

10. Region 4 – South East New South Wales

10.1. Description

The extent of the South East New South Wales Region (SENSW) is defined by the South Coast-Illawarra Vegetation Integration Project (SCIVI) map (Tozer *et al.* 2006; Figure 10.1). It covers 4,006,650 hectares of land located between latitudes 33°30'S and 37°30'S and longitudes 149°00'E and 151°30'E. The region is bounded on the east by the Pacific Ocean, and on the south by the NSW – Victoria border. The northern boundary is defined by 1:100,000 map sheets that include the Sydney metropolitan area and the western boundary is defined by 1:100,000 map sheets that contain the escarpment and eastern tablelands. The western extent of the Eden CRA vegetation classification project (Keith and Bedward 1999) defines the south western limit. The region includes the entire NSW South East Corner IBRA bioregion and portions of the Sydney Basin and South Eastern Highlands bioregions. All of the Sydney Metropolitan CMA is included as are substantial portions of the Hawkesbury-Nepean, Southern Rivers and Lachlan CMAs, and small areas of the Central West, Hunter/Central Rivers and Murrumbidgee CMAs.

Major landscapes in the region include temperate and warm-temperate coastal lowlands, escarpment, undulating highlands and tablelands (Tozer *et al.* 2006). Fertile shale-dominated soils occur on lowlands and plains. The northern part of the region is dominated by the Sydney Basin which runs south to the Clyde River and is bounded by infertile sandstone scarps and plateaux. Further south, the coastal plain is confined to a narrow strip of low-lying floodplain which extends inland along major rivers such as the Shoalhaven and Bega. The escarpment rises quickly from the plain forming a coastal range of 300-600 m elevation with a small number of higher peaks. Beyond this range lies an undulating hinterland which rises 800-1000 m to the eastern edge of the tablelands, which form an extensive, gently sloping landscape. The tablelands contain mainly granitic and meta-sedimentary substrates that produce low to moderately fertile soils. Occasional soils of high fertility in the tablelands are derived from volcanic material.

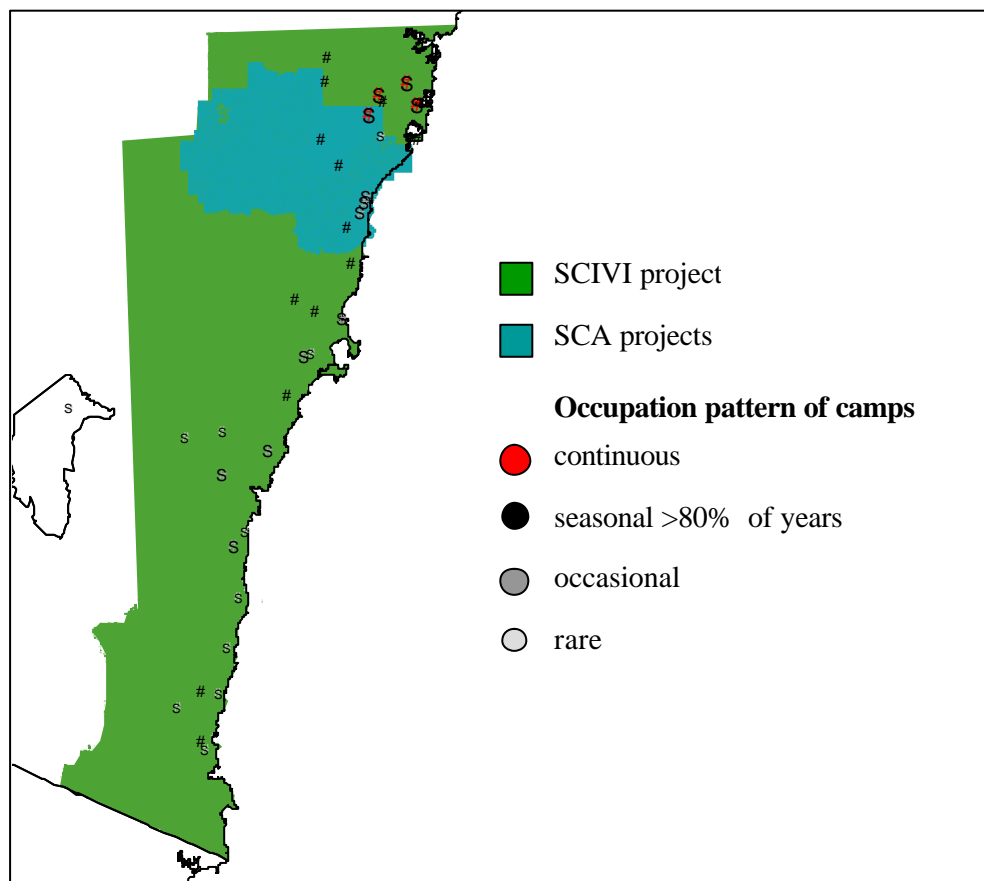
Most of the region experiences a temperate climate of warm summers and cool winters on the coast and mild to warm summers and cold winters on the ranges and tablelands. Daily and annual temperature variations are relatively small in coastal areas which also experience few days of frost. Extensive areas of the tablelands experience 30-50 frost days per year, while restricted areas of highest elevation experience approximately 100 frost days per year. Precipitation varies in relation to altitude and distance from the coast. Areas close to the coast or at high elevations along the coastal ranges typically experience rainfall of 750 - 1300 mm per year. Annual rainfall is lower on the tablelands where averages of 650-750 mm are common. Rainfall is generally weakly seasonal with higher rainfall months occurring in late summer and lower rainfall months in late winter to early spring.

