

GIS project
Fall 2010
Stephen Goodyear

Impact of vegetation heterogeneity on species composition of lizards in arid interior Australia

The goal of this project is to develop a model that predicts lizard species presence using vegetation data collected through aerial photographs. I will classify vegetation at an ecological research site using a single high-resolution aerial photograph of an area approximately 350 m². This study site is termed the “B-area” as it was part of a large scale wildfire experiment conducted in 1995. I will use data from classified vegetation maps to summarize the proportions of vegetation types within a radius of a determined length around individual pitfall traps. The outcome will be a table listing every lizard captured at the study site (rows) and proportions of vegetation observed by type (columns). Vegetation types will include mature spinifex grass, intermediate spinifex, young spinifex grass, various shrubs, and dirt roads. Identifications of some shrub species come from ground truthing. Vegetation data will be used with species abundance data, which is explicit in the previously described table, to determine associations between lizard species and vegetation types. The aerial photograph was captured in Austral spring of 1993 and I have lizard census data collected during Austral spring and summer of 1992 totaling 675 captured animals. For this study I will only focus on lizard species of a single species rich genus, *Ctenotus* skinks. We have samples of 506 individuals representing 12 species. I will use principle component analyses and other multi-dimensional scaling methods to find ecological associations between lizard abundance and vegetation. All analyses performed after classifying vegetation in ArcGIS will be done using R statistical software. These data will allow me to develop a model that predicts lizard assemblage structure (species abundance and composition) based on vegetation. The utility of this approach is that vegetation can be identified over large areas with high-resolution area photography. Using vegetation to predict presence of animal species can be used as a fast method of environmental assessment.

GEOREFERENCING

I used Google Earth for georeferencing a high-resolution aerial photograph of the study site. I aligned landmarks from our photo with more recent images shown in Google Earth. To match images, I used approximate GPS coordinates, recognition of know topographical landmarks (sand ridges and areas burned by recent wildfires), and alignment of roads and some larger old shrubs that appear on both images. I adjusted the transparency of our overlain image to match landmarks (roads, shrubs) seen on both aerial photograph and satellite image (figure 1).

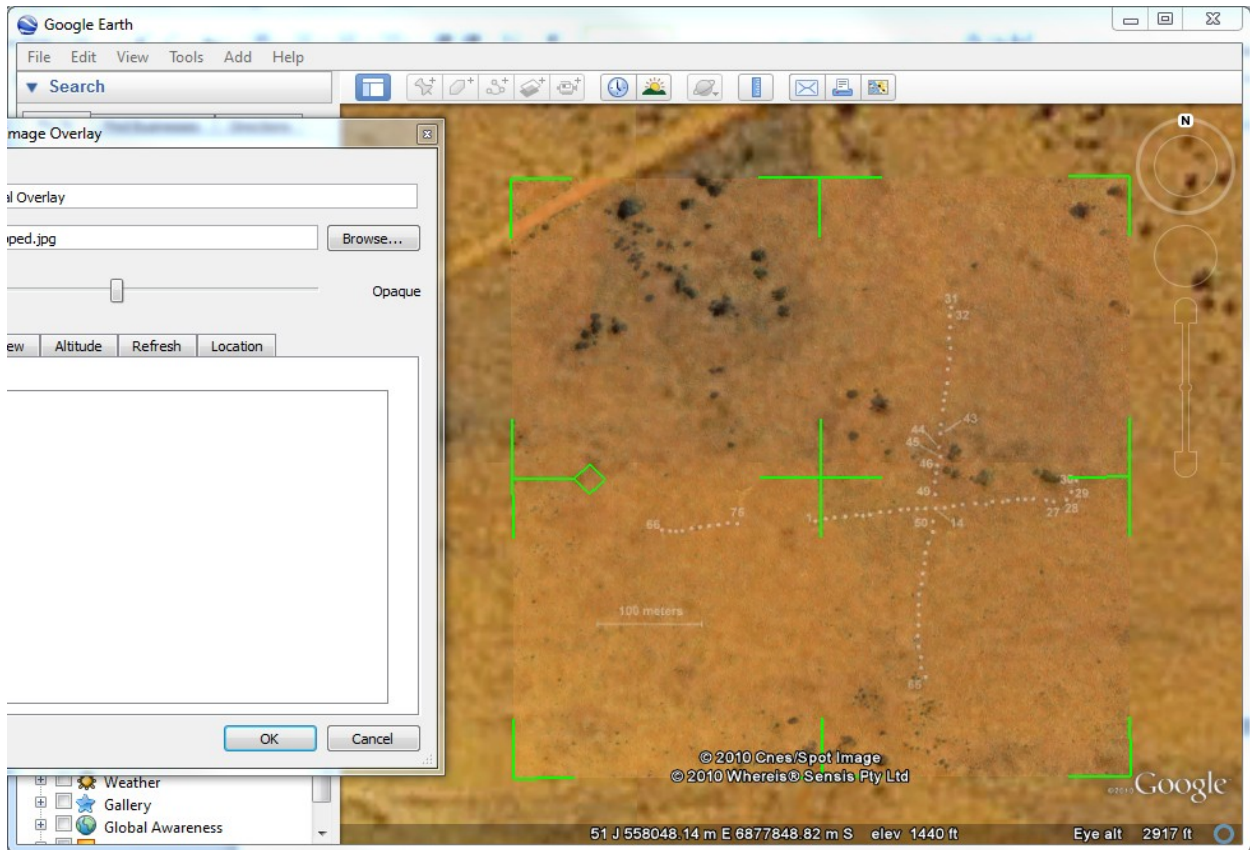


Figure 1 Adjusting transparency of overlain image in Google Earth to match landmarks on aerial and satellite images

The projected reference datum used is WGS 1984 UTM Zone 51S. I acquired the following coordinates in decimal degrees by placing markers at each corner of the overlain image in Google Earth (figure 2). I rectified the raster image using the bilinear interpolation technique for continuous data and saved it as a .jpg file.

