitic mudstone, chert, and felsic to mafic volcanic sandstone; metamorphosed
A-HAd-kd-HAW	WITTENOOM FORMATION	Thin- to medium-bedded dolomite, dolomitic mudstone, chert, and felsic to mafic volcanic sandstone; metamorphosed
A-HAm-cib-HAE	MARRA MAMBA IRON FORMATION	Chert, banded iron-formation, mudstone, and siltstone; metamorphosed
A-HAm-cib-HAS	MARRA MAMBA IRON FORMATION	Chert, banded iron-formation, mudstone, and siltstone; metamorphosed
A-HAm-cib-HAW	MARRA MAMBA IRON FORMATION	Chert, banded iron-formation, mudstone, and siltstone; metamorphosed
A-HAs-xsl-ci	MOUNT McRAE SHALE and MOUNT SYLVIA FORMATION	Mudstone, siltstone, chert, banded iron-formation, and dolomite; metamorphosed
A-KEw-xf-s	WYMAN FORMATION	Felsic volcanic and volcaniclastic rocks; local clastic sedimentary rocks, chert and basalt; metamorphosed
A-mgn-PRK	ROCKLEA DOME	Foliated; gneissic; or migmatitic granitoids
A-mg-PK	KURRANA GRANITIC COMPLEX	Biotite metamonzogranite and gneissic metagranodiorite with greenstone xenoliths, foliated to gneissic biotite metamonzogranite and metasyenogranite, and muscovite-bearing monzogranite
A-MRer-gm	ERAMURRA MONZOGRANITE	Seriate biotite monzogranite containing mafic schlieren and veins of pegmatite; metamorphosed
A-MR-gm	MAITLAND RIVER SUPERSUITE	Monzogranite, minor granodiorite, locally K-feldspar porphyritic, and local gneissic granitic rocks
A-MRwh-ggp	WHYJABBY GRANODIORITE	Foliated, microcline porphyritic hornblende granodiorite; locally contains xenoliths of tonalite gneiss; metamorphosed
A-NUq-mh	MOSQUITO CREEK FORMATION	Metamorphosed sandstone, siltstone, and shale; graded bedding and local cross-bedding; includes metamorphosed turbidite deposits
A-og-PSY	SYLVANIA INLIER	Gabbro sills and dykes; metamorphosed
A-OPan-xo-a	ANDOVER INTRUSION	Gabbro, leucogabbro, serpentinised peridotite and dunite, pyroxenite, and minor anorthosite; metamorphosed
AP_-_pj-ccx	PINJIAN CHERT BRECCIA	Chert breccia and poorly bedded chert
A-PI-xb-s	PILBARA SUPERGROUP	Mafic and ultramafic volcanic rocks; minor chert; metamorphosed
A-ROn-xca-f	NICKOL RIVER FORMATION	Chert, banded iron-formation, sedimentary carbonate rocks, ferruginous siliciclastic rocks, quartzose sandstone, conglomerate, felsic volcanic and intrusive rocks; metamorphosed
A-ROr-xb-u	RUTH WELL FORMATION	Mafic and ultramafic volcanic and intrusive rocks; minor chert; metamorphosed
A-SR-g	COONDINA, COOGLEGONG, and SPEAR HILL MONZOGRANITES	Younger granitic rocks related to tin—tantalum mineralisation; locally abundant pegmatite

A-SRnu-gmp	NUMBANA MONZOGRANITE	Medium- to coarse-grained feldspar(-quartz) porphyritic monzogranite; massive to weakly foliated; local flow-aligned feldspar phenocrysts; local garnet-bearing pegmatite and granite dykes
A-STpe-gi	PEAWAH GRANODIORITE	Hornblende-biotite high-Mg diorite, granodiorite and tonalite; metamorphosed
A-STpt-gf	PORTREE GRANITE	Alkali granite, medium-grained, pyroxene-bearing, foliated to massive; metamorphosed
A-u-PSY	SYLVANIA INLIER	Ultramafic rock; undivided; includes metamorphosed peridotite; dunite; pyroxene peridotite; and serpentinite and talc schist
A-WAp-f	PANORAMA FORMATION	Felsic volcanic rock; local sedimentary rock; metamorphosed
A-WA-xb-f	WARRAWOONA GROUP	Mafic, ultramafic, and felsic volcanic and intrusive rocks, and sedimentary rocks; metamorphosed
A-WC-f	WHIM CREEK GROUP	Felsic volcanic and sedimentary rocks; interpreted from aeromagnetic data
A-WCr-f	RED HILL VOLCANICS	Felsic volcaniclastic rocks, intrusive porphyritic dacite and dacitic to rhyolitic lava; includes debris-flow, turbidite and fluvial facies; metamorphosed
A-WHb-b	BRADLEY BASALT	Pillow basalt, massive basalt, dolerite sills, and minor felsic tuff, sandstone, shale and chert; metamorphosed
CP-_pa-sepg-CA	PATERSON FORMATION	Conglomerate (including diamictite), sandstone and siltstone; largely glacigene
K-_ca-sp	CALLAWA FORMATION	Very fine- to coarse-grained sandstone, conglomerate
K-_na-ss	NANUTARRA FORMATION	Silty, fine- to coarse-grained, poorly sorted sandstone, siltstone, claystone, greensand, minor conglomerate
K-_ny-sp	NANUTARRA FORMATION and YARRALOOLA CONGOMERATE	Poorly sorted sandstone (in places glauconitic), cobble to boulder conglomerate, and siltstone
K-WN-sfl-WC	WINNING GROUP	Shale, siltstone, marl, and basal sandstone; commonly glauconitic
P_-HAb-cib	BROCKMAN IRON FORMATION	Banded iron-formation, chert, mudstone, and siltstone; metamorphosed
P_-HAj-xci-od	WEELI WOLLI FORMATION	Banded iron-formation (often jaspilitic), mudstone, siltstone, and numerous dolerite sills; metamorphosed
P_-HAo-cib	BOOLGEEDA IRON FORMATION	Fine-grained, finely laminated banded iron-formation; mudstone, siltstone and chert; metamorphosed
P_-HAw-fr	WOONGARRA RHYOLITE	Rhyolite, rhyodacite, rhyolitic breccia, and banded iron-formation; metamorphosed
P_-MEP1-kt	YILGATHERRA and IRREGULLY FORMATIONS	Stromatolitic and non-stromatolitic dolostone, dolomitic siltstone, sandstone, siltstone, and conglomerate
P_-MM-s	MOUNT MINNIE GROUP	Undivided, quartz sandstone, conglomerate, siltstone and mudstone
P_-MN-s	MANGANESE GROUP	Sandstone, siltstone, mudstone, conglomerate, chert and dolostone
P_-MO-mg	MOORARIE SUPERSUITE	Foliated and gneissic granite
P_-MR-xmd-mk	MORRISSEY METAMORPHICS	Pelitic and psammitic schist; calc-silicate rock; minor amphibolite
P_-od		Dolerite dyke, sill, and plug; includes cumulate and granophyric differentiates
P_-TK-s	TUREE CREEK GROUP	Mudstone; siltstone; sandstone; conglomerate; local stromatolitic dolomite; and basalt; metamorphosed
P_-WYL-xs-b	LOWER WYLOO GROUP	Conglomerate, sandstone, mudstone, basalt, chert, and locally stromatolitic dolomite
P_-WYU-xs-k	UPPER WYLOO GROUP	Wacke, mudstone, ferruginous mudstone, banded iron formation, chert, sandstone, conglomerate, felsic and mafic volcanic rocks, and locally stromatolitic dolomite

REGOLITH CODE	REGOLITH
A1c	Sand, silt and gravel in active drainage channels; includes clay, silt and sand in poorly defined drainage courses on floodplains
A1fcb	Alluvial sand, silt and clay on floodplains, with gilgai surface in areas of expansive clay
B1b	Coastal dunes and beach deposits; shelly sand containing Anandara granosa; includes backshore deposits
C1	Colluvial sand, silt and gravel in outwash fans; scree and talus; proximal mass-wasting deposits; unconsolidated
C1f	Ferruginous colluvium; unconsolidated silt, sand and rock debris; proximal mass-wasting deposits
Czag	Consolidated alluvial gravel, sand and silt; local carbonate cement; dissected
Czaz	Silicified and ferruginised channel deposits; cemented quartzite and banded-iron formation clasts in conglomerate
Czc	Colluvium; partly consolidated and consolidated ferruginised silt, sand and gravel; valley-fill deposits dissected by present drainage
Czc	Colluvium; partly consolidated quartz and rock fragments in silt and sand matrix; old valley-fill deposits; locally derived
Czcb	Colluvium, dissected by present-day drainage, with gilgai surface in areas of expansive clay
Czcg	Colluvium; clay, silt, sand and gravel derived from granitic rock; variably consolidated and dissected
Czk	Calcrete, sandy limestone; in sheets and lenses; old valley fill
Czk	Calcrete; impure earthy limestone and white porcellanite; with alluvium at the base in places; correlated in part with Oakover Formation
Czk	Calcrete; lumpy to nodular or massive, authigenic limestone
Czk	Calcrete; sheet carbonate usually formed in major drainage lines
Czm	Millstream Formation; dolomite and calcareous dolomite, with silcrete, clay and local basal conglomerate
Czos	Oakover Formation, upper unit; vuggy, white to grey opaline silica; silicified carbonate; minor calcareous sandstone
Czp	Claypan-dominated terrain; claypans with longitudinal and net dunes, and/or flat deflation-lag surfaces; clay, silt, sand and gravel
Czp	Robe Pisolite; pisolitic limonite deposits; developed along river channels
Czr	Laterite; includes surficial hematite-goethite deposits on banded iron-formation and adjacent scree deposits; forms Hamersley Surface
Czrk	Calcrete; massive, nodular and cavernous limestone, variably silicified; residual origin
Enrb-cip	Robe Pisolite; pisolitic limonite, goethite and hematite deposits; developed along palaeodrainage lines; dissected by present-day drainage
Qa	Alluvium; unconsolidated or partly consolidated silt, sand and gravel; in drainage channels and adjacent floodplains
Qaa	Alluvium; sand and gravel in rivers and creeks; clay, silt and sand in channels on floodplains
Qaas	Alluvium; unconsolidated sand, silt and gravel in discrete channel beds
Qao	Overbank deposits; alluvial sand, silt and gravel on floodplains adjacent to main drainage channels and interchannel islands; minor clay
Qaob	Alluvial clay and silt deposits on floodplains with gilgai (crabhole) surface in areas of expansive clay
Qaoc	Alluvial sand, silt and clay; mixed floodplain deposits characterised by numerous small claypans
Qas	Alluvial and aeolian coastal sand deposits
Qb	Alluvium; unconsolidated sand, gravel and pebbled; over kunkar or granite
Qc	Colluvium and minor alluvium; quartz pebble and rock fragments in silt and sand; adjacent to bedrock; scree, talus slope deposits
Qe	Colluvium and eluvium; clay, hardpan, partly ferruginised silt, sand and gravel derived from and overlying older colluvium and caprock

Qg	Colluvium; unconsolidated to loosely consolidated piedmont deposits; scree, talus
Qhm	Marine mud and silt on supratidal flats; includes intertidal deposits with mangroves
Qhms	Coastal sand in beach deposits and dunes; chiefly marine sand reworked by wind, but includes some reworked alluvium near deltas; shelly sand contains *Anandra granosa* (Malaysian Cockle)
Qhmu	Silt and mud in supratidal to intertidal flats and lagoons
Ql	Flood deposits; unconsolidated fluviatile and sheet-flood deposits in levees, river terraces
Qp	Eluvium and alluvium; residual 'high level' clay and sandy clay plain with gilgais; intermittent veneer of alluvium; residual deposits of sand, gravel and pebbles; sheet kunkar in places
Qpmb	Coastal limestone; lime-cemented shelly sand, dune sand and beach conglomerate
Qpt	Eluvium; residual, unconsolidated or loosely consolidated, low-angle slope deposits; angular to subrounded shale and ironstone fragments; quartz and quartzite pebbles
Qr	Alluvium; unconsolidated fluviatile sediments
Qrg	Quartzofeldspathic eluvial sand, with quartz and rock fragments; overlying and derived from granitic rock
Qs	Aeolian sand; light to dark red sand in sheets, and longitudinal (seif) and chain dunes
Qsf	Aeolian sand with lag deposits; ironstone-pebble, rock-fragment, or quartz-pebble veneer; in sheets and between dunes
Qw	Low-gradient sheetwash deposits; red-brown sandy and clayey alluvium and colluvium and pebbles on distal outwash fans; no defined drainage; distinctive vegetation; striped photo tone
Qwb	Sheetwash clay and silt in distal outwash fans, with gilgai (crabhole) surface in areas of expansive clay
Qwc	Sheetwash sand, silt and clay in distal outwash fans, with numerous claypans and minor clay-filled drainages
Qwg	Sheetwash sand and quartz pebbles overlying and derived from granitoid rocks
R1tpa	Residual boulders, cobbles and pebbles in clay, silt and sand; includes locally transported material; derived from fluvioglacial Paterson Formation
R2CbVb	Residual and sheetwash clay and silt containing fragments of basalt; expansive clay with gilgai surface; overlies basalt on areas of plateau; locally dissected by present-day drainage
Tb	Mixed siliceous caprock and colluvium; secondary siliceous breccia, jasperoidal chalcedony over ultramafic rocks
Tc	Colluvium; consolidated, ferruginised silt, sand and gravel; dissected by present drainage
Tp	Robe Pisolite; pisolitic, oolitic and massive limonite goethite hematite deposits containing fossil wood fragments; iron ore; correlated with Poondano Formation
W1	Silt, sand and pebbles in distal sheetwash fans; no defined drainage

APPENDIX B

Temperature (°C) and precipitation (mm) estimates for the 304 terrestrial biodiversity sites sampled during the Pilbara biodiversity survey, derived from ANUCLIM (Houlder *et al*. 2000). Key to column labels: Tann Annual mean temperature; **Tdir** Temperature diurnal range; **isoT** isothermality; **Tsea** Temperature seasonality; **mxTwP** Warmest period maximum temperature; **mnTcP** Coldest period minimum temperature; **Tar** Temperature annual range; **TweQ** Wettest quarter mean temperature; **TdrQ** Driest quarter mean temperature; **TwmQ** Warmest quarter mean temperature; **TcoQ** Coldest quarter mean temperature; **Pann** Annual mean precipitation; **PweP** Wettest period precipitation; **Psea** Precipitation seasonality; **PweQ** Wettest Quarter precipitation; **PwmQ** Warmest quarter precipitation; **PcoQ** Coldest quarter precipitation. Further explanation is provided below the tabulation.

Site	Tann	Tdir	isoT	Tsea	mxTwP	mnTcP	Tar	TweQ	TdrQ	TwmQ	TcoQ	Pann	PweP	Psea	PweQ	PwmQ	PcoQ
BDRN01	24.9	15.5	0.48	1.98	39.9	7.7	32.2	31.1	24.8	31.6	16.9	229	14	88	129	112	36
BDRN02	24.6	15.5	0.48	1.99	39.7	7.5	32.2	30.8	24.5	31.3	16.5	237	15	87	133	115	38
BDRN03	24.8	15.6	0.48	1.98	39.8	7.6	32.3	31.0	24.6	31.5	16.7	236	15	88	134	116	37
BDRN04	24.5	15.5	0.48	2.02	39.6	7.2	32.4	30.8	24.3	31.3	16.3	230	15	87	129	112	32
BDRN05	24.2	15.6	0.48	2.02	39.5	7.0	32.5	30.6	24.0	31.1	16.1	249	15	86	139	121	35
BDRN06	24.2	15.5	0.48	2.02	39.4	7.0	32.5	30.5	24.0	31.0	16.0	251	15	86	140	122	35
BDRN07	24.3	15.6	0.48	2.01	39.5	7.1	32.5	30.6	24.1	31.1	16.1	250	15	86	140	122	35
BDRN08	24.3	15.6	0.48	2.01	39.5	7.1	32.5	30.6	24.1	31.1	16.1	251	15	86	141	122	35
BDRN09	24.2	15.6	0.48	2.02	39.4	6.9	32.5	30.5	23.9	31.0	16.0	252	16	86	141	123	35
BDRN10	23.9	15.5	0.48	2.02	39.2	6.8	32.4	30.2	23.7	30.7	15.8	265	16	84	147	129	38
BDRN11	23.8	15.5	0.48	2.02	39.2	6.7	32.4	30.2	23.6	30.7	15.7	268	16	84	149	130	39
BDRN12	23.8	15.4	0.48	2.04	39.2	6.7	32.5	30.3	23.6	30.8	15.6	258	16	85	143	125	37
BDRN13	24.0	15.5	0.48	2.04	39.3	6.8	32.5	30.4	23.8	30.9	15.8	250	16	86	139	122	35
BDRS01	23.5	15.1	0.46	2.10	38.9	6.2	32.7	29.9	23.1	30.7	15.1	248	15	80	131	115	37
BDRS02	23.5	15.1	0.46	2.10	38.9	6.2	32.7	30.2	23.1	30.7	15.1	248	15	80	132	115	37
BDRS03	23.6	15.2	0.46	2.09	39.0	6.3	32.7	30.3	23.2	30.8	15.3	247	15	81	132	115	36
BDRS04	23.6	15.1	0.46	2.09	38.9	6.3	32.7	30.3	23.2	30.7	15.2	247	15	80	132	115	37
BDRS05	23.6	15.1	0.46	2.09	38.9	6.3	32.6	30.3	23.2	30.8	15.3	249	15	81	134	117	37
BDRS06	23.6	15.1	0.46	2.09	38.9	6.3	32.5	30.3	23.2	30.8	15.3	251	15	81	135	118	38
BDRS07	23.6	15.1	0.46	2.09	38.8	6.3	32.5	30.3	23.2	30.7	15.3	253	15	81	136	119	38
BDRS08	23.3	14.9	0.46	2.10	38.6	6.1	32.5	30.1	22.0	30.5	15.0	256	16	80	137	128	40
BDRS09	23.3	14.9	0.46	2.10	38.6	6.1	32.5	30.1	22.9	30.6	15.0	254	15	80	136	126	39