Clearing for agriculture and urban development has removed an estimated 34% of total native vegetation in the region (Tozer *et al.* 2006). The vegetation types most impacted by clearing occur along the coastal strip or on soils of moderate to high fertility. They

include the grassy woodlands of the tablelands, forested wetlands of the alluvial plains, wet sclerophyll forests of the coastal lowlands and lowland rainforests. Conservation reserves cover approximately one third of the region. However, they are not randomly distributed across the landscape. The majority of reserves are on steep terrains and infertile soils. Consequently, various forests on land suitable for agricultural and urban development continue to face significant threats from clearing.

Thirty-nine camps used by Grey-headed flying foxes are currently known in the region (Figure 10.1.). The majority occur along the coastal lowlands and ranges. A small number of camps in the Sydney metropolitan area are occupied continuously. The majority of these have been established in recent years, apparently in response to increasing volumes of food in the gardens and streetscapes of Sydney. All camps associated with native vegetation in the region have less consistent patterns of occupation and the majority are occupied occasionally or rarely. The presence of flying foxes decreases rapidly south of the Illawarra where few camps are occupied on a regular basis. Recent sightings of Grey-headed flying foxes on the tablelands to the west of the region are confined to the Canberra metropolitan area where a camp at Commonwealth Park is infrequently occupied by small numbers of animals.

Figure 10.1. Map of the SE NSW region showing the extents of the SCIVI and SCA vegetation maps and the locations and general patterns of occupation of known Grey-headed flying fox camps.



10.2. Grey-headed flying fox diet plants

10.2.1. Nectar diet

Twenty six species of plants in the nectar diet of Grey-headed flying foxes occur in the SENSW region including one hybrid (Table 10.1). The lists comprises 24 species of Myrtaceae: two *Angophora*, three *Corymbia*, 18 *Eucalyptus* and one *Syncarpia*; and two species of Proteaceae, both *Banksia*.

Nectar scores and bi-monthly flowering schedules

Four highly productive species (productivity scores ≥ 0.91) occur in the region: Red Bloodwood *C. gummifera*, Spotted Gum *C. maculata*, Blackbutt *E. pilularis* and Swamp Mahogany *E. robusta*. However, they do not typically provide annually reliable resources. Only Swamp Mahogany flowers with an annual frequency > 0.4 . The median weighted productivity x reliability score (wt p*r) for diet plants in the region is 0.54. Eight species score in the upper quartile of all diet plants in this project (wt p*r ≥ 0.65): Swamp Mahogany, Coast Banksia *B. integrifolia*, Blackbutt, Mountain Blue Gum *E. deanei*, Sydney Blue Gum *E. saligna*, Forest Red Gum *E. tereticornis*, Red Blood wood and Spotted Gum.

Diet plants found in the region are productive in each bi-month, although species richness varies through the year (Table 10.2). Broad seasonal patterns in the number of productive species are in keeping with other regional areas. A high proportion flower in summer (14 spp in Dec/Jan) and species richness reaches lowest levels in late winter and early spring (4 spp in Aug/Sep). The flowering schedules of seven species vary within the region. The majority of these follow latitudinal or altitudinal gradients. Difficulties were encountered in reliably attributing bi-months to *E. pilularis* and *E. paniculata*. In many local areas, the phenological data collated for these species were highly inconsistent. This result is supported by field studies (Florence 1964, Lawet *al.* 2000, Law and Chidel 2007). The rules set for identifying bi-months were relaxed for these two species and users of this work should be aware that they may be highly productive in bi-months not identified in Table 10.2.

10.2.2. Fruit diet

Subtropical, warm temperate, cool temperate and littoral rainforests are found in the region as are various wet sclerophyll types with substantial rainforest elements (Tozer *et al.* 2006, NPWS 2003a, b and c). All but cool temperate types contain trees and vines in the fruit diet of Grey-headed flying foxes. Both the extent and the floristic diversity of rainforest decreases rapidly with latitude along the south coast of NSW and the species richness of fruiting diet plants falls from 30 in the Illawarra to 10 near Eden (Table 10.3). The regional list comprises members of 22 families and 25 genera. Only *Ficus* and *Syzygium* are represented by more than one species in the region.

Table 10.1. The nectar scores of diet plants found in the SE NSW Region.