The coordinates are as follows:

Corners:

NW: 557887 E
6878021 S

NE: 558243 E
6878021 S

SW: 557887 E
6877671 S

SE: 558243 E
6877671 S

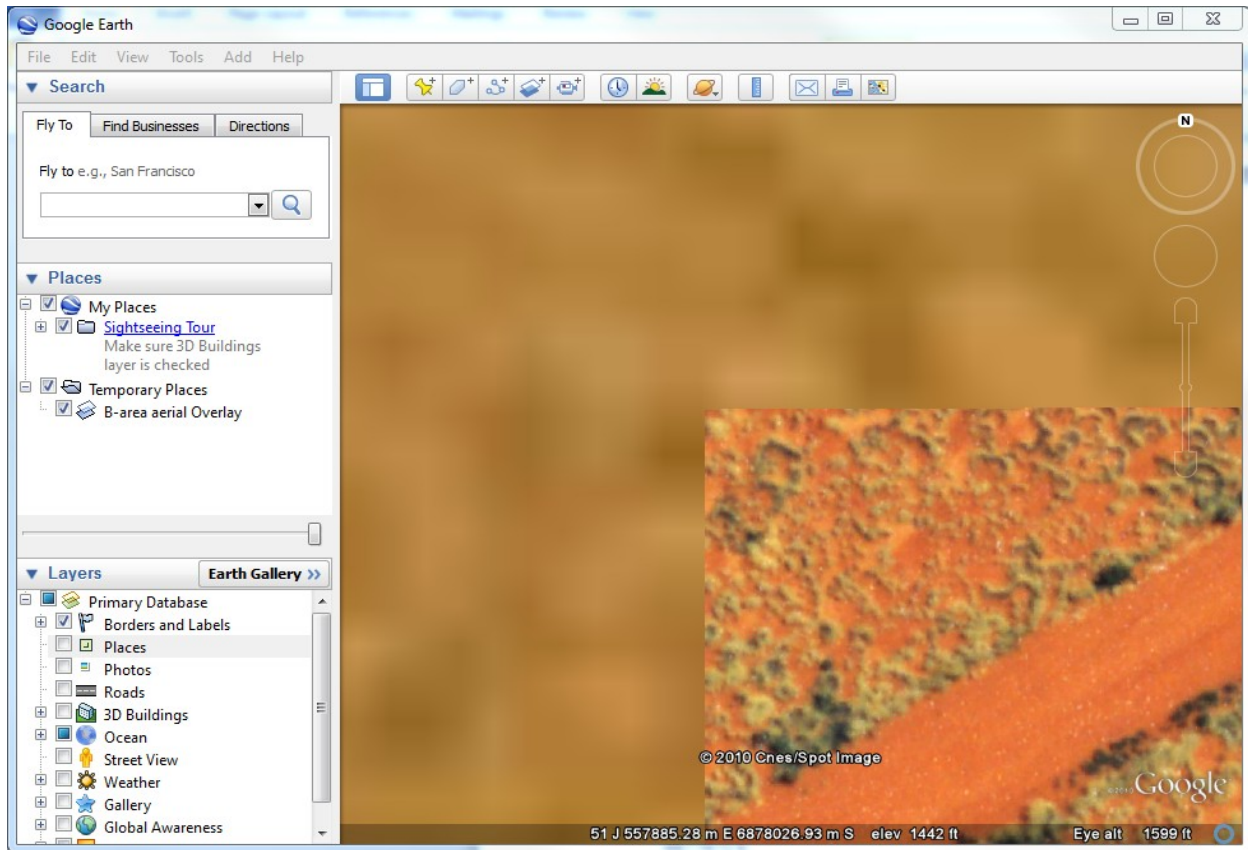


Figure 2 Using corners of image to obtain x,y coordinates for georeferencing in ArcMap.

DIGITIZING

I used the editor tools to draw polygons over all vegetation features identified in the aerial photograph. I identified three grades of spinifex grass growth (young, intermediate, and mature). Spinifex is the dominant vegetation in this part of the Australian continent. It is an arid adapted species that is highly flammable and grows again quickly after wildfires. Only the pitfall trap layer uses points rather than polygons as features. Pitfall traps are 10 gallon buckets buried with the lid flush with the ground. Connecting adjacent traps are lines of drift fence, 1 foot tall fine wire mesh. This trapping method works by stopping small vertebrates that attempt to cross the fence, the animals try to walk around the fence and eventually fall in a nearby trap. This is common and productive method for capturing many kinds of ground dwelling terrestrial animals.

I made 5 feature class layers: pitfall traps, vegetation type (shrub type), road, spinifex, and map area. Within the spinifex layer are three aged categories (mature, intermediate, and young) and within the vegetation type category are the following categories of shrub types: Acacia, Eremophila, Grevillea, Hakea, Mallee, Mulga, and other shrub. These were all linked to a domain type using the exact same method as described in the “Digitizing in ArcMap” lab exercise. I assigned attribute values to every polygon featured within the total area of the image.

I used the map area layer (outline of perimeter of image) for snapping together other polygons and the border of the image.

