- Smooth Barked Apple forest (Site A) has a lower density of native grasses and a higher density of shrubs. The litter layer fuel levels are higher and generally lying on the ground.
- The Spotted Gum / Ironbark Forest (Sites B, C, D & E) have, on average, a higher density of native grasses; and a lower density of shrubs. Litter layer fuel levels are high and generally lay both on the ground and hanging amongst the grasses at an elevated level. This elevated litter adds to potential fire behaviour characteristics during a bushfire event by being more readily available to consumption by fire.

3.2 Measuring Fire Behaviour in Fuel

The industry standard is to measure the surface fuel weights in a given sample area and compare those weights in a statistical measure. This is measured in tonnes per hectare (*McArthur*).

Similar work by *Rothermal* estimated the weights of not only the surface weights but also the aerial shrub layer. This provides a greater understanding of flammability because aerial fuels contribute significantly to fire behaviour characteristics. In the case of the Spotted Gum Forest the additional litter layer hanging in the denser grasses would be calculated using the Rothermal model.

The accepted fuel level where a fire can be expected to be minimal in its ability to cause excessive fire behaviour is between 3 - 4 tonnes per hectare *(Conacher Travers 1997).* The figure of ten (10) tonnes per hectare is the range where the fire behaviour is regarded as being too severe to allow possible control by fire fighting suppression operations (*Luke, H, 1978*).

The mid level of 4-6 tonnes per hectare is where fire behaviour is expected to be moderate in terms of intensity but in practical terms will still produce tall flame heights (2-10 metres) and high levels of radiant heat flux. The main point is that fire control is able to occur without putting fire fighters into unsafe conditions.

Research has shown that by reducing under storey height and increasing fuel compaction, the rate of combustion and therefore the potential fire behaviour is reduced (G*ould, 1992*). Compaction being the reduction of aerial fuels to surface fuels through mulching and then retaining the insitu fuels on the ground which inturn allows faster decomposition into organic soil matter.

It is possible that aerial fuels can have up to five times the effect on fire behaviour as the same amount of fuel on the ground (*Gould, 1992*). This is because fuel is more available for consumption by advancing fire and if that fuel is aerially dominated it then has ability to ignite tree bark and or tree canopies which inturn increases fire behaviour. Spotted Gum Forest has a greater tendency to have higher aerial fuel levels as shown above.

Breaking this cycle of elevated fuels burning creates a '*vertical fuel discontinuity'* which makes it more difficult for fires to climb from the surface into tree canopies and then becoming a crown fire.

Notwithstanding this finding there is the alternative approach to lessening fuel in any given area. By modifying the majority of the surface litter layer whilst retaining the majority of the aerial fuels (shrubs) there will be a dramatic loss of fuel to actually start and spread the fire which inturn has a profound affect on the eventual consumption of available elevated fuels such as shrubs, bark and tree canopies.

By understanding this behaviour fire managers are able to manage fire better by managing the vegetation better. So by understanding the type of vegetation, its height, its fuel weight and its potentially combustibility then a better understanding of a fires *rate of spread* and or *flame height* and ultimately its *potential fire intensity*, can be determined.

In terms of fuel availability within Sample Areas A, B, C, D & E, the capability for these fuel types to continue to accrue fuel weight are known to be a maximum of 25 t/ha (at any one time) for both the Smooth Barked Apple Forest and the Spotted Gum / Ironbark Forest. However the fuel weights collected were considerably less for Smooth Barked Apple Forest being 18.7 t/ha (not burnt since 1980 i.e. >24 years). In the case of Spotted Gum / Ironbark Forest mean fuel levels were assessed at 13.9 t/ha and this is expected given that these areas had burnt approximately 4.5 years ago.

These results show that the two vegetation communities have a less than optimum fuel weight and are possibly still amassing fuel weights. The impact of drought condition during the past 5 years is a likely contributor to not achieving optimum fuel weights.

It is known that fuel is broken down more quickly when those fuels are moist. Dry fuels are not readily decomposed and they are prone to being blown by wind and amassed at a blockage point in the landscape e.g. up against a tree or against a rock outcrop.

In respect of fuel weight growth within the Sample Areas any measurable increase will be manifested in the form of branches, branchlets and or leaf mass on shrubs whilst also manifesting in the form of an increased production of the litter layer.