Species	Abundance	Synchrony	% yrs	Variation	Duration	Productivity	Reliability	wt P*R
<i>Angophora costata</i>	0.30	0.70	0.40	0.70	0.33	0.37	0.30	0.35
<i>A. floribunda</i>	0.50	0.70	0.40	0.70	0.33	0.54	0.30	0.45
<i>Banksia integrifolia</i>	0.70	1.00	1.00	1.00	1.00	0.77	1.00	0.83
<i>B. serrata</i>	0.50	0.70	0.70	0.70	0.67	0.54	0.60	0.56
<i>Corymbia eximia</i>	0.70	0.70	0.40	0.70	0.33	0.70	0.30	0.54
<i>C. gummifera</i>	1.00	0.70	0.40	0.70	0.67	0.91	0.30	0.65
<i>C. maculata</i>	1.00	0.70	0.40	0.70	1.00	0.91	0.30	0.65
<i>Eucalyptus amplifolia</i>	0.50	0.70	0.40	0.40	0.67	0.54	0.15	0.37
<i>E. botryoides</i>	0.50	0.70	0.40	1.00	0.67	0.54	0.45	0.51
<i>E. deanei</i>	0.70	0.70	0.70	1.00	0.33	0.70	0.80	0.73
<i>E. fibrosa</i>	0.70	0.70	0.40	0.70	0.67	0.70	0.30	0.54
<i>E. maidenii</i>	0.50	0.70	0.70	0.40	0.67	0.54	0.30	0.45
<i>E. melliodora</i>	0.70	0.70	0.40	0.70	0.67	0.70	0.30	0.54
<i>E. mollucana</i>	0.30	0.70	0.40	0.70	0.67	0.37	0.30	0.35
<i>E. muelleriana</i>	0.50	0.40	0.40	0.70	0.67	0.47	0.30	0.41
<i>E. paniculate</i>	0.70	0.40	0.40	0.70	0.67	0.61	0.30	0.49
<i>E. parramattensis</i>	0.50	0.70	0.40	0.70	1.00	0.54	0.30	0.45
<i>E. pilularis</i>	1.00	0.70	0.40	1.00	0.67	0.91	0.45	0.74
<i>E. piperita</i>	0.50	1.00	0.40	1.00	0.33	0.59	0.45	0.55
<i>E. punctata</i>	0.50	0.70	0.70	0.70	0.33	0.54	0.60	0.56
<i>E. robusta</i>	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>E. saligna</i>	0.70	0.70	0.70	1.00	0.33	0.70	0.80	0.73
<i>E. saligna</i> x <i>E. botryoides</i>	0.60	0.70	0.55	1.00	0.50	0.62	0.70	0.64
<i>E. tereticornis</i>	0.70	0.70	0.70	0.70	0.67	0.70	0.60	0.67
<i>E. tereticornis</i> (high elevation)	0.50	0.70	0.40	0.40	0.67	0.54	0.15	0.37
<i>E. tricarpa</i>	0.50	0.40	0.40	0.40	0.67	0.47	0.15	0.34
<i>Syncarpia glomulifera</i>	0.50	0.70	0.70	0.70	0.67	0.54	0.60	0.56

Table 10.2. Bi-monthly flowering schedules of diet plants found in the SE NSW Region. The flowering schedules of some species vary within the region. X = uniform; A = north from the Illawarra; B = from the Illawarra to Bega; C = south from Bega.

Species	Dec/Jan	Feb/Mar	Apr/May	Jun/Jul	Aug/Sep	Oct/Nov
<i>Angophora costata</i>						X
<i>A. floribunda</i>	X	B,C				
<i>Banksia integrifolia</i>			X	X	X	
<i>B. serrata</i>	X	X				
<i>Corymbia eximia</i>						X
<i>C. gummifera</i>		X	C			
<i>C. maculata</i>		A	X	B		
<i>Eucalyptus amplifolia</i>	X					
<i>E. botryoides</i>	X	B				
<i>E. deanei</i>	X	X				
<i>E. fibrosa</i>	X	X				
<i>E. maidenii</i>		X				
<i>E. melliodora</i>						X
<i>E. moluccana</i>		X				
<i>E. muelleriana</i>	X	B,C				
<i>E. paniculata</i>	B	B	A	A	X	B
<i>E. parramattensis</i>	X					
<i>E. pilularis</i>	X	X				
<i>E. piperita</i>	X	X				
<i>E. punctata</i>	X	X				
<i>E. robusta</i>			X	X	X	
<i>E. saligna</i>	X	X				
<i>E. saligna x botryoides</i>	X					
<i>E. tereticornis</i>					X	X
<i>E. tereticornis</i> (high elevation)						X
<i>E. tricarpa</i>			X	X		
<i>Syncarpia glomulifera</i>						X
Number of species	14	15	6	5	4	6

Table 10.3. Fruits in the diet of Grey-headed flying foxes that occur in the SE NSW Region. The approximate latitude of the southern limit to each species is given to demonstrate the decline in species richness within the region.

Family	Species	Common Name	Latitude of southern limit
GYMNOSPERMAE			
Podocarpaceae	<i>Podocarpus elatus</i>	Plum Pine	35.5
ANGIOSPERMAE			
Apocynaceae	<i>Melodinus australis</i>	Southern Melodinus	34.6
Arecaceae	<i>Livistona australis</i>	Cabbage Palm	38
	<i>Archontophoenix cunninghamiana</i>	Bangalow Palm	35.5
Avicenniaceae	<i>Avicennia marina</i>	Grey Mangrove	38
Cunoniaceae	<i>Schizomeria ovata</i>	Crabapple	36.2
Ebenaceae	<i>Diospyros pentamera</i>	Myrtle Ebony	35.6
Ehretiaceae	<i>Ehretia acuminata</i>	Koda	37
Elaeocarpaceae	<i>Elaeocarpus reticulatus</i>	Blueberry Ash	40
Escalloniaceae	<i>Polyosma cunninghamii</i>	Featherwood	35.6
Icacinaceae	<i>Pennantia cunninghamii</i>	Brown Beech	35.5
Meliaceae	<i>Melia azedarach</i>	White Cedar	34.8
Monimiaceae	<i>Hedycarya angustifolia</i>	Native Mulberry	40
Moraceae	<i>Ficus coronata</i>	Creek Sandpaper Fig	38
	<i>F. macrophylla</i>	Moreton Bay Fig	34.8
	<i>F. obliqua</i>	Small-leaved Fig	36.2
	<i>F. rubiginosa</i>	Rusty Fig	37
	<i>F. superba</i>	Deciduous Fig	35.2
	<i>Maclura cochinchinensis</i>	Cockspur Thorn	35.2
Myrtaceae	<i>Acmena smithii</i>	Lilly Pilly	40
	<i>Syzygium australe</i>	Brush Cherry	35.5
	<i>S. oleosum</i>	Blue Lilly Pilly	34.5
Passifloraceae	<i>Passiflora herbertiana</i>	Native Passionfruit	36.2
Pittosporaceae	<i>Pittosporum undulatum</i>	Sweet Pittosporum	38
Rhamnaceae	<i>Alphitonia excelsa</i>	Red Ash	36.2
Rubiaceae	<i>Morinda jasminoides</i>	Morinda	38
Sapindaceae	<i>Diploglottis australis</i>	Native Tamarind	34.75
Sapotaceae	<i>Planchonella australis</i>	Black Apple	34.5
Urticaceae	<i>Dendrocnide excelsa</i>	Giant Stinging Tree	37
Vitidaceae	<i>Cissus hypogaluca</i>	Five-leaf Water Vine	38