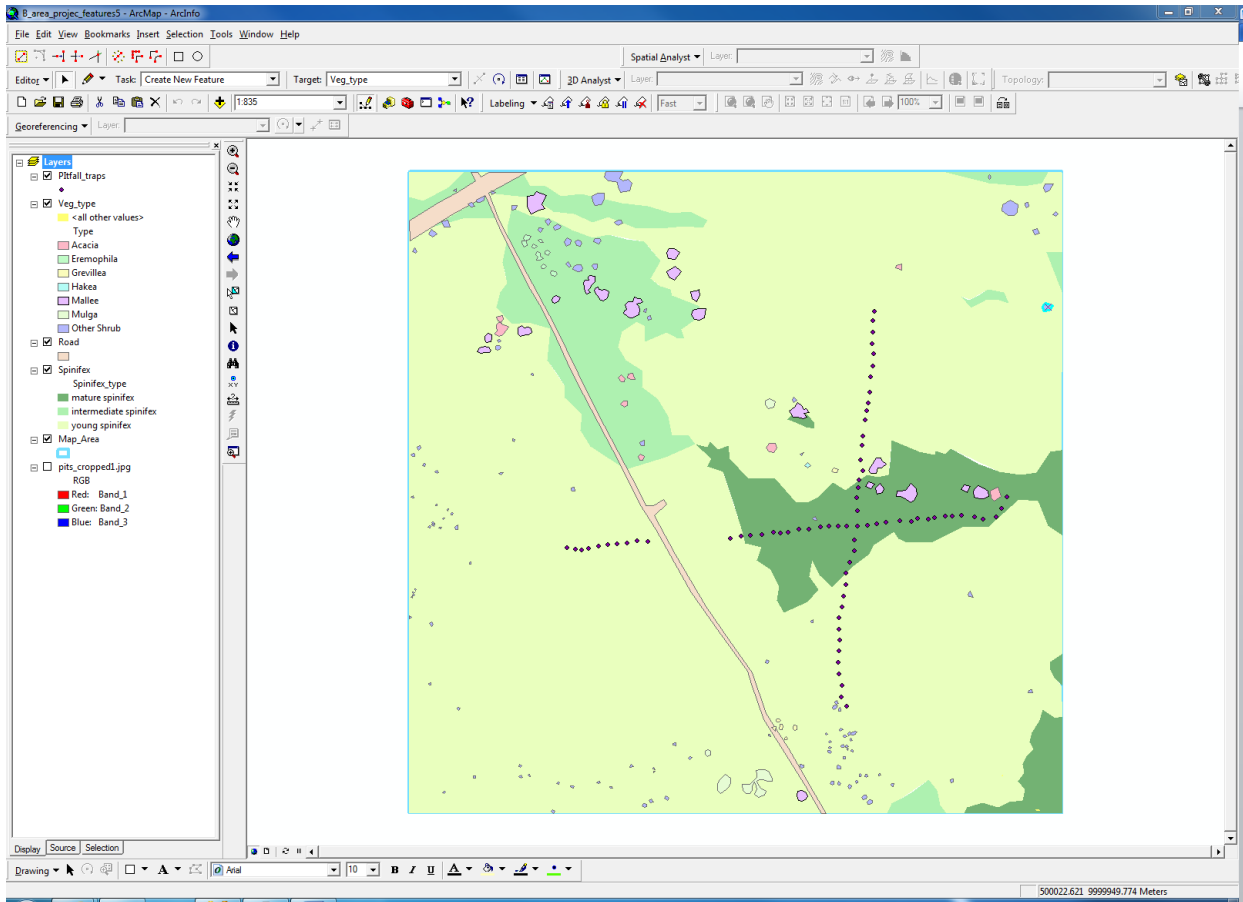


Figure 3 Digitizing all features as points and polygons.

I used ground truth data giving shrub types to classify these as attributes within the “Veg_type” layer. From aerial photographs I can only identify the darker small green shapes as some kind of shrub. Ground truthing is absolutely vital for recognizing shrub species. All shrubs that were not identified by ground truthing are marked as “Other Shrub.” Figure 4 shows a map outlining the different shrub types. These data along with the lizards captured for this study were collected by Eric R. Pianka.