BDRS10	23.4	15.0	0.46	2.10	38.7	6.2	32.5	30.2	23.0	30.6	15.0	252	15	80	135	125	39
BDRS11	23.4	15.0	0.46	2.10	38.7	6.1	32.6	29.8	22.9	30.6	15.0	249	15	79	133	123	38
BDRS12	23.3	15.0	0.46	2.11	38.7	6.0	32.7	29.8	22.9	30.5	14.9	247	14	79	131	120	38
BDRS13	23.5	15.1	0.46	2.09	38.8	6.3	32.6	30.3	23.1	30.7	15.2	250	15	80	134	125	38
DRC01	25.8	12.9	0.53	1.45	36.7	12.2	24.5	30.6	25.4	30.7	19.9	278	17	94	164	154	49
DRC02	25.8	12.9	0.53	1.45	36.7	12.2	24.5	30.6	25.4	30.7	19.9	278	17	94	164	154	49
DRC03	26.0	13.0	0.53	1.45	36.9	12.3	24.7	30.8	25.6	30.9	20.1	276	17	95	164	154	48
DRC04	26.0	13.2	0.53	1.47	37.2	12.1	25.1	30.9	25.6	31.0	20.0	284	18	98	174	166	46
DRC05	26.0	13.4	0.53	1.50	37.4	11.9	25.5	30.9	25.7	31.1	19.9	296	20	103	188	182	44
DRC06	25.6	13.4	0.52	1.54	37.3	11.4	25.9	30.7	24.7	30.8	19.3	317	23	108	207	203	43
DRC07	26.1	13.4	0.53	1.50	37.5	12.0	25.6	31.0	25.8	31.2	20.0	299	20	104	192	186	43
DRC08	26.1	13.3	0.53	1.48	37.2	12.1	25.2	30.9	25.7	31.1	20.0	296	19	101	186	177	45
DRC09	26.0	13.1	0.53	1.47	37.0	12.1	25.0	30.8	25.6	30.9	20.0	294	18	99	182	172	46
DRC10	26.0	13.0	0.53	1.45	36.9	12.2	24.7	30.8	25.6	30.9	20.1	293	18	97	180	168	47
DRC11	25.9	12.9	0.53	1.44	36.7	12.3	24.4	30.7	25.5	30.8	20.1	286	17	96	173	161	48
DRC12	26.0	12.8	0.53	1.43	36.6	12.3	24.3	30.7	25.5	30.8	20.1	284	17	96	171	159	48
DRE01	25.9	13.0	0.53	1.42	36.3	12.0	24.3	30.6	25.6	30.7	20.1	302	20	101	192	178	41
DRE02	25.9	13.0	0.53	1.42	36.3	12.0	24.3	30.6	25.6	30.7	20.1	302	20	101	192	178	41
DRE03	25.8	12.9	0.53	1.41	36.1	11.9	24.2	30.4	25.5	30.5	20.0	304	20	101	192	179	41
DRE04	25.8	12.9	0.53	1.41	36.1	11.9	24.2	30.4	25.5	30.5	20.0	304	20	101	192	179	41
DRE05	25.9	13.0	0.53	1.42	36.2	11.9	24.3	30.5	25.0	30.6	20.0	304	20	101	193	179	41
DRE06	25.9	13.1	0.53	1.43	36.4	11.8	24.5	30.5	25.0	30.7	20.0	304	20	101	193	180	41
DRE07	25.9	13.3	0.53	1.46	36.6	11.6	25.0	30.6	25.0	30.7	19.9	307	20	101	196	184	41
DRE08	26.0	13.6	0.53	1.51	37.4	11.6	25.8	30.9	25.2	31.0	19.8	312	20	102	201	192	41
DRE09	26.0	13.6	0.52	1.51	37.5	11.5	25.9	30.8	25.2	31.0	19.8	314	20	102	203	184	42
DRE10	25.9	13.7	0.52	1.53	37.5	11.4	26.1	30.8	25.1	31.0	19.6	318	21	103	206	188	42
DRE11	26.0	13.7	0.52	1.53	37.7	11.5	26.3	31.0	25.2	31.2	19.8	316	21	104	205	188	41
DRE12	26.0	13.8	0.52	1.53	37.6	11.4	26.2	30.9	25.2	31.1	19.7	315	20	102	204	184	41
DRE13	26.0	13.9	0.52	1.55	37.9	11.3	26.6	30.9	25.2	31.2	19.7	317	20	102	205	186	41
DRW01	25.9	13.1	0.54	1.40	36.7	12.3	24.3	30.6	25.4	30.7	20.2	264	16	91	144	140	49

Site	Tann	Tdir	isoT	Tsea	mxTwP	mnTcP	Tar	TweQ	TdrQ	TwmQ	TcoQ	Pann	PweP	Psea	PweQ	PwmQ	PcoQ
DRW02	25.9	13.1	0.54	1.40	36.7	12.3	24.3	30.6	25.4	30.7	20.2	264	16	91	144	140	49
DRW03	25.9	13.2	0.54	1.41	36.7	12.3	24.4	30.7	25.4	30.7	20.2	264	16	91	145	141	49
DRW04	26.0	13.2	0.53	1.45	37.0	12.2	24.8	30.8	25.5	30.9	20.1	265	16	91	151	140	51
DRW05	26.0	13.2	0.53	1.45	37.0	12.2	24.8	30.8	25.5	30.9	20.1	265	16	92	152	141	50
DRW06	25.8	13.8	0.54	1.45	37.1	11.7	25.4	30.7	25.3	30.8	19.9	273	17	91	148	139	53
DRW07	25.8	13.8	0.54	1.45	37.1	11.7	25.4	30.7	25.3	30.8	19.9	273	17	91	148	139	53
DRW08	25.8	13.8	0.54	1.45	37.1	11.7	25.4	30.7	25.3	30.8	20.0	272	16	91	146	136	53
DRW09	25.6	13.8	0.54	1.45	37.0	11.5	25.4	30.5	25.1	30.6	19.8	277	17	90	148	138	55
DRW10	25.6	13.8	0.54	1.45	37.0	11.5	25.4	30.5	25.1	30.6	19.8	277	17	90	148	138	55
DRW11	25.9	13.8	0.55	1.43	37.0	11.7	25.3	30.7	25.3	30.8	20.1	267	16	91	140	136	53
DRW12	25.9	13.8	0.55	1.43	37.0	11.7	25.2	30.7	25.3	30.8	20.1	267	16	91	140	136	53
DRW13	25.9	13.7	0.55	1.41	36.9	11.9	25.0	30.6	25.2	30.7	20.1	267	15	92	140	135	53
MBE01	26.4	15.5	0.51	1.76	40.8	10.3	30.5	31.9	26.2	32.2	19.2	325	21	100	206	180	42
MBE02	26.1	15.6	0.51	1.76	40.6	10.1	30.5	31.6	25.9	32.0	18.9	329	22	100	209	182	42
MBE03	25.8	15.7	0.51	1.78	40.6	9.7	30.9	31.4	24.7	31.8	18.5	325	21	99	206	181	41
MBE04	25.9	15.8	0.51	1.79	40.6	9.7	31.0	31.5	24.7	31.8	18.6	324	21	99	205	181	40
MBE05	25.8	15.8	0.51	1.79	40.6	9.6	31.0	31.5	24.7	31.8	18.5	323	21	99	204	180	40
MBE06	25.9	15.9	0.51	1.79	40.7	9.6	31.1	31.5	24.7	31.9	18.6	321	21	99	202	180	39
MBE07	26.1	15.9	0.52	1.75	40.7	9.9	30.8	31.6	25.7	32.0	18.9	326	22	101	207	183	40
MBE08	26.1	15.9	0.52	1.74	40.7	9.9	30.7	31.6	25.7	31.9	19.0	328	22	101	209	184	40
MBE09	25.3	15.4	0.51	1.75	39.8	9.5	30.3	30.8	24.9	31.1	18.2	342	23	99	216	191	44
MBE11	25.3	15.3	0.51	1.74	39.7	9.6	30.1	30.8	24.9	31.1	18.2	344	23	100	217	192	44
MBE12	25.5	15.4	0.51	1.73	39.9	9.8	30.1	31.0	25.1	31.3	18.4	343	23	100	217	191	44
MBE13	26.1	15.4	0.52	1.71	40.2	10.3	29.9	31.4	25.7	31.7	19.1	340	24	102	218	190	43
MBW01	25.6	15.1	0.52	1.63	39.0	10.2	28.9	30.9	25.0	31.1	19.0	320	22	103	207	187	40
MBW02	25.6	15.1	0.52	1.63	39.0	10.2	28.9	30.9	25.0	31.1	19.0	320	22	103	207	187	40
MBW03	25.5	15.2	0.52	1.65	39.1	10.0	29.1	30.8	24.9	31.0	18.8	324	22	103	208	190	40
MBW04	25.6	15.3	0.52	1.65	39.3	10.1	29.2	31.0	25.0	31.2	18.9	321	22	103	206	188	40
MBW05	25.5	15.3	0.52	1.65	39.2	10.0	29.3	30.8	24.9	31.1	18.8	323	22	102	208	190	40
MBW06	25.7	15.4	0.52	1.66	39.5	10.0	29.4	31.0	25.0	31.3	18.9	320	22	102	206	188	39

MBW07	25.8	15.1	0.53	1.62	39.1	10.3	28.7	31.0	25.1	31.2	19.2	315	21	103	203	183	39
MBW08	25.8	15.0	0.53	1.62	39.0	10.4	28.6	31.1	25.1	31.2	19.2	314	21	102	203	181	39
MBW09	25.8	15.2	0.52	1.64	39.2	10.3	28.9	31.1	25.1	31.3	19.1	316	21	102	203	183	39
MBW10	25.7	15.5	0.52	1.68	39.7	10.0	29.7	31.1	25.1	31.4	18.9	318	20	101	204	187	39
MBW11	25.6	15.6	0.52	1.70	39.9	9.9	30.0	31.1	25.0	31.4	18.7	320	20	101	205	189	39
MBW12	25.6	15.7	0.52	1.71	40.0	9.8	30.2	31.1	25.0	31.4	18.6	320	20	100	204	189	38
MBW13	25.6	15.7	0.52	1.72	40.2	9.8	30.4	31.2	25.0	31.5	18.6	319	20	100	204	189	38
NE01	26.3	15.4	0.51	1.74	40.5	10.2	30.3	31.7	26.2	32.0	19.1	302	18	98	190	166	37
NE02	26.3	15.4	0.51	1.74	40.5	10.2	30.3	31.6	26.2	32.0	19.1	303	18	98	190	166	37
NE03	26.1	15.4	0.51	1.76	40.3	9.9	30.4	31.4	25.9	31.8	18.8	304	18	96	189	165	38
NE04	26.0	15.4	0.50	1.77	40.3	9.7	30.6	31.5	25.9	31.8	18.7	294	17	94	180	156	38
NE05	26.0	15.4	0.51	1.77	40.3	9.7	30.6	31.5	25.9	31.8	18.7	293	17	94	179	156	38
NE06	26.1	15.4	0.51	1.76	40.2	9.8	30.5	31.5	26.0	31.8	18.8	289	17	94	176	153	38
NE07	26.2	15.4	0.51	1.75	40.3	9.9	30.4	31.5	26.1	31.9	18.9	289	17	94	176	153	38
NE08	26.1	15.4	0.51	1.76	40.2	9.8	30.4	31.5	26.0	31.9	18.9	285	17	93	172	149	38
NE09	26.2	15.4	0.51	1.76	40.3	9.9	30.4	31.6	26.1	31.9	18.9	282	16	93	170	147	37
NE10	26.3	15.4	0.51	1.75	40.3	9.9	30.4	31.6	26.2	32.0	19.0	279	16	93	169	146	37
NE11	25.7	15.2	0.50	1.76	39.7	9.5	30.2	31.0	24.8	31.4	18.4	291	16	90	171	148	41
NE12	25.7	15.2	0.50	1.76	39.7	9.5	30.1	31.1	24.8	31.4	18.4	289	16	90	170	147	41
NE13	25.7	15.2	0.50	1.76	39.7	9.6	30.1	31.1	24.9	31.5	18.5	288	16	90	170	147	40
NW01	24.7	16.3	0.50	1.96	40.2	7.3	32.9	30.8	24.5	31.3	16.8	308	16	88	179	160	44
NW02	24.6	16.3	0.50	1.96	40.1	7.3	32.9	30.7	24.4	31.2	16.7	312	17	88	182	163	44
NW03	24.9	16.3	0.50	1.92	40.3	7.7	32.6	30.9	23.8	31.3	17.1	315	18	92	189	170	41
NW04	25.0	16.1	0.50	1.90	40.2	8.1	32.1	30.9	23.9	31.3	17.3	317	19	93	192	171	42
NW05	25.1	16.1	0.50	1.90	40.3	8.2	32.2	31.0	24.1	31.5	17.4	313	18	93	190	169	41
NW06	25.0	16.0	0.50	1.89	40.2	8.2	32.0	30.8	23.9	31.3	17.3	320	19	93	194	173	42
NW07	25.3	15.7	0.50	1.85	40.2	8.8	31.4	31.0	24.3	31.4	17.7	318	19	95	196	174	41
NW08	25.4	15.7	0.50	1.84	40.3	9.0	31.3	31.1	24.4	31.5	17.9	317	19	96	197	174	41
NW09	25.8	15.7	0.50	1.82	40.6	9.3	31.3	31.4	24.7	31.8	18.3	312	20	98	196	173	39
NW10	25.7	15.8	0.50	1.83	40.5	9.2	31.3	31.3	24.6	31.7	18.2	313	19	98	196	173	39
NW11	25.8	15.6	0.50	1.81	40.5	9.5	31.1	31.4	24.8	31.8	18.4	312	19	98	197	173	39

Site	Tann	Tdir	isoT	Tsea	mxTwP	mnTcP	Tar	TweQ	TdrQ	TwmQ	TcoQ	Pann	PweP	Psea	PweQ	PwmQ	PcoQ
NW12	26.0	15.6	0.50	1.80	40.6	9.6	31.0	31.5	25.0	31.9	18.6	311	19	99	197	173	39
OYE01	26.1	14.7	0.52	1.63	39.6	11.3	28.3	31.6	25.2	31.7	19.5	344	21	93	203	191	59
OYE02	25.9	14.6	0.52	1.64	39.4	11.1	28.2	31.4	25.0	31.5	19.3	349	22	93	207	196	59
OYE03	25.6	14.5	0.51	1.65	39.1	10.9	28.2	31.1	24.7	31.2	18.9	356	22	93	211	201	60
OYE04	25.6	14.4	0.51	1.67	39.1	10.8	28.3	31.1	24.7	31.3	18.8	354	23	95	213	207	55
OYE05	25.6	14.4	0.51	1.67	39.1	10.8	28.3	31.1	24.7	31.3	18.8	354	23	95	213	207	55
OYE06	25.6	14.4	0.51	1.68	39.2	10.7	28.4	31.2	24.7	31.3	18.8	354	23	95	213	208	54
OYE07	25.6	14.4	0.51	1.68	39.2	10.7	28.4	31.2	24.7	31.3	18.8	354	23	95	213	208	54
OYE08	25.6	14.6	0.51	1.70	39.4	10.6	28.8	31.3	24.7	31.4	18.7	358	23	93	213	206	57
OYE09	25.9	14.8	0.51	1.69	39.8	10.8	29.0	31.6	25.0	31.7	19.1	351	22	92	207	198	58
OYE10	25.9	14.8	0.51	1.69	39.8	10.8	29.0	31.6	25.0	31.7	19.1	351	22	92	207	198	58
OYE11	26.0	14.9	0.51	1.68	40.0	10.9	29.0	31.7	25.1	31.8	19.2	348	22	92	205	195	58
OYE12	26.1	14.9	0.52	1.67	40.0	11.1	28.9	31.6	25.2	31.8	19.4	340	21	91	199	187	58
OYE13	25.5	14.7	0.50	1.71	39.6	10.5	29.1	31.3	24.6	31.4	18.7	356	22	91	208	198	61
OYW01	25.9	14.8	0.52	1.64	39.6	11.0	28.6	31.3	25.4	31.5	19.3	328	20	92	189	182	62
OYW02	25.9	14.7	0.52	1.62	39.5	11.1	28.4	31.3	25.3	31.5	19.4	323	20	94	187	179	62
OYW03	25.8	14.6	0.52	1.61	39.3	11.2	28.1	31.2	25.3	31.4	19.4	320	20	94	185	177	62
OYW04	25.6	14.4	0.52	1.59	38.9	11.2	27.7	31.0	25.0	31.2	19.3	321	20	95	184	175	64
OYW05	25.6	14.4	0.52	1.58	38.9	11.2	27.6	31.0	25.0	31.2	19.3	321	20	95	184	174	64
OYW06	25.7	14.4	0.52	1.58	38.8	11.3	27.5	31.0	25.0	31.2	19.4	318	20	95	182	172	64
OYW07	25.9	14.4	0.53	1.55	38.8	11.5	27.3	31.2	25.3	31.3	19.7	306	19	93	174	163	61
OYW08	25.9	14.4	0.53	1.55	38.7	11.5	27.2	31.2	25.4	31.3	19.7	305	18	93	173	162	61
OYW09	25.9	14.4	0.53	1.54	38.7	11.5	27.2	31.2	25.4	31.3	19.7	303	18	93	172	161	61
OYW10	25.7	14.1	0.53	1.54	38.5	11.6	26.8	31.0	25.0	31.1	19.6	311	19	95	175	163	66
OYW11	25.6	13.8	0.53	1.50	38.0	11.9	26.1	30.8	25.5	30.9	19.7	307	18	94	169	155	60
OYW12	25.5	13.5	0.53	1.48	37.7	12.1	25.6	30.7	25.3	30.7	19.6	307	18	93	165	150	63
OYW13	25.4	13.3	0.53	1.46	37.4	12.2	25.2	30.5	25.2	30.6	19.6	305	17	93	160	155	66
PE01	25.6	14.0	0.49	1.74	39.1	10.5	28.6	31.2	25.0	31.4	18.5	349	23	102	225	206	46
PE02	25.2	13.9	0.49	1.76	38.8	10.2	28.6	30.9	24.6	31.1	18.1	357	23	101	227	210	48
PE03	25.6	14.0	0.49	1.75	39.2	10.5	28.7	31.2	25.0	31.5	18.5	351	23	102	226	208	46