10.3. Vegetation classification and map

10.3.1. Description

The vegetation classification and map for this region has been derived from a compilation of the SCIVI (Tozer *et al.* 2006) and Sydney Catchment Authority projects (NPWS 2003a, b and c). Details of these projects including detailed descriptions of the methods and summaries of results can be found in the relevant reports. The reports also contain profiles of each vegetation type which provide a general description, a floristic summary, an assessment of conservation status and a list of diagnostic species to assist with field identification. These profiles were used to describe the distribution and relative densities of diet plants in the SE NSW region.

The SCIVI project produced a uniform vegetation classification and map for the entire region. It identified 184 vegetation types and mapped their extant distributions at a 1:100,000 interpretation scale. The accuracy of extant vegetation coverage varied across the region according to the standards of previous API work. Minimum polygon size ranged from 1 to 10 ha.

The SCA vegetation classification covers 761,400 ha in the northern portion of the region (Figure 10.1.). This project was incorporated into the SCIVI regional map for this work because it produced a uniform, fine scale product designed for land management use in the major water catchments of the Sydney Basin. There were 192 vegetation types identified within the Warragamba, Woronora, O'Hares and Metropolitan catchments, and the Illawarra escarpment and coastal plains. API line work for the project was completed at scales of 1:25,000 and 1:16,000 and minimum polygon size ranged from 0.5 to 1 ha.

Both the SCIVI and the SCA vegetation classifications followed methods recommended by Siversten and Smith (2001). Vegetation types were modelled from standardised and stratified field samples and cover/abundance scores and frequency data were used to describe the performance of individual species within vegetation types. The C/A - Freq method was used to calculate relative densities of nectar diet plants in each type and score the species richness of rainforest types (see accompanying data).

