4. Summary and discussion

The SWALE project described eight sites that displayed some of the very wide range of physical settings found in the South West region of Western Australia. The variety of physical settings surveyed corresponded with large floristic and structural differences in the vegetation between sites. A number of taxa poorly represented in the WA Herbarium collection, undescribed taxa, new populations of DCLM Priority Species and range extensions were recorded. This was so not only in the vegetation of the Quindalup Dunes, that has received the most attention from previous researchers, but particularly in the vegetation of Cape Le Grand National Park. It is clear that many elements of the coastal flora of this region are not well known and considering the intense pressures on coastal vegetation due to development and recreation, it is a priority that coastal vegetation be surveyed more adequately to ensure adequate conservation of this diversity in reserves. The methods used by the SWALE project with Regional Herbarium volunteers were effective in surveying the flora and vegetation and establishing a baseline for monitoring change. These methods can be used in the future at various levels ranging from qualitative assessment of vegetation to multivariate analysis of quantitative trends to both assess diversity of vegetation between sites and inform management decisions. In addition, management issues were identified during the course of the SWALE project which should be addressed in the near future to protect these high conservation areas.

A total of 243 taxa were recorded from the eight SWALE transects and another 23 taxa were collected opportunistically nearby.The transects were repeatedly visited for the purposes of flora collection over about 18 months. The total recorded exceeded the 110 taxa of Sauer (1965) from 50 transects in a larger survey from Port Hedland to Albany. The latter probably involved only one visit to each site and the survey was carried out in late summer therefore transects would probably have been devoid of many winter and spring-flowering geophytes and annuals. Apart from the season and intensity of survey, it is also probable that the inclusion of the species-rich Cape Le Grand area and its complement of south coast siliceous (quartz) sand endemics in the SWALE project also contributed to the large number of taxa collected. The SWALE flora inventory also contributed 76 taxa above those known to inhabit the coast by Beard (1990b) (whose list was sourced from all published records to 1990). Most of these additions were taxa

from the Cape Le Grand area, thus again underscoring a relative paucity of floristic survey in coastal habitats of this region.

The Mt Le Grand transect was by far the most species-rich of the transects and most taxa from this site did not occur elsewhere in the study (Table 12). It was also the transect with the most numerous undescribed and DCLM Priority Species and a very low proportion of naturalized alien taxa. The transect encompassed a catena of soils developed on the rocky slope colluvium and thus a wide array of plant habitats. The Hellfire Beach transect was the least alien-invaded transect, had an average species richness and a high proportion of taxa found only in this transect of the study. The very thick, undisturbed heath occurring on the slope was probably not conducive to invasion by the relatively low pool of alien taxa occurring in the area. The uniformity of edaphic conditions on the slope (deep siliceous sands throughout the transect) contrasted with the complexity of the Mt Le Grand slope and this could explain the comparatively low species richness and high distinctiveness of the flora. The Dalyellup Beach transect was significantly more species-rich than all the other Quindalup Dunes in the survey and was second in this attribute only to Mt Le Grand. However it had a higher proportion of alien taxa than many of the other Quindalup Dunes transects (e.g. the Port Kennedy plain transect PK1) and a relatively low rate of taxa which did not occur elsewhere in the survey. The Port Kennedy beachridge plain transect was notable as the Quindalup Dunes transect with the most undescribed taxa, its relatively low rate of alien taxa and the numerous taxa which did not occur in other transects. The latter was probably due to the freshwater wetland habitats of this transect which were not present elsewhere in the survey. The Becher Point transect was considerably more invaded by alien taxa and less species-rich than the saltmarsh at the Preston River Delta. The number of weeds is not surprising considering the large swathes cut through this transect by vehicle tracks. One of the tracks is currently being rehabilitated by the manager of the Port Kennedy reserve (DCLM). The low species richness probably reflects the relatively uniform edaphic conditions over the saltmarsh compared to the complex tide-related habitats of the delta and perhaps the relative youth of the Becher Point wetland (see Fig 8). The Greenough Dunes and Drummonds Cove were similar to each other in floristics, with average species richness and proportions of alien taxa. They were however sharply differentiated from the southern Quindalup Dunes transects on floristics.