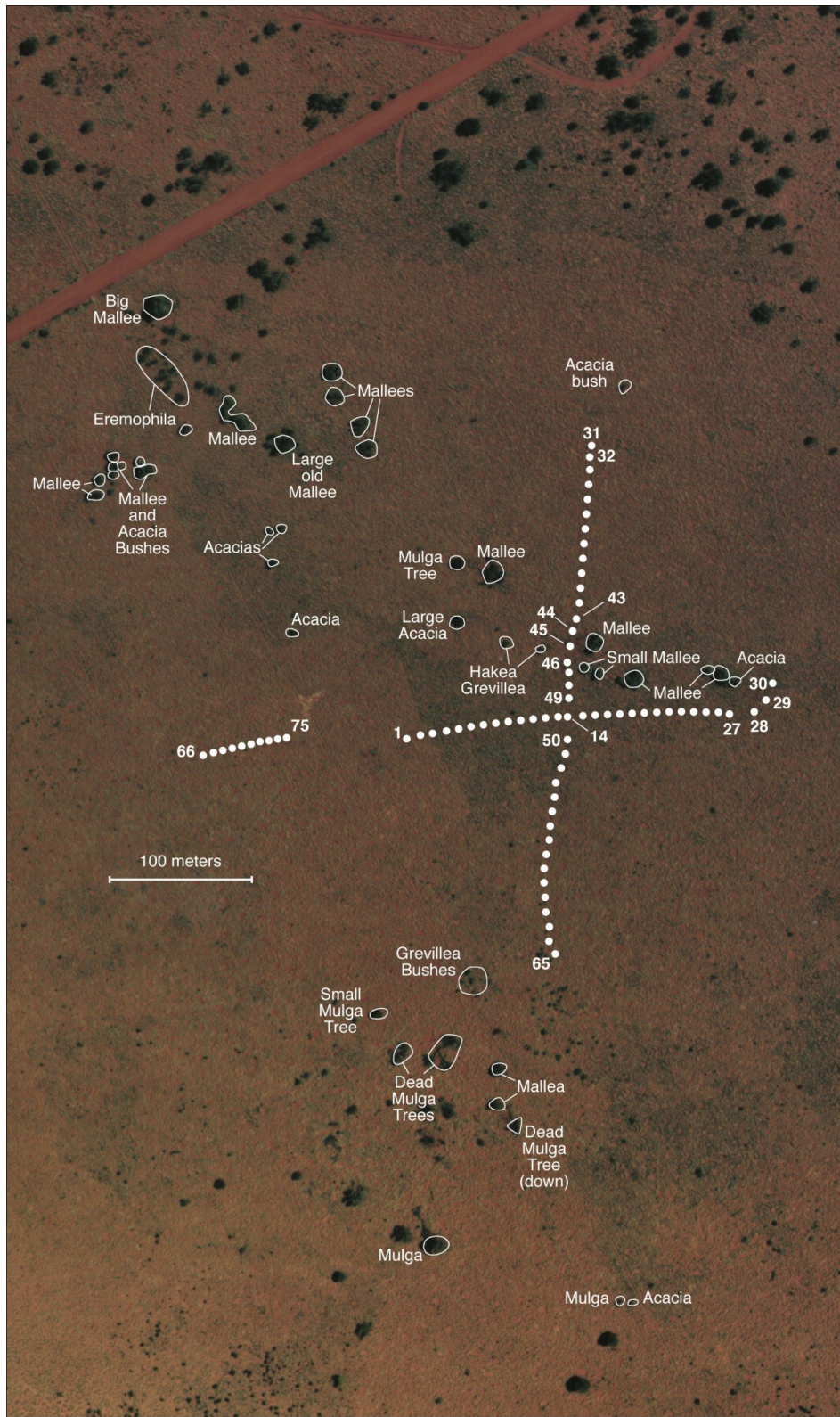


Figure 4 Ground truth identification of shrubs incorporated into digitized map

ANALYZING SPATIAL DATA

I want to acquire information on vegetation types surrounding each of the 75 pitfall traps. If vegetation type influences lizard species presence, then we might predict what pitfall traps will capture lizard species with a preference for vegetation surrounding a trap. I used circular buffers surrounding each trap to extract information on vegetation. In the Arc Toolbox I selected: Analysis tools → Proximity → Buffer. This opens the “Buffer” tool. I set buffers to be 5 meter radius rings surrounding each pitfall trap by selecting the following options in the window.

Input Features: Pitfall_traps

Output Feature Class: Pitfall_traps_Buffer_5m

I experimented with buffers of various sizes, including 2.5 meters and 10 meters but settled on only using 5 meter buffers for clarity in the presenting the summary data. Figure 5 shows the circular buffers drawn around each pitfall traps point. Notice the large amount of overlap between buffers. Had this GIS analysis been foreseen at the time when these traps were laid, a more suitable design would have been to place traps much further apart from one another to cover a larger area.