PE04	25.3	13.9	0.49	1.74	38.8	10.4	28.5	30.9	24.8	31.2	18.3	352	23	102	226	207	46
PE05	25.5	14.0	0.49	1.76	39.2	10.4	28.8	31.2	25.0	31.4	18.4	345	22	101	221	204	44
PE06	25.4	13.9	0.49	1.76	39.0	10.3	28.7	31.0	24.8	31.2	18.2	349	22	101	223	206	45
PE07	25.3	13.9	0.49	1.74	38.8	10.4	28.5	30.9	24.8	31.2	18.3	352	23	102	226	207	46
PE08	25.3	13.9	0.49	1.74	38.8	10.4	28.4	30.9	24.8	31.2	18.3	355	24	102	228	210	47
PE09	25.1	13.9	0.49	1.72	38.5	10.3	28.2	30.7	24.5	30.9	18.1	368	24	103	238	220	48
PE10	24.9	13.8	0.49	1.72	38.2	10.2	28.0	30.5	24.3	30.7	18.0	380	25	104	246	229	50
PE11	25.4	14.0	0.49	1.74	39.0	10.4	28.6	31.1	24.8	31.3	18.4	365	24	103	235	218	48
PE12	25.0	13.8	0.48	1.79	38.9	10.0	28.9	30.8	24.5	31.1	17.8	357	22	98	223	207	49
PHYC01	26.9	13.7	0.52	1.47	39.1	12.8	26.3	31.4	26.5	31.5	20.7	327	23	104	212	202	38
PHYC02	26.9	13.7	0.52	1.48	39.1	12.8	26.4	31.5	26.6	31.6	20.7	327	23	104	212	202	38
PHYC03	27.0	13.7	0.52	1.49	39.4	12.9	26.5	31.5	26.7	31.7	20.8	327	23	105	213	203	38
PHYC04	26.8	14.7	0.51	1.65	40.5	11.5	28.9	31.9	26.6	32.2	20.0	330	22	103	214	186	38
PHYC05	27.0	14.8	0.51	1.65	40.6	11.6	29.0	32.1	26.8	32.3	20.2	327	22	104	212	183	38
PHYC06	26.9	14.6	0.52	1.62	40.1	11.7	28.4	31.9	26.6	32.1	20.2	331	23	104	214	196	39
PHYC07	26.8	14.8	0.52	1.64	40.2	11.5	28.7	31.9	26.5	32.1	20.0	331	23	104	214	196	39
PHYC08	26.7	14.8	0.52	1.64	40.2	11.4	28.8	31.9	26.5	32.1	19.9	332	23	103	214	197	40
PHYC09	26.8	14.8	0.52	1.63	40.1	11.5	28.6	31.9	26.5	32.1	20.0	331	23	104	214	196	39
PHYC10	26.8	14.8	0.52	1.64	40.1	11.4	28.7	31.9	26.5	32.1	20.0	331	23	104	214	196	39
PHYC11	26.3	14.6	0.51	1.63	39.6	11.2	28.4	31.4	26.0	31.6	19.5	339	24	103	218	200	41
PHYC12	26.7	14.7	0.52	1.61	39.8	11.5	28.3	31.8	26.4	32.0	20.1	329	24	104	213	194	39
PHYE01	26.6	14.8	0.52	1.57	39.6	11.3	28.3	31.4	26.4	31.6	20.0	315	19	101	203	174	35
PHYE02	26.5	14.8	0.52	1.58	39.6	11.1	28.4	31.3	26.3	31.5	19.9	314	19	101	202	173	35
PHYE03	26.5	14.9	0.52	1.59	39.6	11.1	28.6	31.4	26.4	31.6	19.9	311	19	101	200	171	35
PHYE04	26.6	14.9	0.52	1.58	39.7	11.2	28.5	31.4	26.4	31.6	20.0	311	19	101	200	171	35
PHYE05	26.7	15.0	0.52	1.62	40.0	11.1	28.9	31.6	26.5	31.9	20.0	303	18	100	194	167	34
PHYE06	26.7	15.0	0.52	1.62	40.0	11.1	28.9	31.6	26.5	31.9	20.0	304	19	100	195	168	34
PHYE07	26.6	15.1	0.52	1.64	40.1	10.9	29.2	31.6	26.5	31.9	19.8	300	18	99	190	164	35
PHYE08	26.7	14.9	0.52	1.62	40.1	11.2	28.9	31.6	26.5	31.8	19.9	308	19	101	198	170	35
PHYE09	26.3	14.8	0.51	1.65	40.0	10.9	29.1	31.4	26.2	31.6	19.5	319	19	99	203	176	38
PHYE10	26.9	14.7	0.51	1.61	40.3	11.6	28.7	31.7	26.7	32.0	20.2	315	20	103	205	177	35

Site	Tann	Tdir	isoT	Tsea	mxTwP	mnTcP	Tar	TweQ	TdrQ	TwmQ	TcoQ	Pann	PweP	Psea	PweQ	PwmQ	PcoQ
PHYE11	27.1	14.5	0.51	1.58	40.5	12.1	28.4	32.0	26.9	32.2	20.5	318	21	105	209	180	35
PHYE12	27.2	14.4	0.51	1.57	40.5	12.4	28.1	32.0	27.0	32.2	20.6	321	22	106	212	182	35
PHYE13	27.3	14.3	0.51	1.57	40.5	12.5	28.0	32.0	27.1	32.2	20.7	321	22	106	212	183	35
PHYW01	26.4	13.1	0.54	1.37	36.7	12.6	24.2	30.7	26.4	30.8	20.7	294	21	104	189	182	35
PHYW02	26.4	13.2	0.54	1.38	36.8	12.5	24.3	30.7	26.4	30.8	20.6	294	21	104	189	183	35
PHYW03	26.4	13.4	0.54	1.42	37.2	12.4	24.8	30.9	25.9	31.0	20.6	297	21	103	190	185	35
PHYW04	26.5	13.6	0.53	1.45	37.6	12.3	25.3	31.0	26.0	31.2	20.5	304	21	103	194	189	35
PHYW05	26.5	13.6	0.53	1.46	37.7	12.2	25.5	31.1	26.0	31.2	20.5	305	21	103	195	191	35
PHYW06	26.6	13.6	0.53	1.45	37.9	12.4	25.5	31.0	26.1	31.2	20.5	310	21	101	197	192	38
PHYW07	26.3	13.5	0.54	1.45	37.3	12.0	25.3	30.9	26.4	31.0	20.3	290	24	110	190	186	33
PHYW08	26.0	13.4	0.53	1.45	37.0	11.8	25.2	30.6	26.1	30.7	20.0	292	24	111	191	188	34
PHYW09	26.2	13.5	0.54	1.45	37.1	11.9	25.2	30.8	26.2	30.9	20.2	290	24	111	191	186	33
PHYW10	26.1	13.4	0.54	1.44	36.8	11.9	24.9	30.7	26.1	30.8	20.2	291	23	110	191	185	34
PHYW11	26.0	13.2	0.54	1.42	36.4	11.8	24.6	30.5	25.9	30.7	20.1	294	23	108	192	183	37
PHYW12	25.9	13.4	0.54	1.44	36.6	11.7	24.9	30.5	25.2	30.7	20.0	295	23	108	193	184	38
PHYW13	26.0	13.2	0.54	1.42	36.3	11.8	24.6	30.5	25.2	30.6	20.1	294	22	107	192	183	37
PW01	26.0	14.0	0.51	1.61	38.5	11.3	27.2	31.3	25.2	31.4	19.5	336	25	111	224	216	41
PW02	25.8	13.9	0.51	1.61	38.3	11.2	27.1	31.1	25.0	31.2	19.3	338	26	111	225	217	42
PW03	25.0	13.6	0.51	1.63	37.6	10.7	26.9	30.3	24.2	30.5	18.4	356	26	106	228	222	48
PW04	25.1	13.7	0.51	1.63	37.8	10.7	27.1	30.5	24.3	30.6	18.5	357	26	105	228	223	48
PW05	25.6	14.1	0.51	1.66	38.7	10.8	27.9	31.1	24.8	31.2	18.9	352	24	100	219	214	48
PW06	25.4	14.2	0.50	1.68	38.8	10.6	28.2	31.0	24.6	31.1	18.6	356	24	97	218	214	51
PW07	25.5	14.2	0.50	1.68	38.8	10.7	28.1	31.0	24.7	31.2	18.7	356	24	99	221	216	50
PW08	25.6	14.1	0.50	1.67	38.8	10.7	28.0	31.1	24.7	31.2	18.8	355	24	100	222	216	49
PW09	25.6	14.1	0.51	1.66	38.7	10.8	27.9	31.1	24.8	31.2	18.9	352	24	100	219	214	48
PW10	25.5	14.1	0.51	1.66	38.7	10.8	27.9	31.0	24.7	31.2	18.8	352	24	100	220	215	48
PW11	25.2	14.0	0.50	1.66	38.3	10.6	27.7	30.7	24.4	30.8	18.5	359	25	100	222	218	50
PW12	25.2	13.8	0.51	1.63	37.9	10.7	27.2	30.6	24.3	30.7	18.6	349	25	103	220	215	49
PW13	26.1	14.0	0.52	1.60	38.5	11.4	27.1	31.4	25.3	31.5	19.6	331	25	112	222	214	40
RHNC01	23.1	14.3	0.45	2.06	38.3	6.7	31.6	29.8	22.5	30.2	14.9	301	17	80	163	154	47

RHNC02	23.1	14.3	0.45	2.06	38.2	6.8	31.5	29.8	22.5	30.2	14.9	305	17	81	166	157	47
RHNC03	23.1	14.2	0.45	2.05	38.2	6.8	31.4	29.7	22.5	30.2	14.9	308	18	81	168	160	48
RHNC04	23.1	14.2	0.45	2.05	38.2	6.8	31.4	29.7	22.5	30.1	14.9	309	18	82	169	161	48
RHNC05	23.1	14.3	0.46	2.05	38.1	6.8	31.3	29.9	22.5	30.1	14.9	310	18	82	170	163	47
RHNC06	23.1	14.3	0.46	2.04	38.2	6.9	31.3	30.0	22.6	30.2	15.0	309	18	82	170	163	47
RHNC07	23.2	14.3	0.46	2.04	38.2	6.9	31.3	30.0	22.7	30.2	15.1	310	18	83	172	165	47
RHNC08	23.4	14.2	0.46	2.02	38.3	7.3	31.1	30.1	22.8	30.3	15.3	311	18	84	173	167	47
RHNC09	23.0	14.2	0.46	2.03	38.0	7.0	31.1	29.7	22.5	29.9	14.9	319	19	84	178	172	49
RHNC10	24.1	14.5	0.47	1.99	39.1	7.9	31.2	30.7	23.6	31.0	16.1	296	18	89	171	156	44
RHNC11	24.2	14.6	0.47	1.99	39.2	7.9	31.3	30.8	23.7	31.0	16.2	294	18	89	171	155	44
RHNC12	24.3	14.7	0.47	1.98	39.4	8.1	31.3	30.9	23.9	31.1	16.4	290	18	90	169	153	43
RHNC13	24.4	14.7	0.47	1.98	39.5	8.1	31.4	30.9	23.9	31.2	16.5	288	18	90	168	152	43
RHNE01	24.6	15.2	0.47	1.99	40.0	7.9	32.1	30.9	24.2	31.5	16.6	275	17	87	157	141	45
RHNE02	24.6	15.2	0.47	1.99	40.0	7.9	32.1	30.9	24.2	31.5	16.6	277	17	87	158	141	45
RHNE03	24.7	15.4	0.48	1.98	40.1	7.9	32.2	31.0	24.3	31.6	16.7	274	17	87	156	140	44
RHNE04	24.7	15.4	0.48	1.99	40.1	7.8	32.3	31.0	24.3	31.5	16.7	273	17	86	155	138	43
RHNE05	24.6	15.5	0.48	1.99	40.1	7.7	32.4	31.0	23.4	31.5	16.7	271	17	86	154	137	43
RHNE06	24.6	15.6	0.48	2.00	40.0	7.6	32.4	30.9	23.4	31.5	16.6	269	17	85	152	135	42
RHNE07	24.8	15.6	0.48	1.97	40.2	7.9	32.3	31.0	24.4	31.5	16.8	279	17	88	161	144	42
RHNE08	24.4	15.7	0.48	1.99	39.9	7.4	32.5	30.6	24.0	31.2	16.4	283	17	86	162	144	39
RHNE09	24.2	15.7	0.48	1.99	39.7	7.3	32.5	30.5	23.9	31.0	16.2	290	17	86	165	148	40
RHNE10	24.2	15.8	0.49	1.96	39.7	7.4	32.3	30.6	23.9	30.8	16.3	310	18	89	181	164	41
RHNE11	24.2	15.7	0.49	1.94	39.7	7.7	32.0	30.5	23.9	30.8	16.4	312	18	90	184	167	42
RHNE12	24.7	15.8	0.49	1.93	40.1	8.0	32.0	31.0	24.3	31.2	16.9	304	18	91	181	164	40
RHNW01	23.6	14.0	0.46	1.94	38.4	8.2	30.2	29.9	23.1	30.2	15.8	333	20	91	197	181	47
RHNW02	23.8	14.1	0.47	1.93	38.6	8.4	30.3	30.1	23.3	30.3	16.0	328	20	91	195	179	46
RHNW03	25.0	14.6	0.48	1.89	39.8	9.3	30.5	31.1	24.6	31.5	17.4	305	19	93	184	164	41
RHNW04	25.3	14.6	0.48	1.86	40.0	9.7	30.3	31.2	24.8	31.6	17.8	309	19	94	188	165	40
RHNW05	25.3	14.6	0.48	1.86	39.9	9.7	30.2	31.2	24.8	31.6	17.8	311	19	94	189	166	41
RHNW06	25.2	14.6	0.48	1.86	39.9	9.7	30.3	31.1	24.8	31.6	17.7	310	19	94	189	166	40
RHNW07	25.1	14.6	0.48	1.85	39.8	9.7	30.1	30.9	24.6	31.3	17.6	316	19	93	192	168	41

Site	Tann	Tdir	isoT	Tsea	mxTwP	mnTcP	Tar	TweQ	TdrQ	TwmQ	TcoQ	Pann	PweP	Psea	PweQ	PwmQ	PcoQ
RHNW08	24.6	14.4	0.48	1.83	39.3	9.5	29.8	30.5	24.2	30.9	17.3	330	19	93	200	186	43
RHNW09	24.8	14.5	0.49	1.82	39.5	9.7	29.8	30.6	24.3	31.0	17.5	328	19	93	199	184	42
RHNW10	24.9	14.5	0.49	1.83	39.6	9.6	29.9	30.7	24.4	31.1	17.5	323	19	93	196	182	42
RHNW11	25.2	14.7	0.48	1.86	40.0	9.6	30.3	31.1	24.7	31.5	17.7	309	18	93	188	165	40
RHNW12	25.3	14.6	0.48	1.86	40.0	9.7	30.3	31.2	24.9	31.7	17.8	307	19	94	187	164	40
RHNW13	25.3	14.6	0.48	1.87	40.0	9.6	30.3	31.2	24.8	31.6	17.7	307	19	94	187	165	40
TCMBC01	25.6	14.8	0.46	1.97	41.0	8.9	32.1	32.0	25.4	32.6	17.7	239	12	73	122	109	48
TCMBC02	25.5	14.8	0.46	1.98	40.9	8.9	32.0	31.9	25.4	32.5	17.7	241	12	73	123	110	48
TCMBC03	25.2	14.6	0.46	1.99	40.6	8.7	31.9	31.6	25.1	32.2	17.3	250	13	74	128	115	49
TCMBC04	24.9	14.5	0.46	2.00	40.2	8.4	31.8	31.2	24.8	31.9	16.9	259	13	74	132	120	51
TCMBC05	24.4	14.3	0.45	2.00	39.8	8.1	31.6	30.8	23.5	31.5	16.4	269	14	73	137	125	52
TCMBC06	24.3	14.4	0.45	2.02	39.7	7.9	31.8	30.7	23.3	31.4	16.2	260	13	71	129	118	53
TCMBC07	24.8	14.5	0.46	2.01	40.3	8.3	32.0	31.3	24.7	31.9	16.9	250	13	73	126	114	50
TCMBC08	25.0	14.5	0.46	2.00	40.3	8.4	31.9	31.4	24.9	32.0	17.0	255	14	75	132	119	49
TCMBC09	24.8	14.5	0.46	2.00	40.1	8.4	31.7	31.2	24.8	31.8	16.8	263	14	76	137	123	50
TCMBC10	24.9	14.4	0.46	2.00	40.1	8.5	31.6	31.2	24.9	31.9	16.9	268	15	78	141	127	49
TCMBC11	24.8	14.4	0.46	2.00	40.0	8.4	31.6	31.1	24.8	31.8	16.8	270	15	78	142	129	49
TCMBC12	24.7	14.4	0.46	2.00	39.9	8.4	31.6	31.1	24.8	31.7	16.7	272	15	78	143	130	49
TCMBE01	23.6	13.3	0.45	1.92	38.0	8.6	29.5	29.9	23.1	30.1	15.9	377	21	86	218	211	54
TCMBE02	23.8	13.4	0.45	1.92	38.2	8.7	29.5	30.1	23.3	30.3	16.0	374	20	86	216	209	53
TCMBE03	23.7	13.4	0.45	1.93	38.2	8.6	29.6	30.1	23.3	30.2	16.0	372	20	86	214	207	54
TCMBE04	23.7	13.4	0.45	1.93	38.2	8.6	29.6	30.1	23.2	30.2	16.0	373	20	86	214	208	54
TCMBE05	23.0	13.2	0.45	1.94	37.5	8.1	29.4	29.4	22.5	29.6	15.2	386	20	84	218	213	57
TCMBE06	24.0	13.5	0.45	1.92	38.5	8.8	29.7	30.4	23.5	30.5	16.3	370	20	86	214	206	52
TCMBE07	24.0	13.6	0.45	1.94	38.6	8.7	29.9	30.4	23.5	30.6	16.2	365	20	85	209	201	53
TCMBE08	23.8	13.5	0.45	1.94	38.4	8.5	29.9	30.2	23.3	30.4	16.0	367	20	84	208	201	54
TCMBE09	23.8	13.4	0.45	1.92	38.3	8.7	29.6	30.2	23.3	30.3	16.1	373	20	87	216	207	52
TCMBE10	23.2	13.3	0.45	1.93	37.8	8.3	29.5	29.6	22.7	29.8	15.5	375	20	84	213	205	55
TCMBE11	23.4	13.4	0.45	1.93	38.1	8.3	29.7	29.8	22.8	30.0	15.7	363	19	83	204	196	55
TCMBE12	23.4	13.5	0.45	1.93	38.1	8.3	29.8	29.9	22.8	30.0	15.7	360	19	83	201	193	55

TCMBE13	23.7	13.6	0.45	1.93	38.4	8.5	30.0	30.2	23.1	30.3	16.0	348	18	83	194	186	53
TCMBW01	25.2	14.5	0.47	1.90	40.2	9.3	30.9	31.6	24.4	31.8	17.6	288	15	80	156	143	50
TCMBW02	25.2	14.5	0.47	1.90	40.2	9.2	31.0	31.6	24.3	31.8	17.6	286	15	80	155	142	50
TCMBW03	25.1	14.3	0.47	1.91	40.0	9.2	30.8	31.4	24.3	31.7	17.4	291	16	80	158	146	49
TCMBW04	25.0	14.3	0.46	1.91	39.9	9.2	30.7	31.3	24.2	31.6	17.4	293	16	80	159	147	49
TCMBW05	24.8	14.2	0.46	1.90	39.6	9.1	30.5	31.1	24.0	31.4	17.2	299	16	81	164	152	49
TCMBW06	24.6	14.0	0.46	1.90	39.3	9.1	30.2	30.8	23.9	31.1	17.0	305	17	82	169	158	48
TCMBW07	24.2	13.7	0.46	1.88	38.7	9.0	29.7	30.3	23.5	30.6	16.6	332	18	85	188	178	51
TCMBW08	24.3	13.7	0.46	1.88	38.8	9.1	29.7	30.4	23.7	30.7	16.7	335	18	86	193	182	50
TCMBW09	24.4	13.9	0.47	1.85	38.8	9.3	29.6	30.5	23.7	30.7	17.0	341	18	86	196	181	54
TCMBW10	24.5	13.8	0.47	1.85	38.8	9.3	29.5	30.5	23.8	30.8	17.0	344	19	87	200	185	53
TCMBW11	24.5	13.9	0.47	1.84	38.9	9.4	29.5	30.5	23.8	30.8	17.1	345	19	87	201	186	54
TCMBW12	24.6	13.9	0.47	1.84	38.9	9.4	29.5	30.6	23.9	30.8	17.2	347	19	88	202	187	54
TCMBW13	24.0	13.7	0.47	1.85	38.3	9.0	29.2	30.0	23.3	30.2	16.5	358	20	86	207	192	57
WYE01	25.4	15.0	0.48	1.85	40.7	9.5	31.2	31.5	24.2	31.9	18.0	304	17	82	165	155	59
WYE02	25.6	15.1	0.48	1.84	40.9	9.7	31.2	31.7	24.5	32.1	18.3	300	17	83	163	153	58
WYE03	25.8	15.2	0.49	1.82	41.0	9.8	31.2	31.9	24.6	32.2	18.5	297	17	84	163	152	58
WYE04	25.9	15.3	0.49	1.81	41.1	10.0	31.1	32.0	24.7	32.3	18.7	293	17	85	162	150	59
WYE05	25.5	15.2	0.50	1.78	40.6	10.0	30.6	31.5	25.0	31.8	18.5	301	18	87	166	154	63
WYE06	25.9	15.2	0.50	1.72	40.6	10.5	30.1	31.7	25.3	32.0	19.0	299	18	91	169	155	62
WYE07	25.6	15.1	0.50	1.72	40.3	10.4	29.9	31.5	25.0	31.7	18.8	304	19	91	170	164	64
WYE08	25.8	15.1	0.50	1.76	40.5	10.3	30.3	31.6	25.3	31.9	18.7	316	19	89	178	167	62
WYE09	25.2	14.9	0.49	1.78	40.0	9.8	30.2	31.1	24.0	31.4	18.1	331	20	86	184	173	65
WYE10	25.2	14.9	0.49	1.77	40.0	9.9	30.2	31.1	24.1	31.4	18.1	332	20	86	184	174	65
WYE11	25.6	15.0	0.50	1.77	40.4	10.1	30.3	31.6	24.5	31.8	18.5	332	20	87	186	176	62
WYE12	25.6	15.0	0.50	1.77	40.4	10.1	30.3	31.6	24.5	31.8	18.5	333	20	86	187	177	62
WYE13	25.8	15.1	0.50	1.78	40.5	10.2	30.4	31.8	24.7	32.0	18.6	331	20	86	186	176	61
WYW01	25.4	14.5	0.52	1.61	39.0	11.0	28.1	30.9	24.7	31.1	19.0	322	20	95	184	175	67
WYW02	25.5	14.5	0.52	1.62	39.2	11.0	28.2	31.0	24.8	31.2	19.1	320	20	96	183	174	66
WYW03	25.5	14.6	0.51	1.63	39.3	10.9	28.3	31.0	24.8	31.2	19.0	317	20	95	180	171	67
WYW04	25.3	14.5	0.51	1.63	39.2	10.8	28.4	30.9	24.6	31.1	18.8	319	20	94	180	172	68

