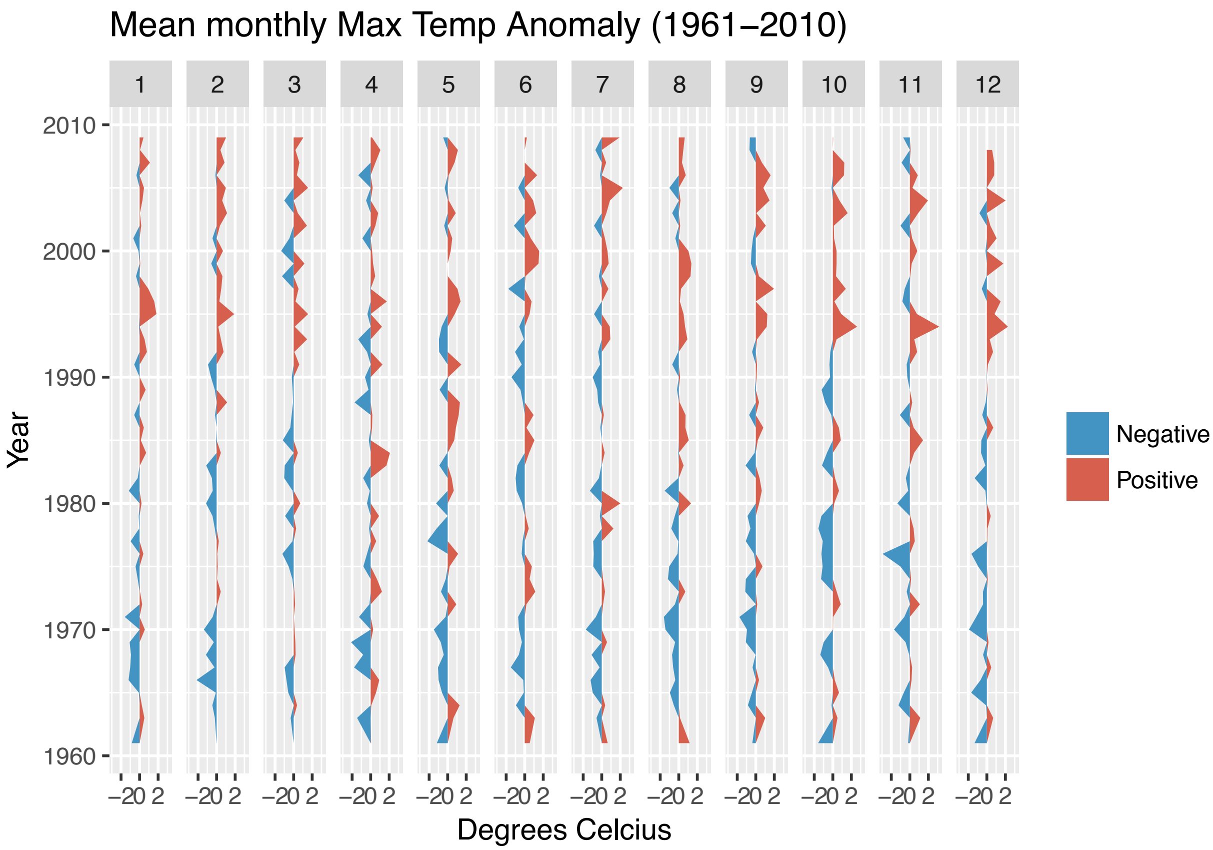
Weather Data Analysis

Jasper Slingsby

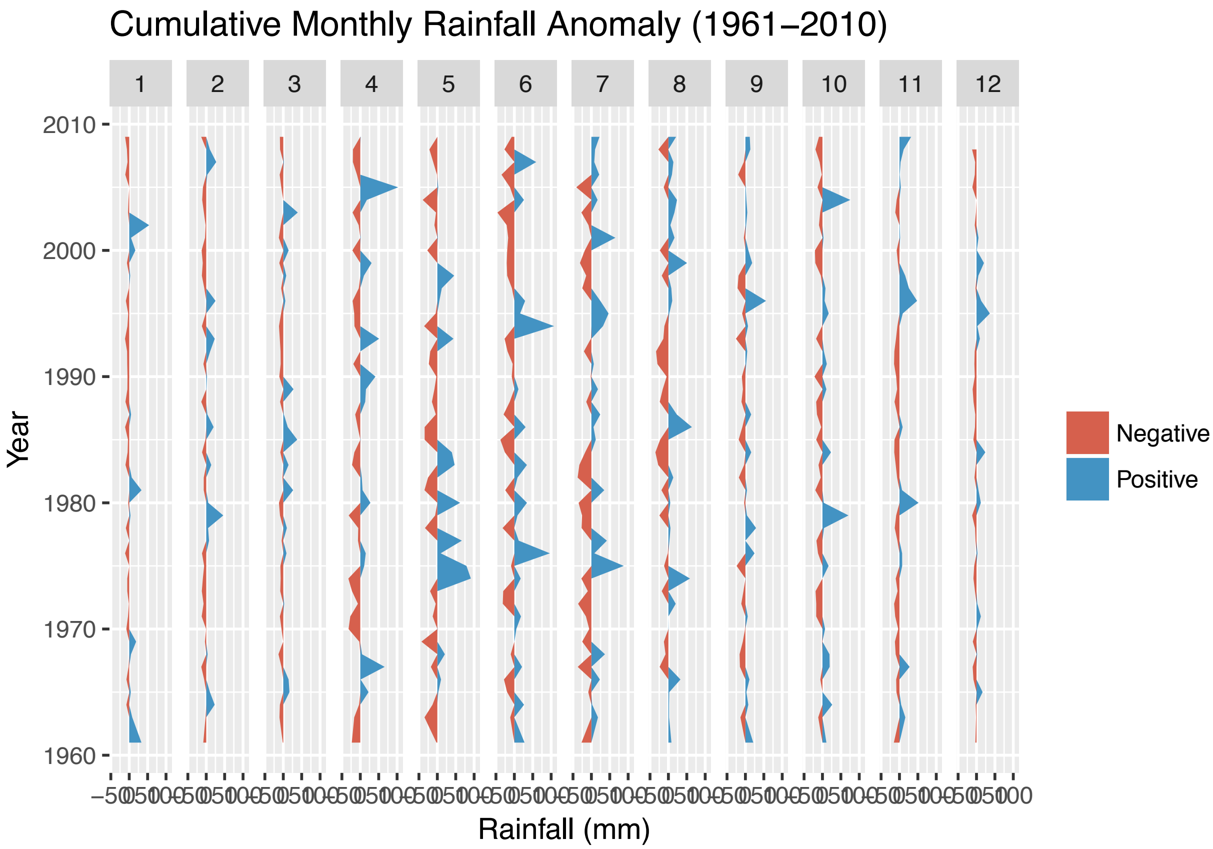
9 March 2017

Trends in mean monthly maximum temperature anomalies:



Pretty clear increases in positive anomalies.