Fuel accretion for both vegetation communities is expected between 5-7 years to achieve 75% of possible fuel accretion and a further 2-5 years to achieve the remaining maximum level/s. (source: empirical assessment by *Travers, J* and survey by *Conroy 1991.*

The fact that the Sample Areas displayed two distinct fire histories as expressed in Section 2.4 above does not cause the results of this survey to be skewed or unreliable. The results simply show the rapid build up of fuels in the 0-5 year period following fire. This is manifested in the case of the Spotted Gum Forest in Areas B, C, D & E. There is a clear difference in plant diversity, aerial growth characteristics and or the density of native grasses and forbes etc but the essential fuel characteristics of weight are predominantly attributed to surface fuels in the litter layer.

3.3 Primary Areas Available for Fuel Management

In the case of Wallarah Peninsula it is proposed to retain vegetation within most lots such that the fuel levels will be no greater than 4 tonnes per hectare on average. This will then achieve relativity with *Planning for Bushfire Protection* (PBP). This is a planning document prepared by the NSW Rural Fire Service and Planning NSW for development in bushfire prone areas.

Section 4 of that document deals with asset protection zones and whilst it does not identify specific fuel weights it is common industry practice to apply 0-4 tonnes per hectare for Inner Protection Areas (IPA) and 6-8 tonnes for Outer Protection Areas

(OPA). Notwithstanding industry practice it is the authors opinion that 4-6 Tonnes is a more appropriate figure for an OPA as opposed to the RFS concept as outlined in Section 4.2.2a (iv) of PBP due principally to the potential impact of strong winds fanning moderate fuel loads.

Given that the measurements are relative to a hectare as the industry standard then the achievement of best practice fuel management will be to maintain each lot as a percentage of that statistic. For example if a residential allotment is 510 m^2 is size then it is 19.607 times smaller than a hectare and therefore that lot would be measured in line with the following equation i.e. 4 t/ha (Max fuel weight within an IPA) divided by 19.607. This means that the lot should have no more than 0.24 t/ha (240 kilograms) of fuel weight insitu.

The figure of 240 kilograms is therefore the maximum fuel level that can occur on each lot of 510 m^2 so that it can be within the tolerances accepted by the Rural Fire Service.

3.4 Fuel Availability in Residential Allotments

The ability to use fuel sampling and fuel weights in an urban residential subdivision is difficult to calculate accurate fuel weights across the hectare when that area of one hectare is comprised of areas that will have no fuel in perpetuity. For example within each dwelling allotment in Stages 1-12 there will be areas that will contain fuel and areas that will not contain fuel. For instance the areas that will not contain fuel are:

1. Dwelling footprint (approx' 14x14=196m^2)
2. Dwelling curtilage areas (approx' 115m^2)
3. Driveways (approx' 8x4=32m^2)
4. Other infrastructure (approx'10m^2)

This totals approximately 353m^2.

If the lot size of 510 m^2 is added to the component of public roadway (approx' 17m (length of lot) x 3m (50% portion of 6.0m wide roadway) = 51m^2) then a figure of 561m^2 is derived.

This retains approximately 208m^2 (561-353) of bushland within the lot and a further possible bushland in the road verge (say, 17x2.5) amounting to 42.5^2. Therefore a total of 250.5m^2.

Therefore in each hectare of developed landscape it would be expected that items noted above would contribute to approximately 44% retention of native shrubs, forbes, ferns and grasses in addition to the trees identified on the plans (>70%).
Note: The figure of 44% is derived from a percentage of the lot size plus road verge divided by the possible retained vegetation. E.g. 561/250.5 = 0.44

3.5 Native Vegetation Retention Capability

The aim of these derived statistics is to ensure that, on average, the total weight of fuel across the proposed retained vegetation areas within the example lot is generally no heavier than 240 kilograms for 510 m^2 or 305 Kilograms for 650 m^2. This will achieve the performance standard of the RFS in *Planning for Bushfire Protection*.

The impact of 44% native vegetation retention entails those parts of the;

1. Residential development allotment within Stages 1-7 and 8-12 that will not be developed as identified in 3.4 above.
2. Road network that front the residential allotments within Stages 1-7 and 8-12.

