LITERATURE REVIEW OF ENVIRONMENTAL ISSUES CONCERNING THE HONEYBEE *APIS MELLIFERA* IN WESTERN AUSTRALIA.

(in relationship to other uses of the environment
with facts and figures)

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CONTENTS:

NECTAR SOURCE

A (i) - **RENEWABLE RESOURCE**

Daily renewable resource, dependant on the age of the flowers and the species flowering season [see B5 (i)]. A limiting resource where flowers have developed morphological, structural and colour specializations for specific pollinators and the timing of nectar production e.g. *Eucalyptus* flowers are very generalised in structure being visited and pollinated by insects as well as birds (and animals) both day and night. Other plants have shown a wide range of adaptations to attract birds to their flowers or to deter insects (Ford *et al.* 1979).

Many species of plants have extra-floral nectaries, these would supply insects with additional food, particularly ants. Many of these nectaries are to be found on the leaves: e.g *Vicia faba* (Shuel, 1955; *Acacia* spp. (Bernhardt and Walker, 1984). **"Birds are very fond of feijoa flowers, not for the non-existent nectar, but for the high sugar content in the petals. The period of highest sugar content coincides with pollen availability"** (Stewart, 1986).

Some species produce nectar at night, during the day or both but a greater amount in one of the two periods (Carpenter, 1978; Ford *et al.* 1979). Production of nectar to attract pollinator(s) to the pollen source (Brown and Kodric-Brown, 1979). Matthews (1984) says that nectar is always a limited resource. In *Eucalyptus sideroxylon* nectar production is mainly produced between midnight and sunrise (Buys, 1987).

Many observations on nectar secretion have been made that show that repeated removal of the nectar actually stimulates further nectar production (Koreshkov, 1967; Raw, 1953, Boëtuis, 1948). In comparison with a single nectar removal in the evening, nectar removal 3 times during the day increased the quantity of sugar produced in *Lonicera* by 67% and in *Helianthus* by 58% (Bogoyavlenskii and Kovarskaya, 1956). Multiple visits by bees increased the nectar productivity by 50-75% (Mel`nichenko, 1963).

Complete cessation of nectar secretion occurs after complete fertilization of the flower (Mel`nichenko, 1963). The age of the flower influences secretory activity (Pankratova, 1950).

Shuel (1970) suggests that a critical threshold temperature, below which nectar is not secreted seems to exist in some species. Nectar production affected by soil moisture, humidity, Age of flowers, evaporation potential and temperature of the air.

"It remains debatable whether pollinator attraction is the primary stimulus for nectar secretion in plants or just a secondary bonus resulting from secretion for some other primary reason such as maintaining a balanced carbohydrate / nitrogen ratio in the plant" (Moezel, 1981).

"When comparing the attractiveness of two or more species, one should not jump to the conclusion that the number of bees attracted to a given plant is inextricably related to the amount of nectar derived from it. In many instances it is, but this may not always be the case". (Ayers *et al.* 1987).

Corbet *et al.* (1984) conclude **"that bees can, and sometimes do, visit nectar-rich flowers preferentially".**

Table 1 shows a wide variation of nectar production for different species and at different periods throughout the year. *Banksia attenuata* was the highest at 100.2 µl/flower and both *Adenanthos cygnorum* and *Eucalyptus drummondi* were the lowest at 0.5µl/flower in the month of June.

Species	March	June	Sept	Dec
	[nectar = µl per flower; sucrose conc =(%)]			
Adenanthos argyrea	-	-	4.1(30.4)	1.3(27.8)
A. cygnorum	0.7(22.3)	0.5(7)	7(21.7)	-
Anigozanthos humilis	-	-	5.6(20.5)	-
Banksia attenuata	-	-	-	100.2(15.5)
B. prionotes	67.8(18.2)	16(16.1)	-	-
Calothamnus quadrifidus	-	-	5.8(26.7)	5(25.4)
C. sanguineus	-	0.9(25.7)	-	-
Dryandra carduacea	-	-	17.4(27.9)	-
D. sessilis	-	27.1(22.5)	43.5(25.2)	-
Eucalyptus drummondii	-	0.5(21.1)	9.6(23.8)	-
E. macrocarpa	-	-	-	82(12)
E. wandoo	-	1.1(20.7)	-	-

Table 1
Mean standing crops and equivalent sucrose concentrations (W:V) of nectar from plants [after Collins and Briffa, 1982].

(ii) Nectar production.
Would over-produce as a survival mechanism to attract pollinators (Thorp, 1985). Birds require significant rewards so that flowers must produce copius nectar - nectar often drips from *Banksia* inflorescences (Ford *et al.* (1979). Nutrients are often limiting in Australian ecosystems, whereas energy rarely is (i.e. sunlight) and therefore massive nectar production is unlikely to place a strain on plants, unless water is scarce (Ford *et al.* 1979).

(iii) Nectar scent.
Different odours of nectars (and flower colour) attract different pollinators (Raven *et al.* 1976).

(iv) Sucrose level.
Suitable level of sucrose is needed before bees will exploit the nectar. (Also quality, quantity and concentration of nectar) e.g *Eucalyptus incrassata* has on average 7.4% sucrose (Bond and Brown, 1979). *Eucalyptus diversicolor* nectar is 19.2% (Churchill and Christensen, 1970). (see also Table 1)

Composition of nectar is important in attracting pollinators: **"It appears that the sugar composition of nectar may be a contributory factor influencing the visit of bees to flowers - a high preference for sucrose-glucose-fructose solutions"** (Wykes, 1952).

"Attractiveness of a source of nectar was dependant on the amount available and the concentration of sugar in it" (Vansell, 1934; Butler, 1945).

Table 1 shows the variation in sucrose levels occurring over different months for the same species and the range of sucrose levels between species.

In Panama, Central America, native bees collected nectar with sucrose concentrations ranging from 24 to 63% with a preference imbibing rate at 45% sucrose (Roubik *et al.* (1984). The nectar from their study plant *Hybanthus prunifolius* progressed from 15 to 60% sugar during the day.

(v) Dependant upon rainfall.
e.g. Karri (*Eucalyptus diversicolor*) has floral cycles that are dependant upon cummulative rainfall (Loneragan, 1979; Anon. 1982).

Humidity has a pronounced effect on the nectar concentration (Shuel, 1954). [attempts to correlate honey yields with weather in Canada and U.S.A. have been disappointing]. When humidity is high and sugar content is higher than 50%, nectars will absorb water from the air (Barbier, 1956). A significant positive effect of air humidity on the amount of nectar was established (Kropácová, 1963). Over a 12 year period in Canada, *Meliltus* spp. showed reduced nectar levels from 1-3pm which corresponded to the lowest daily relative humidity and a reduced sugar concentration of nectar also occurred (Braun, 1950).

When rainfall in the preceeding year was greater than 140mm, then a crop of Limes would produce nectar (Bulanov, 1956).

"Both beekeepers and Forest Officers agree that a good downpour of rain will trigger off the flowering of those buds remaining on the Karri trees" [Report on the Karri flow (1965-66)- an internal report by A. Kessell, Western Australian Department of Agriculture].

{The area of most significance to beekeepers is the south-west botanical province (Moezel *et al.* 1987) and has an area of 309,840km^2 of which 107,522km^2 is still regarded as being intact (Beard and Sprenger, 1984)}.

(vi) Dependant upon carbohydrate.

Concentration of the nectar and the amount of nectar secreted are directly related to the amount of carbohydrate available (Wykes, 1950), and is influenced by soluble carbohydrates (Czarnowski, 1952).

(vii) Dependant upon Nutrients.

In agricultural crops, addition of certain elements will increase nectar production. Examples: **"Colbalt and Zinc stimulated nectar secretion in buckwheat where the seed yield was in direct proportion to nectar secretion"** (Semina, 1967).

"Potassium deficiency resulted in a general reduction in the average amount and sugar concentration of nectar secreted per flower" (Hasler and Maurizio, 1950).

"High concentrations of potassium consistently reduced the sugar concentration of the nectar" (Shuel, 1957).

Kaziev (1959) showed that the addition of nitrogen only produced about the same or less than the controls; Potassium increased nectar production by 58%; Phosphorus by 45%; N.P.K by 32-44%; Organic manure by 45-60% and Organic manure and mineral fertilizer increased production by 56-67% greater than controls. [see Fire page 9]

In addition, different soil types play an important role in nutrient loadings which would affect the nectar secretion. O'Connell *et al.* (1978) showed that in a forest near Dwellingup (W. A.) the forest litter on reddish gravels contains more than twice the amounts of N, P, K and S in litter on yellow sand and grey and yellow gravels.

viii) Altitude:

Honey production statistics in France by Tschudin (1921) showed that average colony gains were three times as great at altitudes of 1200 - 1500m as they were between sea level and 300m. The same species have also been recorded to secrete copius quantities of nectar in alpine areas and less at lower altitudes.

B REDUCTION OF NECTAR SOURCE:

(B1) Land Clearing:

(i) - Farm lands.

Extensive clearing of the south west province (esp. during the 1950's). Some farms are being replanted with Pine plantations and wildflower farms (though some of these are being developed from virgin bush). Agro-forestry is being developed.

Regulations regarding land clearing: Must advise the Commissioner of Soil Conservation of their intention at least 90 days before clearing. Land clearing without approval is illegal.

"A progressive annual decline in seed yields of lucerne (*Medicago sativa*) in Manitoba (Canada) is attributed to a reduction of native bee fauna due to agricultural practices" (Stephen, 1955).