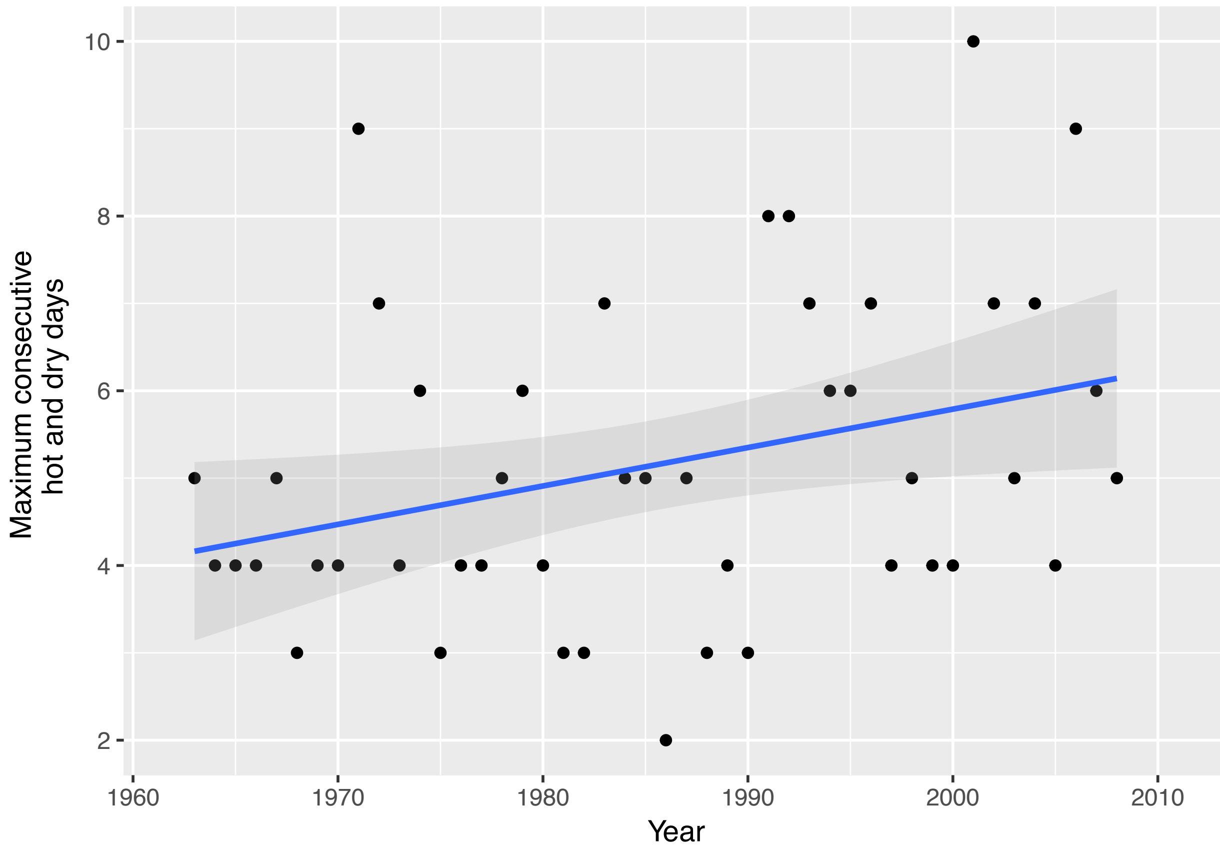
Trends in cumulative monthly rainfall anomalies:



Not much trend. There's bigger variance in April to September because this spans the wet season.

Analysis of maximum count of consecutive hot and dry days (1963-2009)

Let's look at the plot of consecutive hot and dry days and then model them as a function of year with MCMCglmm (default priors and normal errors).




```
##
##  Iterations = 3001:12991
##  Thinning interval  = 10
##  Sample size  = 1000
##
##  DIC: 185.8413
##
##  R-structure:  ~units
##
##       post.mean l-95% CI u-95% CI eff.samp
## units     3.171    1.957      4.6    869.9
##
##  Location effects: Consecutive_Hot_and_Dry_Days ~ Year
##
##              post.mean   l-95% CI   u-95% CI eff.samp pMCMC
## (Intercept) -8.294e+01 -1.620e+02 -7.261e+00     1000  0.04 *
## Year         4.437e-02  4.028e-03  8.194e-02     1000  0.03 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Lastly, hidden code calculates the most extreme post fire weather (CDD and CHD) experienced in the first year after fire and outputs this as *postfireweather.csv*. This can be altered to change thresholds etc for downstream analyses if desired.

Vegetation Data Analyses

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1. Data Description

Instructions for interpreting column names:

"**SR**" = species count

The prefix "**d**" = "delta" (i.e. change), and there is usually a suffix indicating years compared, e.g. dSR66_10 is the change in species numbers between 1966 and 2010

The suffix "**r**" indicates "resprouter" while the suffix "**s**" indicates "seeder", so SR66s is the seeder species numbers in 1966

"**lshrub**", "**tshrub**", "**gram**", "**herb**", "**geo**" represent the different growth forms (see paper)

"**Age**" is the age of the plot in a particular year (e.g. "Age66") or change in age between years (e.g. dAge66_10), while "**dAge66_96_std**" and "**dAge66_10_std**" are standardized for use in the models

"**cdd**" is a factor for the maximum count of consecutive dry days experienced in the first year after a fire between 1966 and 2010 ("**cdd66_96**" is the same but for the period 1966 to 1996) binned into 0-49 days or 50-200 days (see paper)

"**chd**" is a factor for the maximum count of consecutive hot and dry days experienced in the first year after a fire between 1966 and 2010 ("**chd66_96**" is the same but for the period 1966 to 1996) binned into 0-5 days or 6-9 days (see paper)

"**Aliens**" is the maximum density of woody alien shrubs previously recorded in the plot binned into the classes 0, 1-49, 50-199, >200 (see paper)

A quick look at the data

```
##    Plot Moisture_class Age1996 Age2010 Age1966 Aliens_max firecount66_10
## 1  CP_1              5      10      10       8          3              3
## 2 CP_10              5      10      24       2          0              2
## 3 CP_12              4      10       3       3          1              2
## 4 CP_13              3      10      24       5          1              1
## 5 CP_14              2      10       5       3          2              3
## 6 CP_15              4      10       3       3          3              2
##   firecount66_96 firecount96_10 Consecutive_Hot_and_Dry_Days_66_96
## 1              1              2                                  2
## 2              1              1                                  2
## 3              1              1                                  2
## 4              1              0                                  2
## 5              2              1                                  3
## 6              1              1                                  2
##   Consecutive_Hot_and_Dry_Days chd66_96 chd66_10 SR66 SR96 SR10 SR66r
## 1                            5    (0,5]    (0,5]   50   44   50    22
## 2                            5    (0,5]    (0,5]   48   51   46    23
## 3                            6    (0,5]   (5,11]   63   44   48    27
## 4                            2    (0,5]    (0,5]   43   34   25    16
```

```
## 5                          4    (0,5]    (0,5]   43   32   26    22
## 6                          6    (0,5]   (5,11]   63   26   48    26
##   SR96r SR10r SR66s SR96s SR10s lshrub66 tshrub66 gram66 herb66 geo66
## 1    16    23    28    28    27       25       10      8      2     4
## 2    21    21    25    30    25       19        6     12      4     6
## 3    21    20    36    23    28       32       12     13      1     4
## 4    15     9    27    19    16       18        8     15      0     1
## 5    21    11    21    11    15       14        5     18      3     3
## 6    12    20    37    14    28       34        3     18      4     4
##   lshrub96 tshrub96 gram96 herb96 geo96 lshrub10 tshrub10 gram10 herb10
## 1       22       10      7      1     3       26        8      8      3
## 2       22        9     11      5     3       22        6     11      3
## 3       16        9     14      2     2       30        6      8      1
## 4       14        6     11      1     1       10        5      9      0
## 5       12        6     11      1     2        8        5     10      2
## 6       12        2     10      1     1       27        2     15      1
##   geo10 dSR66_96 dSR66_10 dSR66_96r dSR66_10r dSR66_96s dSR66_10s
## 1     4       -6        0        -6         1         0        -1
## 2     3        3       -2        -2        -2         5         0
## 3     3      -19      -15        -6        -7       -13        -8
## 4     0       -9      -18        -1        -7        -8       -11
## 5     0      -11      -17        -1       -11       -10        -6
## 6     3      -37      -15       -14        -6       -23        -9
##   lshrub66_10 tshrub66_10 gram66_10 herb66_10 geo66_10 lshrub66_96
## 1           1          -2         0         1        0          -3
## 2           3           0        -1        -1       -3           3
## 3          -2          -6        -5         0       -1         -16
## 4          -8          -3        -6         0       -1          -4
## 5          -6           0        -8        -1       -3          -2
## 6          -7          -1        -3        -3       -1         -22
##   tshrub66_96 gram66_96 herb66_96 geo66_96 dAge66_96 dAge66_10
## 1           0        -1        -1       -1         2         2
## 2           3        -1         1       -3         8        22
## 3          -3         1         1       -2         7         0
## 4          -2        -4         1        0         5        19
## 5           1        -7        -2       -1         7         2
## 6          -1        -8        -3       -3         7         0
##   dAge66_10_std dAge66_96_std tss66_96 tss66_10 Moisture
## 1    0.09905243     0.6127811        0        0        5
## 2    1.69571842     1.4231528        1        1        5
## 3   -0.06061417     1.2880909        1        1        4
## 4    1.45621852     1.0179670        0        0        3
## 5    0.09905243     1.2880909       -1       -1        2
## 6   -0.06061417     1.2880909        1        1        4
```

The total number of species and per survey and their growth form composition