Table 12: Summary of floristic characteristics of the SWALE transects.
* This transect varies considerably in species richness and vegetation condition. The figure below was calculated from the section between 200-300m along transect PK1 as this did not include any vehicle tracks.

Transect	Total taxa	% alien taxa	% taxa in this transect only	Taxa/m^2	Total priority & undescribed taxa
Mt Le Grand	91	8	71	0.85	6
Hellfire Bay	26	2	38	0.44	-
Port Kennedy plain	76	18	32	*0.43	3
Drummonds Cove	48	23	6	0.32	1
Greenough Dunes	54	24	22	0.40	-
Dalyellup Beach	65	26	15	0.71	2
Preston River Delta	57	28	33	0.46	-
Becher Point	30	57	13	0.21	-

Over 500 voucher specimens were databased and incorporated into the WA Herbarium by the SWALE project and the names assigned to these specimens are now constantly updated and available on line. Unfortunately all but one of the specimens from Sauer's collection were lodged with herbaria in the United States of America. About 29% of the names assigned to taxa in the latter inventory are no longer valid due to taxonomic revisions and other scientific reasons. It would therefore be a relatively specialized task to research vegetation changes of the Sauer transects over time compared to conducting similar studies of the SWALE transects in which name changes are available on line to volunteers without need to refer to taxonomic journals. With the assistance of the distribution records of flora now available via Florabase, a number of significant range extensions of coastal taxa were determined from the SWALE project collections (Table 13). Seven new populations of DCLM Priority Taxa were also found (Table 14). (Note: some of the latter were collected opportunistically from Cape Le Grand coastal wetlands not included in transects).

There were no CALM Priority taxa collected in the Geraldton transects however a significant collection from the Drummonds transect was *Calandrinia* sp. Drummonds AA Brooker 110. This is a previously undescribed taxon and appears to have affinities with *Calandrinia remota* and *Calandrinia polyandra* (neither of which have been collected at Geraldton before). It differs however in several diagnostic character states from the latter taxa.

Table 13 : SWALE flora taxon range extensions

Taxon	Previous records	Extension
Platysace haplosciadia	Margaret River area	East to Mt Le Grand
Sphaerolobium pubescens	Albany area	East to Cape Le Grand
Zygophyllum fruticulosum	Claremont-Cottesloe, Perth	South to Dalyellup
Xanthosia tasmanica	West of Ravensthorpe	East to Mt Le Grand
Logania litoralis	Horrocks Beach north of Geraldton	South to Greenough Dunes

Table 14: DCLM Priority Taxa new populations found in the SWALE project.

Taxon	Priority	Location
Dampiera decurrens	P2	Mt Le Grand transect
Goodenia quadrilocularis	P2	Cape Le Grand coastal wetlands
Lepyrodia fortunata ms	P2	Cape Le Grand coastal wetlands
Leucopogon rotundifolius	P3	Mt Le Grand transect
Sphaerolobium pubescens	P3	Cape Le Grand coastal wetlands
Verticordia vicinella	P3	Mt Le Grand transect
Conostylis pauciflora subsp. *pauciflora*	P4	Port Kennedy both transects

Many taxa collected in the Geraldton transects were at the southern end of their coastal range including *Ptilotus divaricatus* var. *divaricatus*, *Rhagodia latifolia, Rhagodia preissii* subsp. *obovata, Euphorbia tannensis* subsp. *eremophila*, *Logania litoralis, Commicarpus australis* and *Lotus australis*. Therefore the importance of the Geraldton coastal vegetation is not based on the rarity of constituent taxa but on its embodiment of ecological and biogeographical trends.

Unfortunately coastal vegetation in the immediate vicinity of the town of Geraldton has effectively all been cleared for the installation of the port, the town centre and the expanding suburbs. A railway line runs immediately adjacent to the beach along much of the urban shoreline. Fringing the beach-side suburbs there is, at most, a narrow and often degraded ribbon