"If the land could weep from the abuse it has suffered, our streams would be swollen with tears. If all the farmers and pastoralists who are trying to heal the wounds from that abuse were to cry out in their frustration, the roar would echo from Esperence to the Kimberley. Ecological devastation has brought enormous areas of the state to the point where there survival hangs in the balance" (Ayris and Ellis, 1989).

Native bees are suffering from the lack of suitable food plants and nesting sites which have decreased due to modern agriculture (Pekkarinen *et al.* 1987; Pawlikowski, 1987).

(ii) Pine plantations.
[see B1(i)] By 1975, 8000ha ($80Km^2$) had been planted. A proposal at this stage was to increase plantings by 4000ha per annum (Anon. 1976).

By 1981, the Forests Department had purchased on the open market 17,000 ha of farmland in the Blackwood Valley for replanting of pines (Christensen *et al.* 1981).

Burrows *et al.* (1988) By 1988 some 27,000ha of *Pinus radiata* plantations had been established on land held as State Forest.

Scale insects (*Lecaniidae*) including Aphis produce honeydew on pines (Fossel, 1962). In Europe, honeydews are eagerly gathered by honeybees (Gontarski, 1951).

(iii) Vineyards.
Recent development of the large vineyard industry in the Margaret River region.

(iv) Urban and Industrial development.

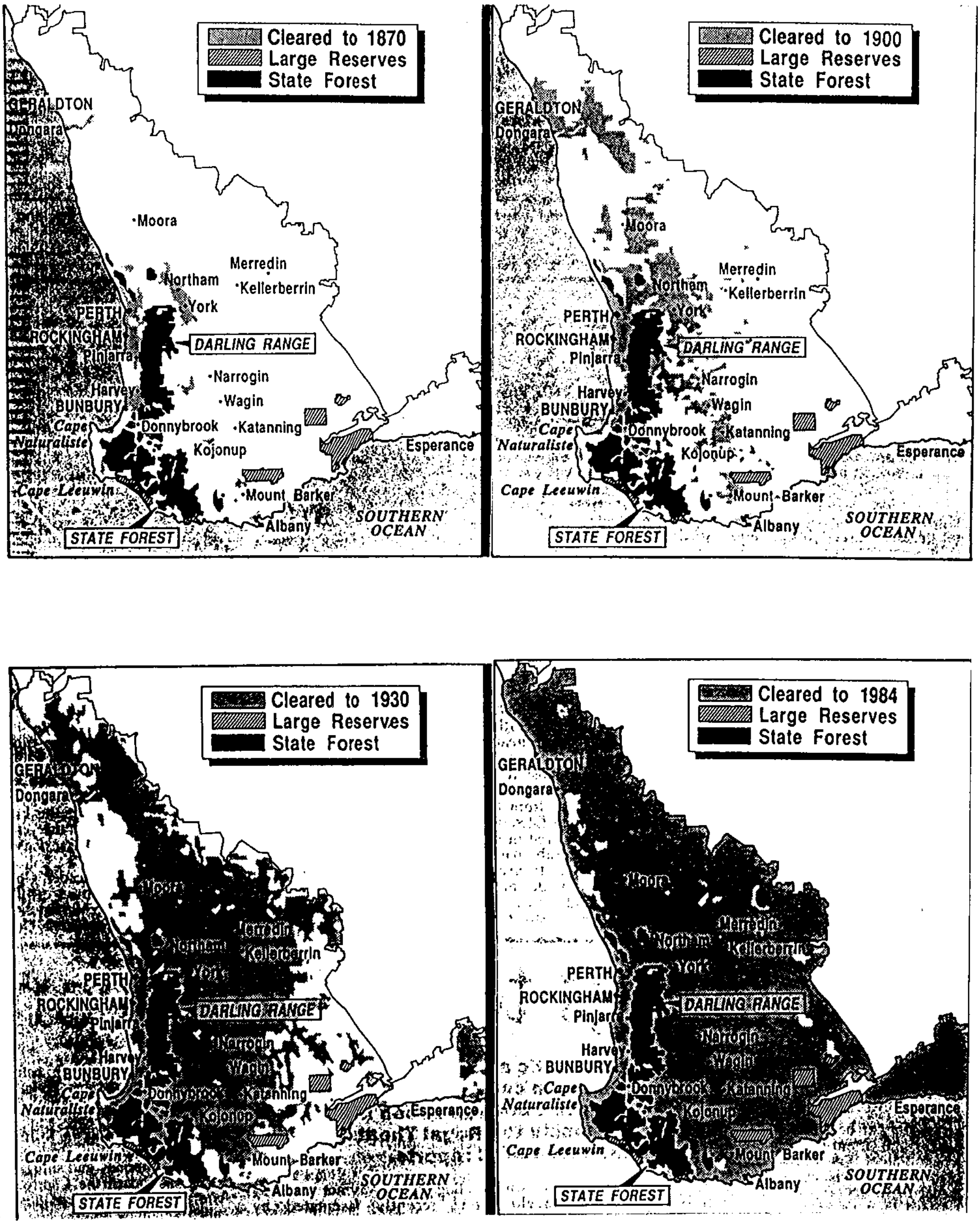
(v) Mining.
Opencut gold mines e.g Boddington; Bauxite e.g Alcoa [located in the Western Forest zone (Shea and Herbert, 1977)]; Mineral sand mining e.g. Greenbushes; and exploration grids. Most mining areas are revegetated after many years, in drier inland and northern areas revegetation takes a lot longer to achieve. Additional loss of apiary sites.

(vi) Timber.
Logging and woodchip (e.g Jarrah, Karri) industries remove mature trees that are the major producers of nectar. Areas revegetated with (often with introduced species) timber species which take many years to mature.

Karri will take 40-45 years to produce a canopy that will support beekeeper usage (Burking and Kessell, 1986). The area of south west timber reserves is 1,948,000ha [$19{,}480Km^2$ - approx. 18.1% of the remaining bush] and National Parks in the area total 415,000ha [$4{,}150Km^2$ - 3.9% of the remaining bush] (Anon. 1976).

The value of the forests is also in its intrinsic value e.g. in a survey by Jakob-Hoff (1986), 81% of people went to a National Park to admire the scenery.
As at 30th June 1988*:
State Forests = 1,820,365ha; Nature Reserves = 9,994,972ha
National Parks = 4,652,106ha; Conservation/recreation reserves = 190,412ha
Timber reserves = 144,855ha; [*Annual Report C.A.L.M. 1987-1988]

Figure 1: The extent of land clearing in south Western Australia.
[Ex The West Australian, March 19th 1989]



{Land clearing has accounted for 65% decrease (202,318Km^2 cleared) in native plant species in the south-west province (Beard and Sprenger, 1984), the major area of beekeeping in the state.}

(B2) **FIRE** (inevitable event)

(i) - Wild fires.

During 1984-86, wildfires swept through the northern Drummond (vegetation zone) - a district covering 14,637Km^2 (Beard and Sprenger, 1984) burning out an area of 1173Km^2 (Burking, 1986). The fires are estimated* to have burnt out 35.8% of this zone. For an insight into how much nectar and pollen was lost, Burking (1986) estimated that 5,460Kg of pollen and 32,210Kg of honey (not nectar) was lost in the first year. The lost would gradually decrease as the country regenerated (estimated to take 5 years). The figures mentioned are "bee collected" and would not reflect the real loss.

Largest fire in Kings Park in 56 years: Mr. Place, Acting manager (Operations), Bushfires Board said **"Parks management was reluctant to burn off because regular fires often changed the ecosystem of an area"** (Anon. 1989a).

Inappropriate fire regimes have been cited as detrimental to the Donkey Orchid's, (*Diuris purdiei*) existence, though a hot summer burn is essential for this orchid to flower (Leeuwin, 1988/89).

A report by Mr A. Kessell, Senior Apiculturist, noted: where areas were controlled burnt the previous year, Jarrah either completely lacked or had only formed very light bud. In areas not burnt, Jarrah had very heavy bud. [Internal report (Department of Agriculture) on Budding of forest areas: Bedfordale to Bannister, 1/11/1973].

Scheltema (1981) states that the low honey and beeswax production in 1977-78 in W.A. was due to drought conditions and associated bushfires which caused destruction of significant areas of native flora.

* The Drummond zone is estimated to be 78% cleared (Beard and Sprenger, 1984) and the fire damaged area estimate was for the northern area of this province, therefore the % area burnt is an underestimate. Beekeepers estimate an area closer to 75% was burnt (Burking and Kessell, 1986). 89% of beekeepers reserve No. 24496 (i.e. 67,600 ha) was burnt affecting 113 apiary sites and 28 beekeepers in 1984 (Burking and Kessell, 1984).

(ii) - Prescribed burning.

Developed to lessen the impact of a major wild fire. The frequency of burning is subject to dispute and is widely carried out during the spring months, destroying flowers of many understory species. The frequency of burns may be too high and plants will not reach maturity and therefore set seed. For example the 1987 aerial burning programme, burnt 57 of the 65 sites targeted in spring (88%) and the rest (8) in autumn. Davies (1985) estimates fire damaged areas to take eight years to recover to be a viable nectar source. Saxon (1984) said if disturbances by fire are frequent, the ability of the vegetation to recover is diminished. He goes further to say that fires should occur at intervals sufficient to allow each plant community to mature.

Prior to settlement by Europeans, the aborigines used low intensity burning known as "firestick farming" in the south-west. The Jarrah and Karri forests were little used by the aborigines (Christensen *et al.* 1981).

During 1987-1988, an area of 234,200ha of indigenous State Forest was prescribed burned. Over the same period there were 279 wildfires in the south west forest region affecting 70,150ha (CALM 1987-88 Annual Report).