The vegetation retention figure does not relate to the residual lands that are not identified in 1 and 2 above, for example;

- riparian corridors
- drainage corridors
- private open space
- public open space that occurs within the external boundaries of the Wallarah Peninsula development area
- residual lots not identified for development at this time.

3.6 Measurement of Shrub Retention

The data in Tables 4a, 4b & 4c would see a reduction of fuel from an average of 10.90, 13.32 & 8.17 t/ha for the litter layer to figures commensurate with 4.79, 5.86 & 3.59 t/ha or an average of 4.74 t/ha. This figure would see the average fuel levels for litter layer being close to the industry standard of 4 t/ha for an Inner Protection Area.

Similarly if a similar assessment of aerial fuels (grasses/forbes/shrubs) was undertaken then the averages shown in Tables 4a, 4b & 4c of 4.42, 2.81 & 5.55 t/ha respectively would alter to 1.94, 1.23 & 2.44 t/ha or an average of 1.87 t/ha.

This will see the collective averages of the litter layer, aerial layer & grasses/forbes being 6.61 t/ha. This figure means that only 2.61 t/ha (6.61-4.00) will require modification and or removal to achieve adherence to *Planning for Bushfire Protection* for an Inner Protection Area.

In respect of identifying the number of shrubs that might occur in the asset protection zone one can review the data in Tables 2a, 2b & 2c to estimate shrub presence/density in any given area.

For instance Table 2a shows an adjusted average of 3.88 shrubs per 16m^2 (2,425 shrubs / ha) whilst Table 2b shows an average of 7.6 shrubs per 16 m^2 (4,750 shrubs / ha) and Table 2c shows an average of 16.6 shrubs per 16 m^2 (10,375 shrubs / ha).

Again by averaging the results the figures would change to see an average of 9.36 shrubs per 16 m^2 or 5,850 shrubs per hectare.

By applying the 44% figure of possible retained native shrubs retained after development of each residential allotment within Stage 1-7 and 8-12 (not including trees) one can then estimate that 9.36 shrubs would become 4.11 shrubs in every 16 m^2 or 2,568 shrubs per hectare retained, subject to the environmental and botanical consistency of the landscape.

Again by adjusting this figure to achieve the maximum 4 t/ha figure the number of shrubs would be adjusted to the following formulae:

Mean shrub weight of 4.11 t/ha minus 4.00 t/ha being the APZ (IPA) performance standard

= 0.11 t/ha (or 0.027 % of 4.11t/ha).

4.11 t/ha represents a total of 9.36 shrubs (refer to Tables 2a, 2b & 2c).

By adjusting this figure to 4.00 t/ha will achieve the 'desired shrub numbers to achieve the Inner Protection Area performance standard'. The formulae would be;

9.36 shrubs multiplied by 84.4% (100%-0.11%)
= 7.89 shrubs for 16 m^2 or 4,931 shrubs / ha

3.7 Measurement of Litter Retention

The retention of 4.00 t/ha of shrubs only in the landscape would not provide for any litter layer to remain insitu. This would be environmentally unacceptable so a proportion of litter layer is required to remain. This would require a lowering of the shrub figure/s.

If litter layer was to remain insitu after modification. For instance if 15% litter layer was proposed to remain then the mean weight of 10.79 t/ha over Areas A, B, C, D, E as shown in Tables 4a, 4b & 4c would see a reduction of 9.18 t/ha to retain 1.61 t/ha of litter layer.

This then would see an adjustment to the shrub density by deducting 1.61 from 4.00 t/ha. A figure of 2.39 t/ha is derived. This figure would allow 5.43 shrubs per 16m^2 or 3,393 shrubs per hectare.

3.8 Measurement of Grasses, Forbes Retention

By adding the grasses and forbes to the equation a complication occurs in attempting to design or calculate these vegetation types for the purpose of fuel weight analysis.

The averages for grasses / forbes and shrubs shown in Tables 4a, 4b & 4c of 2.27, 2.58 & 2.55 t/ha are reduced to 1.94, 1.23 & 2.44 t/ha when multiplied by the 44% vegetation reduction factor. This averages at 1.87 t/ha.