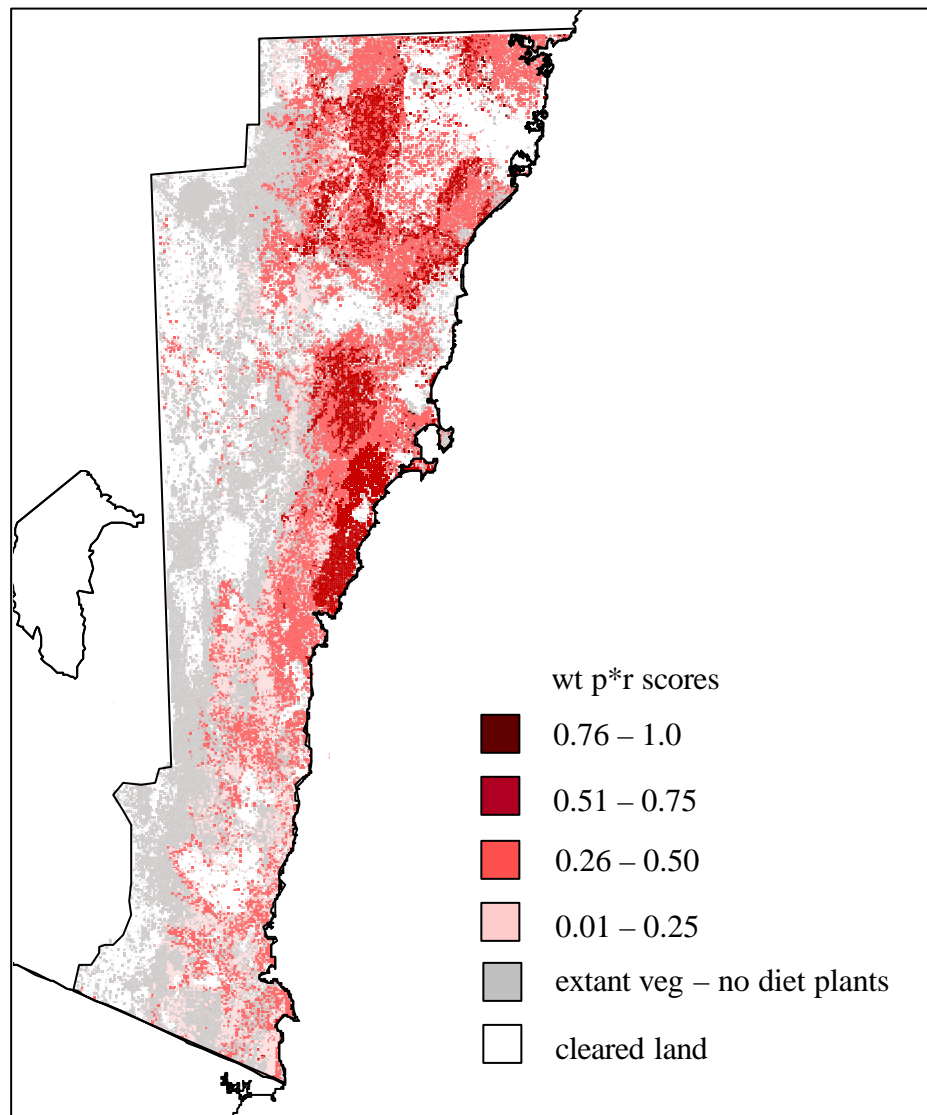
10.3.2. Habitat scores - nectar

Of the 376 vegetation types identified in the SENSW region, 160 (43%) contain plants in the nectar diet of Grey-headed flying foxes. Forests and woodlands that potentially produce nectar for the animals cover 35.4% of the region, or approximately 50% of extant vegetation (Figure 10.2). They are largely found on the coastal plains, plateaux and coastal ranges. Few productive habitats occur on the highlands and tablelands in the west of the region. Those on the tablelands have been extensively cleared for agriculture.

Scores for total nectar productivity, reliability and weighted productivity x reliability were calculated for each vegetation type. These 'total' habitat scores do not take seasonal variations into account and so are of limited assistance in assessing the significance of vegetation types for Grey-headed flying foxes. However, they provide a means of summarising patterns of overall habitat quality within the region. Wt p*r scores are of greatest interest. Vegetation types having wt p*r scores >0.75 are rare in the SE NSW region and account for less than 1% of the land area. They primarily comprise small

remnants of swamp forest containing Swamp Mahogany on alluvial or sandy soils of the coastal plain. Approximately 7% of the land area in the region supports forests and woodlands with total wt p*r scores >0.50. These vegetation types are primarily found on coastal plains and plateaux north from Batemans Bay. Diet plants that feature in these types include Spotted Gum, Red Bloodwood, Forest Red Gum, Sydney Blue Gum, Blackbutt, Turpentine and Coast Banksia. Types with high wt p*r scores are uncommon south from Batemans Bay, reflecting limits to the distribution of several highly productive diet plants and the distinctive narrowing of the coastal strip.

Figure 10.2. Map of the SE NSW region showing the extent of remnant vegetation and cleared land. Vegetation types that contain plants in the nectar diet of Grey-headed flying foxes are depicted in graduated colours of red which indicate increasing wt p*r scores. Seasonal variations are not taken into account. Polygons containing high-scoring vegetation (wt p*r = 0.76 – 1.0) are small, rare and not discernible at the scale of this map.



10.3.2.1. Bi-monthly nectar scores

When habitat nectar scores are calculated including only the species that flower in each bi-monthly interval, distinctive seasonal patterns become apparent in the extent, distribution and nectar characteristics of productive habitat (Table 10.4, Figures 10.3. and 10.4.).

Extensive tracts of native vegetation contain a diverse range of diet plants that flower in summer and early autumn. Productive habitat is distributed on coastal plains, plateaux, coastal ranges and highlands throughout the region. February-March is the most productive bi-monthly period in SE NSW; wt p*r scores are high in this bi-month and the greatest land area is productive. In this bi-month, SE NSW scores the highest area-weighted index of habitat quality in the study area (see Figure 3.6). However, the extent of productive habitat falls substantially in April-May and remains low through August-September. Few diet plants flower during this time and few vegetation types are productive. Although vegetation types dominated by Swamp Mahogany and Coastal Banksia achieve bi-monthly wt p*r scores that are among the highest in the region, these types have highly restricted distributions and primarily occur as remnants <50 ha.

The Spotted Gum forests in the Batemans Bay area are an exception. This species is widely distributed on the coastal plains in this area and can secrete substantial amounts of nectar over several months (Law and Chidel 2007). Forests that contain Spotted Gum are known to support populations of Grey-flying-foxes that exceed 100,000 individuals. However, annual reliability is poor and highly productive flowering occurs approximately one year in five (Pook *et al.* 1997). In spring the centre of productive habitat shifts north to the Sydney Basin to types containing Forest Red Gum on the Cumberland Plain and Turpentine on the rim of the Cumberland Plain and lower Blue Mountains. Red Gum – Yellow Box woodlands are also productive on the tablelands and areas surrounding the Wollondilly River Valley. However, nectar habitat scores fall during spring and indices of habitat quality remain low relative to summer and early autumn.

Table 10.4. Features of habitat productive for Grey-headed flying foxes in the SE NSW region in each bi-month.

	Dec-Jan	Feb-Mar	Apr-May	Jun-Jul	Aug-Sep	Oct-Nov
n vegetation types	115	119	25	21	27	61
productive area (ha)	1,064,891	1,301,561	298,059	179,221	123,388	510,553
% regional land area	26.2	32.0	7.3	4.4	3.0	12.5
area-weighted index	0.07	0.10	0.02	0.01	0.01	0.03

Figure 10.3. Maps of the SE NSW region showing the wt p*r scores of vegetation types calculated at bi-monthly intervals. Graduated colours indicate increasing values. For key see Figure 10.2.