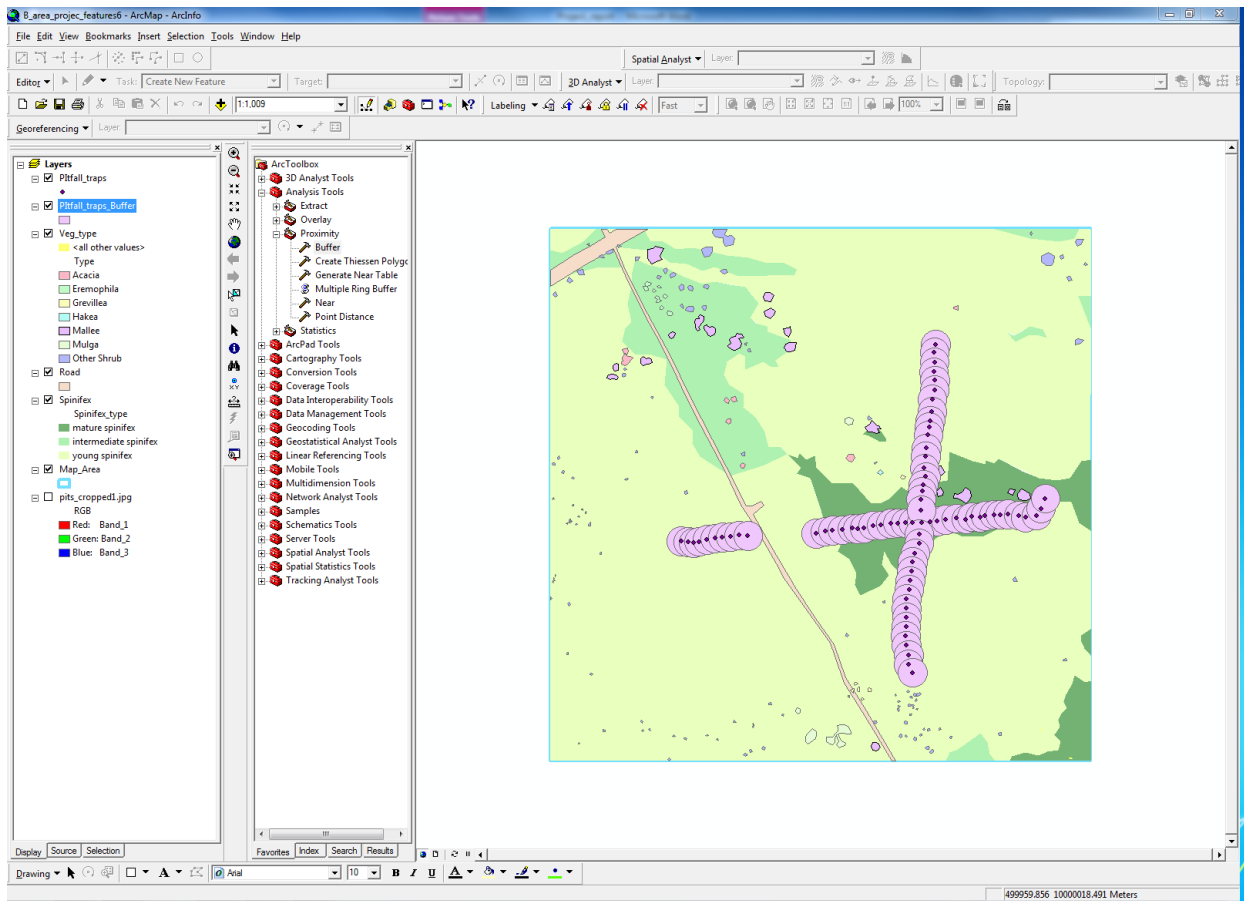


Figure 5 Drawing buffers around each pitfall trap point

Next, I want to extract information on vegetation content within the areas of each of the 75 buffers. I identified each polygon and measured the amount of overlap with a buffer using the “Identify” tool. In the Arc Toolbox I selected the following: Analysis tools → Overlay → Identity. I selected the following options in the “Identity” tool options window:

Input features: Pitfall_traps_Buffer

Identity Features: veg_type, spinifex, roads (each layer analyzed separately)

Each of these new layers contained information of the amount of raw space in square meters occupied within each 5 meter radius circular buffers. I exported information from the attribute tables in each of these three new feature class layers as text files. I opened the text files in MS excel to clean up and summarize the amount of coverage of each vegetation type for each pitfall trap buffer. I transformed three data tables (spinifex, shrubs, road) into a single all encompassing table with pitfall trap numbers as rows and vegetation types as columns. Each cell of the table gives the absolute amount of coverage for each vegetation type in square meters.

FINAL ANALYSES AND SUMMARY

The full extent of the digitized area of the map is equal to the size of the aerial image. I report here the absolute cover of each type of categorized vegetation as best estimated from photographs and ground truth information (table 1). Spinifex and shrubs were placed into separate layers to allow for some overlap between features in these two layers. In nature, there may be some spinifex growth underneath or immediately surrounding shrubs. I modeled the growth of spinifex around shrubs so that there is continuous growth over the same area as any shrub. A common case where this may not be true is when kangaroos dig out shady hollows where they rest during mid-day. However, there were no kangaroo digs observed at this study site. Figures 6 and 7 present graphically the proportionate amounts of vegetation type for each spinifex and shrubs within the entire area of the aerial image.

Feature	Absolute cover (m ²)
Intermediate spinifex	3069.15
Mature spinifex	2454.28
Young spinifex	29044.87
Acacia	36.81
Eremophila	14.15
Grevillea	6.08
Hakea	1.59
Mallee	192.13
Mulga	48.76
Other Shrub	145.23
road	432.70

Table 1 Summary of absolute cover of each type of vegetation and road within the entire area of the aerial photographed image