3.9 Estimation of Fuel Loading Performance Standard

The achievement of complying with PBP 2001 requires a modification of the fuel levels that comprise the litter, grasses/forbes and shrub layers. This is manifested in the following formulae:-

Mean overall (litter, grasses / forbes and shrubs) fuel weights as shown in Tables 4a, 4b & 4c being

10.79 : 4.26 (t/ha)
litter : Grasses / Shrubs

with the total fuel being 15.05 t / ha a ratio of 72 : 28 occurs. If adjusted to achieve the maximum 4.00 t / ha in accordance with *PBP 2001* the results would see the following

2.88 (litter) : 1.12 grasses / Shrubs (t / ha)

If adjusted to a 15 : 85 ratio (less litter and more shrubs) the results would be

0.60 t/ha (litter) : 3.40 t / ha (grasses / shrubs)

Thus leaving a percentage of litter layer, percentage of shrub layer and a percentage of grasses & forbes layer.

The use of a percentage figure of 15% for the litter layer is a misconception. If the litter layer is to be removed then it is recommended that 15% be retained for soil protection reasons. However if the litter layer is recycled on site in the form of fines then 100% of that material may remain on site without adding to the overall fuel weight. Which inturn can impact fire behaviour characteristics.

Fines should be considered to be material pieces less than 5-10mm in diameter. In most mulching processes the leaf litter and small bark pieces will be broken down into very small sizes leaving only branches that would be larger pieces and predicably in the 5-10mm size.

3.10 Impact of Vegetation Loss or Retention to the Environmental and or Ecological Landscape

This combination of retaining a percentage of litter, shrubs and forbes/grasses on the site will ensure that there is compliance with the principles and objectives enunciated in the ecological considerations within the *Ecological Site Management Plan* (*Manidis Roberts 2003*) and the specifications provided in the *Bushfire Protection Assessment Report* (*Conacher Travers 2004)*.

The application of the results above will require a further breakdown of the methodology to apply correct interpretations for the two vegetation communities, namely Spotted Gum Forest and Smooth–barked Apple Forest. The methodology allows this to occur and at the appropriate time the separation of data can be undertaken to provide detailed vegetation community information to further enhance the ability to apply accurate and practical landscape management within the areas identified as requiring asset protection zones.

3.11 Guiding Rules for Native Landscape Management

Guiding rules relevant to the implementation of an APZ (IPA) performance standard would therefore involve determining a balance of retaining surface and aerial fuels.

A suggested balance is as follows:

Vegetation layer	**Litter**	**Shrubs / Grasses**
Suggested balance as a percentage cover	15 %	85 %
Conversion of Balance to tons per hectare to achieve max' of 4 t /ha	0.60 t/ha	3.40 t/ha
Distribution	Spread over 100% of APZ	Spread over 100% of APZ
Number of Species able to be present in an area of 100 m^2	Not applicable	* Shrubs = 23.95 plants per 100 m^2 * Grasses = 87.34 plants per 100 m^2

** based on Tables 2a, 2b & 2c Mean calculations x vegetation reduction figure of 0.44%*

The use of the 15% litter figure may be superseded if all litter is recycled onsite and well distributed across the site. In this case the fuel weight allowed for the litter layer can be distributed to increase the fuel weights of the either the shrubs or the grasses/forbes.

4.0 CONCLUSION

The study has undertaken a floristic assessment of all living and dead vegetation and then assessed the bushfire hazards that are able to be manipulated to achieve acceptable environmental and ecological retention.

A number of relevant matters have been found to result.

- The use of a percentage presence 'rule' for the management of the understorey vegetation can be used to design asset protection zones that adhere to *Planning for Bushfire Protection (RFS)*.

- The use of a percentage presence 'rule' for the management of the understorey vegetation can provide acceptable fuel load within a bushfire prone area.

- Fuel management to the degree required for inner protection zones does not equate to ecological degradation through excessive vegetation or possible significant habitat loss for wildlife.

- The lessening of percentage cover in shrubs presence will not contribute in a measurable form to any loss of habitat protection or availability.

- The nature of the landscape post development within Wallarah Peninsula Stages 1-7 and Stages 8-12 will see habitat remain insitu for fauna species both in the surface and aerial fuels.

- The removal of a high proportion of the litter layer in the surface fuel zone will not contribute in a measurable form any loss of habitat protection or foraging resources.

- Litter vegetation can be reconstituted onsite through a mulching process to form fines (*after Gould 1992*) which can in turn be recycled insitu to eventually become soil. These fines do not add measurably to bushfire hazardous fuels.