```
## Total  1966  1996  2010
##   381   298   283   261
```

```
##       herb geophyte graminoid low_shrub tall_shrub
## Total   26       19        97       184         54
## 1966    19       16        75       145         40
## 1996    14       14        78       136         40
```

```
## 2010    13       14        62       125         45
```

Spatial turnover between plots within each survey as measured using Sorenson's dissimilarity

```
##        Min. 1st Qu. Median   Mean 3rd Qu. Max.
## 1966 0.2787  0.5931 0.7097 0.7082  0.8313    1
## 1996 0.2773  0.5738 0.6977 0.6966  0.8292    1
## 2010 0.3131  0.6000 0.7273 0.7242  0.8515    1
```

The number and names of the unique species per survey.

```
## $`1966`
## [1] 41
##
## $`1996`
## [1] 29
##
## $`2010`
## [1] 37
```

```
## $`1966`
##  [1] "Agathosma lanceolata"      "Anthochortus laxiflorus"
##  [3] "Aristea glauca"            "Aspalathus ericifolia"
##  [5] "Aspalathus sericea"        "Bobartia filiformis"
##  [7] "Capeobolus brevicaulis"    "Carpacoce spermacocea"
##  [9] "Centella affinis"          "Crassula flava"
## [11] "Crassula nudicaulis"       "Crassula subulata"
## [13] "Cynanchum obtusifolium"    "Ehrharta bulbosa"
## [15] "Erica parviflora"          "Euphorbia silenifolia"
## [17] "Ficinia anceps"            "Ficinia paradoxa"
## [19] "Helichrysum cymosum"       "Helichrysum patulum"
## [21] "Hypodiscus albo-aristatus" "Indigofera sarmentosa"
## [23] "Linum africanum"           "Linum thunbergii"
## [25] "Lobostemon fruticosus"     "Manulea tomentosa"
## [27] "Muraltia filiformis"       "Oedera imbricata"
## [29] "Osteospermum moniliferum"  "Pentameris aurea"
## [31] "Psoralea imbricata"        "Rafnia crassifolia"
## [33] "Roella prostrata"          "Salvia africana-lutea"
## [35] "Searsia rosmarinifolia"    "Selago luxurians"
## [37] "Stoebe rosea"              "Syncarpha canescens"
## [39] "Tetraria ustulata"         "Thesium carinatum"
## [41] "Willdenowia humilis"
##
## $`1996`
##  [1] "Agathosma bifida"         "Agathosma capensis"
##  [3] "Arctotis acaulis"         "Arctotis aspera"
##  [5] "Arctotis stoechadifolia"  "Aspalathus laricifolia"
##  [7] "Asparagus rubicundus"     "Ehrharta setacea"
##  [9] "Elegia thyrsifera"        "Erica spumosa"
## [11] "Erica subdivaricata"      "Ficinia indica"
## [13] "Helichrysum crispum"      "Hermas villosa"
## [15] "Indigofera candolleana"   "Lampranthus falciformis"
## [17] "Muraltia spinosa"         "Othonna digitata"
```

```
## [19] "Pelargonium myrrhifolium" "Pentameris acinosa"
## [21] "Phylica dodii"            "Restio leptostachyus"
## [23] "Stoebe fusca"             "Tetraria fimbriolata"
## [25] "Tetraria ligulata"        "Thamnochortus gracilis"
## [27] "Thesium schumannianum"    "Vellereophyton dealbatum"
## [29] "Wahlenbergia pyrophila"
##
## $`2010`
##  [1] "Aspalathus ciliaris"          "Bolusafra bituminosa"
##  [3] "Bulbine alooides"             "Caesia contorta"
##  [5] "Chironia baccifera"           "Drosera trinervia"
##  [7] "Elegia persistens"            "Eragrostis capensis"
##  [9] "Erica hirtiflora"             "Erica lasciva"
## [11] "Erica muscosa"                "Erica obliqua"
## [13] "Erica subcapitata"            "Erica tristis"
## [15] "Euclea racemosa"              "Euphorbia erythrina"
## [17] "Ficinia nigrescens"           "Ficinia trichodes"
## [19] "Gnidia juniperifolia"         "Helichrysum dasyanthum"
## [21] "Indigofera ionii"             "Lampranthus elegans"
## [23] "Lampranthus emarginatus"      "Metalasia densa"
## [25] "Muraltia alopecuroides"       "Muraltia ericoides"
## [27] "Olea exasperata"              "Othonna quinquedentata"
## [29] "Phylica ericoides"            "Prismatocarpus sessilis"
## [31] "Psoralea aphylla"             "Pterocelastrus tricuspidatus"
## [33] "Searsia glauca"               "Struthiola dodecandra"
## [35] "Tetraria bromoides"           "Thamnochortus insignis"
## [37] "Thesium nigromontanum"
```

2. Testing for change in species number within sites between surveys (Table 1 in the manuscript)

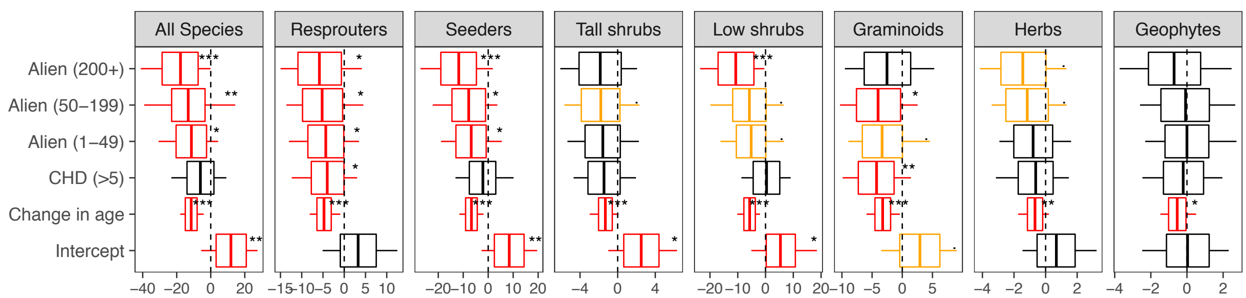
Here we explore the effects of vegetation age and survey year on species counts within plots for all species, then seeders, resprouters and each of the growth forms separately (see Table 1 of the paper). Analyses are done with MCMCglmm. Age and year are fixed effects while plot is a random effect, creating a repeated measures design.

Set	Statistic	Intercept	Age	1996	2010
All species	post.mean	3.859	-0.022	-0.087	-0.091
	pMCMC	***	***	**	*
Resprouters	post.mean	3.078	-0.016	-0.088	-0.226
	pMCMC	***	***	.	***
Seeders	post.mean	3.259	-0.027	-0.095	0.007
	pMCMC	***	***	*	NS
Tall shrubs	post.mean	1.63	-0.011	0.055	-0.006
	pMCMC	***	*	NS	NS
Low shrubs	post.mean	3.05	-0.032	-0.095	0.027
	pMCMC	***	***	*	NS
Herbs	post.mean	0.634	-0.028	-0.207	-0.507
	pMCMC	***	*	NS	***
Graminoids	post.mean	2.749	-0.014	-0.106	-0.251
	pMCMC	***	***	*	***
Geophytes	post.mean	0.921	-0.015	-0.098	-0.111
	pMCMC	***	*	NS	NS

Note that results may differ slightly from the published tables and figures due to the MCMC sampling process!

3. Testing for differences in the drivers of change in species number within sites between surveys across plots (Figure 2 in the manuscript)

Here we perform the analysis of drivers of change in species numbers through time as described in the paper. The output is presented as boxplots on their side indicating the posterior mean, 95% HPD interval (box) and maximum and minimum values. pMCMC <0.1, <0.05, <0.005, <0.001 are indicated by `.`, `*`, `**`, `***`. Each individual model's results are printed below.