of foredune vegetation. The large Southgate Dunes on the southern outskirts of the city are in the process of being homogenized into a suburban precinct. North from the city, the Drummonds Cove suburban development is destined to consume almost all the remaining coastal scrub. The loss of indigenous vegetation is compounded by a major invasion of the coastal scrub throughout the area by **Lycium ferocissimum* (African Boxthorn), which spreads rapidly forming massive prickly stands excluding all indigenous plants. Other serious weeds are also rampant. The Greenough Dunes faces serious threats from indiscriminant use of off-road vehicles in the reserve as well as weed invasion. Two distinctive landform and vegetation features are encompassed by the project areas at Geraldton transects which have considerable conservation value as landscape features and embody some of the sense of place which make Geraldton different to other coastal towns. These are the unique Greenough Dunes and the acute foredune crests vegetated by *Atriplex isatidea* scrub in the Geraldton suburb of Drummonds Cove. Unfortunately, it seems almost certain that Geraldton will lose most of its remnant indigenous vegetation unless local awareness is raised. Major funding directed to the management of weeds, revegetation and the reservation of larger areas of coastal vegetation would be required in the near future to reverse current trends and this seems unlikely in the social and economic climate of the region which favours development over conservation.

At Port Kennedy Scientific Park, the SWALE project was part of a long-term and committed effort by local volunteers to conserve and manage the Port Kennedy Scientific Park and it provided floristic and hydrological data in a form useful for public education and ongoing management of the reserve. A number of flora taxa previously not recorded from the area were collected by the SWALE project (Table 14). These additions probably reflected the difference in sampling strategies between the SWALE study, which intensively sampled near-coastal areas, and previous extensive sampling of the entire reserve (Keighery and Keighery, 1993). Two previously undescribed taxa of *Calandrinia* (F. Littleton 66 & 68) were of particular significance amongst the new flora records from Port Kennedy Scientific Park. These have affinities with *Calandrinia polyandra* and *Calandrinia eremaea* respectively (both of which have never been collected from the Perth Coastal Plain and are generally plants of the arid zone) but differ significantly from the latter taxa. The Port Kennedy *Calandrinia* spp. also differ from *Calandrinia* sp. Drummonds Cove A.A. Brooker 110 which was collected at Geraldton. *Calandrinia* is a genus of the family Portulacaceae, whose constituents are usually succulent plants with very delicate, ephemeral flowers. Material of these taxa is difficult to collect and

preserve in a condition that retains essential features for taxonomic study. This difficulty is partly responsible for these taxa being poorly known by botanists. Trained volunteers in the SWALE project have thus made a large contribution in their skillful and patient collection of these specimens.

Table 14 : New flora records for the Port Kennedy Scientific Park

Taxon
**Atriplex prostrata*
Calandrinia sp. 1 Becher. F Littleton 66
Calandrinia sp. 2 Becher. F.Littleton 68
Conostylis pauciflora subsp. *pauciflora* P4
Hydrocotyle tetragonocarpa
Lepidosperma squamatum
**Polypogon maritimus*
Rhodanthe citrina
Sarcocornia quinqueflora subsp. *quinqueflora*
Scaevola anchusifolia
Suaeda australis
Threlkeldia diffusa
Triglochin mucronata
**Vulpia fasciculata*

The indigenous vegetation of the Port Kennedy Scientific Park was generally in good condition and species-rich over much of the reserve. However this fact is not always obvious to the casual observer because much of the area's diversity resides in assemblages of poorly-known native grasses, sedges and herbs. There were few serious invasive weeds in the area surveyed except for **Euphorbia terracina* (present at a low rate) and small localized infestations of **Asparagus asparagoides* (Bridal Creeper). The latter has now been eradicated. The SWALE survey showed these two weeds were by no means widespread at present in the western parts of the reserve. However **Euphorbia terracina* does have the potential to be invasive as a consequence of frequent fires. Fire control is thus an important issue in park management along with controlling illegal use of the park by visitors in off-road vehicles. Revegetation of numerous poorly-sited tracks which currently abound in the area is also a priority.