- Soil erosion and or soil sedimentation is not able to occur with a vegetated presence across the landscape.

- Riparian impacts should not be attributed to soil loss from fuel management activities.

- Visual amenity should be maintained with no apparent loss.

Notwithstanding the above the implementation of the fuel management works will require further sampling of the various vegetation communities to ensure that sampling does in fact replicate the site and its natural vegetative resources. Failure to undertake this work would see a possible false application of ecological stewardship.

It is concluded that the ecological stewardship of the site as required by the *Conservation Land Usage Management Plan Ecological Masterplan 2003* and the

Ecological Assessment 2004 can be implemented and or maintained in accordance with the requirements of the *Fuel Management Plan 2004* and as amended in 2007.

Research by fire management authorities e.g. NPWS, State Forest and CSIRO, are yet to consider or determine the suitability of assessing fuels on smaller landscapes (<10 hectares) in the tonnes per hectare format. Typically fuel assessment has been landscape wide for larger areas e.g. national parks and state forests. The assessments have been useful for that purpose but less than useful for smaller areas such as around residential landscapes.

It is the belief of the author that a combination of fuel weight assessment coupled with floristic assessment of fuel arrangement is a better analyser of fuel flammability and ultimately fire behaviour potential on these small areas.

This approach would see an ecological engineering approach in that a certain number of shrubs can occur in a given area containing grasses / forbes / ferns etc. This work will require detailed assessment by skilled persons to estimate fuel weights and then calculate a practical approach through ecological engineering for bushfire protection.

This can be estimated by reviewing each typical shrub and providing a given weight. e.g. 1 x specimen of *Personnia leavis* = 0.18 Kilogram per hectare, and coupled with an m^2 of grass / forbs / herbs (e.g. 2.8 kilograms per hectare can be added together to design a native landscape that is commensurate with bushfire performance standards.

This can then be used to allocate a category of low, medium or high fuel weight. Whilst initially time consuming the benefits are significant. A table of species weights can be designed and replicated for use by industry.

The method of applying percentage cover estimates can then be used with some degree of approximate accuracy for asset protection zone design and construction.

In the assessment of this study one aspect of 'results presentation' was to attempt photographic representation of a site for use as a management tool. This would have been valuable in presenting graphic evidence of example fuel weights approximate to 3-5 t/ha.

However photographic presentation of fuels was found to be highly variable in results due to the one colour of most vegetation remnants, the blending of individual plants into one viewing landscape and the limited capability to gain anything more than a one dimensional view. This was also found to be a problem by the US Forest Service (*Fire in Forestry Vol. 1 1983*).

At best photography could only be used on a small area commensurate with some 12-16 m^2. Photos taken would need to be taken from a ladder to at least gain a (semi) multiple dimensional views.

Attachments: Site details for Sample Areas A, B, C, D & E.

Authorship: The study concept / methodology and author was John Travers. Botanical survey was undertaken by Elizabeth Ashby (Area A) and Barry Collier (Areas B & C) of *Conacher Travers*. Fuel sampling was undertaken by Bob Coffee (Coastal Bushland Services). Tree survey and cadastral survey works was undertaken by *Carman Surveyors.* Corey Shackleton undertook mapping using *Arcview* mapping software*.*

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Site Details

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SITE A – Lot 127

Location

The site is known as Lot 127 and is situated to the north west of the trail from the major intersection in the Lake Sector to the water reservoir. It is situated approximately 200 metres from that intersection.

Geology

The geology of the subject site is characterised by sediments of the Newcastle Coal Measures which are within the Permian Period. The sediments underlying the site are a mixture of conglomerate and shale. The soils are moderately deep and clayey, with some embedded rocks from a rocky outcrop immediately above the site.

Topography and Drainage

The site is situated on the north western side of the ridge which is traversed by the abovementioned trail and drains into an unnamed watercourse which discharges into Lake Macquarie to the north west of the site.

Gradients of the subject site are generally 10-20%. The approximate elevation of the site is 31-42 metres Australian Height Datum (AHD).
Vegetation

The site is vegetated with woodland containing a grassy understorey with patches of shrubs. Similar vegetation surrounds the site.

Conservation Reserves

The nearest conservation reserve is Wallarah National Park, approximately 1 km to the south east.