```
## $`All Species`
##
##  Iterations = 3001:52991
##  Thinning interval  = 10
##  Sample size  = 5000
##
##  DIC: 411.0407
##
##  R-structure:  ~units
##
##       post.mean l-95% CI u-95% CI eff.samp
## units     106.8    66.34    151.9     5000
```

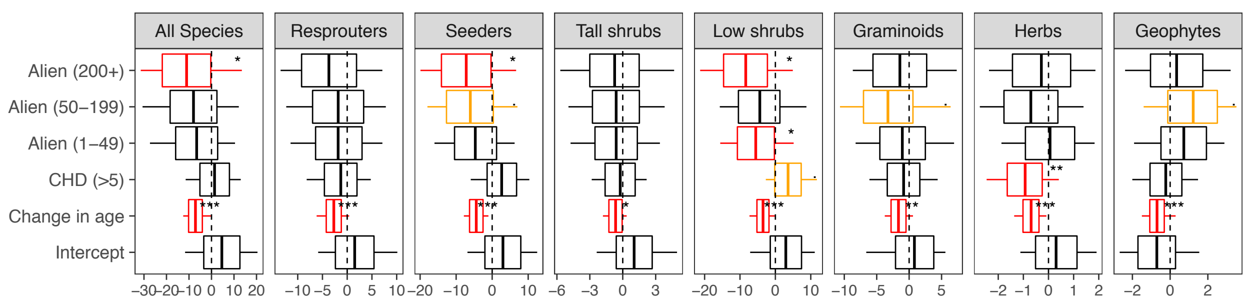
```
##
##  Location effects: dSR66_10 ~ dAge66_10_std + chd66_10 + Aliens_max
##
##                 post.mean l-95% CI u-95% CI eff.samp  pMCMC
## (Intercept)       11.860    2.783   20.480     5000 0.0084 **
## dAge66_10_std    -11.484  -14.858   -7.969     5000 <2e-04 ***
## chd66_10(5,11]    -6.073  -13.649    2.093     5000 0.1344
## Aliens_max1      -11.356  -20.428   -2.613     5000 0.0112 *
## Aliens_max2      -13.229  -22.755   -3.125     4202 0.0084 **
## Aliens_max3      -17.777  -28.962   -7.891     5000 <2e-04 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Resprouters
##
##  Iterations = 3001:52991
##  Thinning interval  = 10
##  Sample size  = 5000
##
##  DIC: 332.7535
##
##  R-structure:  ~units
##
##       post.mean l-95% CI u-95% CI eff.samp
## units     24.88    15.51    34.95     4622
##
##  Location effects: dSR66_10r ~ dAge66_10_std + chd66_10 + Aliens_max
##
##                 post.mean  l-95% CI  u-95% CI eff.samp  pMCMC
## (Intercept)      3.27050  -0.66464   7.67908     5000 0.1248
## dAge66_10_std   -4.75914  -6.42809  -3.06531     5000 <2e-04 ***
## chd66_10(5,11]  -3.99795  -7.77126  -0.10982     5000 0.0484 *
## Aliens_max1     -4.34469  -8.50475  -0.07507     5000 0.0464 *
## Aliens_max2     -5.20067  -9.85485  -0.43762     5000 0.0376 *
## Aliens_max3     -5.83792 -10.66913  -0.53478     5000 0.0224 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Seeders
##
##  Iterations = 3001:52991
##  Thinning interval  = 10
##  Sample size  = 5000
##
##  DIC: 370.2936
##
##  R-structure:  ~units
##
##       post.mean l-95% CI u-95% CI eff.samp
## units     49.93    32.08    71.77     5313
##
##  Location effects: dSR66_10s ~ dAge66_10_std + chd66_10 + Aliens_max
##
##                 post.mean l-95% CI u-95% CI eff.samp  pMCMC
```

```
## (Intercept)       8.4347   2.4668  14.3152     5000 0.0080 **
## dAge66_10_std    -6.7113  -8.9310  -4.2570     5000 <2e-04 ***
## chd66_10(5,11]   -2.1297  -7.5536   3.0437     4632 0.4412
## Aliens_max1      -6.7971 -12.5833  -0.5681     5000 0.0256 *
## Aliens_max2      -7.8137 -14.5652  -1.1968     4934 0.0280 *
## Aliens_max3     -11.7944 -19.0444  -4.8720     4722 0.0012 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`Tall shrubs`
##
##  Iterations = 3001:52991
##  Thinning interval  = 10
##  Sample size  = 5000
##
##  DIC: 243.3486
##
##  R-structure:  ~units
##
##       post.mean l-95% CI u-95% CI eff.samp
## units     4.777    2.951    6.689     6024
##
##  Location effects: tshrub66_10 ~ dAge66_10_std + chd66_10 + Aliens_max
##
##                post.mean l-95% CI u-95% CI eff.samp  pMCMC
## (Intercept)       2.5050   0.7685   4.4928     5000 0.0120 *
## dAge66_10_std    -1.3069  -2.0602  -0.6039     5000 0.0016 **
## chd66_10(5,11]   -1.4509  -3.2096   0.2051     5000 0.1024
## Aliens_max1      -1.5766  -3.4501   0.2862     5000 0.1008
## Aliens_max2      -1.7910  -3.8656   0.2464     5000 0.0820 .
## Aliens_max3      -1.8505  -4.1781   0.2715     5000 0.1052
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`Low shrubs`
##
##  Iterations = 3001:52991
##  Thinning interval  = 10
##  Sample size  = 5000
##
##  DIC: 357.9061
##
##  R-structure:  ~units
##
##       post.mean l-95% CI u-95% CI eff.samp
## units     39.81    25.12    57.49     4754
##
##  Location effects: lshrub66_10 ~ dAge66_10_std + chd66_10 + Aliens_max
##
##                post.mean  l-95% CI  u-95% CI eff.samp  pMCMC
## (Intercept)      5.36394   0.24312  10.71944     5000 0.0384 *
## dAge66_10_std   -5.72166  -7.79702  -3.67713     5000 <2e-04 ***
## chd66_10(5,11]   0.36858  -4.29919   5.22303     5000 0.8712
## Aliens_max1     -5.16495 -10.61423  -0.04139     5000 0.0556 .
```