Site	Tann	Tdir	isoT	Tsea	mxTwP	mnTcP	Tar	TweQ	TdrQ	TwmQ	TcoQ	Pann	PweP	Psea	PweQ	PwmQ	PcoQ
WYW05	25.3	14.5	0.51	1.63	39.2	10.8	28.4	30.9	24.6	31.1	18.8	319	20	94	180	172	68
WYW06	25.3	14.6	0.51	1.64	39.3	10.7	28.5	30.9	24.5	31.1	18.8	314	19	92	174	166	70
WYW07	25.5	14.6	0.51	1.63	39.4	10.9	28.5	31.1	24.7	31.3	19.0	308	19	92	170	161	70
WYW08	25.0	14.9	0.50	1.71	39.7	10.1	29.6	30.9	24.3	31.1	18.3	306	18	88	165	158	72
WYW09	25.6	15.1	0.51	1.70	40.2	10.5	29.7	31.5	24.9	31.7	18.9	297	18	90	164	157	67
WYW10	25.6	15.1	0.51	1.70	40.2	10.5	29.7	31.5	24.9	31.7	18.9	297	18	90	164	157	66
WYW11	25.4	15.5	0.50	1.77	40.8	9.9	31.0	31.5	24.5	31.8	18.4	276	16	86	145	139	67
WYW12	25.2	15.4	0.49	1.79	40.8	9.6	31.2	31.4	24.3	31.6	18.1	274	16	85	143	137	67

1. **Tann** The mean of all the weekly mean temperatures. Each weekly mean temperature is the mean of that week's maximum and minimum temperature.
2. **Tdir** The mean of all the weekly diurnal temperature ranges. Each weekly diurnal range is the difference between that week's maximum and minimum temperature.
3. **isoT** The mean diurnal range (parameter 2) divided by the Annual Temperature Range (parameter 7).
4. **Tsea** The temperature Coefficient of Variation (C of V) is the standard deviation of the weekly mean temperatures expressed as a percentage of the mean of those temperatures (i.e. the annual mean). For this calculation, the mean in degrees Kelvin is used. This avoids the possibility of having to divide by zero, but does mean that the values are usually quite small.
5. **mxTwP** The highest temperature of any weekly maximum temperature.
6. **mnTcP** The lowest temperature of any weekly minimum temperature.
7. **Tar** The difference between the Max Temperature of Warmest Period and the Min Temperature of Coldest Period.
8. **TweQ** The wettest quarter of the year is determined (to the nearest week), and the mean temperature of this period is calculated.
9. **TdrQ** The driest quarter of the year is determined (to the nearest week), and the mean temperature of this period is calculated.
10. **TwmQ** The warmest quarter of the year is determined (to the nearest week), and the mean temperature of this period is calculated.
11. **TcoQ** The coldest quarter of the year is determined (to the nearest week), and the mean temperature of this period is calculated.
12. **Pann** The sum of all the monthly precipitation estimates.
13. **PweP** The precipitation of the wettest week or month, depending on the time step.
14. **Psea** The Coefficient of Variation (C of V) is the standard deviation of the weekly precipitation estimates expressed as a percentage of the mean of those estimates (i.e. the annual mean).
15. **PweQ** The wettest quarter of the year is determined (to the nearest week), and the total precipitation over this period is calculated.
16. **PwmQ** The warmest quarter of the year is determined (to the nearest week), and the total precipitation over this period is calculated.
17. **PcoQ** The coldest quarter of the year is determined (to the nearest week), and the total precipitation over this period is calculated.

APPENDIX C

Soil chemical data for the 304 terrestrial biodiversity sites sampled during the Pilbara biodiversity survey. See below for descriptions of analysis methods and units. Reported values of <0.02 for exchangeable cations were treated as 0.01 me% for all statistical/multivariate analyses Site locations are provided in **Appendix A**.

Site	EC	pH	Sand	Silt	Clay	orgC	totN	totP	totK	P	exMethod	exCa	exMg	exNa	exK
BDRN01	1	5.6	95	1.5	3.5	0.08	0.006	44	0.15	1	a	0.3	0.14	0.04	0.06
BDRN02	2	5.2	79	7.5	13.5	0.28	0.02	250	0.39	10	a	0.56	0.23	0.01	0.18
BDRN03	1	5.8	86.5	4	9.5	0.17	0.017	110	0.33	2	a	0.71	0.31	0.01	0.19
BDRN04	2	5.7	77.5	8	14.5	0.23	0.026	330	0.64	21	a	1.24	0.42	0.01	0.33
BDRN05	8	5.5	76.5	8	15.5	0.5	0.026	220	0.67	4	a	1.64	2.23	0.11	0.24
BDRN06	12	8.5	69.5	15	15.5	0.6	0.073	290	1.64	20	c	12.6	2.14	0.06	0.94
BDRN07	66	6.3	81	10	9	0.3	0.033	310	0.9	16	a	3.28	2.17	0.44	0.35
BDRN08	8	8.9	64.5	27	8.5	0.5	0.062	71	0.19	2	c	7.09	1.99	0.01	0.18
BDRN09	5	6.7	77	8.5	14.5	1.22	0.086	690	0.73	14	a	3.8	1.37	0.06	0.54
BDRN10	15	6.7	69	14.5	16.5	0.38	0.035	250	0.49	6	a	4.84	1.44	0.29	0.23
BDRN11	2	6.8	80	9.5	10.5	0.44	0.047	330	0.91	20	a	6.86	6.68	0.14	0.39
BDRN12	1	5.7	86	7	7	0.72	0.039	120	2.5	10	a	1.24	0.52	0.03	0.2
BDRN13	2	6.3	80.5	8	11.5	0.67	0.049	330	1.62	14	a	4.3	3.28	0.08	0.55
BDRS01	58	5.6	85	4.5	10.5	0.22	0.031	140	0.66	3	a	2.01	0.98	0.16	0.28
BDRS02	3	6.4	76	13.5	10.5	0.45	0.043	220	1.13	17	a	3.02	1.18	0.04	0.61
BDRS03	2	5.6	85.5	5	9.5	0.39	0.038	230	0.89	17	a	1.12	0.33	0.01	0.3
BDRS04	1	6.7	92.5	3	4.5	0.11	0.011	100	1.39	9	a	1.42	0.38	0.02	0.18
BDRS05	2	5.9	86.5	4	9.5	0.18	0.016	93	1.72	4	a	1	0.67	0.04	0.17
BDRS06	3	5.4	73.5	10	16.5	0.33	0.032	270	1.2	10	a	1.48	0.51	0.02	0.41
BDRS07	2	5.4	87	5	8	0.19	0.02	150	1.28	2	a	0.68	0.23	0.01	0.2
BDRS08	2	7	85.5	7.5	7	0.41	0.038	160	1.14	5	c	2.3	1.83	0.01	0.23
BDRS09	3	6	84.5	5	10.5	0.71	0.059	220	1.13	6	a	2.23	1.01	0.01	0.36
BDRS10	1	6.5	78	11.5	10.5	0.26	0.032	140	1.25	4	a	2.22	1.6	0.05	0.46
BDRS11	8	8.8	87.5	7	5.5	0.63	0.052	120	1.19	6	c	6.52	1.45	0.01	0.28
BDRS12	2	6.5	83	8	9	0.25	0.028	140	1.82	6	a	1.91	1.52	0.06	0.37
BDRS13	6	6.3	77.5	12.5	10	0.29	0.029	200	2.14	13	a	1.94	1.04	0.1	0.48

Site	EC	pH	Sand	Silt	Clay	orgC	totN	totP	totK	P	exMethod	exCa	exMg	exNa	exK
DRC01	12	8.5	76	10.5	13.5	0.66	0.048	120	0.83	5	c	11.52	2.68	0.12	0.36
DRC02	12	8.8	50.5	16.5	33	0.42	0.052	94	1.23	4	c	19.8	4.09	0.31	0.79
DRC03	14	7.5	73	13	14	0.19	0.018	120	2.66	13	a	4.76	2.53	0.48	0.35
DRC04	12	8.3	71	14.5	14.5	0.54	0.043	220	1.32	14	c	10.08	2.06	0.06	0.32
DRC05	11	8.5	70.5	14	15.5	0.49	0.042	200	1.18	13	c	11.9	2.26	0.27	0.36
DRC06	4	6.4	48.5	16.5	35	0.69	0.05	180	1.34	10	a	5.42	4.91	0.13	0.5
DRC07	3	6.8	75.5	11.5	13	0.36	0.044	330	1.35	24	a	4.51	3.54	0.1	0.49
DRC08	15	8.2	64	15.5	20.5	1.06	0.069	420	0.9	39	c	13.04	2.64	0.08	1.2
DRC09	4	6.8	74	11	15	0.4	0.036	150	1.32	5	a	4.2	3.11	0.13	0.38
DRC10	5	7.2	75	12.5	12.5	0.62	0.048	180	1.32	6	a	5.7	2.04	0.11	0.33
DRC11	6	7.2	71.5	12.5	16	0.9	0.058	210	1.22	8	a	9.52	4.14	0.15	0.7
DRC12	1100	8.5	80.5	8.5	11	0.3	0.017	330	1.21	14	c	3.6	9.08	6.18	1.36
DRE01	1100	8.1	25	35.5	39.5	0.91	0.064	450	1.81	26	c	9.9	12.54	5.92	2.5
DRE02	8	9.1	97	0.5	2.5	0.23	0.021	210	2.57	17	c	1.32	0.31	0.06	0.09
DRE03	59	8	82	8	10	0.38	0.038	170	2.62	20	c	4.04	1.97	0.56	0.43
DRE04	21	8.6	54	17.5	28.5	0.76	0.08	480	2.34	14	c	8.02	9.61	0.04	1.28
DRE05	24	7.1	84.5	9	6.5	0.32	0.029	210	2.67	27	a	2.52	2.68	0.4	0.96
DRE06	7	7.6	68.5	19.5	12	1.08	0.083	260	2.04	31	a	10.54	3.28	0.23	1.62
DRE07	2	6.4	89.5	4.5	6	0.39	0.028	72	2.7	5	a	1.45	0.77	0.04	0.23
DRE08	7	6.5	81.5	9	9.5	0.76	0.05	250	1.51	18	a	3.95	1.51	0.1	0.65
DRE09	6	7.8	76	10.5	13.5	0.39	0.034	270	1.63	13	a	10.95	1.88	0.1	0.46
DRE10	4	8.6	81.5	9.5	9	0.62	0.046	97	0.96	5	c	3.88	2.54	0.08	0.26
DRE11	6	7.7	82	8.5	9.5	0.51	0.043	120	1.05	9	a	5.41	0.54	0.04	0.26
DRE12	3	6.9	64	18.5	17.5	0.48	0.037	140	1.76	10	a	5.45	2.69	0.09	0.51
DRE13	4	6.5	84	6	10	0.23	0.02	220	2.54	20	a	1.69	1.75	0.06	0.28
DRW01	7	9.3	98.5	0.5	1	0.26	0.023	240	1.12	30	c	1.38	0.23	0.07	0.04
DRW02	10	9.1	88	4.5	7.5	0.44	0.042	150	1.32	14	c	5	1.11	0.27	0.48
DRW03	4	7.9	93.5	3	3.5	0.19	0.019	94	1.24	8	c	1.52	1.14	0.14	0.25
DRW04	11	8.4	87	4.5	8.5	0.69	0.053	120	1.74	6	c	5.74	1.83	0.24	0.66
DRW05	34	7.1	69.5	16.5	14	1.44	0.11	220	1.32	13	a	10.69	2.92	0.31	0.87
DRW06	10	8.9	48.5	26.5	25	0.33	0.039	160	1.18	13	c	17.18	3.16	0.17	0.96

DRW07	13	8.8	71	15.5	13.5	0.75	0.065	160	1.95	8	c	13.41	1.42	0.17	0.73
DRW08	3	7	79	9	12	0.28	0.027	110	2.91	6	a	3.2	2.06	0.1	0.35
DRW09	7	7.1	72.5	14	13.5	1	0.081	260	1.1	18	a	8.58	4.03	0.12	0.92
DRW10	4	7.3	73.5	12.5	14	0.5	0.045	170	0.87	8	a	8.72	4.75	0.1	0.5
DRW11	6	7.3	72.5	10.5	17	0.7	0.067	220	0.97	6	a	8.39	3.11	0.10	0.61
DRW12	53	7.4	67	17.5	15.5	0.7	0.062	310	1.22	19	a	8.47	4.47	0.7	1
DRW13	1400	8.4	70	18.5	11.5	0.53	0.033	240	1.47	20	c	6.25	11.49	2.49	2.3
MBE01	160	8.2	65.5	19.5	15	0.38	0.04	240	1.62	7	c	13.23	3.13	0.66	0.4
MBE02	3	6.4	61	16.5	22.5	0.81	0.072	350	0.92	25	a	5.63	6.3	0.39	0.72
MBE03	2	7.3	83.5	6.5	10	0.31	0.029	97	2.18	7	c	4.31	1.04	0.01	0.34
MBE04	6	8.4	96.5	2	1.5	0.26	0.02	71	3.02	2	c	2.44	0.54	0.01	0.1
MBE05	4	6.7	77	12	11	0.86	0.072	350	2.17	37	a	6.62	2.76	0.08	0.62
MBE06	6	5.9	85.5	7.5	7	0.88	0.066	250	3.29	12	a	2.52	0.68	0.08	0.31
MBE07	2	6.7	94	3.5	2.5	0.3	0.026	94	3.15	8	a	1.72	0.74	0.04	0.34
MBE08	6	8.5	39.5	22	38.5	0.43	0.042	120	1.02	10	c	24.1	5.04	0.16	0.99
MBE09	9	8	82.5	9.5	8	0.86	0.06	170	0.56	8	c	11.04	2.88	0.02	0.41
MBE11	4	7.6	80.5	11.5	8	0.52	0.033	200	0.38	7	c	7.23	4.64	0.01	0.27
MBE12	8	8.2	77	11	12	0.49	0.037	260	1.29	10	c	9.14	2.12	0.01	0.24
MBE13	10	8.8	71.5	17	11.5	1.08	0.105	140	0.46	5	c	9.42	2.21	0.01	0.32
MBW01	3	7.2	72	14	14	0.34	0.033	170	1.04	9	c	5.64	3.95	0.04	0.39
MBW02	2	7.3	75	11	14	0.46	0.039	170	1.14	11	c	5.97	2.26	0.01	0.43
MBW03	7	8.8	77.5	11.5	11	0.59	0.053	130	1.14	8	c	12.78	1.65	0.04	0.42
MBW04	4	7.6	79	10	11	0.5	0.04	140	0.69	7	c	7.41	3.06	0.02	0.3
MBW05	7	8.7	76	14	10	0.71	0.069	140	1.34	6	c	10.63	2.68	0.04	0.47
MBW06	2	6	74.5	8.5	17	0.67	0.049	160	1.73	3	a	1.6	0.99	0.13	0.5
MBW07	3	8.4	94.5	2.5	3	0.2	0.019	100	1.51	2	c	2.33	1.06	0.1	0.19
MBW08	2	6.3	70.5	6	23.5	0.2	0.019	110	2.24	3	a	1.7	1.4	1.11	0.33
MBW09	2	6.4	82.5	5	12.5	0.24	0.022	140	1.92	4	a	2.32	1.84	0.13	0.28
MBW10	4	7.1	86	8	6	0.31	0.025	120	2.71	4	c	1.75	0.72	0.08	0.25
MBW11	2	6.1	83	8.5	8.5	0.89	0.07	250	3.14	7	a	1.84	0.77	0.13	0.28
MBW12	1	6.5	84	5.5	10.5	0.24	0.025	130	3.67	3	a	1.91	1.22	0.1	0.24
MBW13	2	6.2	80.5	7	12.5	0.22	0.024	100	3.16	3	a	1.96	1	0.1	0.31