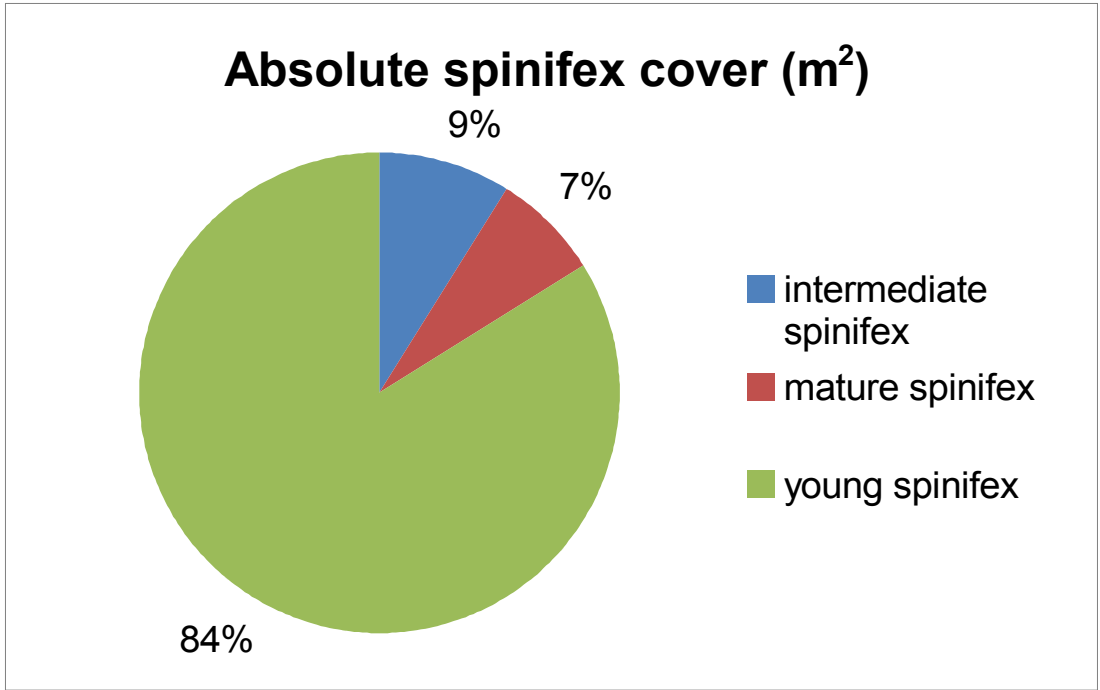


Figure 6 Absolute amount of spinifex cover over the entire photographed area

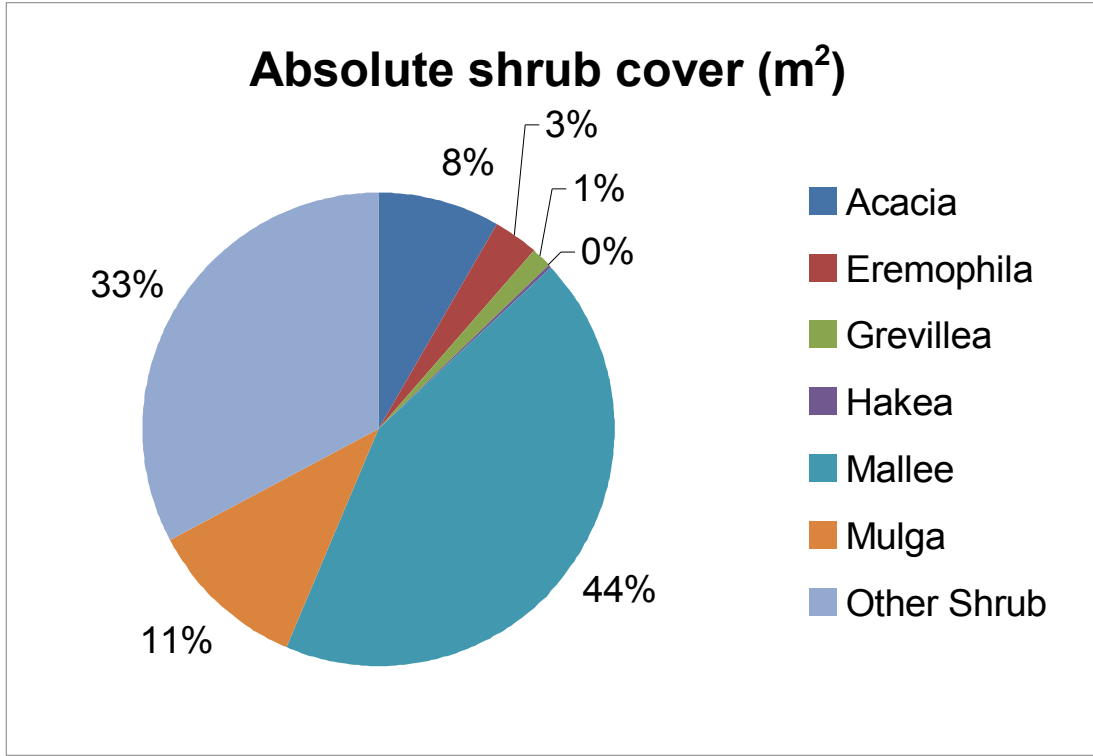


Figure 7 Absolute amount of shrub cover over the entire photographed area

I will incorporate information from a census of lizard species taken during the 1992 Austral spring to compare to vegetation cover surrounding pitfall traps where these animals were captured. In these censuses, all lizards were trapped and preserved for laboratory analyses and museum collections. Here, I analyze information on members of the species rich genus of *Ctenotus* skinks. Table 2 gives information about sample size of all the *Ctenotus* skinks collected over approximately four months.

I combined tables showing the amount of vegetation cover within a circular buffer surrounding each pitfall trap with a table that listed every individual lizard along with the trap where it was captured. From this I made a table giving species summaries of vegetation occupancy, with species as rows and vegetation types as columns (table 3). Some vegetation types observed in the full image were not represented in the area immediately surrounding trapping locations. These features are not listed in table 3, because cells within these columns all have values of zero.

The data presented in table 3 were input through a principal components analysis, one of the more basic clustering analyses which provide a visual means of identifying objects of varying similarities based on multiple attributes. There are 12 species included in this analysis, which means there are 11 ($= N-1$) principal components calculated. Only the first two principal components can be displayed on a 2-dimensional graph. In this case, well over 90% of the variation in principal component space is observed in the first two principal components. This is not surprising considering the large amount of vegetation cover in two dominant categories, mature and young spinifex.

Figure 8 presents the results of a biplot analysis which analyzes species and vegetation as both dependent and independent variables. The results indicate that *C. ariadnae*, *C. hanloni*, *C. pantherinus*, and *C. piankai* are dependent on mature spinifex for shelter, whereas *C. calurus* may thrive in young spinifex cover. The other species that converge around (0, 0) x and y coordinates may be habitat generalists or samples sizes were too small to detect any bias towards a particular vegetation type. None of these species eat vegetation, they only eat insects. Diet in these species is well documented and is in some cases strongly tied to vegetation composition.