```
## Aliens_max2     -5.80689 -11.77154   0.23840     5000 0.0600 .
## Aliens_max3    -10.71818 -16.75530  -3.91608     5211 <2e-04 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Graminoids
##
##  Iterations = 3001:52991
##  Thinning interval  = 10
##  Sample size  = 5000
##
##  DIC: 304.1245
##
##  R-structure:  ~units
##
##       post.mean l-95% CI u-95% CI eff.samp
## units     14.71    9.279     20.8     5906
##
##  Location effects: gram66_10 ~ dAge66_10_std + chd66_10 + Aliens_max
##
##                 post.mean l-95% CI u-95% CI eff.samp  pMCMC
## (Intercept)      2.92435 -0.53614  6.06464     6187 0.0852 .
## dAge66_10_std   -3.25100 -4.53552 -1.94748     5000 <2e-04 ***
## chd66_10(5,11]  -4.25976 -7.10519 -1.23588     5000 0.0052 **
## Aliens_max1     -3.34164 -6.64509 -0.02797     5282 0.0508 .
## Aliens_max2     -4.00696 -7.63356 -0.36615     5222 0.0304 *
## Aliens_max3     -2.53017 -6.30530  1.39460     5000 0.1988
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Herbs
##
##  Iterations = 3001:52991
##  Thinning interval  = 10
##  Sample size  = 5000
##
##  DIC: 197.5528
##
##  R-structure:  ~units
##
##       post.mean l-95% CI u-95% CI eff.samp
## units     2.046     1.22    2.883     5000
##
##  Location effects: herb66_10 ~ dAge66_10_std + chd66_10 + Aliens_max
##
##                 post.mean l-95% CI u-95% CI eff.samp  pMCMC
## (Intercept)      0.68151 -0.55174  1.85548     4677 0.2716
## dAge66_10_std   -0.67191 -1.16234 -0.20601     5267 0.0064 **
## chd66_10(5,11]  -0.62696 -1.70357  0.49567     5000 0.2600
## Aliens_max1     -0.79120 -1.98095  0.45973     4886 0.1976
## Aliens_max2     -1.16249 -2.48029  0.19810     5084 0.0928 .
## Aliens_max3     -1.44375 -2.89397 -0.05774     5000 0.0520 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## $Geophytes
##
##  Iterations = 3001:52991
##  Thinning interval  = 10
##  Sample size  = 5000
##
##  DIC: 197.8163
##
##  R-structure:  ~units
##
##       post.mean l-95% CI u-95% CI eff.samp
## units     2.055     1.29    2.923     5000
##
##  Location effects: geo66_10 ~ dAge66_10_std + chd66_10 + Aliens_max
##
##                  post.mean  l-95% CI  u-95% CI eff.samp pMCMC
## (Intercept)      0.032169 -1.135289  1.228516     5000 0.960
## dAge66_10_std   -0.539463 -1.022537 -0.060092     5000 0.034 *
## chd66_10(5,11]  -0.207878 -1.306494  0.906624     5000 0.707
## Aliens_max1     -0.001126 -1.197948  1.224256     5000 0.998
## Aliens_max2     -0.078490 -1.377375  1.270526     5000 0.909
## Aliens_max3     -0.713170 -2.184106  0.662119     5000 0.319
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

And the period 1966 to 1996 (Fig. S1)




```
## $`All Species`
##
##  Iterations = 3001:52991
##  Thinning interval  = 10
##  Sample size  = 5000
##
##  DIC: 414.0423
##
##  R-structure:  ~units
##
##       post.mean l-95% CI u-95% CI eff.samp
## units     112.7    72.18    160.9     5000
##
##  Location effects: dSR66_96 ~ dAge66_96_std + chd66_96 + Aliens_max
```

```
##
##                post.mean l-95% CI u-95% CI eff.samp  pMCMC
## (Intercept)       4.5914  -3.3669  12.6431     5224 0.2584
## dAge66_96_std    -7.1269 -10.0965  -4.0013     5000 <2e-04 ***
## chd66_96(5,11]    1.3605  -5.1143   7.9978     5000 0.6876
## Aliens_max1      -6.5906 -15.3450   3.1537     5691 0.1536
## Aliens_max2      -7.9979 -18.8502   1.8982     5000 0.1260
## Aliens_max3     -11.0643 -22.0475  -0.5504     5622 0.0448 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Resprouters
##
##  Iterations = 3001:52991
##  Thinning interval  = 10
##  Sample size  = 5000
##
##  DIC: 340.0175
##
##  R-structure:  ~units
##
##       post.mean l-95% CI u-95% CI eff.samp
## units     28.55    18.35    40.74     5831
##
##  Location effects: dSR66_96r ~ dAge66_96_std + chd66_96 + Aliens_max
##
##                post.mean l-95% CI u-95% CI eff.samp  pMCMC
## (Intercept)        1.514   -2.465    5.333     5000 0.4604
## dAge66_96_std     -2.706   -4.312   -1.283     5000 0.0012 **
## chd66_96(5,11]    -1.297   -4.630    1.951     5000 0.4336
## Aliens_max1       -1.830   -6.541    2.762     5000 0.4600
## Aliens_max2       -1.820   -7.007    3.317     5000 0.4888
## Aliens_max3       -3.700   -9.191    1.905     5000 0.2000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Seeders
##
##  Iterations = 3001:52991
##  Thinning interval  = 10
##  Sample size  = 5000
##
##  DIC: 361.6669
##
##  R-structure:  ~units
##
##       post.mean l-95% CI u-95% CI eff.samp
## units     42.97    26.35    61.39     5000
##
##  Location effects: dSR66_96s ~ dAge66_96_std + chd66_96 + Aliens_max
##
##                post.mean l-95% CI u-95% CI eff.samp  pMCMC
## (Intercept)       2.9921  -2.1425   7.8258     4771 0.2352
## dAge66_96_std    -4.4139  -6.2587  -2.5326     5000 <2e-04 ***
```

```
## chd66_96(5,11]    2.6410  -1.3694   6.7973     5000 0.1968
## Aliens_max1      -4.6804 -10.4558   1.1943     4392 0.1208
## Aliens_max2      -6.0626 -12.7043   0.2953     4240 0.0668 .
## Aliens_max3      -7.1991 -14.3174  -0.6537     5000 0.0396 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`Tall shrubs`
##
##  Iterations = 3001:52991
##  Thinning interval  = 10
##  Sample size  = 5000
##
##  DIC: 242.0081
##
##  R-structure:  ~units
##
##       post.mean l-95% CI u-95% CI eff.samp
## units     4.658    2.979    6.702     4705
##
##  Location effects: tshrub66_96 ~ dAge66_96_std + chd66_96 + Aliens_max
##
##                 post.mean l-95% CI u-95% CI eff.samp  pMCMC
## (Intercept)       1.0375  -0.5769   2.6953     5000 0.2072
## dAge66_96_std    -0.6517  -1.2674  -0.0583     5000 0.0364 *
## chd66_96(5,11]   -0.2299  -1.5410   1.1631     5000 0.7240
## Aliens_max1      -0.5978  -2.5155   1.3439     5000 0.5340
## Aliens_max2      -0.5995  -2.7943   1.4609     5000 0.5912
## Aliens_max3      -0.7391  -2.9423   1.5371     5000 0.5192
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`Low shrubs`
##
##  Iterations = 3001:52991
##  Thinning interval  = 10
##  Sample size  = 5000
##
##  DIC: 350.8701
##
##  R-structure:  ~units
##
##       post.mean l-95% CI u-95% CI eff.samp
## units     35.04    22.06    50.04     5458
##
##  Location effects: lshrub66_96 ~ dAge66_96_std + chd66_96 + Aliens_max
##
##                 post.mean l-95% CI u-95% CI eff.samp  pMCMC
## (Intercept)       2.9473  -1.2156   7.5723     5000 0.1844
## dAge66_96_std    -3.4871  -5.2293  -1.8261     5000 <2e-04 ***
## chd66_96(5,11]    3.5877  -0.2153   7.2508     4789 0.0632 .
## Aliens_max1      -5.5488 -10.7571  -0.3458     5000 0.0416 *
## Aliens_max2      -4.3983 -10.1822   1.4129     5000 0.1348
## Aliens_max3      -8.3767 -14.5906  -2.2305     5000 0.0120 *
```