The level of nutrients, as outlined in **"Factors affecting nectar production"** is also dependant on forest fires. Grove *et al.* (1986) found that in a Jarrah forest immediately after a fire, concentrations of nutrients in the surface of the soil increased markedly. For example, percentage increase in nutrients over pre-burn concentrations were:

Nitrogen = 32.6% (221 to 293kg/ha)
Phosphorus = 33.5% (28.4 to 37.9kg/ha)
Potassium = 25.6% (117 to 147kg/ha)
Sulphur = 34.3% (39.9 to 53.6kg/ha)
Calcium = 71.8% (458 to 787kg/ha)
Magnesium = 66.7% (111 to 185kg/ha)

Grove *et al.* (1986) results indicate that large (37-79%) proportions of the nutrients in ash were derived from components of above ground biomass.

(B3) DIEBACK *(Phytophthora cinnamomi)*

(i) - Affected plant species from the families: Proteaceae, Epacridaceae and Myrtaceae. The majority of all *Banksia* species are susceptable with some resistance shown by the prostrate species (McCredie *et al.* 1985). The effect of dieback is similar to agricultural clearing (Shea and Herbert, 1977).

(ii) - Other species effects not studied: e.g. *P. megasperma* and *P. citricola* (Burking and Kessell, 1986).

(iii) - Spread by vehicles, beekeepers implicated [see B4(v)].

(B4) OTHER FACTORS

(i) - Environmental damage.
e.g. erosion, storm, cyclone (destroying plants/flowers). Long term drought conditions affect nectar production.

In Brown and Kodric-Brown's (1979) study, a drought year produced similar rates of nectar to normal years but there was a reduce quantity of nectar [4-10x lower than normal] in flowers available which reflected an increased rate of visitation of hummingbirds due to the poor flowering. The increased competition during this time caused many birds to emigrate or undoubtedly die of starvation.

Increasing concern of salinity affecting large areas of native bush e.g River gums - a very good source of nectar, also *Melaleuca* in low lying areas. Approximately, 30,000 ha per year are being lost to salinity (Anon, 1988b).

In Europe, *Phacelia tanacetifolia* , flowers will produce av.1.53mg of nectar with a sugar concentration of av. 28.7% over a wet summer and av. 0.112mg nectar and a sugar concentration of av. 51.8% over a dry summer (Anghel *et al.* 1961). Very high temperatures and prolonged drought are unfavourable for nectar production, particulary by plants with open nectaries (Demianowicz, 1962).

(ii) Commercial wildflower picking.
From 1980-81 Burgman and Hopper (1982) found 550 licenced commercial wildflower pickers operated collectively picking 13,814,000 flowering stems, 2,613kg of seed and 6,054kg *Boronia megastigma* (The figures represent 66% of the actual quantity harvested) also Dryandra (an important honey producer) accounted for 52% of all cut flowers and 50% of all cut flowers from Crown Land. The selective removal of the "best" flowers may reduce the genetic pool of individual species locally. Some private land is being planted with wildflower species for the export cut-flower trade (most plants used are honey producers).

Floriculture field research by the Western Australian Department of Agriculture stated that

"An initial knockdown of native vegetation results in greater production of ti-tree as the site regenerates" (Anon. 1988a).

(iii) Damage or removal of flowers and seed pods by native animals.
e.g. birds (esp. parrots) and animals feeding on flowers. Rare flora at risk here.

(iv) Damage to flora by feral animals.
e.g. rabbits, pigs and goats. Rare flora at risk here. Pigs and goats not easily removed (Sugden, 1986a) especially pigs (Anon. 1987). Combined with wildfires, rabbits are also the most devastating cause of soil erosion (Cribb, 1988).

(v) Recreational damage.
Offroad vehicles are responsible for considerable damage to the environment.

Surveys conducted in 1970-71 show that some 250,000 people visited the forests within 60Km of Perth (Hewett, 1975). Over 1.1 million people visited National Parks in Western Australia during 1982 (Jakob-Hoff, 1986). These figures vastly outnumber beekeepers using these areas.

(vi) Insect damage.
Trees attacked by insects in plague proportions:
"Thousands of newly planted trees in the Great Southern are being devastated by insects - sap-sucking Rutherglen bugs and wingless grasshoppers" (Zekulich, 1989). [The Rutherglen bugs, *Nysius vinitor*, are Australian native species, as are the wingless grasshoppers, *Phaulacridium vittatum* .]

The Western Australian native *Banksia's*, are host to the larvae of the moth *Arotrophora acruatalis* and has now become a major pest where the flowers are damaged. (Woods, 1988).

(vii) Mistletoe.
"Trees heavily infested, that is greater than 30% will most likely die..." (Anon, 1989b). The problem is causing serious concern in South Australia and Victoria.

"Some trees which support large numbers of mistletoe may eventually die" (Hart, 1987).

"*Amyema preissii* is shown to be a significant water and nutrient drain on its host.." (Lamont and Southall, 1982).

In South Australia, two birds are responsible for mistletoe seed dispersal, the Spiny-checked Honeyeater and the Mistletoe Bird. The Mistletoe bird disperses 4x as many seeds as honeyeaters (Reid, 1989).

(B5) HONEYBEES (*Apis mellifera*)

In all studies one must remember that the honey bee has been in the Australian environment for a long time [the initial shipment in 1810, (Alexander, 1977), in Western Australia 1846 (Smith, 1964)] and that feral bees exist in all areas where studies on : pollination, honeyeaters and "honeybee impacts" etc have been carried out. The data of these research projects has already been subjected to the influences of the honeybee. The honeybees may have already found a niche in the Australian environment [ecosystems are dynamic by nature] and as Sugden (1986a) states **"The Australian flora and fauna may have already been irreversably impacted by honeybees"**, Douglas (1977 & 1980) thought the honeybee was now an essential part of ecologically disturbed areas and Schaffer *et al.* (1983) has suggested the feral bees and their native counterparts are always in equilibrium and if you introduce hives to an area, then the populations of these bees will be in equilibrium after a period of time and that the equilibrium may change from year to year. For example Hopper's (1980) study of Bird and Mammal Pollen Vectors in *Banksia* communities shows that throughout the study numerous honeybees were present and both the honeyeaters and honey possums studied still carried large loads of pollen. Indicating that the bees had not exploited all of the pollen source.

No study has directly implicated the bees as successful competitors in terms of reducing populations of other species and there is no proof that traditional apiary sites within National Parks are causing problems for other species (Sugden, 1986b).

Stace (1988) researched the literature and came to the conclusion **"properly organised migratory, commercial beekeeping is not in conflict with the objectives of conservation areas".**

Wapshere (1987) [CSIRO] also conducted a literature search which indicated that the effect of honeybees on the Australian natural environment may well be nil or slight.

Some extreme views: Matthews (1984) **"exploitation of the park flora by the apiary industry is no different in principle to the opening of the reserves to grazing by cattle or sheep"**. In the same reference, a letter from Dr. G. Pyke states **"I believe that honeybees have had a larger effect than rabbits or any other better known introduction"**.

(i) - Consumption of nectar and pollen.
Beekeepers are usually migratory, moving into areas of "honey flows" (excess nectar) for up to three months (Weir, 1986). The Smith brothers began migratory beekeeping with horse-drawn vehicles in 1896 in W.A. (Smith, 1964).

It is known that 95% of the bees will be found within 6km of the hive and 50% will be found within 1.6km from the nest/hive and in agricultural areas most forage within 250m of the hive, 80-90% are found within 1.5km (Thorp, 1985).

Honeybees do not fly at temperatures below 13°C, in strong wind (30-40km/hr) or in the rain (Giordani, 1953).

Moore *et al.* (1983) recognized that the flora of the eastern area of Western Australia can occasionally produce nectar in 'superabundance' (sic).

Bee visits to flowers are correlated positively with temperature and not nectar availability (Bond and Brown, 1979) [see B7 (ii)-opposite to birds].

A positive correlation was found between temperature and the numbers of honeybees visiting crops (Wafa and Ibrahim, 1957).

Carpenter (1978) reported that bird visited *Banksias* are characterised by copius diurnal nectar production [see B7]. During spring in S.E. Australia nectar production in *Eucalyptus incrassata* (Yellow Mallee) occurs in the early morning (most prior to dawn) when temperatures are too low for insects to forage, but honeyeaters are able to exploit the early morning nectar production (Bond and Brown, 1979). Honey bees foraged principally at dawn which are the periods of greatest nectar availability (Schaffer *et al.* (1983).

An average of 40Kg of honey is produced per hive per site (Burking, 1986). Honeybees consumed 36% of the nectar produced by *Grevillea aquifolium*, 52% of the nectar of *Callistemon macropunctatus*, and 34% of the nectar of *Amyema pendulum* during early summer in Victoria (Paton, 1979). Bond and Brown (1979) showed that the bee had potential access to 35-47% of the nectar produced in *E. incrassata* , but actually harvested much less (calculated to be 13-20%). Schaffer *et al.* (1979) suggested that honeybees preferentially exploit rich sources of nectar thereby reducing the standing crop of available nectar and the utilization of these sites by native bees, - a hypothesis that was later examined by Schaffer *et al.* (1983) where they again believed that their data supported the hypothesis, like Pyke and Balzer (1985) the study was carried out in a mountainous area [Schaffer's at 1300 metres in the Santa Catalina Mountains, U.S.A. and Pyke and Balzer in Kosciusko mountains -see B5 xii], the authors also state **"We hasten to observe, however, that the present results do not allow one to state categorically that over** the long term, foraging by *Apis* depresses the biomass of native bees. Other factors e.g. the availability of nest sites, predation etc might limit the densities of native populations to their present levels even in the absence of honey bees". Bernhardt and Walker (1984) show native bees regularly visit nectarless and nectar-poor angiosperms.