Site	EC	pH	Sand	Silt	Clay	orgC	totN	totP	totK	P	exMethod	exCa	exMg	exNa	exK
NE01	3	6.8	72	13.5	14.5	0.71	0.051	520	1.18	33	a	10.25	8.49	0.03	0.58
NE02	12	8.1	78.5	10	11.5	0.67	0.052	600	1.47	25	c	13.78	1.47	0.08	0.68
NE03	13	8.3	70	10.5	19.5	0.45	0.042	260	0.74	12	c	24.16	4.92	0.07	0.55
NE04	9	8.6	75.5	10.5	14	0.67	0.052	330	1.6	12	c	9.25	2.64	0.07	0.46
NE05	8	9	70.5	15.5	14	0.29	0.034	190	1.92	11	c	12.23	0.64	0.07	0.42
NE06	8	8.8	66.5	16.5	17	0.24	0.031	150	1.46	7	c	8.38	1.92	0.06	0.61
NE07	6	8.2	51	11.5	37.5	0.34	0.044	120	1.82	8	c	13.9	4.83	0.16	1.11
NE08	3	7.4	78.5	7	14.5	0.18	0.02	170	0.85	6	a	3.01	1.69	0.01	0.33
NE09	9	8.6	80	11.5	8.5	0.74	0.062	130	0.88	7	c	9.01	1.33	0.06	0.33
NE10	7	8.3	74.5	14	11.5	0.57	0.052	230	1.18	17	c	7.16	2	0.06	0.53
NE11	10	7.9	79	10.5	10.5	0.31	0.032	220	1.04	16	c	6.88	2.21	0.01	0.3
NE12	1	6.3	92.5	3	4.5	0.26	0.02	68	1.71	2	a	0.93	0.26	0.01	0.12
NE13	1	6.1	96.5	0.5	3	0.11	0.009	53	1.17	2	a	0.46	0.12	0.01	0.04
NW01	2	6.7	85.5	6.5	8	0.24	0.026	160	2.02	12	a	2.36	0.93	0.01	0.2
NW02	410	9.8	65	24	11	0.26	0.029	76	0.67	3	c	1.3	0.15	20	0.39
NW03	2	6.5	81	8.5	10.5	0.36	0.038	370	3.11	28	a	2.67	1.4	0.02	0.41
NW04	3	6.2	75	12	13	0.65	0.046	350	2	13	a	2.89	2.51	0.01	0.3
NW05	110	10.1	85	10	5	0.28	0.027	220	1.17	6	c	1.24	0.34	5.57	0.14
NW06	2	6.7	85.5	8	6.5	0.27	0.025	89	1.41	4	a	1.83	0.93	0.01	0.12
NW07	63	8.3	63.5	21	15.5	0.51	0.052	280	1.87	6	c	6.25	1.81	0.49	0.39
NW08	6	7.2	72.5	15	12.5	0.99	0.061	130	1.09	4	a	5.95	2.11	0.01	0.22
NW09	4	7.3	84	7.5	8.5	0.39	0.04	190	2.41	13	a	7.1	1.92	0.020	0.260
NW10	9	9	86.5	7	6.5	0.77	0.057	180	2.89	6	c	6.66	0.87	0.45	0.36
NW11	4	7.7	83.5	7	9.5	0.25	0.026	210	1.01	14	c	4.18	1.83	0.01	0.27
NW12	2	6.6	84	7	9	0.32	0.023	150	1.17	15	a	1.92	1.06	0.02	0.2
OYE01	4	8	25.5	28	46.5	0.27	0.033	92	0.99	3	c	23.43	8.02	0.56	1.35
OYE02	2	6.8	77	7.5	15.5	0.31	0.034	260	0.93	16	a	5.2	4.16	0.1	0.42
OYE03	2	6.3	64.5	14.5	21	0.46	0.053	300	1.68	19	a	3.62	3.23	0.15	0.49
OYE04	3	6.7	82	9.5	8.5	0.57	0.049	480	2.02	27	a	5.01	1.79	0.1	0.95
OYE05	4	6.3	63.5	19	17.5	0.76	0.06	350	1.62	9	a	5.33	2.01	0.1	0.58
OYE06	12	8.3	57	31	12	1.7	0.134	280	1.27	8	c	16.48	1.58	0.01	1.64

OYE07	11	8.5	65	24	11	1.67	0.164	300	0.9	10	c	19.9	1.14	0.01	0.82
OYE08	6	5.6	64.5	14	21.5	0.4	0.039	390	0.6	7	a	2.45	1.2	0.16	0.32
OYE09	7	8.6	72	20	8	0.79	0.08	370	1.29	13	c	11.08	3.49	0.01	0.5
OYE10	2	6.6	78.5	9.5	12	0.4	0.031	530	0.61	7	a	3.45	1.61	0.07	0.42
OYE11	2	5.9	78	11	11	0.75	0.057	670	0.61	14	a	2.61	1.02	0.05	0.29
OYE12	4	6.8	58.5	29.5	12	1.02	0.071	530	0.75	22	a	7.99	2.39	0.15	1.08
OYE13	2	6.3	72.5	15	12.5	1.07	0.063	440	0.57	11	a	4.96	1.65	0.08	0.38
OYW01	4	6.2	84.5	7	8.5	0.28	0.023	170	0.73	3	a	1.21	0.57	0.1	0.28
OYW02	4	6.5	33.5	41.5	25	1.12	0.111	300	2.42	19	a	6.3	2.37	0.22	1.01
OYW03	76	8.6	63	23	14	0.38	0.045	160	1.36	6	c	5	1.63	0.67	0.23
OYW04	92	6.9	74.5	14.5	11	0.22	0.025	170	1.09	3	a	3.16	1.52	1.24	0.25
OYW05	3	6.9	76	9	15	0.16	0.018	170	0.77	4	a	2.28	1.98	0.16	0.28
OYW06	14	7.1	76	9	15	0.19	0.019	180	0.7	4	c	5.32	1.48	0.3	0.34
OYW07	2	7.1	85.5	8.5	6	0.4	0.034	210	0.92	4	c	3.01	0.92	0.01	0.38
OYW08	7	6.4	80	9	11	0.31	0.034	350	0.82	8	a	2.3	1.24	0.15	0.32
OYW09	2	6.2	75	9.5	15.5	0.2	0.021	430	0.58	9	a	1.98	1.36	0.1	0.4
OYW10	2	6.1	72	12	16	0.31	0.03	200	1.02	10	a	2.23	1.15	0.08	0.51
OYW11	2	6.7	77.5	6.5	16	0.34	0.03	160	0.75	5	a	2.04	1.06	0.13	0.37
OYW12	94	6.7	86	4.5	9.5	0.1	0.014	110	1.01	4	a	1.57	1.2	0.59	0.26
OYW13	1	6.6	90	2	8	0.13	0.013	77	0.72	2	a	0.87	0.66	0.06	0.16
PE01	7	7.4	29.5	25.5	45	0.47	0.046	270	1.3	19	a	15.47	8.56	0.35	1.24
PE02	2	6.3	71	13.5	15.5	0.28	0.023	380	0.85	8	a	2.41	1.49	0.03	0.59
PE03	7	8	21	33	46	0.46	0.048	240	1.42	9	c	14.45	4.79	0.09	1.65
PE04	4	6.2	62	15.5	22.5	0.5	0.041	240	2.18	6	a	3.55	1.75	0.04	0.62
PE05	44	8.1	36	21	43	0.31	0.033	160	1.24	9	c	15.32	6.95	1.28	1.18
PE06	4	5.7	44.5	28	27.5	0.68	0.051	270	1.2	9	a	3.6	1.33	0.02	0.73
PE07	2	5.6	68	12.5	19.5	0.86	0.066	270	1.66	7	a	2.07	0.94	0.01	0.42
PE08	3	6.5	67	14	19	1.35	0.092	520	1.46	34	a	7.41	2.62	0.03	0.93
PE09	2	6.8	63.5	10.5	26	0.56	0.055	300	1.54	12	a	4.52	3.89	0.04	0.73
PE10	4	7.2	33.5	18.5	48	0.39	0.039	150	1.29	6	a	14.31	12.3	0.17	0.88
PE11	3	5.6	71	14	15	0.58	0.049	360	0.72	8	a	1.8	0.9	0.01	0.35
PE12	9	8.4	76.5	14	9.5	1.12	0.087	300	2.06	12	c	14.14	1.89	0.04	0.43

Site	EC	pH	Sand	Silt	Clay	orgC	totN	totP	totK	P	exMethod	exCa	exMg	exNa	exK
PHYC01	1	5.3	91.5	1.5	7	0.22	0.012	58	0.19	3	a	0.35	0.15	0.05	0.07
PHYC02	30	5.9	76	6	18	0.76	0.037	86	0.38	2	a	1.44	0.82	0.7	0.32
PHYC03	3	6.5	89	5.5	5.5	0.52	0.038	160	1.7	10	a	1.89	0.7	0.12	0.18
PHYC04	4	8.2	93.5	3.5	3	0.56	0.039	98	2.2	8	c	3.98	1.12	0.01	0.3
PHYC05	150	9.1	67.5	19.5	13	0.58	0.053	220	1.49	10	c	8.28	1.5	7.04	0.25
PHYC06	2	6.4	84	5	11	0.28	0.024	110	1.83	9	a	1.62	0.85	0.08	0.27
PHYC07	3	6.6	79.5	9.5	11	0.82	0.06	220	1.66	14	a	3.6	1.28	0.12	0.42
PHYC08	7	8.9	78	12.5	9.5	0.44	0.043	180	1.22	10	c	11.34	0.64	0.01	0.31
PHYC09	7	9.2	79.5	10.5	10	0.51	0.047	98	0.66	7	c	7.01	1.2	0.01	0.2
PHYC10	7	9.1	78.5	12	9.5	0.54	0.043	140	0.84	8	c	6.7	0.92	0.01	0.29
PHYC11	2	6.4	85	5	10	0.6	0.034	270	0.81	12	c	1.67	0.59	0.01	0.22
PHYC12	7	8.4	50	14	36	0.26	0.03	86	0.91	6	c	19.51	3.72	0.1	0.67
PHYE01	1	6.4	98	0.1	2	0.05	0.001	21	0.39	1	a	0.26	0.08	0.01	0.02
PHYE02	1	5.9	95.5	0.5	4	0.09	0.007	33	0.36	1	a	0.36	0.18	0.01	0.05
PHYE03	6	8	85	8	7	0.49	0.045	98	0.6	5	c	6.16	1.16	0.07	0.27
PHYE04	2	6.9	84	4	12	0.22	0.016	63	0.77	2	a	2.25	1.42	0.04	0.27
PHYE05	8	8.1	64.5	19	16.5	0.83	0.072	240	1.42	21	c	10.52	3.47	0.07	0.6
PHYE06	9	8.9	71.5	13.5	15	0.5	0.043	99	0.7	2	c	12.88	1.28	0.04	0.48
PHYE07	2	6.4	76	8	16	0.24	0.026	160	1.08	7	a	1.74	2.16	0.18	0.43
PHYE08	13	8.4	45.5	16	38.5	0.23	0.03	83	0.76	3	c	24.49	2.44	0.1	0.54
PHYE09	2	6.8	82	9.5	8.5	0.27	0.038	310	1.52	25	a	3.48	3.79	0.14	0.4
PHYE10	3	8	87	5.5	7.5	0.29	0.024	100	2.41	7	c	2.98	0.69	0.01	0.31
PHYE11	2	8	89	3.5	7.5	0.16	0.013	81	2.01	5	c	2.27	0.71	0.01	0.15
PHYE12	2	6.6	84.5	7.5	8	0.52	0.031	220	1.09	12	a	3.22	1.17	0.1	0.23
PHYE13	1	6.4	89	6	5	0.32	0.025	120	1.68	7	a	1.92	0.8	0.05	0.18
PHYW01	5	9.2	95.5	2	2.5	0.26	0.026	360	1.61	33	c	1.96	0.26	0.01	0.08
PHYW02	16	8.7	34	36	30	0.89	0.098	440	1.62	23	c	14.64	9.3	0.44	1.18
PHYW03	2	6.5	82.5	7.5	10	0.26	0.024	250	1.6	24	a	2	1.69	0.08	0.4
PHYW04	2	6.3	87.5	4	8.5	0.28	0.017	89	0.55	4	a	1.1	0.49	0.06	0.17
PHYW05	3	6	68	8	24	0.22	0.032	130	0.79	11	a	1.24	3.09	0.39	0.48
PHYW06	1	5.4	91.5	2	7	0.31	0.018	59	0.24	3	a	0.46	0.18	0.03	0.08

PHYW07	7	7.9	61.5	16.5	22	1.07	0.082	230	1.98	29	c	9.16	5.22	1.03	0.65
PHYW08	3	6.5	82	9	9	0.93	0.069	320	1.75	34	a	3.21	1.97	0.06	0.52
PHYW09	4	6.5	83.5	7.5	9	1.32	0.099	420	1.67	39	a	4.22	1.94	0.07	0.64
PHYW10	1	6.3	88.5	5.5	6	0.28	0.017	75	2.21	5	a	1.21	0.96	0.01	0.18
PHYW11	1	6.2	90.5	3.5	6	0.28	0.015	65	2.71	3	a	0.98	0.68	0.02	0.15
PHYW12	2	6	86.5	3.5	10	0.3	0.019	71	2.46	3	a	1.18	0.62	0.03	0.18
PHYW13	2	6.6	89	6	5	0.38	0.026	110	2.64	11	a	2.28	1.06	0.06	0.31
PW01	3	6.7	66	15	19	0.92	0.057	260	1.99	12	a	5.84	4.26	0.08	0.56
PW02	5	7.3	71	11	18	0.64	0.047	230	1.81	9	a	11.92	4.5	0.06	0.64
PW03	4	6.7	57.5	16.5	26	0.98	0.063	410	1.61	16	a	6.67	3.31	0.08	0.65
PW04	5	7.9	21	26.5	52.5	0.28	0.031	68	0.96	2	c	27.2	10.16	0.89	1.05
PW05	460	8.2	54.5	26.5	19	3.27	0.252	260	0.86	8	c	11.94	20.13	4.63	2.41
PW06	3	6.3	79	9	12	0.36	0.028	390	0.35	7	a	2.19	1	0.08	0.37
PW07	14	8.6	29.5	31.5	39	0.84	0.075	200	1.1	10	c	32.37	2.46	0.11	1.68
PW08	11	8.7	53	28	19	1.11	0.084	180	0.83	5	c	24.45	2.43	0.15	1.01
PW09	160	8.3	64	21	15	2.1	0.167	230	0.96	6	c	13.92	9.33	1.75	1.93
PW10	4	6.3	51.5	30	18.5	1.7	0.098	210	1.46	2	a	4.42	2.37	0.04	0.41
PW11	21	6.2	66.5	14	19.5	0.48	0.036	130	0.85	4	a	3.26	1.94	0.28	0.33
PW12	2	6.6	62.5	13	24.5	0.33	0.049	390	1.75	30	a	3.7	4.88	0.05	0.66
PW13	3	7	67	16	17	0.6	0.052	250	1.65	15	a	6.73	4.13	0.07	0.92
RHNC01	2	5.9	73.5	9.5	17	0.8	0.048	240	0.6	4	a	3.13	0.98	0.01	0.6
RHNC02	8	8.9	75.5	13.5	11	0.55	0.056	130	0.35	8	c	6.79	1.15	0.05	0.28
RHNC03	4	5.8	39	35.5	25.5	0.34	0.045	320	0.85	8	a	2.94	2.68	0.08	0.77
RHNC04	3	6.4	64	18.5	17.5	2.18	0.103	340	1.12	8	a	4.77	1.54	0.01	0.55
RHNC05	8	7.2	50	26	24	0.6	0.055	610	0.99	41	a	6.17	0.81	0.01	1.4
RHNC06	2	5	74.5	11.5	14	0.23	0.025	410	0.61	8	a	0.91	0.4	0.01	0.29
RHNC07	18	5.8	73.5	10.5	16	1.48	0.094	320	0.78	4	a	4.46	1.35	0.05	0.55
RHNC08	10	8.4	77.5	11	11.5	0.84	0.068	140	0.36	7	c	13.14	3.04	0.06	0.34
RHNC09	2	7	77	14	9	0.68	0.059	280	2.05	7	a	6.57	2.05	0.01	0.46
RHNC10	9	8.4	87	7.5	5.5	0.76	0.06	250	0.52	3	c	6.78	1.76	0.03	0.57
RHNC11	2	6	80.5	8	11.5	1.18	0.063	410	0.68	6	a	2.69	0.77	0.01	0.34
RHNC12	14	6.4	75.5	12	12.5	0.76	0.057	270	0.78	6	a	4.14	1.27	0.04	0.4

Site	EC	pH	Sand	Silt	Clay	orgC	totN	totP	totK	P	exMethod	exCa	exMg	exNa	exK
RHNC13	8	8.8	90	5	5	0.53	0.041	250	0.65	5	c	6.53	1.51	0.05	0.55
RHNE01	1	6.4	96	0.5	3.5	0.1	0.011	200	1.28	2	a	1.01	0.64	0.01	0.24
RHNE02	3	7.6	77	15	8	0.16	0.019	280	1.4	14	a	1.76	1.19	0.28	0.77
RHNE03	4	6.1	56.5	17	26.5	0.5	0.05	320	1.51	19	a	3.46	1.6	0.02	0.71
RHNE04	7	6.6	80	6.5	13.5	0.15	0.016	110	2.16	3	a	1.51	1.68	0.31	0.5
RHNE05	3	7.5	91	4.5	4.5	0.26	0.02	120	2.19	8	a	2.28	0.67	0.02	0.55
RHNE06	11	8.7	71.5	14.5	14	0.6	0.057	260	1.54	18	c	7.53	2.5	0.01	0.91
RHNE07	1900	7.5	72	16.5	11.5	0.42	0.023	250	1.71	14	c	8.11	4.28	2.16	2.73
RHNE08	7	6.1	74.5	11	14.5	0.59	0.055	310	0.9	11	a	3.41	1.03	0.07	0.53
RHNE09	9	8.6	72	15	13	0.63	0.066	250	0.95	9	c	16.5	1.05	0.01	0.83
RHNE10	3	5.7	58.5	14.5	27	0.46	0.042	290	0.57	7	a	2.42	1.9	0.08	0.45
RHNE11	2	6.8	75	9.5	15.5	0.42	0.049	410	0.55	19	a	10.19	10.71	0.04	0.44
RHNE12	10	8.2	78.5	8	13.5	0.6	0.056	270	1.34	14	c	14.29	4.15	0.01	0.59
RHNW01	5	6	79	9.5	11.5	1.25	0.084	340	0.71	5	a	3.43	0.83	0.06	0.39
RHNW02	2	5.9	79	9.5	11.5	0.41	0.033	330	0.72	6	a	1.82	0.67	0.02	0.37
RHNW03	2	6.2	86.5	4.5	9	0.21	0.016	400	0.53	27	a	1.34	0.64	0.01	0.33
RHNW04	9	6.8	43	27.5	29.5	0.82	0.078	460	1.45	14	a	10.55	3.14	0.25	1.47
RHNW05	8	7.8	51.5	17	31.5	0.35	0.04	240	1.53	17	c	7.7	2.42	0.6	1.28
RHNW06	10	8.1	48	22	30	0.52	0.056	200	1.41	7	c	13.11	2.5	0.03	1.84
RHNW07	8	5.8	66.5	13	20.5	0.6	0.049	340	1.06	8	a	3.83	0.8	0.02	0.52
RHNW08	6	8.1	34	18	48	0.48	0.052	140	0.84	15	c	40	5.83	0.23	1.12
RHNW09	2	6.8	76	9.5	14.5	0.32	0.04	270	1.16	19	a	6.95	7.24	0.04	0.66
RHNW10	3	6.4	63	17	20	1.66	0.113	360	1.24	9	a	6.59	1.72	0.01	0.67
RHNW11	5	7.9	45	16.5	38.5	0.42	0.047	230	1.5	12	c	9.27	2.72	0.1	1.41
RHNW12	1100	8.6	65	27	8	0.64	0.058	200	1.27	4	c	6.82	6.95	5.03	3.95
RHNW13	21	7.4	78	7.5	14.5	0.27	0.024	160	0.82	5	c	2.84	0.99	0.27	1.12
TCMBC01	11	7.4	86.5	6.5	7	0.08	0.013	180	1.24	7	c	2.41	2.01	0.32	0.54
TCMBC02	16	6.7	81.5	12	6.5	0.11	0.017	300	0.9	9	a	2.41	1.69	0.32	0.32
TCMBC03	9	9	75.5	15.5	9	0.4	0.05	98	0.57	2	c	8.84	3.84	0.01	0.3
TCMBC04	3	6.1	60.5	18.5	21	0.26	0.034	310	1.02	7	a	2.07	1.76	0.01	0.48
TCMBC05	3	5.7	67	13.5	19.5	0.66	0.057	340	1.02	7	a	2.41	0.85	0.04	0.4