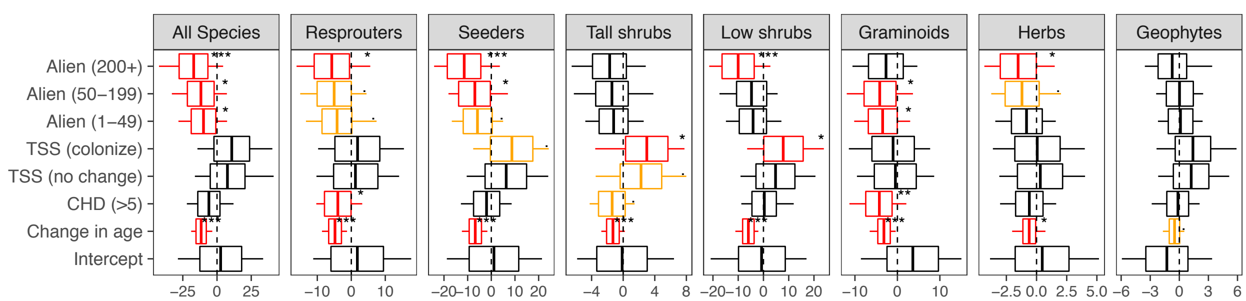
```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Graminoids
##
##  Iterations = 3001:52991
##  Thinning interval  = 10
##  Sample size  = 5000
##
##  DIC: 308.8513
##
##  R-structure:  ~units
##
##       post.mean l-95% CI u-95% CI eff.samp
## units     15.98    10.11    22.86     5000
##
##  Location effects: gram66_96 ~ dAge66_96_std + chd66_96 + Aliens_max
##
##                 post.mean l-95% CI u-95% CI eff.samp  pMCMC
## (Intercept)       0.8158  -2.2743   3.5322     4291 0.5844
## dAge66_96_std    -1.6443  -2.7842  -0.4804     5000 0.0076 **
## chd66_96(5,11]   -0.8495  -3.2232   1.7487     4595 0.5080
## Aliens_max1      -1.0491  -4.5405   2.4642     5000 0.5680
## Aliens_max2      -3.2711  -7.1821   0.4216     4313 0.0980 .
## Aliens_max3      -1.4264  -5.4679   2.8014     4576 0.4912
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Herbs
##
##  Iterations = 3001:52991
##  Thinning interval  = 10
##  Sample size  = 5000
##
##  DIC: 169.8687
##
##  R-structure:  ~units
##
##       post.mean l-95% CI u-95% CI eff.samp
## units     1.226   0.7731    1.743     5301
##
##  Location effects: herb66_96 ~ dAge66_96_std + chd66_96 + Aliens_max
##
##                 post.mean l-95% CI u-95% CI eff.samp  pMCMC
## (Intercept)      0.30239 -0.49260  1.15339     6025  0.469
## dAge66_96_std   -0.69125 -1.00446 -0.36908     5000 <2e-04 ***
## chd66_96(5,11]  -0.92887 -1.62445 -0.24000     5000  0.006 **
## Aliens_max1      0.06176 -0.95879  0.99471     5000  0.893
## Aliens_max2     -0.70351 -1.71747  0.42832     5000  0.205
## Aliens_max3     -0.28372 -1.44621  0.85599     5000  0.618
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Geophytes
```

```
##
##  Iterations = 3001:52991
##  Thinning interval  = 10
##  Sample size  = 5000
##
##  DIC: 191.3897
##
##  R-structure:  ~units
##
##       post.mean l-95% CI u-95% CI eff.samp
## units     1.828    1.142    2.628     5000
##
##  Location effects: geo66_96 ~ dAge66_96_std + chd66_96 + Aliens_max
##
##                 post.mean l-95% CI u-95% CI eff.samp  pMCMC
## (Intercept)       -0.7051  -1.6914   0.2957     5000 0.1656
## dAge66_96_std     -0.6947  -1.0699  -0.3044     5000 0.0012 **
## chd66_96(5,11]    -0.2313  -1.1073   0.5700     5000 0.5756
## Aliens_max1        0.7259  -0.5732   1.8236     5000 0.2372
## Aliens_max2        1.2235  -0.1277   2.4940     4610 0.0764 .
## Aliens_max3        0.3435  -1.0736   1.6921     5000 0.6152
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

4. Include testing the impact of changes in the presence of serotinous tall shrubs

Cowling and Gxaba (1990) found evidence that serotinous overstorey shrub species in our study area are highly variable in distribution and density between fire events and that their density alters understorey community structure and diversity. We tested for this by rerunning our models exploring the drivers of change in species numbers, including the change in presence/absence of serotinous overstorey shrub species as a co-variate.

Cowling RM, Gxaba T (1990) Effects of a fynbos overstorey shrub on understorey community structure: implications for the maintenance of community-wide species richness. South African Journal of Ecology 1: 1–7.



The results show that the additional co-variate affects only response variables with which it is auto-correlated (i.e. positive effects on the diversity of tall shrubs, seeder species and the sum of all species), and a weak positive effect on low shrubs. No groups were negatively affected by the colonization of plots by serotinous tall shrubs. Serotinous tall shrubs showed no change across most plots (37) through time, while they were lost from 3 plots and gained in 14.

Analysis of Climate-driven Shifts in Species Composition

Jasper Slingsby

9 March 2017

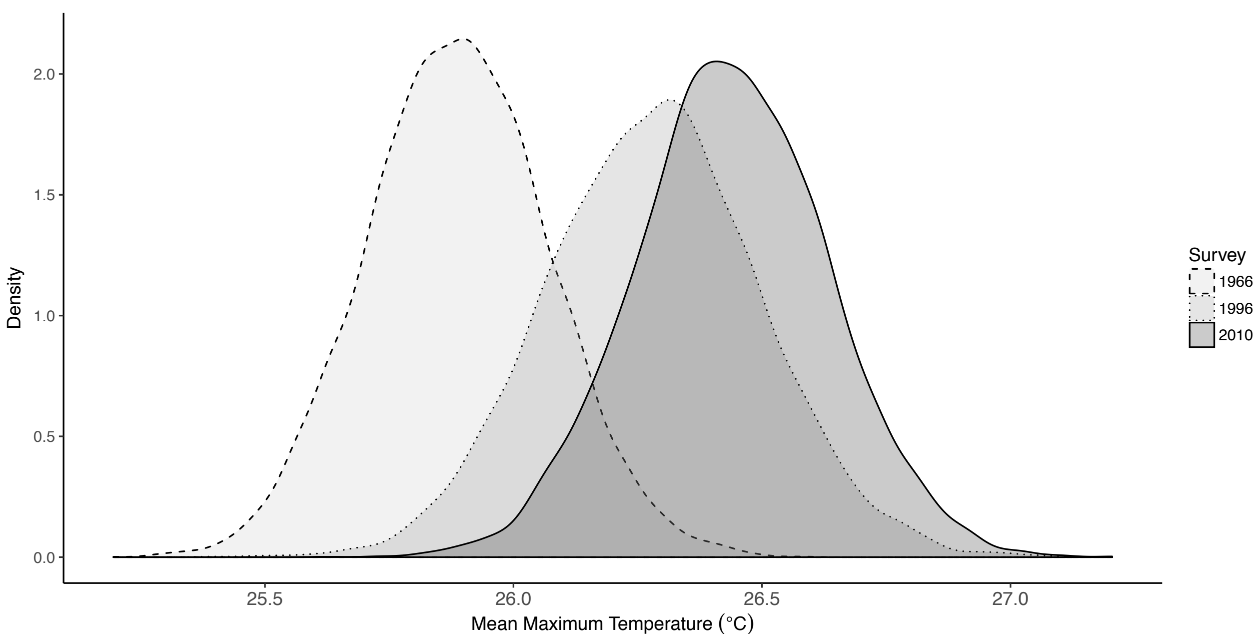
This script uses *MCMCregress()* from R library(MCMCpack) to estimate each species' mean maximum temperature tolerance and then estimate and compare the mean maximum temperature tolerance for each set of species unique to each vegetation survey. We repeat this with 3 separate climate data sources. *This entire script take ~10 minutes to run on a 2015 MacBook-Pro x86_64.*

The extracted climate data:

```
##          Species  tmax_Wi  tmax_Hi  tmax_Sc
## 1 Acacia saligna 30.78617 28.32350 30.28106
## 2 Acacia saligna 30.67951 28.34709 30.18046
## 3 Acacia saligna 30.58243 28.47810 30.07987
## 4 Acacia saligna 30.79390 28.20000 30.25791
## 5 Acacia saligna 30.82104 28.22695 30.22332
## 6 Acacia saligna 30.71092 28.37541 30.11724
```

Schulze et al. 2007

Schulze RE (2007) South African Atlas of Climatology and Agrohydrology., (Water Research Commission, Pretoria, RSA, WRC Report 1489/1/06,), Technical report.

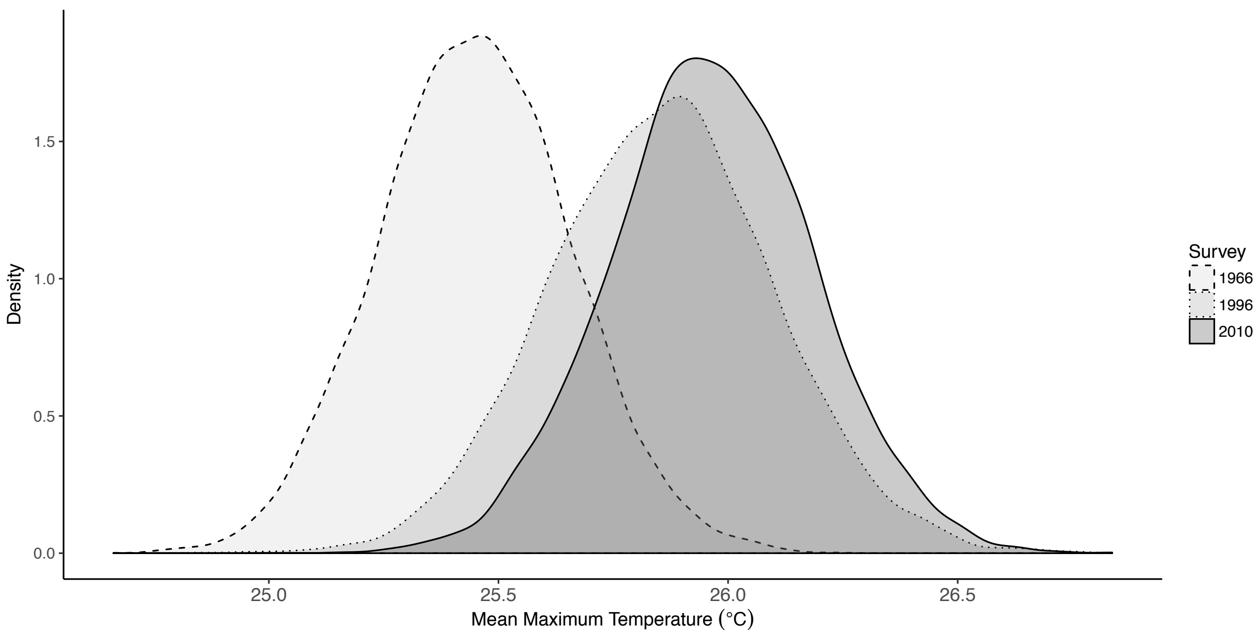



```
##
## Iterations = 1001:11000
## Thinning interval = 1
## Number of chains = 1
## Sample size per chain = 10000
##
## 1. Empirical mean and standard deviation for each variable,
```

```
##    plus standard error of the mean:
##
##                Mean     SD Naive SE Time-series SE
## (Intercept) 25.8875 0.1826 0.001826       0.001833
## Survey1996   0.3935 0.2817 0.002817       0.002817
## Survey2010   0.5501 0.2657 0.002657       0.002715
## sigma2       1.3415 0.1920 0.001920       0.002001
##
## 2. Quantiles for each variable:
##
##                 2.5%     25%     50%     75%   97.5%
## (Intercept) 25.53735 25.7643 25.8872 26.0094 26.2477
## Survey1996  -0.15381  0.2018  0.3979  0.5827  0.9421
## Survey2010   0.03092  0.3724  0.5492  0.7298  1.0661
## sigma2       1.01741  1.2041  1.3231  1.4557  1.7686
```

Hijmans et al. 2005

Hijmans RJ, Cameron SE, Parra JL, Jones PG, Jarvis A (2005) Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25(15):1965– 1978.

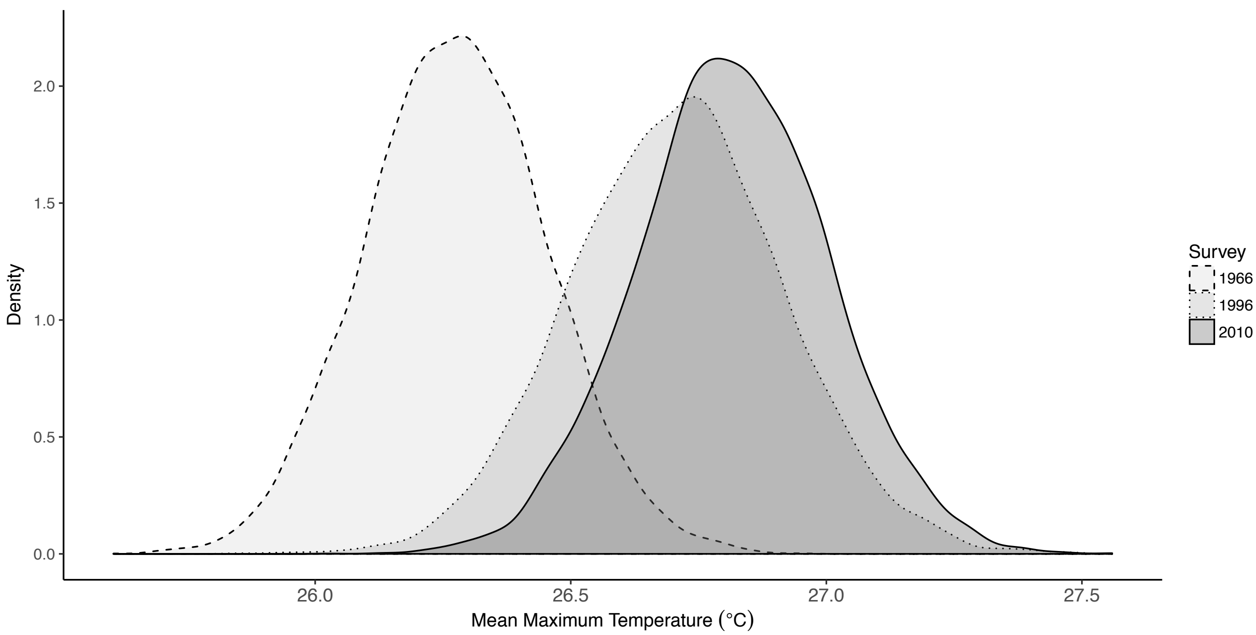



```
##
## Iterations = 1001:11000
## Thinning interval = 1
## Number of chains = 1
## Sample size per chain = 10000
##
## 1. Empirical mean and standard deviation for each variable,
##    plus standard error of the mean:
##
##                Mean     SD Naive SE Time-series SE
## (Intercept) 25.4494 0.2078 0.002078       0.002086
## Survey1996   0.4060 0.3206 0.003206       0.003206
```