Wills *et al.* (1988) - Honeybees utilised 30% of the 413 plant species recorded as a source of pollen and/or nectar. Native bees foraged on 70% of the 53 plants honeybees foraged on.

A reduction in nectar would affect the territorial behaviour of nectar-feeding birds (Ford, 1981).

In the Karri forests, honey flows last from 3 - 5 months and yield 45kg of honey per month. An apiary site of 800ha can support 40 hives in light blossom, 120 in moderate blossom and 600 in prime flows [occurring every 4 to 12 years] (Loneragan, 1979).

Observations and a limited number of diurnal measures of the nectar resources of *Hakea trifurcata* in the Northern Sandplains during the winter flowering period indicate that neither the native bees, honeybees or a combination were capable of completely depleting the nectar resource during the day (Bell, 1988; Dr D. T. Bell[1]).

Foraging bees always left some nectar in the flowers (Bogoyavlenskii and Kovarskaya, 1956).

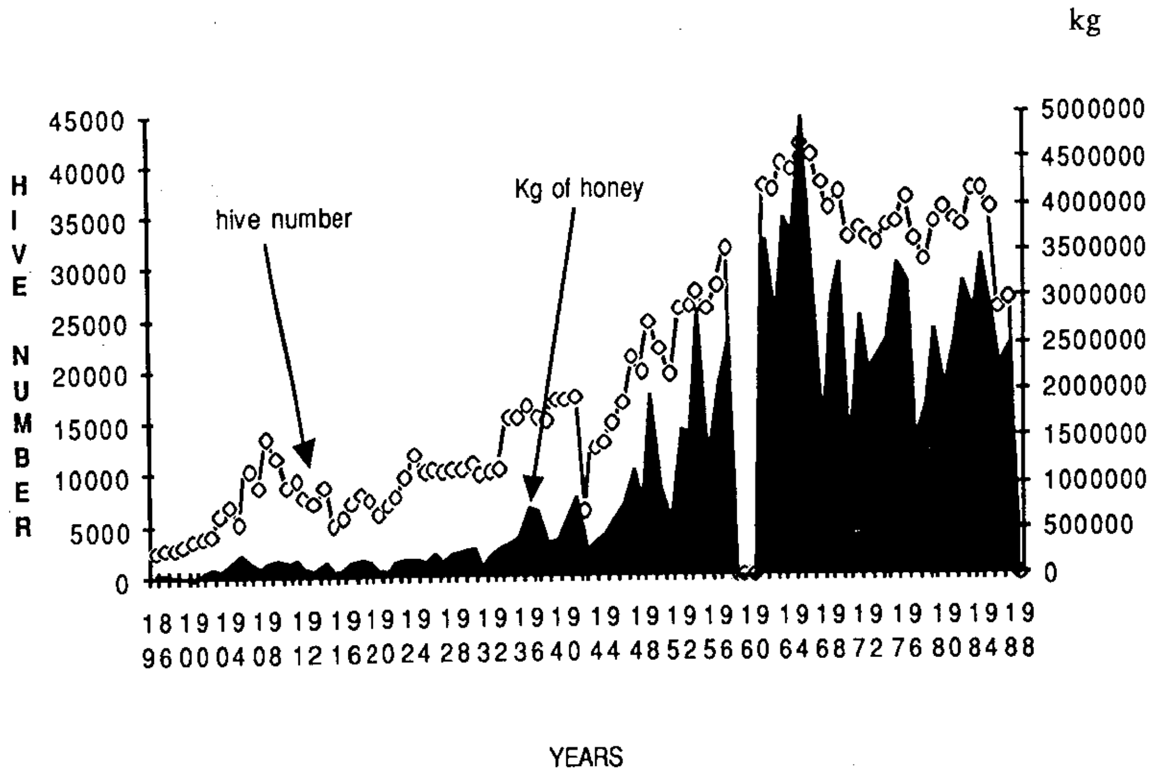


Figure 2 Honey production (Kg) and productive hive numbers 1896-1987. Prior to 1972 statistics based on 5 or more hives, after 1972 statistics based on 40 or more hives. 1963 - 1987 ABS data. 1896 - 1957 data collected Apiculture section, Agriculture Department of Western Australia. Years 1958-1960 data not available.

Figure 2 shows the production of honey (kg) and number of beehives since 1896. The graph shows constant production of honey to the early 1930's, thereafter (particularly after World War II) the production increased enormously to reach a peak in 1965 of nearly 5 million kg. Since that peak, production has remained at a relatively high stable level despite yearly fluctuations. The graph illustrates the point about honey flows. The high honey production in 1965 due to extremely good nectar flows, and contrasts to 1967 level of 1.5 million kg - a difference of 3.5 million kg. In terms of nectar produced, it is obvious that the beekeepers followed this enormous flow of nectar.

1941 peak = heavy Whitegum flow.
1949 peak = huge crop of Karri & some Redgum.
1954 peak = Karri
1959 "Slump of 1959", West Germany stopped buying Australian Honey, prices went to 7.3c/Kg. [local information from beekeeper].
1975 peak = Jarrah
1977 (Cyclone Alby, bushfires & drought) *lowest crop (1965-1988).

Research by Moezel *et al*. (1987) showed honeybees collected pollen from 36 species of native plants in the northern sandplains (over wintering area) with two sequentially flowering species from the same genus, *Leucopogon conostephioides* and *L. striatus* clearly being dominant. Pollen from *Acacia stenoptera* were also collected in abundance in one year of the research programme.

(ii) Additional food source.
Bees are additional food for birds e.g. wattlebirds, beeeaters (esp. Rainbow birds in the tropics) and native freshwater fish e.g. *Galaxiids* (pers comm L. Pen). The rainbow birds can eat "bees by the thousand" and can wipe out the entire work force of a hive (Kessell, 1979).

(iii) Increased seed set of native plant species.
e.g. timber species. The Karri is known to have a poor seed set and with the introduction of introduced honeybees, an increase in the number of seeds per capsule was recorded and seed collection was most economical in times of prime honey flows [nine months after flowering] (Loneragan, 1979).

The Jarrah forests are known to have lower densities of insects than Marri trees. The introduction of bees may increase the Jarrah seed set than otherwise would occur.

The increased weight of seed especially on Marri trees can contribute to the breakage of branches during storms and add to the forest litter that is avaliable as fuel for fire, one benefit could be the increase in the number of hollow branches avaliable for nesting sites (if the white ants are active in the trees).

In Brazil, *Eucalyptus alba* honeybees increased the fertilized seeds by 93%, whereas hand pollination gave only 5% (Foot Guimaraes and Kerr, 1959). In Australia, *Eucalyptus regnens* growing under natural conditions only produces 10% viable seed and this figure was not enhanced by the introduction of beehives (Eldridge, 1963).

Fruits of many plants are important food to wildlife. The importance of honeybees in relation to this is highlighted by Bales (1985). He found 100 plants to be of exceptional value to wildlife and of these 65% of these important food plants are pollinated by honeybees. In another study, Martin *et al.* (1951) found that 86% of woody plants known to be valuable to wildlife are also pollinated by honey bees.

Studies in 1960-64 by the Apiculture section, W.A.D.A. show that seed production in Karri forest is high per acre when honeybees have been present and is highest when the Karri has been logged or cut over:

Central Karri Forest	Seed per acre
Virgin forest	170,000
85yr regrowth forest	332,000
cut over 1954	290,000

Peripheral Karri Forest	
Cut over early 1960's	306,000*
(Recently cut when sampled) *= average of 3 locations.	

Loneragan (1979) stated that 15 to 20 trees can produce 3.2 to 4.2 million seeds when honeybees have been in the forest.

Dr F. J. Hingston[5] said **"there was little doubt that (honey) bees have a role in pollination and were unlikely to have a negative impact".**

(iv) Hybridization.
Some hybridization may occur, but there are many reported occurences of very old trees that are hybrids (Weir, 1986). Wilson (1970) suggested that general land disturbance encouraged the production of hybrid *Phebalium* plant species which may have been furthered by recent introduction of honeybees [in Ford *et al.* (1979) *Phebalium* are specifically bird-pollinated].

Many bird species and the huge numbers of native insects (e.g. 3000 species of native bees) are also possible hybridists. Hybridization occurs amongst Hummingbird pollinated flowers by hummingbirds (Brown and Kodric-Brown, 1979)

(v) - Feral bee population.
Feral bees have reached areas of the state where commercial operations have never existed (Pers comm A. Kessell). The feral bees are present throughout the south-west province (Moore *et al.* 1983; Burking and Kessell, 1986) and they swarm from commercial apiaries - a problem that cannot be solved (can be reduced by good management and current queen bee breeding programmes). Historically, bees had spread widely throughout the state by 1881 (Coleman, 1956).

Of the swarms that leave a hive, 75% will die from starvation, chemical sprays, disease and especially lack of water (Douglas, 1977 & 1980). The rate of attrition in proceeding years is 20% per year (Thorp, 1985). It has been observed that most wild nests die out. Douglas (1980) also states **"feral bees do not really constitute a serious ecological problem in areas subject to the hazards of fire, drought, general clearing and flood"**.[All these factors occur at sometime throughout the south-west].

Numbers of bees in feral colonies is approximately half that of a commercially managed hives and feral bees will only produce about 20Kg/ honey/ year (5x less than commercial hives) - Thorp (1985).