Land Use

The study area landscape has been affected by the following impacts:

- *Improvements**:*** There are no improvements within the site.
- *Clearing**:*** There is no evidence of previous clearing.
- *Bushfire**:*** There are no signs of recent bushfire, although there is evidence of a past history of bushfire.
- *Agriculture**:*** There is no evidence of any present or past agricultural activities.
- *Earthworks**:*** No major earthworks have been conducted within the subject site.
- *Introduced weeds**:*** There are significant incursions of the weed species *Chrysanthemoides monilifera* (Bitou Bush).

- *Feral, Introduced and Domestic Fauna:* Native fauna within the subject site is likely to have been impacted upon by the predation of European Red Fox (*Vulpes vulpes*), Cats (*Felis catus*) and Dogs (*Canis familiaris*).

Vegetation Community

The vegetation within the site is part of an area mapped as Smooth-barked Apple Forest.

Structure - Woodland with a canopy cover of approximately 30 % and height of approximately 7-22 metres. The understorey consists of a sparse to moderate shrub layer to 6 metres high and a dense groundcover of herbs and grasses. The understorey also contains some large fallen branches and a fallen stag.

Disturbances - This vegetation community is relatively undisturbed, apart from incursions of weeds.

Common Species

Trees: *Corymbia gummifera* (Red Bloodwood), *Angophora costata* (Sydney Red Gum) and *Allocasuarina torulosa* (Forest Oak).

Shrubs: *Allocasuarina littoralis* (Black She-oak), *Daviesia ulicifolia* (Gorse Bitter-pea), *Dillwynia retorta* (Sweet-scented Wattle), *Dodonaea triquetra* (Hop Bush), *Epacris pulchella*, *Glochidion ferdinandi* (Cheese Tree).

Groundcovers: *Dianella caerulea* (Flax Lily), *Entolasia stricta* (Wiry Panic), *Gahnia radula*, *Hibbertia aspera*, *Lepidosperma laterale* (Variable Sword-sedge), *Pteridium esculentum* (Bracken Fern), *Themeda australis* (Kangaroo Grass), *Xanthorrhoea latifolia*.

Weeds: *Chrysanthemoides monilifera* (Bitou Bush).

SITE A FIELD DATA

X	Y	ID #	Species	Form	Clump Diam	Stem Hgt	Hgt	Canopy
1.2	0.6	1	Xan	Gr	1.2		1	
1.9	2.6	2	BW	T		2.8	6	2.2
2.3	0.3	3	Dill	S		0.3	0.5	0.2
2	0.1	4	Allo	T		0	0.9	0.2
2.1	0	5	Epac	S		0	0.5	0.1
1.3	2.3	6	Bitou	S		0.2	1	1.2
1.7	3.3	7	Allo	T		0.5	1.9	0.6
2.9	2.6	8	Grass	G	0.4		0.9	
2.6	1.5	9	Grass	G	0.3		0.5	
2.2	1.5	10	Grass	G	0.3		0.5	
2	1.6	11	Grass	G	0.3		0.5	
2.4	0.5	12	Grass	G	0.3		0.4	
0.6	0.3	13	Grass	G	0.4		0.4	
3.6	0.5	17	Lepid	Gr	0.5		0.5	
4.3	0.7	18	Lepid	Gr	0.5		0.5	
4.1	2.7	19	Xan	Gr	0.4		0.6	
4.5	3	20	Bitou	S		0	1	1.2
3.2	3.5	21	Acacia long	S		0.3	1.3	0.3
3.9	3.9	22	Grass	G	1.3		0.8	
4.1	1.7	23	Epac	S		0	0.3	0.1
4.8	1.3	24	Grass	G	0.2		0.1	
4.8	0.7	25	Grass	G	0.5		0.3	
3.2	0.9	26	Grass	G	0.3		0.3	
6	1	27	BW	T		0.7	2.2	1
6	2	28	Allo	T		0.6	2.7	0.9
6.4	1.5	29	Allo	T		0.4	1	0.3
5	1.9	30	Bitou	S		0	0.5	0.7
6.3	2	31	BW	T		0	0.5	0.4
5	4	32	Dav	S		0	0.6	0.5
5	3.4	33	Dill	S		0	0.3	0.3
5.6	1.5	34	Grass	G	1.8x0.5		0.8	
5.9	3.6	35	Grass	G	1.5		0.3	
7.8	2.8	36	Allo	T		1.3	3.8	1.1
7.8	4	37	Allo	T		1	2.3	0.6
7.4	1.8	38	Dill	S		0.2	0.6	0.6
7.9	0.9	39	BW	T		0	1.1	1.1
7.4	0.6	40	Xan	Gr	0.6		0.7	
8.5	2	41	Xan	Gr	0.9		1	
7.5	2.8	42	Xan	Gr	0.8		0.5	
7.8	3.5	43	Xan	Gr	0.6		0.7	
8.5	3.1	44	Grass	G	2x1		0.4	
7.4	2.6	45	Grass	G	2x1		0.3	
8.5	1.1	46	Grass	G	0.3		0.3	
8.4	0.5	47	Grass	G	1		1	
10.6	0.5	48	Scribbly	T		0.6	2.2	1.1
9	2.3	49	Bitou	S		0	1	2.3
9.6	2	50	Xan	Gr	1		0.6	
9.2	3.5	51	Allo	T		0.4	2	0.6
9.5	3.7	52	Allo	T		0.4	2	0.6
13.8	3.4	53	Dodo	S		0	0.2	0.2

