Supporting Text

Statistical Analyses

Statistical models were coded in SAS v. 9.0 (SAS Institute, Cary NC). The four experimental fixed effects were analyzed using a factorial split-plot design, using the PROC MIXED method of maximum likelihood estimation. Elevated CO$_2$ and warming were included as whole-plot factors, and precipitation, nitrogen (N) deposition and functional group (for the analysis of first-flowering date only) were included as split-plot factors. Treatment effects were tested with the restricted maximum likelihood method, and the containment method was used for determining degrees of freedom.

The following statistical model was developed to analyze three years of flowering observations for the nine most abundant species in the JRGCE. Due to the patchy nature of species composition in grasslands, many plots did not contain every focal species. For this reason we utilized functional group (fgroup) rather than species in the statistical model as a fifth split-plot factor. In 2000 there were three within-plot observations of grasses and two within-plot observations of forbs. In 2001 and 2002 observations were made for an additional four species, such that there were five within-plot observations of grasses and four within-plot observations of forbs. The best model fit (lowest AIC score) was obtained with an independent structure of the co-variance matrix, making a repeated-measures analysis unnecessary. Measures of flowering onset are sensitive to variation in population size, because they are by definition the measurement of outliers. We observed earlier onset of flowering in plots with higher relative abundance of a given species. To account for this variation we included relative abundance (“relabund”) of each species in each plot as a co-variate in the statistical model.
**Script 1:**

```latex
proc mixed data=JRGCE;
  class year plot CO2 heat water N fgroup;
  model flowerdate=relabund CO2|heat|water|N|fgroup;
  random plot(heat* CO2) N*plot(heat* CO2) water*plot(heat* CO2) water*N*plot(heat* CO2) fgroup*plot(heat* CO2) fgroup*N*plot(heat* CO2) fgroup*water*plot(heat* CO2);
run;
```

A second statistical model was developed to analyze the timing of peak productivity (NDVI) in the JRGCE over four years of observation, from 2000 to 2003. The best overall model fit (indicated by lowest AIC score) was achieved using a repeated measures model that specified compound symmetry for the structure of the covariance matrix.

**Script 2:**

```latex
proc mixed data=ndvi;
  class year plot co2 heat water nutrient;
  model day_of_year= co2|heat|water|nutrient;
  random plot(heat*co2) nutrient*plot(heat*co2) water*plot(heat*co2);
  repeated year/ type=cs subject= nutrient*water*plot(heat*co2);
run;
```