Bees have a preference for 35 litre (modal) volume nesting cavities (20-100l range) with a small entrance (Seeley, 1977). 15-80l range (Seeley and Morse, 1978). This volume preference may differ to those required by birds and animals. It has been noted that feral bees have invaded some Black cockatoo and Galah nesting sites (Bell, 1985). Kookaburras for example are an introduced species to W.A. and their nesting preference is also for hollow logs and branches. Also of note is that 21 litre poly drums are used for duck nesting sites in the field (Burking and Burking, 1987) and personal communication with the authors have stated that none of the drums had ever been used by feral bees. The tropical stingless bees (*Trigona* spp.) nest naturally in hollow tree trunks and branches (Heard, 1988). Many species of parrots and cockatoos are declared vermin by the W.A. Agriculture Protection Board (A.P.B).

In a study by Saunders *et al.* (1982), of hollow logs and hollows in trees showed an occupancy rate of 47% by eight species of birds. In the same paper, Saunders gave dimensions of hollows required by cockatoos which ranged from 0.46 to 3,625 litres [mean 44 litres]. In another study, Braithwaite *et al.* (1984) found that 22.1% of the hollows studied showed signs of habitation by animals and only 3.9% had beehives and 74% were (I presume) empty.

Mitchener (1961) reported nest volumes for the native bees, *Trigona* ranged from 0.9 to 12.4 litres. The volume being dependant upon the species studied. Observations of native bees (*Trigona* spp.) nesting within honeybee hives has been observed by Stace (1988) and under the beehives in South Australia (pers comm: R. Bickle- S. Aust. beekeeper).

A number of people have expressed concern of the 'competition' effects of feral bees and other nectar feeders during times of lean flowering. Dr D. T. Bell [1] says **"It is probably the feral bee populations utilizing nectar and pollen resources during the lean flowering period of late summer and early autumn that could prove to be a period of potential competition in the northern sandplains".**

In Smith *et al.* (1988) report on Yanchep National Park, approximately 100+ feral bee hives were found in the park. The park is 2799 ha in size, each feral hive has (if evenly distributed) access to approximately 28 ha if all other managed hives are removed. In a commercially producing area, where honey is extracted all the time, one hive occupies an area of 5.9 ha (based on calculations in B5(x)).

The Africanised bee problem in central South America has created much research in the field of trying trap swarms of these bees to slow the steady advance of these bees north to U.S.A. Large sums of money and technology have been poured into this project of eradicating and controlling feral bees. Spin-offs of this research, will in the future, benefit all countries in controlling feral bees.

The majority of orchard crops in Western Australia are pollinated by the feral bee population (pers. comm. T. Boughton).

(vi) - Affecting pollination of rare species.
e.g orchids - *Caladenia, Cryptostylis* and *Drakaea*. - in causing extinction of pollinators. Thynnid wasps (all males) are not the only pollinators of orchids. The wasps are sexually attracted (Stoutamire, 1983) to the flowers. The nectar the wasps feed on comes mainly from the Myrtaceae group of plants (Armstrong, 1979; Stoutamire, 1983) also from honey dew exuded by the leafhopper insects (Ridsdill Smith 1970). These plants are found over approximately 95% of the native floral acreage in south Western Australia (derived from Beard and Sprenger, 1984). The distance between the breeding and the feeding area of male wasps is usually 200 metres but less than 800 metres, the wasps feed throughout the day (Ridsdill Smith, 1970).

Where it has been said that honeybees reduce the supply of nectar for other pollinators such as Thynnid wasps and other insects, then a further examination of Ridsdill Smith's (1970) observation of honeydew as a food source for these insects becomes important when overseas research has shown that wasps are major consumers of honeydews. In America, the Tulip tree scale insect on the Tulip tree, over a period of a year, attracted 176 species of wasps (Krombein, 1951). Further, Zoebelein (1955) found the wasp family, Ichneumonidae as the largest consumer of honeydew as well as fifteen other insect families. For an insight as to how much honeydew can be harvested, one colony of Wood ants (*Formica rufa*) in Germany carried into their nests 450-500kg honeydew (equivalent to 90-100kg dry sugar) (Zoebelein, 1955).

Native bees also feed on the honeydew. In Brazil, two species of *Trigona* fed on honeydew exuded from the nymphs of the tree hopper, (*Aconophora* sp.) by day and at night by ants (Hood, 1952).

In Europe, honeydew flows are of major apicultural value, mainly from Lecanids (scale insects) on Spruce. Honeydew is known as "Forest" honey (Fossel, 1962; Lunder, 1961).

In early spring the wasps may only actively seek to pollinate for a few hours each week as they are dependant upon temperatures and only become active above 20° C (Stoutamire, 1983).

Ridsdill Smith (1970) found one Thynnid species became active in the morning when air temperatures rose above 12°C, and stopped flying when the light intensity fell (at sunset). All species of Thynnid wasps show single annual generation times and are usually active during summer (Ridsdill Smith, 1970).

Thynnid wasps are likely candidates for local extinction when placed in competition with hive bees (Hopper, 1985).

Some orchid species will self pollinate if no insect pollinators are present, therefore suggesting that some of the native insect pollinators are normally low in number. The orchids have also developed to produce an enormous quantity of seed - an adaptation to aid its survival because of the low frequency of pollinators? (or adapted because of fire, like most of the other Western Australian plants). Some of the reserves where rare species of plants have been located have been established sites for beekeepers for 30 years or more.

Stoutamire (1983) has noted that besides the target pollinators, orchids are visited by many other insects that do not necessarily pollinate the flower. Hopper's (1980b) study of *Syzygium tierneyanum* showed that whilst the honeybee was by far the most common visitor to the flowers of this species, a further 44 species of animals were utilizing the same source (all pollinating?).

Wills *et al.* (1988) no Orchidaceae were visited by honeybees in their 30 month study. 17 orchid species were present.

(vii) - Affecting natural pollination.

Approximately, 85% of all angiosperm seeds are the result of insect pollination (Giordani, 1953).

"Genetic enrichment of native plants through cross pollination activities is essential for the adaptation of plants.... Genetic enrichment of plants is essential to develop varieties that can change as the ecosystem (or habitat) itself evolves. These genetic enrichment activities are often facilitated by honey bees." (Bales, 1986).

Removal of pollen by honey bees without pollinating the flowers has been observed in two legume species (Pyke and Balzer, 1983, 1985) they also state **"for a number of plant species honey bees foraged in ways unlikely to effect pollination or likely to be deleterious to natural pollination"**. Native bees (*Bombus* spp.) robbed nectar from Hummingbird pollinated flowers by cutting their way through the base of the corolla without contacting the anthers or the stigma (Brown and Kodric-Brown, 1979). Douglas (1977) states that if the construction of the flower prevents the honeybee from reaching the nectar , the bee will tear the flower open and will often not touch the pollen and thus no fertilization takes place.

In Germany, *Bombus* spp. were observed to bite a hole in the corolla of Red clover (*Trifolium pratense*) and 'steal' nectar without pollinating the flower (Schwan, 1953). Pritsch (1966) found bumblebees gained access through the corolla wall on 31% of visits and honeybees on 32%. When bumblebees were excluded there was no 'nectar' stealing by honeybees.

Other examples:

Egypt: **"Both sexes of the (native bee) *Xylocopa* were effective pollinators of citrus, but the males damaged bean flowers, leaving holes through which the honeybees reached the nectaries"** (Wafa and Ibrahim, 1959).

New Zealand: **"It is recommended that fresh colonies should be brought in every 7-14 days, after which time, the foraging honeybees have learned to get nectar through the holes mage by *Bombus terrestris* "** (Brandenburg, 1961).

England: **"honeybees are stated to enter mainly at the front (of the flower) in the early part of the day (for pollen collection), and later in the day at holes previously torn open by the bumblebees"** (Soper, 1952).

America: **"A carpenter bee, *Xylocopa virginica* frequently cut holes through the cup-like blossom; other bees would then suck nectar through them and the blossoms would not be pollinated"** (Martin, 1966).

Only one author, Scriven *et al.* (1961) under **caged** conditions found that **"observations showed that honeybees as well as bumblebees can pierce the corolla and every flower in the plot caged with honeybees was pierced".**

[This indicates that only under starvation conditions honeybees (*Apis*) will pierce the flowers in order to obtain nectar, but does not actively pursue this method as part of its normal behaviour, whereas, it is normal for the bumblebees (*Bombus* and *Xylocopa*) to do this.]

Environmental factors such as heavy rain would also denude the flowers of pollen e.g. the open flowers of *Banksia* .

Bees are selective in the plants they collect pollen from and usually restrict their activity to one species at a time.[e.g. Pollen from *Hibbertia* sp. in W.A. is rarely taken]. Moezel *et al.* (1987) found that 52-79% of the pollen pellets of weekly samples collected by *Apis mellifera* consisted solely of am single plant species and they also said **"species flowering locally in abundance were preferred, but some common species were never visited".**

Observations confirm that insects possess a selective capacity for pollinating plants of definite species (Smaragdova, 1956).

Insects are on the whole plant species selective e.g. on *Acacia* species, most native bees belonged to the genus *Lasioglossum* and *Leioproctus* (short tongues bees). Both native bee species were present in greater numbers than the introduced honey bee in the Brisbane Ranges National Park, 80km from Melbourne (Bernhardt and Walker, (1984).

Lamont (1985) found *Leioproctus* species a major pollinator in his study of native plant species near Perth where honeybees were present . Of all plant species studied, 70-100% of the flowers were pollinated. The author also found the highly floriferous species in his study occurred in dense patches have only a small proportion of receptive flowers (to pollination) at any one time. He goes on further to say that the exceptionally high numbers of flowers per unit canopy volume and the high density of species flowering at the same time indicates strong competition for limited number of pollinators.

Many plants are wind pollinated such as the *Casuarinas* and the effect of bees collecting pollen would be insignificant as they shed huge amounts of pollen most of which will decompose on the grouind. In Western Australia wind pollinated species that honeybees collected pollen from was *Mesomelaena tetragona* (Moezel *et al.* 1987).