SITE A FIELD DATA (CONT.)

X	Y	ID #	Species	Form	Clump Diam	Stem Hgt	Hgt	Canopy
13.3	2.3	54	BW	T		4.5	7	3
14.2	1.9	55	Dav	S		0.3	0.7	0.4
14.2	2.3	56	Dodo	S		0.3	0.2	0.2
15.7	0.6	57	Dodo	S		0.2	0.3	0.1
15.5	1.3	58	Dill	S		0.2	0.8	0.5
16.4	1.2	59	Dill	S		0.2	0.8	0.5
15.4	3.3	60	Dill	S		0.2	0.8	0.5
17.2	3.6	61	Dodo	S		0.5	0.9	0.2
17.7	2	62	Bitou	S		0	0.6	0.8
17.7	0.3	63	Dav	S		0	0.5	0.3
18.3	0	64	Dav	S		0	0.5	0.3
18.5	0.5	65	Xan	Gr	0.4		0.4	
18.5	3.8	66	Hibb	S		0	0.3	0.4
18.2	3.7	67	Hibb	S		0	0.3	0.4
19.6	2	68	Scribbly	T		0	0.3	0.4
18.9	2	69	Scribbly	T		0	0.3	0.2
20.4	1.4	70	Xan	Gr	1.2		0.6	
22.1	1.1	71	BW	T		6	12	10
22.3	3.7	72	Bitou	S		0	1.2	1.8
21.7	3.3	73	Dodo	S		0.4	0.9	0.3
22.2	3.3	74	Bracken	F		0.4	0.7	0.4
22.5	3.1	75	Bracken	F		0.4	0.7	0.4
20.9	3.8	76	Bitou	S		0	0.2	0.2
22.3	1.3	77	Bracken	F		0.25	0.4	0.3
22.6	0.9	78	Bracken	F		0.25	0.4	0.3
23.6	0.1	79	Bracken	F		0.2	0.4	0.3
24	1.5	80	Dodo	S		0.8	1.8	0.6
23.1	1.9	81	Bracken	F		0.2	0.4	0.3
23.3	1.6	82	Bitou	S		0.2	0.6	0.8
24	1.6	83	BW	T		0	0.2	0.2
24.3	1.8	84	BW	T		0	0.3	0.2
24.4	2.8	85	Bitou	S		0	2	3
23.3	3.8	86	Dodo	S		0.5	1.5	0.5
23.7	3.6	87	Hibb	S		0	0.3	0.8
24.6	3.4	88	Bitou	S		0	2	2.5
26.3	3.7	89	Lepid	Gr	1		0.6	
25.6	3.8	90	Bracken	F		0.3	0.7	0.4
25.5	3.5	91	Dodo	S		0.6	1.4	0.7
25.2	3.5	92	BW	T		0	0.2	0.1
25.2	2.3	93	Bracken	F		0.2	0.3	0.2
26.5	2.3	94	Dav	S		0	0.2	0.4
25.6	1.1	95	Phyll	S		0	0.2	0.4
26	1	96	Bracken	F		0.2	0.4	0.3
26.2	0.5	97	Bracken	F		0.2	0.4	0.3
25.7	0.2	98	Bracken	F		0.2	0.4	0.3
27.5	3.7	99	Bitou	S		0.3	0.2	0.1
27	3.5	100	Bracken	F		0.2	0.4	0.3
27	2.8	101	Allo	T		0.5	1.6	0.8
27.4	2.5	102	Bracken	F		0.3	0.6	0.4
27.6	2	103	Bitou	S		0	1.2	2.5
28.5	2	104	Bracken	F		0.6	1	0.5