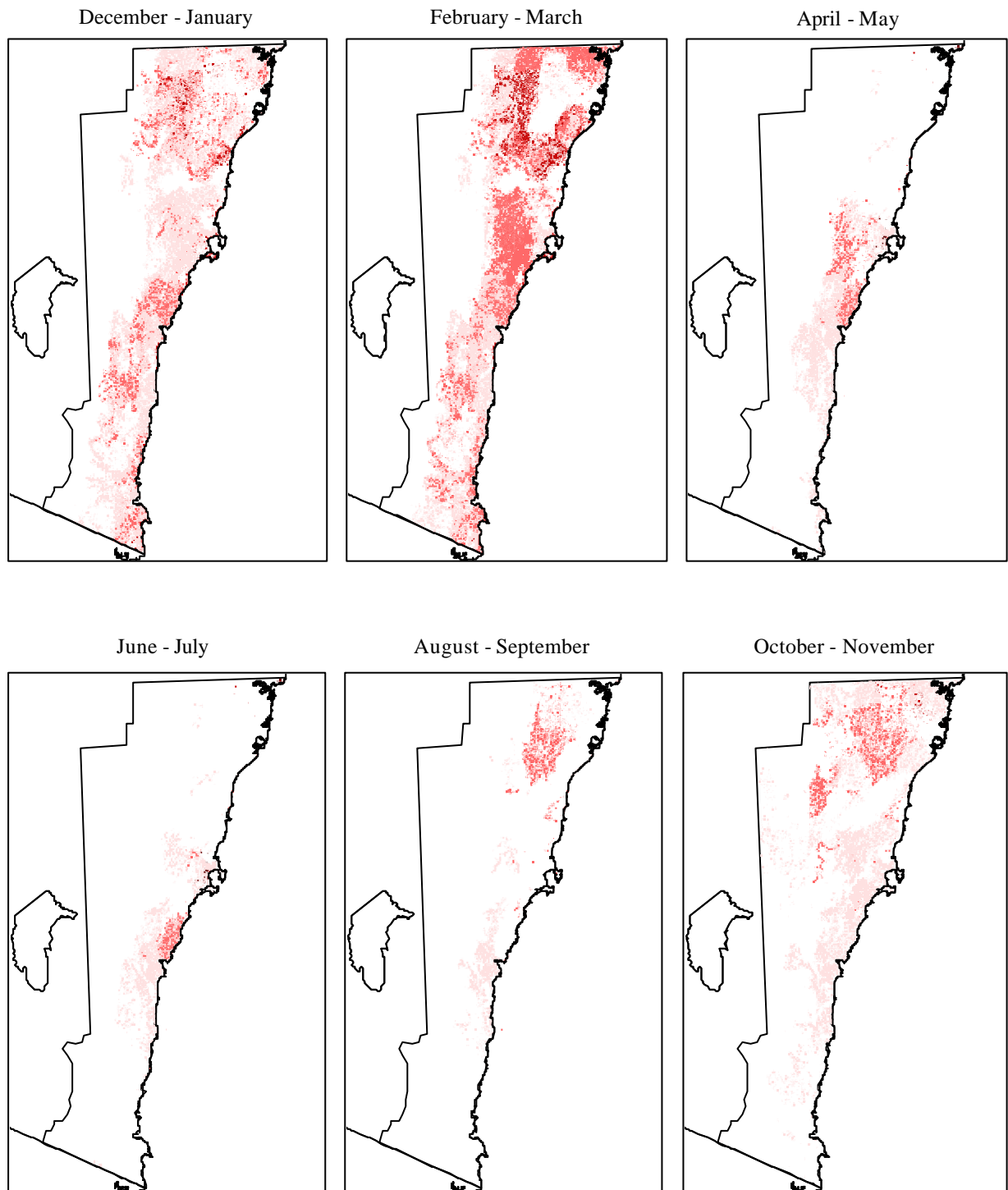
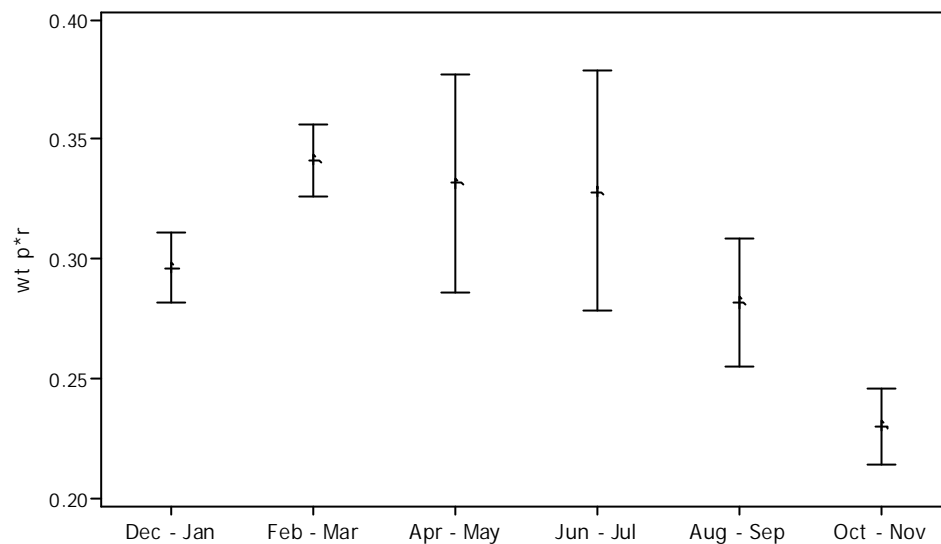