Figure 9 shows the same information given for species position in principal components space, but with species having sample sizes less than 5 removed for clarity. The species named "*Ctenotus grandis/hanloni*" is a putative hybrid between *C. grandis* and *C. hanloni*. This figure indicates varying degrees of preference for mature spinifex grass among seven species and *C. calurus* as an outlier. It may be that *C. calurus* does not have a preference for young spinifex as much as it is the most abundant skink species at the study site and has little habitat preference. Young spinifex covers a much larger portion of the study site than other vegetation type, so having little habitat preference could possibly drive the appearance of habitat preference for young spinifex in *C. calurus*.

Based on these results, with some confidence I would predict that in areas recently burned by wildfire it would be unlikely to observe *C. ariadnae*, *C. hanloni*, *C. pantherinus*, and *C. piankai*. Lizards census conducted around artificial wildfire experiments conducted at this very study confirm that exact trend. Lizards of those four species decrease in numbers greatly following wildfire and increase gradually as spinifex cover increases.

Figure 10 shows my final vegetation coverage map that I edited in ArcMap.

Species	samples (N=)
<i>Ctenotus ariadnae</i>	61
<i>Ctenotus calurus</i>	131
<i>Ctenotus colletti</i>	1
<i>Ctenotus grandis</i>	2
<i>Ctenotus grandis/hanloni</i>	35
<i>Ctenotus greeri</i>	1
<i>Ctenotus hanloni</i>	117
<i>Ctenotus helenae</i>	3
<i>Ctenotus pantherinus</i>	62
<i>Ctenotus piankai</i>	78
<i>Ctenotus quatt.</i>	14
<i>Ctenotus schomburgkii</i>	1
Total	506

Table 2 Sample sizes of each species collected during the 1992 census of the B-area

Species	Mature spini	Young spini	Acacia	Mallee	Other shrub	Road
<i>Ctenotus ariadnae</i>	2562.44	2227.34	22.21	5.84	8.34	6.43
<i>Ctenotus calurus</i>	3136.3	7149.94	25.17	64.12	16.7	25.72
<i>Ctenotus colletti</i>	74.68	3.84	0	0	0	0
<i>Ctenotus grandis</i>	153.2	3.84	0	0	0.73	0
<i>Ctenotus grandis/hanloni</i>	1286.11	1462.16	27.92	11.69	2.83	0
<i>Ctenotus greeri</i>	78.52	0	0	0	0	0
<i>Ctenotus hanloni</i>	4611.69	4575.27	42.27	31.79	6.02	12.86
<i>Ctenotus helenae</i>	170.93	64.64	0	7.74	0	0
<i>Ctenotus pantherinus</i>	2616.23	2252.1	20.27	23.1	1.47	0
<i>Ctenotus piankai</i>	2755.03	3369.57	17.45	37.34	8.27	0
<i>Ctenotus quatt.</i>	606.39	492.93	4.76	21.32	3.56	0
<i>Ctenotus schomburgkii</i>	0	78.52	0	0	0	0

Table 3 Summary of total vegetation coverage surrounding pitfall traps where each species was captured