TCMBC06	3	5.4	80.5	6.5	13	0.62	0.047	320	1	5	a	1.08	0.77	0.01	0.28
TCMBC07	8	8.3	86.5	6.5	7	0.22	0.029	320	1.2	7	c	2.36	1.65	0.37	0.34
TCMBC08	2	6	72	11	17	0.21	0.024	360	0.76	9	a	2.21	1.51	0.03	0.33
TCMBC09	3	6.4	75.5	9	15.5	0.41	0.045	540	1.44	31	a	3.34	1.71	0.04	0.52
TCMBC10	8	8.6	93.5	2.5	4	0.41	0.033	300	1.82	6	c	5.02	1.66	0.13	0.41
TCMBC11	9	8.8	79	14	7	0.61	0.07	210	0.95	14	c	8.26	0.77	0.1	0.83
TCMBC12	2	5.9	67.5	15	17.5	0.21	0.027	340	1.14	12	a	1.81	1.07	0.02	0.46
TCMBE01	4	5.9	72	12	16	0.58	0.044	330	0.55	5	a	2.47	0.86	0.03	0.38
TCMBE02	2	6.4	65.5	15.5	19	0.54	0.046	290	0.92	5	a	3.62	1.26	0.2	0.6
TCMBE03	2	6	77.5	10	12.5	0.62	0.051	260	0.65	3	a	2.26	1.27	0.16	0.37
TCMBE04	2	6.3	77	9	14	0.3	0.028	310	0.49	4	a	2.06	0.91	0.03	0.33
TCMBE05	2	6	70.5	13.5	16	0.95	0.066	450	0.61	6	a	3.05	0.88	0.01	0.53
TCMBE06	5	6.3	40	33	27	0.51	0.056	540	1.1	18	a	6.48	1.93	0.06	1.24
TCMBE07	10	8.8	76.5	15.5	8	0.56	0.056	270	0.52	5	c	9.24	2.02	0.09	0.56
TCMBE08	5	7.4	86	6.5	7.5	0.74	0.056	300	0.76	2	c	5.61	2.04	0.08	0.77
TCMBE09	4	6	72.5	12.5	15	1.08	0.077	420	0.59	6	a	3.93	0.96	0.06	0.45
TCMBE10	4	7.8	24.5	28.5	47	0.34	0.039	95	0.77	2	c	23.27	9.51	0.56	1.31
TCMBE11	4	6.4	65.5	16.5	18	1.17	0.121	290	1.07	13	a	5.08	1.86	0.07	0.89
TCMBE12	9	7	61.5	19.5	19	2.04	0.201	640	0.97	82	c	9.46	1.56	1.06	1.29
TCMBE13	2	6.7	74	13	13	1.33	0.108	200	0.43	4	a	11.14	4.48	0.05	0.37
TCMBW01	2	6.9	85	9.5	5.5	0.16	0.024	240	2.07	19	a	1.91	0.93	0.01	0.33
TCMBW02	7	8.1	80	10.5	9.5	0.33	0.036	180	2.66	13	c	5.69	1.2	0.06	0.41
TCMBW03	3	5.9	79.5	10	10.5	0.44	0.032	460	0.52	5	a	1.7	0.56	0.01	0.23
TCMBW04	27	6.4	67.5	17.5	15	0.61	0.07	210	1.23	10	a	5.71	5.06	0.23	0.44
TCMBW05	10	8.9	65.5	26	8.5	1.17	0.131	170	0.45	3	c	9.66	3.77	0.14	0.44
TCMBW06	4	5.9	59	19	22	1.19	0.104	510	0.74	11	a	3.91	1.13	0.1	0.63
TCMBW07	2	5.8	54.5	19	26.5	0.52	0.046	470	0.63	11	a	2.91	1.01	0.1	0.64
TCMBW08	11	8.4	42	27	31	0.54	0.061	250	1.11	15	c	13.82	6.52	0.2	1.27
TCMBW09	9	5.5	49.5	25	25.5	0.51	0.043	420	0.7	6	a	4.05	1.38	0.16	0.88
TCMBW10	4	6.3	34.5	42	23.5	0.68	0.066	470	0.86	10	a	5.29	1.97	0.17	1.3
TCMBW11	2	6.2	63.5	19.5	17	0.7	0.054	470	0.72	13	a	3.83	1.33	0.15	0.58
TCMBW12	4	7.6	19.5	32	48.5	0.39	0.041	240	0.96	15	c	19.65	10.39	0.27	1.28

Site	EC	pH	Sand	Silt	Clay	orgC	totN	totP	totK	P	exMethod	exCa	exMg	exNa	exK
TCMBW13	13	5.6	78	10	12	0.29	0.026	460	0.55	5	a	1.79	1.1	0.17	0.29
WYE01	4	6	79	10.5	10.5	0.7	0.065	590	0.95	27	a	5.62	1.23	0.01	0.62
WYE02	6	7.6	51.5	31	17.5	0.82	0.082	240	1.01	10	a	11.98	4.62	0.13	0.62
WYE03	4	7.4	77.5	15.5	7	0.44	0.036	400	0.56	17	a	4.83	2.64	0.02	0.25
WYE04	55	7.9	57.5	22	20.5	0.35	0.038	200	1.14	16	c	8.92	2.37	0.07	1
WYE05	2	6.9	81	10.5	8.5	0.35	0.037	230	0.95	9	a	4	3.61	0.03	0.32
WYE06	3	6.2	79.5	7.5	13	0.21	0.021	160	2.76	7	a	1.57	1.21	0.04	0.38
WYE07	12	6.7	86.5	6.5	7	0.35	0.039	160	2.13	8	a	2.37	1	0.36	0.67
WYE08	14	6	77	11	12	0.92	0.08	1200	1.26	100	a	3.34	1.55	0.09	0.9
WYE09	12	8.2	76	15.5	8.5	0.98	0.091	470	1.51	21	c	8.71	2.88	0.19	0.65
WYE10	2	6.4	83.5	9.5	7	0.87	0.077	430	0.74	7	a	3.14	1	0.02	0.37
WYE11	5	5.6	77	11	12	1.13	0.094	820	1.85	140	a	4.06	1.58	0.02	0.62
WYE12	1	6.6	78.5	9	12.5	0.26	0.035	340	2	16	a	2.56	4.31	0.01	0.47
WYE13	4	6.9	76	8.5	15.5	0.63	0.047	330	0.87	12	a	4.01	1.82	0.02	0.59
WYW01	50	6.4	72.5	15.5	12	0.21	0.024	150	1.26	5	a	2.12	2.08	0.38	0.27
WYW02	2	6.7	77.5	14	8.5	0.26	0.028	170	1.56	6	a	2.28	1.21	0.01	0.21
WYW03	10	6.6	78	13	9	0.13	0.015	150	1.05	8	a	2.32	1.03	0.16	0.28
WYW04	1	6.4	97.5	0.5	2	0.08	0.005	55	0.44	2	a	0.44	0.1	0.01	0.03
WYW05	3	6.5	82.5	8.5	9	0.43	0.039	180	1.25	6	a	2.21	0.5	0.01	0.22
WYW06	2	7	82.5	5.5	12	0.18	0.019	130	1.79	6	a	2.7	1.05	0.01	0.27
WYW07	2	6	75.5	8	16.5	0.28	0.028	170	2.12	10	a	1.38	1	0.03	0.42
WYW08	1	6	90.5	3	6.5	0.13	0.012	110	2.02	6	a	0.72	0.5	0.01	0.14
WYW09	7	8.5	80.5	12.5	7	0.38	0.044	180	1.27	7	c	4.99	1.58	0.07	0.32
WYW10	2	6.2	81	9	10	0.23	0.027	150	1.09	6	a	1.88	1.19	0.02	0.3
WYW11	4	6.7	87	6.5	6.5	0.26	0.029	180	1.35	16	a	2.16	0.92	0.04	0.44
WYW12	3	6.3	84.5	9	6.5	0.38	0.039	160	1.44	7	a	2.43	0.95	0.01	0.21

Field Sampling
Samples for analysis were based on composite (bulked) samples taken from the floristic quadrat at each survey site. Ten sub-samples were taken from a regular grid covering each 50 x 50 m quadrat. Sub-samples were taken from the A1 horizon at a uniform depth between 5–15 cm. Bulked samples each about 2 kg were air dried in the field prior to delivery to the laboratory.

Chemical Analysis Methods.
All analyses were conducted by the Western Australian Chemistry Centre, Perth.

EC (1:5) mS/m
Measured by conductivity meter at 25°C on a 1:5 extract of soil and deionised water.

Rayment, G.E. and Higginson, F.R. (1992). Electrical Conductivity pp 15–16. *In: Australian Laboratory Handbook of Soil and Water Chemical Methods*. Inkata Press: Melbourne. (Method 3A1).

pH (H2O)
Measured by pH meter on a 1:5 extract of soil in deionised water.

Rayment, G.E. and Higginson, F.R. (1992). Soil pH. pp 17–18 *In: Australian Laboratory Handbook of Soil and Water Chemical Methods*. Inkata Press, Melbourne. (Method 4A1).

Particle Sizing (% sand, silt, clay)
Determined by modified 'plummet' procedure. Soil dispersed with a solution of Calgon - sodium hydroxide, then silt (0.002–0.020 mm) and clay (<0.002 mm) was measured by density measurements using a plummet after standard settling times.

Loveday, J. (ed) (1974). *Methods for Analysis of Irrigated Soils*. Commonwealth Bureau of Soils, Technical Communication No. 54, Commonwealth Agricultural Bureaux: Farnham Royal, England.

totN (%)
Total nitrogen measured by Kjeldahl digestion of soil.

Rayment, G.E. and Higginson, F.R. (1992). Soil pH. pp 41–43 In: *Australian Laboratory Handbook of Soil and Water Chemical Methods*. Inkata Press: Melbourne. (Method 7A2).

totP (mg/kg)
Measured by colorimetry on the Kjeldahl digest for total N using a modification of the Murphy and Riley molybdenum blue procedure.

Murphy, J. and Riley, J.P. (1962). A modified single solution method for the determination of phosphate in natural waters. *Analytica Chimica Acta* **27**: 31–36.

orgC (%)
Determined by the method of Walkley and Black.

Walkley, A., and Black, I.A. (1934). An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science* **37**: 29–38.

K (XRF) (%)
Extracted in 0.5M NaHCO3 (1:100) using the procedure of Jefferey.

Jefferey R. (1982). *Measurement of Potassium in 0.5M NaHCO3 Extracts of Soil by Flame AAS.* Annual Technical Report No. 2, Agricultural Chemistry Laboratory, Government Chemical Laboratories: Western Australia.

P (HCO3) mg/kg
Extracted in 0.5M NaHCO3 (1:100) using the procedure of Colwell.

Colwell, J.D. (1963). The estimation of phosphorus fertilizer requiremnets on wheat in souther New South Wales, by soil analysis. *Australian Journal of Agriculture and Animal Husbandry* **3**: 190–197.

exMethod: exCa, exMg, exNa, exK (me%)
Exchangeable Cations were measured by inductively coupled plasma - atomic emission spectrophotometry (ICP-AES). Soluble salts were removed from soils with EC (1:5) >20 mS/m by washing with glycol-ethanol. Cations analysed using one of three extraction methods:

a) 1M NH4Cl at pH 7.0 - Used for neutral soils (pH between 6.5 & 8.0).

   Rayment, G.E. & Higginson, F.R. (1992). Ion-exchange Properties. In: *Australian Laboratory Handbook of Soil and Water Chemical Methods*. Inkata Press, Melbourne pp 138–145. (Method 15A1, 15A2).

b) 0.1M BaCl2 (unbuffered) - Used for acidic soils only (pH <6.5)

   Unpublished WA Agricultural Chemistry Laboratory procedure.

   Cations (Ca, Mg, Na, K, Al & Mg) were measured by ICP-AES.

c) 1M NH4Cl at pH 8.5 - Used for calcareous soils

Modified method from Rayment, G.E. & Higginson, F.R. (1992). Ion-exchange Properties pp 148–154. *In: Australian Laboratory Handbook of Soil and Water Chemical Methods*. Inkata Press: Melbourne. (Method 15C1).

APPENDIX D

Geomorphic attributes of the 304 terrestrial biodiversity sites sampled during the Pilbara biodiversity survey. Key to column labels: **soilD** Soil depth (cm); **Subs** main substrate type (sandy, rocky or clayey); **gm7 gm10 gm13** geomorphic unit in 7, 10 and 13 categories, respectively; **Slp** slope; **Elev** elevation (m); **Asp** aspect; **Rug500** topographic ruggedness in 500 m radius; **Sun** sun index; **Fabu** surface rock fragment abundance; **Fmax** surface rock maximum size; **Outcrp** extent of rock outcrop; **Cst** distance to coastline (km); **Riv** distance to a drainage line with a distinct riparian zone (km); **Gcov** total ground vegetation cover. Further explanation is provided below the tabulation.

Site	soilD	Subs	gm7	gm10	gm13	Slp	Elev	Asp	Rug500	Sun	Fabu	Fmax	Outcrp	Cst	Riv	Gcov
BDRN01	100.0	s	F	i	i	1.05	392	0.35	2.15	-0.14	0	0	0	299.7	2.4	12
BDRN02	20.6	r	A	c	c	0.51	403	0.55	1.08	-0.28	5	3	0	296.0	3.3	9
BDRN03	19.6	r	A	c	c	1.30	410	0.21	3.66	2.26	5	3	1	291.4	6.4	9
BDRN04	24.4	r	A	c	c	0.62	448	1.37	1.62	-0.99	5	4	0	312.5	2.1	11
BDRN05	26.6	c	C	f	f	1.60	463	1.07	6.55	1.83	4	3	0	304.3	8.0	11
BDRN06	12.0	r	A	b	b	4.56	467	0.40	7.41	-1.13	4	4	1	302.0	6.1	7
BDRN07	10.4	c	C	f	f	1.21	466	1.66	5.34	0.14	4	3	0	298.3	3.6	8
BDRN08	25.6	r	C	d	d	0.77	458	0.11	3.75	1.27	4	3	0	296.9	2.3	8
BDRN09	17.2	r	A	b	b	1.17	483	1.98	8.57	-1.13	5	5	3	303.9	5.4	10
BDRN10	18.0	r	A	c	c	0.73	496	1.78	3.60	-0.14	4	4	1	292.4	1.5	9
BDRN11	16.6	r	A	b	b	0.69	495	0.01	3.83	0.71	5	5	1	291.4	0.6	11
BDRN12	6.8	r	A	a	a	0.81	527	1.71	3.46	-1.41	4	5	5	311.8	14.3	12
BDRN13	23.6	r	A	c	c	1.62	500	0.29	6.49	0.00	3	4	0	313.4	14.5	12
BDRS01	25.0	c	C	f	f	0.47	530	0.76	3.17	-0.42	4	3	0	379.2	1.7	11
BDRS02	36.4	c	C	f	f	0.57	517	1.60	4.01	-0.99	0	0	0	377.2	0.5	5
BDRS03	8.6	r	A	b	b	7.61	526	0.00	8.29	9.31	5	4	5	374.0	0.1	15
BDRS04	100.0	s	D	j	js	0.41	517	0.45	1.10	-0.14	1	1	0	375.5	0.6	13
BDRS05	48.8	s	F	i	i	0.89	514	0.23	0.97	1.55	0	0	0	372.1	3.0	8
BDRS06	21.4	c	C	f	f	0.98	525	1.94	4.45	-1.55	3	3	0	370.9	1.6	9
BDRS07	10.2	r	A	b	b	3.90	543	1.94	7.23	-2.82	5	4	3	372.0	2.5	10
BDRS08	26.2	r	A	b	b	0.69	559	0.01	8.17	0.99	5	5	4	377.6	3.7	8
BDRS09	15.6	r	A	b	b	10.04	568	1.81	13.70	-17.49	4	4	3	379.2	1.5	15
BDRS10	21.4	c	C	f	f	0.82	552	0.17	3.77	1.41	4	3	0	381.1	1.2	6
BDRS11	35.6	c	C	f	f	0.69	548	1.99	2.50	-0.99	3	3	0	385.5	0.3	5
BDRS12	24.8	s	G	g	gs	0.51	554	0.55	2.15	-0.28	4	4	1	390.2	0.7	8

BDRS13	16.2	c	C	f	f	0.16	526	1.71	1.28	-0.28	0	0	0	376.7	0.4	8
DRC01	30.6	r	A	b	b	1.49	26	1.92	3.79	-0.99	4	4	1	5.7	5.1	7
DRC02	67.8	c	B	e	e	0.26	20	1.45	2.10	0.14	3	3	0	5.8	4.2	7
DRC03	35.6	c	C	f	f	0.57	20	0.20	1.44	0.99	1	3	0	8.1	3.0	13
DRC04	74.4	c	D	j	jc	0.46	23	1.00	2.47	0.56	2	3	0	14.9	0.0	6
DRC05	20.0	r	A	b	b	2.52	83	0.91	4.70	-2.82	4	4	2	27.5	3.2	5
DRC06	3.4	r	A	b	b	20.67	232	1.11	56.03	-29.47	6	5	2	38.8	1.4	7
DRC07	19.0	r	A	c	c	0.91	42	2.00	13.05	-1.13	4	4	0	28.1	0.4	8
DRC08	3.0	r	A	a	a	5.08	54	1.74	11.56	-0.42	5	7	2	20.9	4.4	11
DRC09	10.6	c	C	f	f	2.45	34	1.88	8.06	-4.09	4	3	1	15.9	8.1	8
DRC10	6.2	r	A	b	b	6.56	38	1.78	10.21	-1.27	4	4	2	9.1	4.4	9
DRC11	15.4	r	A	b	b	0.51	13	1.89	3.97	-0.85	4	5	3	3.5	3.7	10
DRC12	71.0	c	E	h	hc	1.21	1	1.75	1.20	-0.14	0	2	0	0.2	5.1	1
DRE01	100.0	c	E	h	hc	0.51	7	1.89	1.17	-0.28	0	0	0	0.9	6.2	3
DRE02	100.0	s	F	i	i	0.57	7	2.00	1.66	-0.71	0	0	0	0.4	6.5	9
DRE03	28.6	r	A	b	b	1.17	8	0.02	1.33	1.13	4	4	4	1.2	6.3	7
DRE04	100.0	c	C	f	f	0.73	7	1.62	1.25	0.14	0	0	0	1.0	6.6	9
DRE05	53.4	s	F	i	i	0.51	8	1.89	0.90	-0.85	0	0	0	3.2	4.7	11
DRE06	100.0	c	C	f	f	0.11	12	2.00	1.34	-0.14	0	0	0	9.5	0.3	5
DRE07	49.6	s	F	i	i	0.46	23	1.00	1.04	-0.56	0	0	0	21.6	2.4	11
DRE08	8.8	r	A	b	b	3.88	49	1.00	9.91	4.79	5	5	4	21.8	0.1	6
DRE09	26.4	c	C	f	f	0.57	59	0.40	4.00	-0.14	4	2	0	24.1	0.8	7
DRE10	22.8	c	C	f	f	0.47	65	0.03	1.96	0.71	3	3	1	29.4	1.1	9
DRE11	48.0	s	F	i	i	0.46	69	1.00	1.76	0.56	0	0	0	32.1	2.6	9
DRE12	32.4	c	C	f	f	0.57	51	1.60	1.19	0.14	1	3	0	34.7	1.2	8
DRE13	28.2	s	G	g	gs	0.57	75	0.40	1.12	-0.14	2	4	2	43.9	3.3	5
DRW01	100.0	s	F	i	i	0.23	10	1.00	1.69	-0.28	0	0	0	0.2	6.9	7
DRW02	19.4	r	A	c	c	0.51	10	0.55	1.62	-0.28	1	3	0	0.3	6.9	10
DRW03	43.4	s	E	h	hs	0.57	7	2.00	1.12	-0.71	0	0	0	1.4	5.7	7
DRW04	6.3	s	D	j	js	0.58	20	0.02	1.61	0.85	3	4	0	15.5	0.0	6
DRW05	20.7	r	A	b	b	3.12	41	1.48	6.87	1.55	5	5	4	14.3	1.4	5
DRW06	58.0	c	C	f	f	0.89	51	0.36	1.63	1.55	5	3	0	12.9	1.2	8