A recently published paper by Taylor and Whelan (1988) found that the honeybee was ineffective in pollinating a *Grevillea* hybrid. This is not surprising as it is an essentially bird pollinated species. The authors themselves state that Eastern Spinebills (*Acanthorhynchus tenuirostris*) were the most abundant native animals visiting the flowers indicating that they were the most likely pollinators. As their results show the honeybees were not the pollinators, the most likely cause of the *Grevillea* becoming a hybrid plant species is from the native fauna within the Wirrimbirra Sanctuary. Interestingly, the authors observations of the *Grevillea* showed the unopened flowers on a raceme of this hybrid to be actively secreting nectar. In their conclusions, the authors state "We have observed that a high level of bee activity appeared to deter honeyeaters from visiting an inflorescence" - how they manage to conclude this from two **one** hour observations, over two days for fifteen infloresences (500 flowers) is anyones guess. The authors also conclude that the bees were found to be **specific** in their foraging.

[The only other fault with the paper is the way the "effectiveness of the bees as pollinators of the *Grevillea* " was assessed. Firstly, they sampled ten bees (two from each hive) for presence of *Grevillea* pollen and five bees flying in the study area were also examined. Personal communication with the authors stated the two one hour observations took place between 11.30am - 12.30pm - well after the birds normally feed].

(viii) - Danger to the public. The figures shown are from 1986 Health Department Epidemiology branch and 1986 census: 1,406,929 people.

	Hospital	Death	% of population
Venomous snakes	48	0	0.0034
Non venomous snakes	63	0	0.0045
Venomous spiders	192	0	0.0137
Bee stings, other insect bites and non venomous spiders	255	0	0.0181

Harvey *et al.* (1984) found that death by bee sting is uncommon in Australia and over a 22 year period from 1961 - 1981, 25 individuals were recorded by Australian Bureau of Statistics as having died shortly after a bee sting. For Western Australia over this period the incidence rate was 0.09 per 1,000,000 per year. The fatality incidence increased with age (15 of the 25 were aged 40+ years).

Smith *et al.* (1988) outlines possible safety conflict between recreational activities and apiary sites in Yanchep National Park.

(ix) Plant pathogen spread.
The number of public vehicles using the National Parks would greatly out number those of the beekeepers. [see B4(v)].

(x) Banning from National Parks.
[see also E]. Majority of the beekeepers cannot own sufficient land to run commercial operations. Private lands surround most National Parks and reserves and bees placed on these areas would be able to forage into these Parks and Reserves. Feral bees would also be present.

Pyke and Balzer (1985) found that by introducing sixty hives to a National Park in N.S.W., the effect on existing populations of feral and native bee densities was **nil.** [one of the authors recommendations to exclude bees from National Parks was based on work done in a sub-alpine area and not in areas where the majority of National Parks occur and beekeeping is commonly practised]. Competition amongst native insects let alone with bees would be intense in the short flowering period of all plants in sub- alpine areas. There are none of these areas in W.A. The authors state: in other areas studied the results do not provide conclusive evidence of competition with other insects.

Douglas (1980) states that it might not be wise to remove bees from parks and reserves now that they are an essential part of a 'disturbed' environment. [to be removed only from virgin forests] - not many of these areas are left and they are generally surrounded by farmland and forest areas where there is beekeeping.

In a public opinion survey carried out by Jakob-Hoff (1986), 59% of Western Australia's population thought that beekeeping should be allowed in, at least, some National Parks and 37% said they were not prepared to allow beekeeping in National Parks.

The draft management plan for the Yanchep National Park (Smith *et al.* 1988) based their proposed management with regard to beekeeping on three references: **"There is evidence to suggest honeybees can have a detrimental effect on native bees and vegetation (Douglas, 1977; Matthews, 1984; Pyke and Balzer, 1985)".**

Moore *et al.* (1983) draft Nature Reserve Management Plan's policy on restricting beekeepers on selected reserves is mainly based on references of Matthews (1982) with others from Pyke and Balzer (1982 [sic]) and Scheltema (1981) [as 1982 in report].

Smith *et al.* (1988) also considered Yanchep National Park **"is not of a sufficient size to support apiary sites"**. The statement conflicts with Western Australian Wildlife Authority (WAWA) policy (25/5/81) of placing beehives on reserves. The policy allows for beehives to be placed on reserves greater than 500ha (Moore *et al.* 1983). From Smith *et al.* (1988) report there are at least 100 feral bee hives and 80 - 100 Department of Agriculture's bee hives present in the park. The park is 2799 ha and at best, 200 hives occupy this area at certain times of the year.

In commercial honey producing areas e.g. the beekeepers reserve No 24496 in the northern sandplains, 113 sites occupy 67,600 ha and each site, by C.A.L.M. regulations are to be 3km apart. The area of each site is therefore 706.5 ha* with an average of 120 hives per site. By this calculation at least four sites and 480 hives could occupy Yanchep National Park. A proposal to add a further 3100 ha to the park which includes three approved apiary sites would then be about 5900 ha, and could support 8 bee sites and 960 beehives. Removal of apiary sites from Yanchep National Park has been given a priority 2 by Smith *et al.* (1988) and from the proposed addition of 3100 ha three apiary sites have been given priority 1 for removal. The Department of Agriculture has been operating apiary sites within Yanchep National Park since 1930 (Kessell, personal communication).

*indicating that there should be 96 sites (not 113) on reserve 24496.

A study of Lane-Poole Reserve by Nichols *et al.* (1986) stated that beekeepers who used several sites in the 54,400 ha reserve have never been a problem. Some aspects related to the future conservation of the reserve are based on Matthews (1984) to review the policy of allowing beekeepers into the reserve. Bees were not placed under "Feral Fauna" in the report.

(B6) NATIVE INSECTS

(i) Competition with similar species.

The introduced honeybee is one of two Apid genera present in Australia (Armstrong, 1979). The other, *Trigona* a stingless bee, is native to northern Australia, though some species extend as far as Sydney (Goebel, 1987). The majority of the introduced honeybees are located in the southern half of Australia. There is an increasing number of beehives being worked in the tropical north (Goebel, 1988; Anon, 1982) for crop pollination (Kessell, 1979) and feral bees are present (Hopper, 1980b). Most Australian native bees are associated with the Myrtaceae (Ford *et al.* 1979) and are solitary and do not form colonies.

Matthews (1976) suggested that the "northern Australian" distribution of *Trigona* in Australia may of resulted (in part) from the displacement by the introduced honeybee. This statement was also expressed by Schwarz (1948).

Goebel (1987) also noted that the native bees collected nectar and pollen from imported crops such as papaw, passionfruit, mango and grape.

Schaffer *et al.* (1983) stated **"In our own studies we have seen too many honey bees feeding together with *Bombus* and *Xylocopa* bees on the same flower stalks to believe that *Apis* excludes its rivals from the most productive sites by active interference"**. They also note that aggression by *Apis* toward other bees in the field, where resources are dispersed in small packets among large numbers of flowers, is extremely rare.

New Zealand is an interesting example of exotic bee introduction to their country. As well as *Apis mellifera* , New Zealand imported three *Bombus* sp. from Britain in 1870 to pollinate Red clover, this first shipment failed, but they were successful in 1885 where these bees increased rapidly and spread throughout the country. Since their establishment, and because they are not managed in apiaries like *Apis mellifera* , the three species have established themselves into particular niches. *Bombus terrestris* is found only around urban and settled areas; *B. ruderatus* is only found around hilly country and *B. subterraneus latreillellus* is confined to one small area (Montgomery, 1951). Another species, *B. hortorum* is also known from New Zealand (de Lacey, 1985).

Not only do introduced species like *Bombus* separate geographically, they also have different foraging times. Laverty and Plowright (1985) found that of two species of *Bombus* studied one foraged early in the morning and was replaced by the other later in the day.

Frankie and Vinson (1977) found that the solitary bee *Xylocopa virginica texana* marked flowers with a scent that deterred conspecifics' visits for about ten minutes.

In Panama, Central America, three of four species from the genus *Melipona* studied displayed greater net intakes of nectar than domesticated European *Apis mellifera* . The rate of caloric intake per forager weight was higher for *Melipona* than *Apis mellifera* and the nectar load capacity of *Apis mellifera* was shown to be greater than that of *Melipona* . (Roubik *et al.* (1984).

(ii) Resident species.

Insects and particulary the honeybees exploit low levels of nectar not harvested by honeyeaters (Bond and Brown, 1979).

It is now known that native insects prefer different species, for example, out of the three species Jarrah, Wandoo and Marri, Jarrah supported the lowest biomass of insects which inturn reflected the number of birds on the trees and the same was true for two eastern states tree species where the birds preferred Ironbark over Greybox (Passmore, 1988).

Native bees (usually the female bees) carry pollen from a restricted number of plants usually at family level e.g. Myrtaceae (Armstrong, 1979); or taxa sympatric: (Bernhardt and Walker , 1984). (Honeybees are usually one pollen load from one species -see Bernhardt and Walker (1984); Moezel (1987).

Schaffer *et al.* (1983) found that ants consumed approximately 85% of the nectar produced at night [90% of nectar was secreted at night] and honey, bumble, carpenter, native bees and wasps were still observed visiting the flowers during the day. The ants had consumed approx. 75% of the nectar available to the bees.Research in South Africa by Buys (1987) showed that ants consume 42% of the nectar before dawn in *Eucalypt* plantations and he concluded **"The results from this study confirm that the (Argentine) ant can be a serious competitor with the honeybee for nectar. The ant has a competitive advantage by being able to forage at night, when nectar secretion in many nectariferous plants takes place"**. Honeybees collected all the nectar on ant-excluded branches in 3.5 hours after they had begun foraging. Ants alone theoretically required almost 5 hours to deplete the day-time residue of nectar in the flowers.