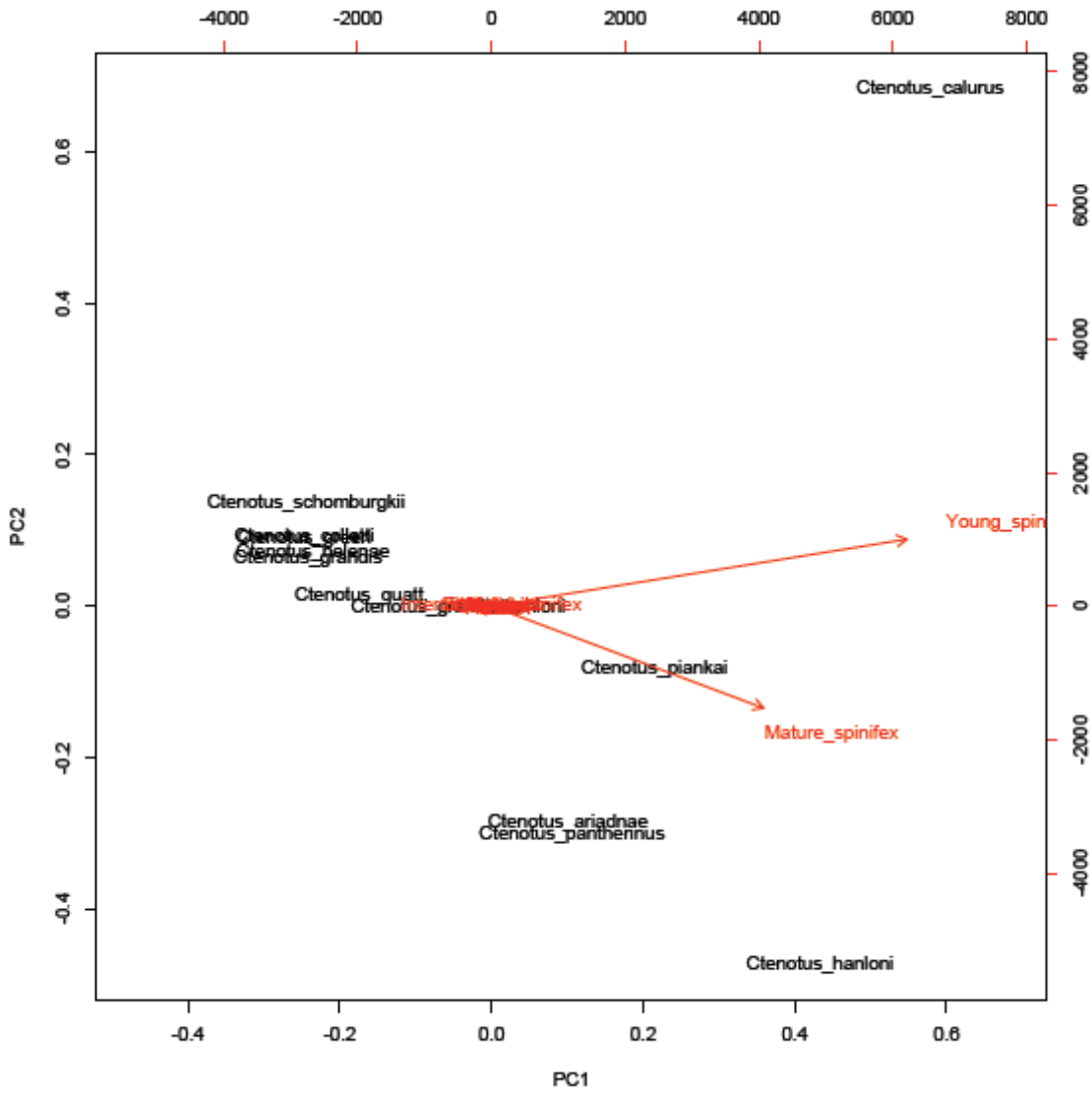


Figure 8 Principal components biplot showing similarities between species composition / abundance and vegetation types

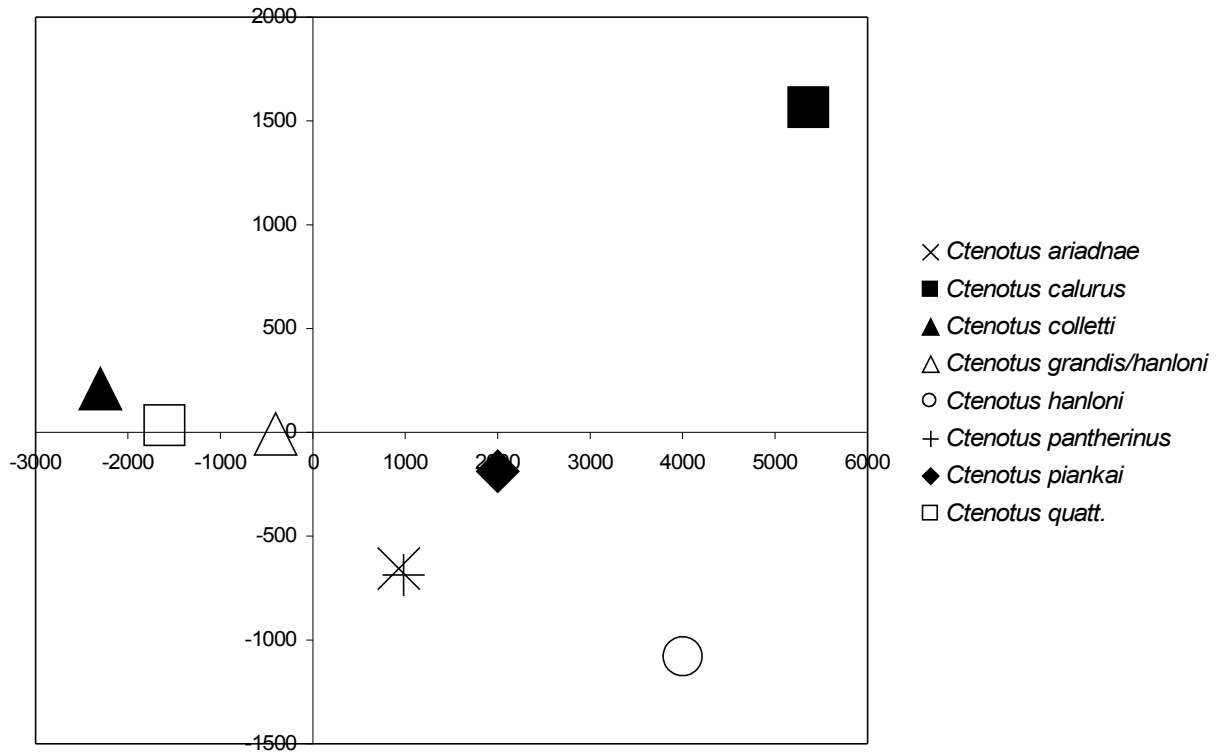


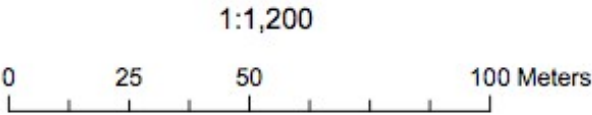
Figure 9 Same data as in figure 8 but shown more clearly to see relative positions of species in principal components space. Species where fewer than five individuals were sampled are eliminated for clarity.

Figure 10 Final Vegetation Map prepared in ArcMap

Vegetation at B-area ecological research site in Western Australia



Shrub type		Spinifex	
Type		Spinifex type	
 Acacia		 mature spinifex	
 Eremophila		 intermediate spinifex	
 Grevillea		 young spinifex	
 Hakea		 Road	
 Mallee		 Pitfall traps	
 Mulga			
 Other Shrub			



WGS 1984 UTM Zone 51S