Site	soilD	Subs	gm7	gm10	gm13	Slp	Elev	Asp	Rug500	Sun	Fabu	Fmax	Outcrp	Cst	Riv	Gcov
DRW07	42.2	c	G	g	gc	0.91	45	1.00	1.63	1.13	4	3	0	11.4	0.3	7
DRW08	9.2	s	G	g	gs	0.16	56	0.29	1.67	0.28	4	4	1	11.1	1.3	6
DRW09	16.0	c	C	f	f	1.38	45	0.25	5.08	0.14	3	4	0	10.5	3.5	6
DRW10	4.6	r	A	b	b	1.95	45	0.00	6.33	2.26	5	5	2	10.3	3.2	7
DRW11	3.6	r	A	b	b	1.72	30	0.00	6.19	2.26	5	5	2	7.2	1.3	10
DRW12	28.8	c	C	f	f	0.11	10	1.00	1.39	-0.14	3	3	0	5.8	1.6	6
DRW13	51.6	c	E	h	hc	0.51	7	0.11	1.35	0.85	1	3	0	1.9	1.7	3
MBE01	76.4	c	C	f	f	1.23	212	1.93	?	-0.85	5	3	0	4.9	1.7	10
MBE02	17.0	r	A	c	c	1.65	253	0.17	7.54	2.82	4	5	1	136.2	3.0	7
MBE03	15.8	s	G	g	gs	0.89	274	0.36	2.47	-0.14	2	4	1	147.3	1.6	11
MBE04	93.4	s	D	j	js	0.41	268	0.17	2.07	0.14	2	3	0	147.8	0.1	10
MBE05	10.0	r	A	b	b	2.28	275	1.80	16.35	-0.56	5	6	1	148.8	0.6	10
MBE06	7.2	r	A	a	a	2.02	243	1.28	21.55	1.69	4	7	5	148.7	2.1	9
MBE07	94.0	c	C	f	f	1.03	198	1.00	2.02	1.27	0	0	0	133.7	0.9	11
MBE08	63.0	c	B	e	e	0.23	202	1.00	2.31	0.28	3	3	0	129.7	1.3	11
MBE09	14.2	r	A	b	b	7.05	262	1.93	14.52	-5.08	4	5	4	125.9	5.2	9
MBE11	11.2	r	A	b	b	1.28	234	1.89	13.16	-2.12	3	4	2	121.6	9.2	8
MBE12	13.0	r	A	c	c	0.67	230	1.51	13.67	-1.13	4	4	0	119.5	9.2	9
MBE13	23.0	r	C	d	d	11.28	236	1.96	17.75	-9.59	4	3	0	111.2	2.8	6
MBW01	28.4	r	A	b	b	1.34	188	0.06	9.55	2.12	3	5	4	81.0	0.0	6
MBW02	23.8	r	A	b	b	5.09	196	0.24	12.27	0.71	5	4	3	80.9	0.1	10
MBW03	17.2	r	A	b	b	2.29	193	0.00	13.62	2.68	5	4	1	84.4	0.0	8
MBW04	22.6	r	A	b	b	3.11	187	0.19	7.91	5.36	5	4	4	84.4	0.3	7
MBW05	19.4	r	C	d	d	1.39	179	0.01	3.09	1.97	4	4	1	87.2	0.7	7
MBW06	58.4	s	F	i	i	1.02	176	1.89	1.61	-1.69	1	2	0	88.5	2.4	8
MBW07	60.8	s	D	j	js	0.47	143	0.76	1.48	0.71	4	4	0	81.4	0.0	18
MBW08	47.4	s	F	i	i	0.48	138	1.71	0.99	0.00	1	1	0	81.5	1.2	7
MBW09	33.2	s	F	i	i	0.67	155	0.49	1.91	1.13	3	2	0	87.7	2.9	9
MBW10	20.6	r	A	a	a	0.81	187	1.14	3.03	0.85	2	3	4	104.5	0.9	16
MBW11	17.6	r	A	a	a	3.49	248	1.20	10.53	-5.08	4	6	5	113.9	5.2	12
MBW12	24.2	s	G	g	gs	0.92	232	0.88	2.86	-0.99	3	2	1	117.9	4.7	9

MBW13	23.8	s	G	g	gs	0.41	229	0.45	2.07	-0.14	3	3	1	124.5	3.1	12
NE01	22.8	r	A	c	c	0.87	241	1.39	9.58	-1.41	4	3	1	150.9	3.5	4
NE02	12.8	r	A	b	b	9.39	274	0.45	13.56	16.22	5	4	3	152.0	4.6	5
NE03	21.6	c	B	f	f	0.47	278	1.24	4.33	0.42	4	3	1	155.9	0.7	6
NE04	21.2	r	A	b	b	3.58	279	1.38	27.34	-5.78	4	5	4	167.3	5.3	8
NE05	36.8	c	B	f	f	0.82	262	0.17	3.01	1.41	4	4	1	168.3	3.4	11
NE06	36.4	c	C	f	f	0.69	250	1.99	2.50	-0.71	4	4	0	171.0	4.9	8
NE07	65.0	c	B	e	e	0.16	234	0.29	1.21	0.00	1	4	0	167.2	1.7	8
NE08	23.4	c	C	f	f	0.58	241	1.20	2.83	-0.85	4	3	0	174.2	3.1	9
NE09	3.8	r	A	d	d	6.30	257	0.02	9.47	9.31	4	3	2	174.9	5.2	8
NE10	92.0	c	D	j	jc	0.36	210	0.68	1.58	-0.28	3	3	0	176.1	0.4	7
NE11	15.6	r	A	b	b	1.08	317	0.47	3.64	-0.42	4	4	2	180.1	2.5	7
NE12	26.8	r	A	a	a	4.91	330	0.14	6.64	2.12	4	5	4	179.8	6.8	9
NE13	100.0	s	F	i	i	1.24	314	0.45	2.36	2.12	0	0	0	181.5	9.2	12
NW01	16.2	s	A	g	gs	2.07	425	1.11	6.12	2.26	4	4	2	220.2	0.4	8
NW02	11.4	r	A	b	b	2.42	396	0.67	3.67	-1.83	5	4	2	215.9	0.7	6
NW03	14.8	r	A	b	b	6.02	409	1.93	14.62	-4.09	4	6	4	194.2	2.6	9
NW04	9.0	r	A	b	b	0.82	398	0.45	5.05	1.41	4	4	2	184.2	6.8	9
NW05	46.2	c	C	f	f	0.92	373	1.50	6.06	0.42	3	2	0	186.1	6.1	13
NW06	7.0	r	A	b	b	3.95	410	1.72	6.12	-0.14	5	4	3	179.8	2.4	7
NW07	30.0	r	A	b	b	2.71	395	1.38	7.40	1.83	2	3	2	165.9	2.5	12
NW08	12.8	r	A	b	b	3.12	372	1.40	6.33	-5.08	4	4	3	163.3	0.9	12
NW09	36.6	c	G	g	gc	1.37	318	0.00	3.34	1.69	2	2	0	155.0	1.3	11
NW10	25.6	s	F	i	i	1.02	321	0.11	3.12	0.56	3	4	1	159.5	0.5	10
NW11	24.8	s	G	g	gs	1.66	305	1.27	3.34	1.41	3	4	2	155.0	1.3	9
NW12	20.4	r	A	a	a	0.98	300	1.94	2.81	-0.71	3	5	3	153.4	0.7	8
OYE01	75.0	c	B	e	e	0.62	259	0.63	4.64	0.99	5	4	0	72.0	1.6	4
OYE02	9.0	r	A	c	c	0.92	260	0.13	3.81	0.42	5	5	1	76.3	4.4	8
OYE03	6.0	c	C	f	f	2.44	282	0.81	7.55	3.53	5	4	1	79.1	5.5	10
OYE04	30.8	c	C	f	f	0.80	308	1.00	5.48	-0.99	0	0	0	95.5	9.1	14
OYE05	9.0	r	A	c	c	2.31	325	1.99	3.98	-2.40	5	4	0	98.1	7.8	14
OYE06	27.8	c	D	j	jc	0.23	301	0.00	4.29	0.28	1	3	0	101.2	5.5	14

Site	soilD	Subs	gm7	gm10	gm13	Slp	Elev	Asp	Rug500	Sun	Fabu	Fmax	Outcrp	Cst	Riv	Gcov
OYE07	4.2	r	C	d	d	1.34	312	0.06	4.96	2.12	4	4	2	101.4	5.1	11
OYE08	26.2	c	C	f	f	1.08	321	0.47	3.41	1.83	5	4	0	108.7	3.3	13
OYE09	3.0	r	A	b	b	2.02	258	0.32	4.25	3.53	4	4	3	100.0	1.8	8
OYE10	14.6	c	C	f	f	0.72	244	0.68	2.66	-0.56	4	3	0	98.8	1.4	9
OYE11	2.8	r	A	c	c	1.64	234	0.79	7.67	2.40	4	3	3	96.4	1.0	8
OYE12	30.4	c	C	f	f	0.16	199	1.71	1.40	0.00	1	2	0	85.7	2.2	19
OYE13	15.6	r	A	b	b	2.89	296	1.32	15.87	-4.51	3	4	1	104.0	0.4	9
OYW01	20.2	s	F	i	i	1.03	148	1.99	2.71	-1.41	1	2	0	70.4	6.4	6
OYW02	28.0	c	C	f	f	0.16	115	0.29	0.84	0.00	0	0	0	62.9	14.8	5
OYW03	36.0	c	C	f	f	0.57	135	1.60	2.69	-0.99	4	3	0	59.1	20.7	6
OYW04	19.6	c	C	f	f	0.73	104	1.62	2.18	-1.27	5	3	0	50.5	13.7	6
OYW05	10.6	r	C	d	d	0.81	113	0.29	3.51	0.00	5	4	0	49.7	12.9	7
OYW06	10.2	r	A	c	c	1.38	108	0.00	2.45	1.55	5	3	0	47.7	10.8	9
OYW07	100.0	s	D	j	js	0.26	67	1.89	6.45	-0.14	1	3	0	40.2	0.5	9
OYW08	5.4	r	A	b	b	1.71	69	1.00	6.05	-2.12	5	4	4	40.1	0.4	8
OYW09	18.2	c	C	f	f	0.47	82	0.76	1.67	-0.42	5	3	0	40.6	4.9	8
OYW10	35.8	c	C	f	f	0.57	57	0.20	1.14	0.99	0	0	0	36.7	7.3	5
OYW11	11.4	c	C	f	f	0.32	35	0.29	1.06	0.56	0	0	0	27.2	4.1	7
OYW12	26.4	s	F	i	i	0.81	27	0.86	1.85	1.13	0	0	0	21.6	4.2	4
OYW13	31.0	s	F	i	i	0.48	11	0.29	0.93	0.85	0	0	0	18.5	16.1	8
PE01	67.2	c	C	f	f	0.23	356	1.00	1.11	0.28	1	2	0	129.2	0.1	10
PE02	15.0	c	C	f	f	1.08	361	0.47	2.38	1.83	2	2	0	131.3	1.0	4
PE03	100.0	c	B	e	e	0.26	354	1.89	1.46	-0.42	1	4	0	129.4	0.8	4
PE04	15.6	c	C	f	f	1.84	368	1.87	4.17	-3.10	4	4	0	122.5	5.2	6
PE05	61.8	c	D	j	jc	0.16	375	0.29	1.00	0.28	5	3	0	136.2	0.4	4
PE06	35.4	c	C	f	f	0.51	382	1.45	2.13	-0.85	4	2	0	131.9	2.5	6
PE07	3.2	r	A	c	c	1.59	380	1.93	6.76	-1.13	4	4	2	121.7	6.2	4
PE08	4.8	r	A	b	b	6.60	383	2.00	7.52	-8.46	4	4	2	118.9	7.0	6
PE09	20.4	c	A	f	f	0.69	407	0.00	2.47	0.85	3	3	0	112.5	2.1	5
PE10	49.4	c	B	e	e	0.36	418	1.95	2.23	-0.56	4	3	0	105.7	0.6	8
PE11	12.0	r	A	c	c	4.11	371	1.55	5.49	-7.05	4	4	1	121.6	1.2	6

PE12	8.8	r	A	b	b	7.61	470	0.99	19.19	-9.31	4	5	0	147.7	0.4	6
PHYC01	93.8	s	F	i	i	0.98	142	0.19	3.08	0.28	2	1	0	44.6	8.9	8
PHYC02	22.4	c	G	g	gc	0.87	130	1.39	1.71	0.56	2	3	0	45.2	5.9	9
PHYC03	5.6	r	A	a	a	0.48	116	1.71	2.27	-0.85	3	6	5	51.7	5.4	10
PHYC04	100.0	c	D	j	jc	0.11	144	1.00	1.84	-0.14	1	2	0	99.7	0.0	11
PHYC05	13.2	c	C	f	f	0.83	140	0.73	3.98	-0.71	3	2	0	98.5	0.5	10
PHYC06	13.4	c	C	f	f	0.26	113	0.11	1.62	0.14	1	3	0	84.0	5.4	11
PHYC07	8.6	r	A	b	b	9.63	138	0.00	36.08	11.56	5	4	2	92.1	2.8	4
PHYC08	36.8	r	A	b	b	1.83	133	2.00	6.03	-2.26	4	4	2	93.3	0.3	6
PHYC09	16.4	r	C	d	d	1.34	131	1.34	2.20	-2.12	3	3	1	90.2	1.9	8
PHYC10	15.2	c	C	f	f	0.69	130	1.16	4.33	0.71	3	3	0	90.5	3.0	11
PHYC11	4.4	r	A	b	b	6.38	128	1.04	13.95	7.61	5	5	2	85.4	1.2	9
PHYC12	42.0	c	B	e	e	0.81	109	1.99	1.27	-1.13	1	2	0	82.5	7.4	7
PHYE01	100.0	s	F	i	i	3.39	164	0.29	3.36	5.92	0	0	0	104.9	13.3	7
PHYE02	100.0	s	F	i	i	0.41	162	0.17	0.82	0.14	0	0	0	107.2	14.9	10
PHYE03	3.0	r	C	d	d	3.80	190	1.66	6.98	0.42	4	3	2	112.7	13.2	8
PHYE04	12.0	c	C	f	f	0.58	162	0.80	1.08	-0.56	3	1	0	110.5	11.4	10
PHYE05	95.4	c	D	j	jc	0.94	158	1.24	2.57	0.85	1	2	0	121.0	0.1	13
PHYE06	31.6	c	C	f	f	0.92	173	0.50	2.77	1.55	3	2	0	120.4	3.0	10
PHYE07	10.8	c	C	f	f	0.67	174	0.49	1.51	-0.28	3	4	0	130.3	1.1	14
PHYE08	65.0	c	B	e	e	0.26	163	0.11	1.49	0.14	1	2	0	118.7	6.9	10
PHYE09	15.4	r	A	c	c	0.47	185	1.97	9.23	-0.42	3	3	0	119.2	1.4	10
PHYE10	21.8	s	G	g	gs	0.47	164	1.24	1.81	-0.71	0	0	0	106.1	4.3	17
PHYE11	16.6	c	C	f	f	0.47	124	0.03	1.25	0.42	1	2	0	96.4	2.7	12
PHYE12	5.2	r	A	b	b	2.55	131	0.82	25.10	-2.54	4	6	4	92.7	5.1	13
PHYE13	16.4	r	A	b	b	8.12	139	0.11	6.93	13.54	4	4	1	89.0	4.4	9
PHYW01	100.0	s	F	i	i	1.62	10	1.63	2.76	-2.82	0	0	0	0.9	14.7	8
PHYW02	48.2	c	B	e	e	0.11	7	1.00	1.24	-0.14	0	0	0	5.0	11.3	13
PHYW03	33.8	c	C	f	f	0.32	19	1.71	0.99	0.00	0	0	0	17.8	14.7	11
PHYW04	45.4	s	F	i	i	0.57	32	0.20	1.88	0.99	0	0	0	25.0	9.6	10
PHYW05	15.0	c	B	e	e	0.82	24	0.45	1.73	1.41	0	0	0	26.5	8.3	7
PHYW06	91.2	s	F	i	i	0.23	55	0.00	1.77	0.28	0	0	0	17.8	5.1	8