Bernhardt and Walker (1984) studies on *Acacia* species showed nine taxa of bees, including *Apis mellifera* present. The honeybee represented 14.6% of the total capture of bees at study sites 80Km north of Melbourne.

In Germany, the feeding of Blossom beetles on *Brassica napus* was not disturbed by the visits of bees (Meyerhoff, 1954). Wild plants of Goldenrod in Canada are valuable nectar producing plants especially in late summer and winter for the Canadian Beekeeper. During a study by Smith (1983) he observed that when beetle populations feeding on the flowers reach levels of 50 -100 per Goldenrod flower raceme interference with honeybee activity was observed. During the study 225 beetles were recovered from one raceme. In addition, he found that beetles chewed off the anthers and petals, and this multilation interfered with nectar production.

In 1988, Bogong moths were in plague proportions. Grey Ironbark trees in blossom were observed to be completely covered by moths, beekeepers nearby, found that their hives were **"going backwards"** (Somerville, 1988). [The moths are predominantly nectar feeders].

Honeybees had no significant effect on the numbers of bees in native *Exoneura* bee nests studied by Sugden (1986b).

Roubik *et al.*, (1986) stated **"Despite sharing most pollen resources and nectar of**

the same quality with 20 introduced colonies of the African honeybee (*Apis mellifera*), **native stingless bees of 12 species were largely unaffected by its activity."** In the same paper Roubik and his co-workers also worked out some theoretical calculations: **"Calculations based upon colony populations, food stores and flight range show that if African honey bees persist at a density of 1x colony per Km^2, colonies of some stingless bee species may disappear after 10 years."**
This calculation was based upon a deterministic model and do not take into account the biology of the bee species or nectar production of the plants within the area. Roubik's paper also said **"Rate of forager return to nests of stingless bee colonies showed no statistically diminished foraging activity in the presence of 20 introduced African honeybee colonies."**

(iii) Adapted to native plants.
Native insects are adapted to native plants and the (sometimes harsh) environment and therefore have an ability to survive. They have very brief breeding stages. Many insects are nocturnal.

(iv) Directly affected by fire [see B2].

(v) Redistributed by the introduction of beehives.
(suggested by Pyke and Balzer, 1985). No evidence of honeybee/native bee competition - only in a sub-alpine park [see B5(x)] (Pyke and Balzer, 1985). The same authors also state that bees displace the native bees and will therefore result in long term reduction in the population size of native bees (though there is no evidence for this).

(B7) BIRDS

Introduction.
In Moore *et al.* (1983) the grounds on which the Western Australian Wildlife Authority (W. A. W. A.) restricted beekeeping on reserves was (from their report) **"(2) Presence of nectivorous and pollenivorous fauna - (iii) ... their (the honeybee) longer proboscis, which enable them to exploit deep flowers which are normally bird pollinated, thus robbing honeyeaters of their food supply".** This is disputed by the fact that the honeyeaters exploit the early morning nectar production (Bond and Brown, 1979) which is prior to the honeybees earliest foraging. Houston (1983) found many nectar feeding bees (e.g *Euryglossa, Chalicodoma, Pseudohylaeus*) to have developed extraordinary elongated palpi to extract nectar from essentially bird-adapted flowers of *Calothamnus* . Houston (1983) also found species of sawfly with enormously developed maxillary palpi.

(i) Resident species.
Honeyeaters having to expand their feeding areas because of the reduced amounts of nectar by the foraging of bees may infact enhance cross-pollination to a greater degree. Seasonal fluctuations in honeyeater density showed no apparent relationship with seasonal fluctuations in nectar-energy productivity or in the biomass of flying insects (Pyke, 1983).

Many examples of specific bird pollinated flowers e.g. some *Banksias* , *Grevilleas* and many *Eucalypt* species that are diurnal nectar producers [see A(i); B5(i); B8]. *Eucalyptus* is the most important genus for birds and approximately half of all species are pollinated by birds (Ford *et al.* 1979).

Nesting behaviour of honeyeaters appears to follow the seasonal pattern of nectar production (Pyke and Recher, 1986). Nectar feeding birds e.g Red wattlebird defends (territorial) feeding areas from other feeding birds where daily nectar production within its territory closely approximates its energy requirement (Ford, 1981). A reduction in nectar would affect the territorial behaviour of nectar-feeding birds (Ford, 1981).

Collins and Newland (1986) found the production of nectar between October and December (in W.A.) was such that more honeyeaters could have been supported than were actually present.

Pyke and Recher (1986) worked out daily production of nectar energy per hectare over the main flowering period studied was well over 1000 Kj/ha (peaking at 4000Kj/ha) at their sites near Sydney. Daily energy per honeyeater is about 79Kj and 2 nesting pairs usually occupy a hectare, requiring 240Kj - this shows a large excess of nectar energy/ha i.e. a surplus of nectar available to other animals. Ford *et al.* (1979) state: flowers from nectar producing plants produce between 0.02 - 0.08Kj nectar per day and *Banksia* flowers (c. 200 flowers) produce up to 16Kj of nectar per day.

McFarland (1986) found seven common honeyeaters studied were significantly correlated in flower density but not correlated with daily energy productivity.

Churchill and Christensen (1970) worked out the amount of nectar necessary for the Purple crowned lorikeet's normal daily requirement to be 297 flowers during periods of maximal nectar flow and 2,970 flowers in periods of average flow and for pollen, the bird needed to visit 300-430 flowers per day. Birds require about 10-50Kcal and visit several hundred to many thousand flowers per day (Ford *et al.* 1979).

The substantial reductions in standing crops of nectar, during the first few hours after dawn are reminiscent of the situation in South Australia described by Ford (1979) and suggest that the honeyeaters were also ingesting significant quantities of nectar (Collins and Briffa, 1982).

(ii) <u>Transient species.</u>
Honeyeaters are known to be transient (Pyke and Recher, 1986) and follow nectar sources and flows (therefore positively correlated). Bond and Brown (1979) observed a significant relationship between numbers of birds and nectar levels.

Collins and Briffa (1982) demonstrated that three species of honeyeaters exhibited movements that were related to the abundance of flowers and associated nectar and none relied on a single plant species for nectar in any given season.

(iii) <u>Specific food source.</u>
Nectar may or may not be a major dietary component. Honeyeaters also ingest about 15mg of pollen per day and is probably collected accidently (Paton, 1981). Other birds, for example, the Purple crowned lorikeet uses pollen as a major source of nutriment, though nectar is ingested (being supplementary) in periods of honey flows (Churchill and Christensen, 1970). These parrots feed mainly in the Karri forests and have to follow a pattern of flowering trees. It is known that Karri flowers irregularly, with prime flowering every 4 to 12 years (Loneragan, 1979). Nectar feeding birds still catch insects for additional food - [see Ford and Paton, (1977); Wolf and Hainsworth (1971); Carpenter and Macmillen (1976)]. Analysis of the gut of the Purple crowned lorikeet showed insects were also consumed (Churchill and Christensen, 1970). Ford *et al.* (1979) states that honeyeaters consume a wide range of insects.

Collins and Briffa (1982) found almost universal occurence of arthropods in faecal samples produced by honeyeaters and suggested that the birds were may have ingested the arthropods during part of the time that they probed for flowers. **"Regardless of the arthropod material, it seemed that (the honeyeaters) *Lichmera indistincta* and *Phylidonyris nigra* ingest a variety of species ranging from ants, in particular, to bees, wasps and flies".**

(B8) ANIMALS

(i) <u>Resident species.</u>
Honey possums are a resident species. Nocturnally feed and therefore do not compete with any other species (except moth species). Some of the *Banksia* species are nocturnal nectar producers [seeB7(i)]. Characteristics of flowers which could specifically favour mammals as pollinators are massive nectar production, strong smell, hooked styles and inflorescences close to the ground and hidden in dense foliage. Again, nectar may not be the major dietary component.

" ..although seed set in most *Banksia* species was closely related to the amounts of their pollen carried by vertebrates, only 30% of *Banksia nutans* inflorescences were pollinated despite heavy loads of pollen on *Tarsipes* (nectar feeding marsupials)" (Wooller *et al.* 1983).

In Arizona, (U.S.A.) the giant Saguaro cactus *Carnegiea gigantea* is of economic importance to the Indian tribes for food and as an alcohol beverage. The lack of repopulation of this species was said to have been caused by honeybees (consuming the nectar?) on the old stands of cactus through lack of pollination. Investigations of the pollination requirements found that Bats (*Leptonycteris nivalis*) set 62% of the fruit, Honeybees set 52% and White winged doves (*Zenaida asiatica mearnsi*) pollinated 45%. In caged and uncaged experiments, flowers in the open set 54% and those hand pollinated set 71% of the fruit. [the fruit were being set both early morning and at night]. (McGregor *et al.* 1962) -The repopulation problem of this species is being affected by other factors.

(ii) Transient animals.
e.g. majority of the bat species are nocturnal feeders of nectar -mainly of *Eucalypts* .

C BENEFITS OF THE INDUSTRY

Like farms, mining, timber, urban and industrial development there are the benefits to Western Australia.

(i) Beekeepers.
Supports 1600 beekeepers that own 57,000 hives (1984 figures) of these 90 are professional [a decrease of 60% over the last 30 years, but hive numbers have increased (Kessell, 1985)]. Commercial apiarists operate between 400-800 hives with some operators working 2000 hives.
ABS data.-update data. Australian Bureau of Statistics ph: 3235140, Perth.