The subtle patterns displayed by near-coastal plant assemblages with regard to groundwater levels is a distinctive feature of the Port Kennedy Scientific Park. To investigate this aspect of the reserve was largely beyond the resources available to the SWALE project. However due to interest and support from the volunteers, a rudimentary hydrological study was conducted over

one year at three sites along the flora transects. The level of monitoring employed was sufficient to classify these wetlands according to hydroperiod and gain some insight into hydrological factors maintaining the wetland conditions. It became apparent however that whilst the wetland swales were largely maintained by rainfall, the Becher Point wetland showed a more complex pattern of groundwater fluctuation. More intensive sampling would be necessary to explain the latter. It is probable that perching of rainwater by organic matter in the basin and the proximity of the wetland to the ocean and thus tidal influence may be implicated in this pattern. Groundwater levels in the area are potentially subject to serious change due to nearby urban development and ground water abstraction by bores. The baseline hydrological data collected by SWALE will be useful in monitoring for such effects and in understanding vegetation change due to climatic fluctuations over time.

The Bunbury transects were located in a rapidly developing urban area. The vegetation of the transects and surrounding areas has high conservation value and use of the transects to monitor change over time in these areas may be crucial, even in the short term, in alerting management authorities with regard to threats to the biodiversity and local character of the vegetation. The vegetation is composed mainly of common taxa however it is in good condition and remarkably species-rich for Quindalup Dunes vegetation. Such vegetation is now becoming scarce in the area. The Dalyellup transect is immediately adjacent to the Dalyellup Beach urban development zone and since the transect was established, much of the hinterland of the transect has been cleared of indigenous vegetation and associated landforms have been modified beyond recognition by large scale earth-moving equipment. It is a hoped that the SWALE data will be used to raise awareness of the need to reserve more of the attractive vegetation of the Quindalup to Leschenault sector of the Quindalup Dunes for conservation reserves.

The Preston River Delta mangrove population is of State-wide conservation significance being the southernmost outlier of *Avicennia marina* in Western Australia. There is evidence to suggest that mangroves have only been present at this site in relatively recent times (*i.e.* for less than 2000 yrs) (Semeniuk *et al.,* 2000). This is thought to be related to climatic change and the variable influence of the Leeuwin Current on the south west coast of Western Australia during this period. A slow expansion of the mangrove population and increase in height of the formation has been documented since the massive anthropogenic alteration of the delta. This proliferation is thought to be linked with the increased salinity of the waters subsequent to human diversion of

freshwater drainage. The vegetation assemblages observed (apart from the mangrove formations) and their fine-scale correlation with height above sea level were in accord with the conclusions of a quantitative study of halophytes at the Peel Inlet and Harvey Estuary by Backshall and Bridgewater (1981). The detailed vegetation monitoring baseline established in the SWALE transect was of particular importance at the Preston River Delta to enable future assessment of flora dispersal in relation to climate change and human intervention. The mangrove and salt marsh vegetation was in good condition but it is unfortunate that the hinterland of the saltmarsh was virtually devoid of indigenous taxa and has a very sparse, low structure. Infrastructure installed in recent years, such as boardwalks and paths protects mangrove and saltmarsh vegetation. A buffer of indigenous vegetation in the degraded hinterland to provide habitat for the indigenous bird fauna attracted to the biologically productive mangrove zone would enhance the picnic area and conservation value of the area. Other issues not successfully addressed at present include weed control and control of litter from boats which floats into the mangroves and can interfere with mangrove seedling recruitment.

Cape Le Grand National Park was impressive by any standards in its biodiversity and the pristine nature of its coastal vegetation. The SWALE project proved inadequate to describe all but a small fraction of the varied coastal landforms and vegetation of the area. It is important that vegetation types in the coastal areas and particularly the coastal wetlands are more adequately surveyed and monitoring systems are established before further pressure from tourist operations and the growing population of the area make adverse impacts. There are few natural bushland areas in the state where weed invasion is at such a low rate as Cape Le Grand National Park. However nearby along the Esperance Bay, serious infestations of invasive weeds (such as **Asparagus asparagoides* and **Leptospermum laevigatum*) are present and these will inevitably disperse to the national park in the very near future unless comprehensive, well-funded controls are implemented. Feral horses are also a growing problem on the fringes of the park. The Hellfire Bay transect set a baseline for collecting information over time regarding the regeneration of small patches of dead *Banksia* vegetation observed in the area and potentially an assessment of the importance of dieback in coastal areas. Dedicated and capable efforts have been made by the community and park managers DCLM to document the local flora. The Esperance region remains however a largely unexplored botanical frontier with many undescribed species and thus potentially lacking the essential data and resources for effective long term management.