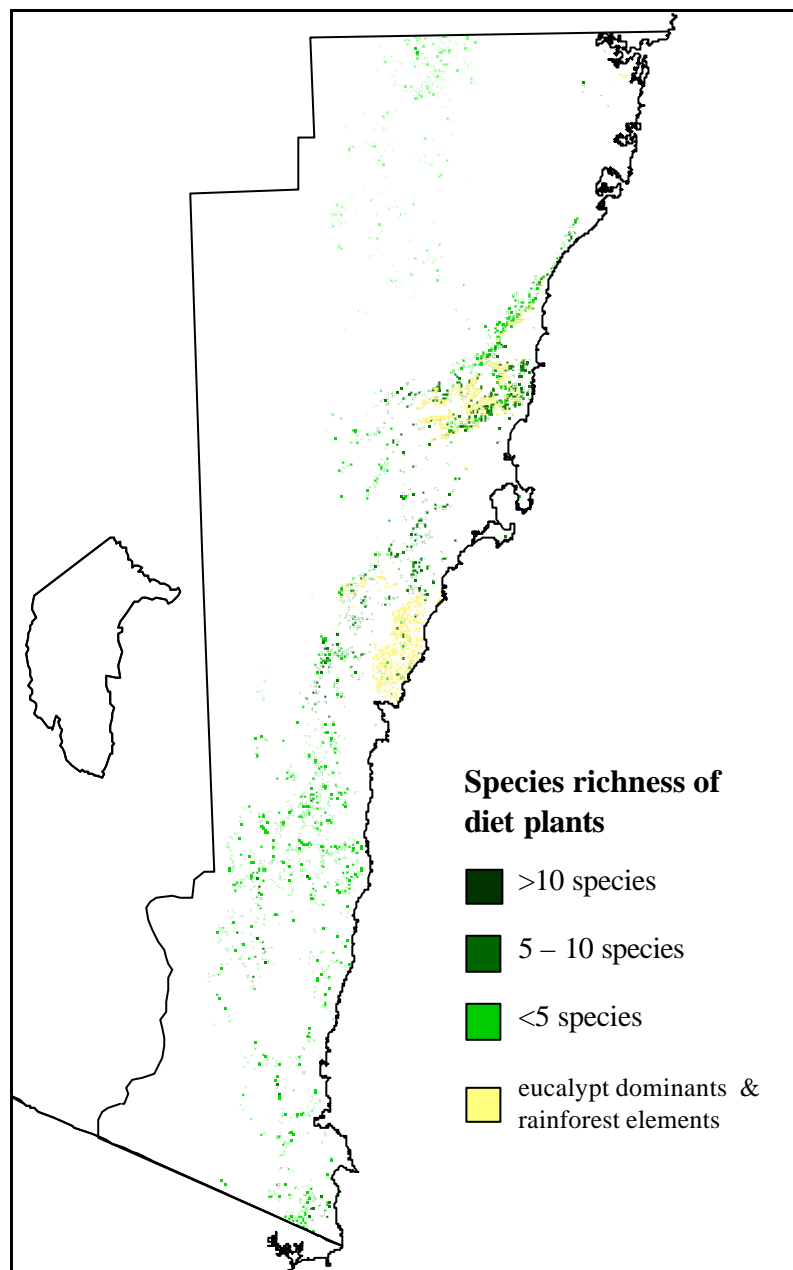
Figure 10.4. Means of bi-monthly weighted productivity x reliability scores, ± 1 s.e. Differences between bi-months area significant (GLM; $p = 0.001$).



10.3.3. Habitat scores - Fruit

Nineteen of the vegetation types identified as rainforest in the SCIVI and SCA classifications contain plants in the fruit diet of the animals. This is a relatively limited resource, making up 1.2% of the land area in the region. A further seven wet sclerophyll types dominated by eucalypts contain a sub-canopy with substantial rainforest elements that include diet plants. The species richness of diet plants in these 26 types varies considerably. In general, subtropical rainforests are the most species-rich, followed by warm temperate, littoral and dry rainforests. Six types contain >10 diet plants, five contain 5-10 and eight contain <5. Subtropical and warm temperate rainforests of the Illawarra and Kangaroo Valley are structurally complex, floristically diverse and contain relatively large numbers of diet plants. Warm temperate rainforests in the catchment of the Clyde River are also relatively rich in diet plants. However, at higher latitudes, several rainforest species reach their southern limit and species distributions become more patchy. While rainforest types persist south of the Clyde R., few contain as many as ten diet plants. Nonetheless, the reliability of the resource is recognised.

Figure 10.5. A map of the region showing the distribution of rainforest vegetation containing plants in the fruit diet of Grey-headed flying foxes. Graduated colours indicate the species richness of diet plants, with deeper colours assigned to more diverse types.



10.4. Habitat ranks

10.4.1. Bi-monthly ranks

Table 10.5. Thresholds of weighted productivity x reliability scores used to set bi-monthly habitat ranks. These thresholds assign approximately equal areas of vegetation to each rank in Dec-Jan, Feb-Mar, Apr-May and Oct-Nov; and assign 50% of area to rank 1 in bi-months when food shortages occur, Jun-Jul and Aug-Sep.