(ii) Local Industry.
Supports a large local industry. Manufacture of equipment, purchase of hardware and fuels. The raw product creates a food supply and many varied products are produced. Adds a major ingredient to the Health food industry.

(iii) Local and vital export income.
Sale of honey, wax, pollen, queen bees and packaged bees. Honey worth $2.5 million for W. A. [1984] (Kessell, 1985).
1986/87 sales of Honey, Beeswax and Pollen reached $4.2 million*.
[*1987/88 Annual Report, Division of Animal Production, W.A.D.A.]

(iv) Pollination of crops.
Estimated to be around $400 million (minimum - Weir, 1986) Australia wide. $250 million benefit to the farming community (Davy, 1983).

In America during 1981, honey bee pollinating activities are estimated to be worth **143** times more than the value of the products the honey bees produced. (Levin, 1984).

(v) Environmental monitoring.
Pollen collected and used as sensors for pesticides and minerals (Thorp, 1985).

(vi) Government revenue.
In 1986-87, C.A.L.M. had registered 2,224 sites which generated annual revenue through rental of $75,616. [based on $34.00 per site in 1988].

(vii) Provision of water.
Water is required at apiary sites by law, and these sources of water are used by other insects and animals in the area (esp. wasps, Emus - pers obs.-author).

(viii) Environmentally conscious.

Beekeepers are environmentally conscious as their livelihood totally depends on the preservation of the native bush.

D INCREASED NECTAR SOURCE

(i) Exotic species.

e.g. Capeweed, Salvation Jane/Paterson's curse (*Echium plantaginium*). Estimated by our Apiculture section that 2-3 tonnes could be collected from these plants in W.A. This source of nectar could be reduced by the biological control of Paterson's curse which is supported by the Industries Assistance Commission (Burking and Kessell, 1986).

The biological control agent *Dialectica scalariella* was released at Middleswan (Perth) on 4th October 1988 to control Paterson's curse. Short term nectar secretion can exceed 300µg/flower/hr in *E. plantagineum* (Corbett and Delfosse, 1984).

(ii) Resource management.

Urban and rural plantations of high yielding nectar and pollen producing plants. Use of rural crops for honey and pollen production.

(iii) Western Australia.

Western Australia has an advantage over other states because the diversity of flora is at its greatest e.g. the greatest diversity of *Banksias* occurs in south Western Australia (Holliday and Watton, 1975; Keighery, 1988). The richness of the widflower community means that some plants will be in flower whatever the season (Hopper, 1985).

The heathlands and related shrublands of south-western Australia have a very high species richness and endemism, and the nectar-producing families Proteaceae and Myrtaceae commonly represent 40-80% of all species present (George *et al.* 1979).

E DETRIMENTAL EFFECTS TO THE INDUSTRY OF PROPOSED CHANGES BY C.A.L.M. (beehives being banned from National Parks).

(i) Closure of apiary sites.

Some 356 apiary sites will be affected - representing a loss of $12,104 in rental income to C.A.L.M. [based on $34.00 per site 1988].

The variety of honeys produced would be reduced. Most of Western Australia's flora produces a unique honey (Burking and Kessell, 1986). Export markets have been established on these honeys. The potential lost to the industry could be as high as $1.5million per year (Burking and Kessell, 1986). [Areas already closed e.g Fitzgerald River area (Biosphere National Park), Lake Magenta Nature Reserve and National Parks near the Perth metropolitian area e.g John Forest National Park].

The economic value of sites are estimated to be $4,500 per site in the Yanchep National Park (Burking and Kessell, 1988).

(ii) Increased costs.

Increased costs to find new sites (if other suitable sites are available) further afield. This would put pressure on a price increase in the end product (could then reduce demand and therefore price). World prices, in times of 'gluts', would also seriously affect the livelihood of the beekeepers if they were to move farther afield.

(iii) Over-crowding.

Crowd beekeepers into existing reserves aggravating the very "reason" that beekeepers be excluded from National Parks and Reserves in the first instance.

(iv) New apiary sites.

Movement to new allocated apiary sites. Beekeepers may not be familiar with new areas e.g.

the bud set of honey producing plants may differ. Any mistake in putting hives into a poor area would be costly. If the hives are allowed to run down because of the lack of flowers, a hive can take up to five weeks to maximise strength (flowering periods of most honey species are of the same duration). During droughts or just hive neglect the time taken for a hive to become productive again when the season is good is approximately 2-3 months (Davies, 1985).

New allocated sites are probably of poorer quality, as the industry by now has selected all the known productive sites.

CALM's position.

-Statutory responsibility primarily to conserve and protect native species of plants and animals and takes precedence over all other activities (B. Hodge MLA 25/7/88)[2]

-the principle of assessment procedures: It is the responsibility of the proponent of a potentially disturbing or degrading activity to prove that adverse effects will not occur (B. Hodge MLA 25/7/88)[2].

-signatory to the National Conservation Strategy.

-The purpose of National Parks is the preservation of indigenous wildlife, at an acceptable level while such activities as recreation are also allowed (Wilson, 1985).

Government statements.

-Policy decisions on beekeeping in conservation areas should be soundly based on objective criteria. (J. Grill, Minister for Agriculture, Fisheries and the South West, W.A. 27/6/88)[3].

- **" at this stage there is a lack of scientific evidence that the presence of bees in reserves interferes with the ecological balance in the long term"**. (D. Wotton, Minister of Environment and Planning S.Aust. 11/1/82 ex: Matthews 1984).

- **"work conducted by Pyke and Balzer (1985) was intellectually unsatisfying and I was not satisfied with the conclusions in the paper"** (T. Moore, Minister for Planning and Environment, N.S.W. ex: Winner, 1988).

- Recent moves to restrict access of beekeepers to forested areas will not be supported by the National Party in government (Victoria) Pers D. Evans Nationals spokesman on Conservation, Forests and Lands. ex: F.C.A.A.A.[4] [details published in a Victorian Newspaper.]

- Overall number of bee sites on land managed by Conservation, Forests and Lands is not being reduced. - J. Kirner, Minister for Conservation, Forests and Lands, Victoria. (Where new Parks are being created and beekeeping was already established, then beekeeping was allowed to be continued). ex: F.C.A.A.A.[4] [Statements to be published in the Australian Bee Journal].

MEDIA STATEMENT 4TH SEPTEMBER 1988

HON. B. Hodge, Minister for Conservation and Land Management states:
(Labour party)

-**"existing sites in National Parks and Nature Reserves would be permitted to continue, or if shown to be unsuitably located, alternative sites would be found"**.
and **"....representatives of the (beekeeping) industry would be consulted before there was any change in policy"**.

-R. Lewis MLA raised in Parliment (Legislative Assembly, Liberal Party) on the 15th September 1988, the controversy of honeybees in National Parks and differences between C.A.L.M. and the W.A.D.A. views and says **"I cannot imagine how the honeybee can endanger our forests"**.

Comments by Hon. B. Hodge MLA, Minister for Conservation and Land Management in a letter to Hon. J. Grill, Minister for Agriculture (7-12-88) p2. (Labour Party)

-"**Environmental protection and management of conservation reserves are not concerned with change per se, but with the protection of specific values which are dictated by the legislation, regulations and corporate plan of the responsible authority. If, in the educated opinion of that authority, those values are put at risk by any planned or existing activities, it is common practise to manage conservatively until the managers are convinced that their concerns are unfounded.**"

-"**Feral hives are to a large extent, controlled by natural processes such as drought, while hive bees are established and maintained artificially at numbers that would not survive in the wild conditions**".

-"**Apiary site rental fees are more than absorbed by administrative and supervisory costs within C. A. L. M.**"

[Revenue from the last five years has been: 1983/84 = $65,530; 1984/85 = $63,801; 1985/86 = $58,086; 1986/87 = $63,136 and 1987/88 = $75,138 ex: Mr Marrable correspondence with Mr R. Pollard ref: 012489F3911].

-David Evans, spokesman on Conservation, Forests and Lands (Victorian National Party) would not support restricted access of beekeepers to forested areas. He said "**artificially denying the honey industry access to forested areas was conservation gone absolutely mad**". (Briggs, 1988).

-"**It is perfectly legitimate and part of the democratic process for criticisms to be made on policies and Departmental (C.A.L.M.) activities where they are demonstrably wrong**" (Shea, 1988).

[In the 1987-1988 C.A.L.M. Annual Report: under "Primary objectives" p7 heading quote: **Ensure that conservation and land management is carried out according to sound well-researched scientific principles.**]

-"**Some agricultural research results can be applied equally well everywhere but most are dependant on the site or environment. Indeed this is the reason why we have to do research in Western Australia; because results from elsewhere <u>cannot normally</u> be applied here directly**".

["Obtaining useful results from agricultural research", a paper presented by Dr Bowden and Mr Halse to the Research Projects Review Committee, Western Australian Department of Agriculture, February 3rd 1982].

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Letters:

(1) 23/6/88 To Mr Hay, Executive Officer, Beekeepers Section, West Australian Farmers Federation, from Dr D. T. Bell, Senior lecturer in Plant Ecology, University of Western Australia.

(2) 25/7/88 To Mr Pollard, President Beekeepers section, West Australian Farmers Federation.

(3) 27/6/88 To Mr Pollard, President Beekeepers section, West Australian Farmers Federation.

(4) 23/9/88 To All State Secretaries and Executive Members, from L. Briggs, Chief Executive Officer, The Federal Council of Australian Apiarists Association (F.C.A.A.A.).

(5) 3/3/89 To G. W. Hay Executive Officer, Beekeepers Section, West Australian Farmers Federation, from Dr F. J. Hingston, Principal Research Scientist CSIRO, Division of Forestry and Forest Products.