SITE A FIELD DATA (CONT.)

X	Y	ID #	Species	Form	Clump Diam	Stem Hgt	Hgt	Canopy
27.1	1.3	105	Xan	Gr	1		0.9	
28.2	0.5	106	Bracken	F		0.6	1	0.5
27.3	0.5	107	Bracken	F		0.6	1	0.5
27.3	0.7	108	Bitou	S		0.1	0.2	0.2
27.3	0.2	109	Hibb	S		0	0.3	0.5
28.9	1.8	110	Bitou	S		0	0.8	1.4
28.8	0.7	111	Bitou	S		0	0.9	0.9
29.8	3.8	112	Bracken	F		0.3	0.5	0.3
29.6	3.7	113	Bracken	F		0.3	0.5	0.3
29.3	3.6	114	Bracken	F		0.3	0.5	0.3
29.4	3.4	115	Bracken	F		0.3	0.5	0.3
29.1	3.3	116	Bracken	F		0.3	0.6	0.4
29.6	2.9	117	Bracken	F		0.6	0.8	0.6
28.2	2.9	118	Bracken	F		0.3	0.5	0.3
29	2.9	119	Bracken	F		0.3	0.5	0.3
6	8.6	120	Allo	T		1.2	4.6	2
5.5	8.8	121	Persoonia	S		0.1	0.25	0.15
6.9	11.3	122	Bitou	S		0	1	2
6.5	9.8	123	Xan	Gr	1		0.7	
6.4	10.2	124	Xan	Gr	1		0.7	
5.4	11.3	125	BW	T		0	0.3	0.1
5.2	10.9	126	BW	T		3	1.2	4
7.9	8	127	Dodo	S		0.3	1.5	0.6
7.9	9	128	Dodo	S		0.3	1.5	0.6
9	9	129	Dodo	S		0.3	1.5	0.6
8.1	8.7	130	Acacia long	S		0.2	0.8	0.2
8.5	9.3	131	Acacia long	S		0.5	1.4	0.5
8.1	9.6	132	Acacia long	S		0.3	0.8	0.2
7.7	9.3	133	Xan	Gr	1.2		1	
8.6	10.2	134	Dodo	S		0.4	1.4	0.4
8.9	10.5	135	Dodo	S		0.4	1.2	0.3
8.1	10.3	136	Dodo	S		0.4	1.2	0.3
7.6	10.5	137	Scribbly	T		0.9	3.2	2.5
7.3	10.5	138	BW	T		3	1.2	4
7.5	10.7	139	Dead shrub	S		0.2	1.9	2.1
8.7	10.5	140	Phyll	S		0	0.2	0.1
7.8	11.5	141	Bitou	S		0.3	0.6	0.3
9	8	142	Allo	T		1.3	4.7	1.3
9.8	8.6	143	Dodo	S		0.3	1.8	1
10.2	8.6	144	Dodo	S		0.3	0.8	0.2
9.6	9.3	145	Dodo	S		0.2	1.1	0.5
9.7	9.5	146	Dodo	S		0.5	1	0.5
10.7	9.3	147	Dodo	S		0.3	0.9	0.2
9.7	9.8	148	Persoonia	S		0.5	1.9	0.9
10	11	149	Dodo	S		0.5	1.5	0.6
9.7	11.1	150	Dodo	S		0.4	0.9	0.1
10.2	10.9	151	Bitou	S		0.3	0.7	0.5
9.5	11.5	152	Bitou	S		0.2	1	0.3
11.2	10.8	153	Allo	T		0.2	0.6	0.2
12.8	11.5	154	Xan	Gr	2		1.1	
14	8	155	Hibb	S		0	0.2	0.1