Site	soilD	Subs	gm7	gm10	gm13	Slp	Elev	Asp	Rug500	Sun	Fabu	Fmax	Outcrp	Cst	Riv	Gcov
PHYW07	49.6	c	D	j	jc	0.34	22	1.00	1.37	-0.42	1	2	0	33.0	0.0	10
PHYW08	5.0	r	A	b	b	3.64	44	1.75	15.75	-6.35	5	5	4	31.4	2.5	12
PHYW09	7.6	r	A	b	b	6.21	55	0.52	13.97	-3.10	4	6	3	29.4	5.4	13
PHYW10	56.0	s	F	i	i	0.11	21	1.00	1.31	0.14	0	0	0	24.3	7.6	7
PHYW11	45.6	c	C	f	f	0.58	10	0.02	1.36	0.85	0	0	0	10.2	3.3	10
PHYW12	35.2	s	F	i	i	0.47	34	1.24	2.15	0.42	1	3	0	15.4	2.7	8
PHYW13	48.6	c	C	f	f	0.94	13	1.24	1.46	0.85	0	0	0	9.5	0.0	12
PW01	1.0	r	A	b	b	3.22	161	0.11	6.34	1.69	5	5	0	65.1	0.5	3
PW02	26.0	r	A	b	b	3.22	186	1.39	19.14	-5.22	4	3	2	64.1	2.4	6
PW03	5.2	r	A	c	c	2.38	348	1.82	5.61	-0.71	4	4	1	66.8	1.4	5
PW04	72.6	c	B	e	e	0.81	345	1.71	3.43	-1.41	5	4	0	72.9	4.1	4
PW05	100.0	c	D	j	jc	1.28	292	0.82	2.17	-1.27	0	0	0	95.5	0.6	8
PW06	30.2	c	C	f	f	0.62	335	0.07	1.95	0.99	3	2	0	105.7	13.2	8
PW07	41.4	c	C	f	f	0.26	317	0.55	1.06	-0.14	2	4	0	102.6	8.0	11
PW08	16.4	r	C	d	d	0.46	307	1.00	1.66	-0.56	2	3	0	97.9	2.5	10
PW09	100.0	c	D	j	jc	2.22	288	0.43	3.24	3.81	2	4	0	95.1	0.0	3
PW10	2.2	r	A	b	b	1.34	309	1.94	5.78	-2.12	4	4	1	94.2	0.6	5
PW11	34.2	r	A	b	b	0.83	337	1.27	3.88	-1.27	4	4	1	91.8	3.2	4
PW12	23.0	c	C	f	f	1.49	316	0.62	4.22	-0.99	4	4	0	74.9	0.3	5
PW13	29.0	c	C	f	f	0.26	130	1.45	1.50	0.14	3	4	0	61.7	0.7	9
RHNC01	17.2	r	A	c	c	1.18	687	1.49	3.55	-1.97	4	3	2	328.7	0.2	10
RHNC02	27.0	r	C	d	d	0.46	703	2.00	2.79	-0.56	4	3	2	324.1	4.4	6
RHNC03	19.0	c	C	f	f	0.32	708	0.29	1.45	0.00	1	2	0	320.2	10.6	12
RHNC04	10.0	r	A	b	b	13.67	742	0.75	42.39	-12.27	4	4	2	319.3	12.3	11
RHNC05	70.6	c	C	f	f	0.48	706	0.29	1.35	0.85	1	2	0	318.2	16.9	8
RHNC06	26.4	c	C	f	f	0.41	694	1.55	1.29	0.14	3	3	0	317.2	16.7	11
RHNC07	10.2	r	A	b	b	4.28	689	1.75	11.74	-7.47	5	4	2	314.8	14.9	9
RHNC08	31.6	r	A	b	b	0.47	701	0.76	5.96	-0.42	4	4	2	299.8	2.5	9
RHNC09	14.0	r	A	b	b	10.51	662	0.11	68.56	17.63	4	4	3	301.5	1.2	8
RHNC10	72.8	c	D	j	jc	2.02	575	0.32	6.18	3.53	3	3	0	290.0	0.0	14
RHNC11	1.8	r	A	b	b	6.17	555	1.87	12.37	-2.82	5	5	4	289.7	0.2	14

RHNC12	6.6	r	A	b	b	4.61	530	0.23	15.02	0.71	5	4	1	285.6	0.4	8
RHNC13	70.2	c	D	j	jc	0.98	507	0.42	2.13	1.69	1	3	0	284.0	0.0	14
RHNE01	100.0	s	F	i	i	0.00	426	0.28	1.00	0.00	0	0	0	292.0	6.9	15
RHNE02	23.6	c	C	f	f	0.26	418	1.89	1.02	-0.42	4	3	0	287.0	9.6	8
RHNE03	29.6	c	C	f	f	0.41	415	1.55	0.83	0.14	0	0	0	283.6	15.2	13
RHNE04	35.8	c	C	f	f	0.57	412	2.00	1.17	-0.71	1	2	0	284.2	16.3	7
RHNE05	32.0	c	C	f	f	0.51	415	1.45	1.09	-0.85	2	1	0	285.1	12.4	9
RHNE06	54.8	c	C	f	f	0.26	416	0.11	0.79	0.14	2	3	1	286.7	4.4	14
RHNE07	23.0	c	E	h	hc	0.48	411	1.71	1.37	-0.85	2	3	0	265.7	1.2	6
RHNE08	7.2	r	A	b	b	4.77	470	0.45	9.26	-1.69	5	4	3	265.6	0.1	13
RHNE09	19.6	r	A	b	b	1.34	492	0.06	3.13	2.12	5	3	1	261.8	1.4	8
RHNE10	29.2	c	C	f	f	0.69	525	0.01	2.77	0.71	5	3	0	227.6	4.9	7
RHNE11	20.8	c	C	f	f	2.10	474	0.13	4.66	0.99	4	4	0	222.4	7.1	6
RHNE12	18.0	s	G	g	gs	1.08	442	0.47	2.88	1.83	3	4	2	219.4	7.3	8
RHNW01	5.2	r	A	b	b	11.62	657	1.96	33.19	-9.87	4	4	4	241.4	16.8	11
RHNW02	11.0	r	A	b	b	4.72	570	1.80	15.29	-1.13	4	4	1	242.7	18.4	8
RHNW03	39.2	c	A	f	f	0.47	442	0.03	2.36	0.71	3	4	0	237.5	11.7	8
RHNW04	31.6	c	D	j	jc	0.57	412	0.00	1.51	0.71	0	0	0	223.5	0.9	8
RHNW05	34.2	c	B	e	e	0.16	412	0.29	1.02	0.28	4	2	0	221.4	3.0	10
RHNW06	47.4	c	C	f	f	0.36	415	0.68	2.13	-0.28	4	3	0	220.9	4.3	14
RHNW07	14.2	r	A	c	c	1.97	447	0.19	5.92	0.56	5	5	1	212.3	13.2	10
RHNW08	55.6	c	B	e	e	1.38	520	0.25	4.98	2.40	4	4	0	199.4	11.3	6
RHNW09	27.0	r	A	c	c	1.49	500	0.08	5.07	0.99	4	4	1	194.8	7.9	9
RHNW10	7.2	r	A	b	b	2.54	489	1.59	9.43	-4.37	4	5	4	202.8	14.4	13
RHNW11	63.8	c	B	e	e	0.23	418	2.00	1.36	-0.28	3	3	0	220.8	7.4	11
RHNW12	45.4	c	E	h	hc	0.47	408	1.97	1.84	-0.42	1	2	0	225.7	0.5	12
RHNW13	20.8	r	C	d	d	0.82	413	1.83	3.05	-0.28	4	3	0	227.0	1.6	11
TCMBC01	36.4	s	F	i	i	0.41	323	0.45	1.00	0.71	2	2	0	289.8	4.5	12
TCMBC02	19.4	c	C	f	f	0.41	348	0.45	1.75	0.71	5	4	0	289.8	1.8	10
TCMBC03	25.2	r	C	d	d	4.44	380	0.33	7.34	-0.42	4	3	0	289.2	0.8	10
TCMBC04	19.0	c	C	f	f	1.38	449	1.41	5.93	-2.26	5	4	0	289.9	0.8	8
TCMBC05	13.6	r	A	b	b	8.20	563	1.37	31.17	-13.25	5	5	3	288.1	2.6	16

Site	soilD	Subs	gm7	gm10	gm13	Slp	Elev	Asp	Rug500	Sun	Fabu	Fmax	Outcrp	Cst	Riv	Gcov
TCMBC06	13.8	r	A	b	b	15.40	442	0.44	35.51	27.07	5	4	2	298.5	4.1	10
TCMBC07	29.4	c	C	f	f	1.13	396	0.59	3.67	1.83	3	3	0	298.7	3.3	13
TCMBC08	28.8	r	C	c	c	1.28	421	0.02	7.02	1.27	5	3	0	296.6	1.3	15
TCMBC09	11.6	r	A	b	b	7.39	446	0.00	21.37	9.02	5	5	1	293.4	0.3	13
TCMBC10	41.8	s	D	j	js	0.65	462	0.29	4.20	0.00	4	3	0	289.2	0.1	10
TCMBC11	31.4	r	C	d	d	0.47	479	1.24	2.80	-0.71	5	3	0	289.9	0.5	9
TCMBC12	23.2	r	C	c	c	0.62	487	0.63	1.25	-0.42	4	3	0	291.1	2.0	10
TCMBE01	31.8	c	C	f	f	1.08	803	0.47	6.92	1.83	4	3	0	217.3	13.8	13
TCMBE02	24.7	c	C	f	f	0.46	762	1.00	7.60	-0.56	4	3	0	218.2	12.6	14
TCMBE03	20.6	c	C	f	f	1.18	756	1.49	9.66	-1.97	4	3	0	224.1	8.7	10
TCMBE04	28.6	c	C	f	f	1.02	752	1.45	6.23	-1.69	4	3	0	223.0	8.1	10
TCMBE05	8.2	r	A	b	b	11.30	828	1.98	30.69	-10.86	4	5	4	221.2	9.6	11
TCMBE06	47.6	c	C	c	c	0.23	708	1.00	1.01	-0.28	1	2	0	221.9	9.9	10
TCMBE07	34.8	r	C	d	d	1.13	683	1.41	3.83	0.71	4	3	0	231.5	0.8	6
TCMBE08	100.0	s	D	j	js	0.41	684	0.17	2.99	0.71	1	3	0	232.3	0.0	14
TCMBE09	7.8	r	A	b	b	2.89	722	0.05	17.81	4.51	4	4	2	214.4	17.7	10
TCMBE10	68.0	c	B	e	e	0.69	764	1.00	6.33	0.85	4	5	0	212.7	17.0	5
TCMBE11	11.6	c	C	f	f	2.17	817	0.05	7.48	3.38	3	4	0	216.6	11.5	17
TCMBE12	7.0	r	A	b	b	7.25	905	0.76	14.60	10.86	4	5	3	218.3	10.4	13
TCMBE13	9.0	r	A	b	b	7.47	825	0.29	25.59	0.14	4	5	4	219.7	11.1	10
TCMBW01	13.0	s	G	i	i	0.57	445	0.40	4.39	0.99	4	4	2	229.0	7.9	16
TCMBW02	31.6	s	F	i	i	1.14	439	1.00	2.82	-1.41	2	2	0	229.9	6.5	18
TCMBW03	13.0	r	A	c	c	0.65	474	1.71	2.06	-1.13	4	4	2	227.4	1.4	12
TCMBW04	10.6	r	A	b	b	2.43	488	1.66	10.37	0.28	5	5	3	226.2	0.6	11
TCMBW05	29.4	r	C	d	d	2.82	532	1.93	7.64	-4.51	4	4	4	217.8	0.6	10
TCMBW06	3.0	r	A	b	b	10.89	586	1.18	33.80	11.00	4	4	4	212.7	4.2	13
TCMBW07	18.2	c	C	f	f	1.08	638	0.15	1.77	0.42	3	2	0	195.5	4.1	17
TCMBW08	69.6	c	B	e	e	0.11	638	1.00	2.64	-0.14	3	4	0	196.4	1.0	12
TCMBW09	20.0	c	C	f	f	1.08	607	0.05	2.49	1.69	5	2	0	179.8	7.8	13
TCMBW10	36.6	c	C	f	f	0.34	587	1.00	1.75	0.42	0	0	0	174.9	3.1	16
TCMBW11	8.4	r	A	b	b	3.20	605	1.57	8.12	0.99	5	3	2	173.5	1.8	13

TCMBW12	60.6	c	B	e	e	0.67	579	0.49	1.41	-0.28	2	2	0	171.9	0.3	8
TCMBW13	14.0	c	C	f	f	0.98	588	1.94	3.35	-1.55	5	3	0	170.6	0.8	9
WYE01	17.0	r	A	b	b	17.13	303	1.76	27.07	-30.74	5	6	4	179.4	5.8	7
WYE02	28.0	c	C	f	f	1.44	246	0.05	2.70	2.26	3	3	0	174.9	4.2	9
WYE03	38.6	r	A	b	b	5.10	242	1.40	5.27	3.24	5	3	3	168.2	3.7	4
WYE04	39.4	c	B	e	e	0.41	195	0.45	1.48	-0.14	3	3	0	161.9	0.9	9
WYE05	10.0	r	A	b	b	3.90	181	1.61	6.12	-6.77	4	3	2	135.0	9.3	4
WYE06	28.8	s	F	i	i	0.67	139	0.14	1.49	0.28	1	1	0	111.3	2.9	6
WYE07	27.0	s	G	g	gs	0.62	155	0.07	2.38	0.99	3	6	2	106.0	11.6	6
WYE08	10.0	r	C	b	b	3.00	210	0.35	4.26	-0.42	5	4	4	125.2	7.5	7
WYE09	13.8	r	A	c	c	3.94	226	0.83	4.80	-3.95	3	4	4	129.9	6.7	6
WYE10	7.2	r	A	b	b	2.08	239	0.01	7.05	2.12	3	3	3	129.7	6.9	4
WYE11	2.4	r	A	b	b	6.13	272	0.42	14.30	10.58	4	5	4	134.0	7.0	5
WYE12	16.0	r	A	c	c	2.25	264	1.41	3.34	1.41	4	4	1	135.6	6.8	5
WYE13	3.6	r	A	b	b	19.54	281	1.11	28.58	-27.64	4	4	2	139.6	5.4	5
WYW01	12.8	r	A	c	c	1.50	108	0.01	4.16	1.55	5	4	1	62.8	5.5	4
WYW02	3.4	r	A	b	b	1.70	117	1.67	17.05	-2.96	5	4	3	64.5	5.6	6
WYW03	16.2	c	C	f	f	0.23	105	2.00	1.66	-0.28	5	3	0	69.2	6.0	5
WYW04	100.0	s	F	i	i	1.54	127	0.26	8.00	0.14	0	0	0	70.9	4.8	6
WYW05	0.8	r	A	b	b	13.21	144	0.35	10.35	-1.69	4	4	4	71.3	4.5	6
WYW06	16.2	r	C	c	c	0.72	111	0.68	1.67	-0.56	2	3	0	75.9	9.3	7
WYW07	11.8	s	F	i	i	0.11	88	0.00	1.59	0.14	1	1	0	74.3	14.7	7
WYW08	87.8	s	F	i	i	0.36	92	1.32	1.79	0.28	0	0	0	103.7	7.7	6
WYW09	10.4	r	A	b	b	1.64	123	0.02	5.03	1.55	4	3	4	102.3	15.2	4
WYW10	17.4	r	A	c	c	2.50	135	1.73	4.43	-4.37	5	4	0	102.1	17.7	5
WYW11	37.4	c	C	f	f	0.41	123	0.45	1.04	0.71	0	0	0	122.7	11.1	4
WYW12	17.6	r	A	b	b	2.40	164	2.00	3.04	-2.96	5	4	2	132.1	12.7	6

soilD Soil profile depth to hardpan, usually sheet rock.
Subs Substrate type in three categories: rocky, sandy or clayey (see Table below).
gm7, gm10, gm13 Geomorphic categorisations.

Substrate	gm7	gm10	gm13	description
Rocky	A	a	a	Granite hills with bare slopes and boulders & patches soil and vegetation in crevices, depressions etc.
Rocky	A	b	b	Massive rocks of hilltops and scree slopes associated with hill scarps, steep slopes etc., usually steep. Soil & vegetation shallow, discontinuous & mainly in crevices and pockets. Rock outcrops frequent
Rocky	A	c	c	Flat stony uplands, slopes and plains with shallow soils (0.5 m) over pavement or hardpan; includes surface geological units Tg, Czl etc. (**Appendix A**). Soils usually stony, but large rocks infrequent or absent
Rocky	C	d	d	Calcrete or opaline hills and mesas. Mantled in shallow soils with fragments (surface geology: Czk, To, Czo).
Clayey	B	e	e	Heavy cracking / heaving clay plains and very gentle slopes, usually with stones
Clayey	C	f	f	Deep clayey profiles, often with surface strew and/or stony profile, as plains, gentle slopes . Qc, Czc etc.
Clayey	G	g	gc	Granitoid slope or plain with **gritty clay** profile mantling sheet granite at >30 cm depth in most places. Sheet or boulder outcrops in places.
Clayey	D	j	jc	Riverine levee of **alluvial clay-silt rather than sand**, or clay pans with River Gums, Paperbark trees or *Eucalyptus victrix* etc. Geological units Ql and Qa.
Clayey	E	h	hc	Saline mud; bare or with samphire.
Sandy	F	i	i	Deep sand and/or firm (slightly clayey) sand as dunes and plains, desert as well as beach sands. May mantle granite or clay at > 0.5 m depth and/or have scattered exposures of clay or rock.
Sandy	G	g	gs	Granitoid slope or plain with **gritty sand** profile mantling sheet granite at >30 cm depth in most places. Sheet or boulder outcrops in places.
Sandy	D	j	js	Riverine levee or river bed of sand or riverine grit-sand mix with river gums, paperbark etc.(Ql mainly sand).
Sandy	E	h	hs	Sand veneer over saline mud with Buffel or *Triodia*

Slp Slope angle. Derived by L.A. Gibson from the STRM (Shuttle Radar Topography Mission) 90-m resolution Digital Elevation Model (DEM) using Spatial Analyst tools in ArcGIS 9.1 (ESRI Inc., Redlands, CA, USA), resampled at 100-m pixel resolution.

Elev Elevation above mean sea level, derived from the DEM as described for **Slp**.

Asp Aspect, derived from the DEM as described for **Slp**, then further transformed [i.e. cos(aspect-135o)+1] to give north-west (value of 0) and south-east (value of 2) as the extremes.

Rug500 Topographic ruggedness was derived from the DEM as described for **Slp** by performing a neighbourhood function in ArcGIS (i.e. standard deviation in elevation) in a 500 m radius.

Sun Sun index = tan(**Slp**) × cos(**Asp**) × 100 expressed in radians, and indicates the amount of solar radiation that a site receives.

Fabu A visual estimation of the abundance of coarse stone fragments on the ground's surface (following McDonald *et al*. 1984).

Fmax The maximum dimension (size-class) of coarse stone fragments on the ground's surface (from McDonald *et al*. 1984).

Fabu	Fmax (mm)
0 = No coarse fragments	0 = None
1 = Very few	1 = Small pebbles (2–6)
2 = Few	2 = Medium pebbles (6–20)
3 = Common	3 = Large pebbles (20–60)
4 = Many	4 = Cobbles (60–200)
5 = Abundant	5 = Stones (200–600)
6 = Very abundant	6 = Boulders (600–2000)
	7 = Large boulders (>2000)

Outcrp The extent of rock outcrop at the site (from McDonald *et al*. 1984).

Cst Distance to the coast was generated from digitised hydrology information available from DEC Corporate GIS dataset.

Riv Distance to as major drainage line was generated from digitised hydrology information available from DEC Corporate GIS dataset.

Gcov An index of total ground cover (i.e. shrubs < 2 metres, grasses and sedges) at each site. The cover of each vegetation stratum was visually estimated, scored (1: <2%, 2: 2–10%, 3: 10–30%, 4: 30–70%, and 5: >70%) and tallied. It is derived from 'vegetation complexity' adapted from Newsome and Catling (1979).

	Score			
Structure	**0**	**1**	**2**	**3**
Tree canopy (%)	0	<30	30–70	>70
Shrub cover (%)	0	<30	30–70	>70
Ground herbs/grasses	Sparse <0.5 m	Sparse >0.5 m	Dense <0.5 m	Dense >0.5 m
Logs, rocks, debris etc.	0	<30	30–70	>70
Complexity Score (**vegC**)	Sum of scores			