	Dec-Jan	Feb-Mar	Apr-May	Jun-Jul	Aug-Sep	Oct-Nov
RANK 1	0.28 - 0.74	0.41 - 0.74	0.28 - 1.0	0.25 - 1.0	0.33 - 1.0	0.26 - 0.67
RANK 2	0.25 - 0.27	0.30 - 0.40	0.23 - 0.25	0.21 - 0.23	0.23 - 0.29	0.19 - 0.25
RANK 3	0.18 - 0.24	0.20 - 0.29	0.18 - 0.21	0.11 - 0.18	0.14 - 0.21	0.14 - 0.18
RANK 4	0.06 - 0.17	0.09 - 0.19	0.09 - 0.13	0.09 - 0.10	0.09 - 0.11	0.05 - 0.13

10.4.2. Final habitat ranks

The highest bi-monthly rank for each of the nectar-producing vegetation types was taken as the final rank for that type. In addition, each of the 13 rainforest types that contain >5 plants in the diet of Grey-headed flying foxes was assigned a rank of 1. Those containing <5 were assigned ranks of 2.

Table 10.6. The extent and diversity of vegetation types assigned to each rank.

	area (ha)	% region	n
RANK 1	679,232	16.7%	98
RANK 2	493,572	12.1%	43
RANK 3	164,991	4.1%	25
RANK 4	152,894	3.8%	13

Figure 10.6. Maps of the SE NSW region showing bi-monthly distributions of vegetation types ranked according to their significance as feeding habitat for Grey-headed flying foxes. Rank 1 ■ Rank 2 ■ Rank 3 ■ Rank 4 ■

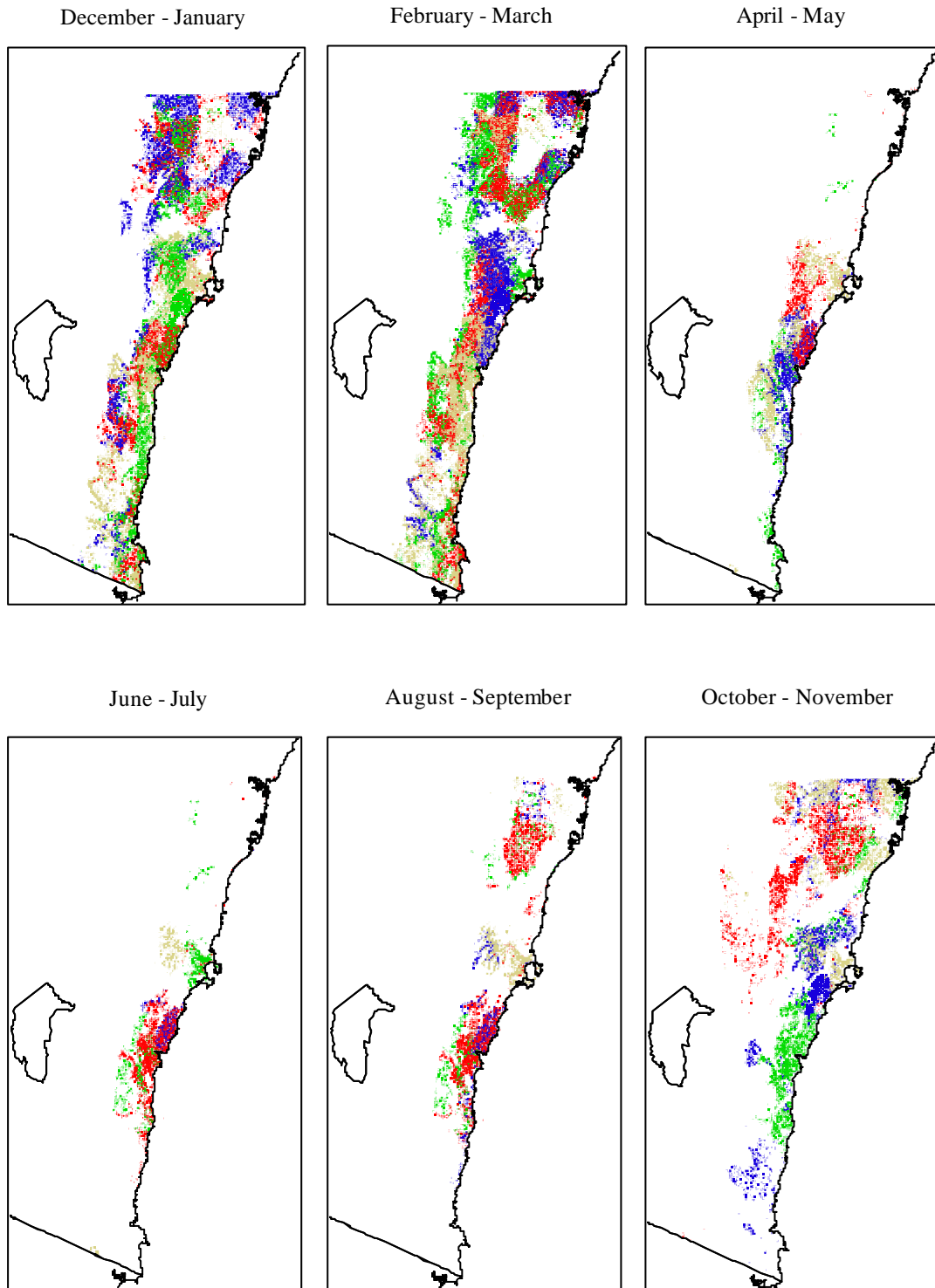


Figure 10.7. A map of the SE NSW region showing the final ranks of vegetation types.