```
## Survey2010   0.5142 0.3023 0.003023       0.003090
## sigma2       1.7374 0.2486 0.002486       0.002591
##
## 2. Quantiles for each variable:
##
##                  2.5%     25%     50%     75%  97.5%
## (Intercept) 25.05095 25.3092 25.4491 25.5882 25.859
## Survey1996  -0.21688  0.1878  0.4110  0.6213  1.030
## Survey2010  -0.07669  0.3119  0.5131  0.7187  1.101
## sigma2       1.31766  1.5595  1.7136  1.8853  2.290
```

Wilson and Silander 2014

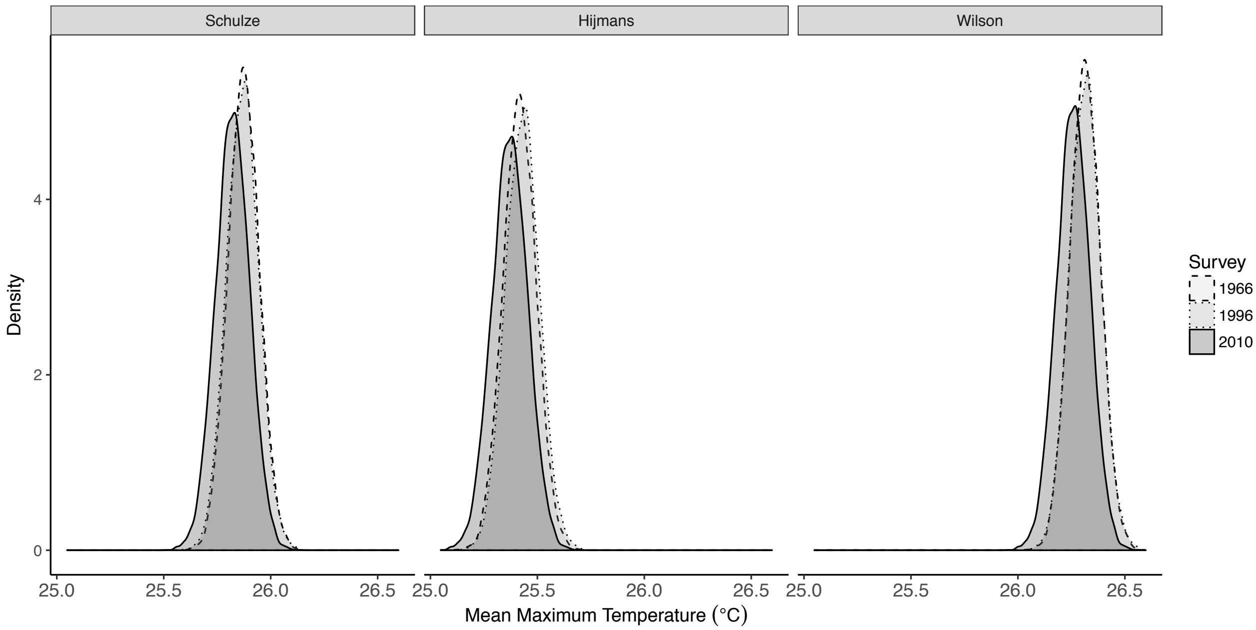
Wilson AM, Silander JA (2014) Estimating uncertainty in daily weather interpolations: a Bayesian framework for developing climate surfaces. International Journal of Climatology 34(8):2573–2584.




```
##
## Iterations = 1001:11000
## Thinning interval = 1
## Number of chains = 1
## Sample size per chain = 10000
##
## 1. Empirical mean and standard deviation for each variable,
##    plus standard error of the mean:
##
##                Mean     SD Naive SE Time-series SE
## (Intercept) 26.2761 0.1769 0.001769       0.001776
## Survey1996   0.4321 0.2730 0.002730       0.002730
## Survey2010   0.5400 0.2574 0.002574       0.002631
## sigma2       1.2593 0.1802 0.001802       0.001878
##
## 2. Quantiles for each variable:
##
```

```
##                  2.5%     25%     50%     75%   97.5%
## (Intercept) 25.93688 26.1568 26.2758 26.3942 26.6252
## Survey1996  -0.09822  0.2463  0.4363  0.6154  0.9636
## Survey2010   0.03694  0.3678  0.5391  0.7141  1.0399
## sigma2       0.95506  1.1303  1.2421  1.3665  1.6602
```

Run all 3 models for the sets of all species from each survey




```
## $Schulze
##
## Iterations = 1001:11000
## Thinning interval = 1
## Number of chains = 1
## Sample size per chain = 10000
##
## 1. Empirical mean and standard deviation for each variable,
##    plus standard error of the mean:
##
##                  Mean      SD  Naive SE Time-series SE
## (Intercept) 25.874267 0.07252 0.0007252      0.0007268
## Survey1996  -0.005403 0.10414 0.0010414      0.0010562
## Survey2010  -0.052262 0.10719 0.0010719      0.0010951
## sigma2       1.558784 0.07711 0.0007711      0.0007711
##
## 2. Quantiles for each variable:
##
##                 2.5%      25%      50%      75%   97.5%
## (Intercept) 25.7338 25.82507 25.87379 25.92346 26.0167
## Survey1996  -0.2076 -0.07632 -0.00427  0.06607  0.1997
## Survey2010  -0.2680 -0.12358 -0.05120  0.01999  0.1538
## sigma2       1.4146  1.50534  1.55614  1.60875  1.7179
##
```

```
##
## $Hijmans
##
## Iterations = 1001:11000
## Thinning interval = 1
## Number of chains = 1
## Sample size per chain = 10000
##
## 1. Empirical mean and standard deviation for each variable,
##    plus standard error of the mean:
##
##                  Mean      SD  Naive SE Time-series SE
## (Intercept) 25.41742 0.07668 0.0007668      0.0007685
## Survey1996   0.01306 0.11011 0.0011011      0.0011168
## Survey2010  -0.04592 0.11335 0.0011335      0.0011580
## sigma2       1.74286 0.08621 0.0008621      0.0008621
##
## 2. Quantiles for each variable:
##
##                2.5%      25%      50%      75%   97.5%
## (Intercept) 25.2689 25.36540 25.41691 25.46944 25.5680
## Survey1996  -0.2008 -0.06193  0.01426  0.08863  0.2300
## Survey2010  -0.2740 -0.12134 -0.04480  0.03048  0.1719
## sigma2       1.5817  1.68311  1.73991  1.79873  1.9208
##
##
## $wilson
##
## Iterations = 1001:11000
## Thinning interval = 1
## Number of chains = 1
## Sample size per chain = 10000
##
## 1. Empirical mean and standard deviation for each variable,
##    plus standard error of the mean:
##
##                    Mean      SD  Naive SE Time-series SE
## (Intercept)  2.631e+01 0.07141 0.0007141      0.0007157
## Survey1996   4.314e-05 0.10255 0.0010255      0.0010401
## Survey2010  -5.555e-02 0.10556 0.0010556      0.0010784
## sigma2       1.512e+00 0.07477 0.0007477      0.0007477
##
## 2. Quantiles for each variable:
##
##                2.5%      25%       50%      75%   97.5%
## (Intercept) 26.1759 26.26576 26.313741 26.36265 26.4545
## Survey1996  -0.1991 -0.06979  0.001159  0.07042  0.2021
## Survey2010  -0.2680 -0.12578 -0.054502  0.01560  0.1473
## sigma2       1.3718  1.45975  1.509006  1.56003  1.6659
```

There are very small differences among years (0.02 to 0.05 of a degree C) with no confidence in them differing between years. Note that a large proportion of species (72%) were stable across time periods at the study level, overwhelming any signal of change in the macro-climatic tolerances. We do not expect species that have not encountered fire and/or unfavorable post-fire weather conditions during the study period to have responded to changes in climate. Similarly, climatic variation among plots and cooler sites within the study area may have allowed species with lower temperature tolerance to persist. It thus makes most sense to compare only species unique to each survey (i.e. those that that did turnover at the study level).