This is an author produced version of Grassland responses to increased rainfall depend on the timescale of forcing.

White Rose Research Online URL for this paper:
http://eprints.whiterose.ac.uk/93375/

Article:
Sullivan, MJP, Thomsen, MA and Suttle, KB (2016) Grassland responses to increased rainfall depend on the timescale of forcing. Global Change Biology, 22 (4). pp. 1655-1665. ISSN 1354-1013

https://doi.org/10.1111/gcb.13206
## Supporting material

**Table S1.** Full statistical models of plant and invertebrate responses to rainy season change. Plot identity was included as a random effect in all models, with year also included as a random effect for invertebrate responses.

<table>
<thead>
<tr>
<th>Response</th>
<th>Rainy season change</th>
<th>( \beta )</th>
<th>SE</th>
<th>( t^* )</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plant production</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensification</td>
<td>Control</td>
<td>178.310</td>
<td>12.190</td>
<td>14.627</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td>( C_{(\text{int})} )</td>
<td>24.790</td>
<td>18.540</td>
<td>1.337</td>
<td>0.208</td>
</tr>
<tr>
<td></td>
<td>( \text{Int}_{(1,2)} )</td>
<td>-10.360</td>
<td>22.440</td>
<td>-0.462</td>
<td>0.653</td>
</tr>
<tr>
<td></td>
<td>( \text{Int}_{(3-10)} )</td>
<td>60.350</td>
<td>17.240</td>
<td>3.500</td>
<td>0.005</td>
</tr>
<tr>
<td>Extension</td>
<td>Control</td>
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<td>9.449</td>
<td>&lt;0.0001</td>
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<td>( C_{(\text{ext})} )</td>
<td>24.450</td>
<td>20.780</td>
<td>1.337</td>
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</tr>
<tr>
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<td>( \text{Ext}_{(1,2)} )</td>
<td>144.890</td>
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<td>4.648</td>
<td>0.001</td>
</tr>
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<td>( \text{Ext}_{(3-10)} )</td>
<td>152.130</td>
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<td>5.698</td>
<td>&lt;0.0001</td>
</tr>
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<td></td>
<td></td>
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<td></td>
<td></td>
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<td>Control</td>
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<td>0.805</td>
<td>19.682</td>
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<tr>
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<td>( C_{(\text{int})} )</td>
<td>-3.344</td>
<td>0.945</td>
<td>-3.537</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
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<td>0.156</td>
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<td>0.115</td>
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<tr>
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<td>0.457</td>
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<tr>
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<td>( C_{(\text{ext})} )</td>
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<td>0.892</td>
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<td>1.934</td>
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<td><strong>Herbivore abundance</strong></td>
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<td></td>
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<td></td>
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</tr>
<tr>
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<td>Control</td>
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<td>11.122</td>
<td>&lt;0.0001</td>
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<td>( C_{(\text{int})} )</td>
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<td>0.149</td>
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<td>( \text{Int}_{(1,2)} )</td>
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<td>0.328</td>
<td>0.743</td>
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<td>0.179</td>
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<tr>
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<td>Control</td>
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<tr>
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<td>( C_{(\text{ext})} )</td>
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<td></td>
<td></td>
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<tr>
<td>Intensification</td>
<td>Control</td>
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<td>0.167</td>
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<td>( C_{(\text{int})} )</td>
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<td>0.233</td>
<td>-1.251</td>
<td>0.211</td>
</tr>
<tr>
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<td>( \text{Int}_{(1,2)} )</td>
<td>0.137</td>
<td>0.226</td>
<td>0.608</td>
<td>0.543</td>
</tr>
<tr>
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<td>( \text{Int}_{(3-10)} )</td>
<td>0.230</td>
<td>0.144</td>
<td>1.601</td>
<td>0.109</td>
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<td>0.211</td>
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<td><strong>Parasitoid abundance</strong></td>
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<tr>
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<td>Control</td>
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<td>-2.278</td>
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<td>Control</td>
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<td>0.047</td>
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<td>------------</td>
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</tr>
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<td>$\text{Ext}_{(3, 10)}$</td>
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<td>-0.090</td>
<td>0.928</td>
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</tr>
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</table>

* Z values for models of herbivore, predator and parasitoid abundance. Degrees of freedom for the t test statistic were estimated using the Kenwood-Roger approximation.
**Table S2.** Full results of post-hoc simultaneous tests of general linear hypotheses.

<table>
<thead>
<tr>
<th>Response</th>
<th>General linear hypothesis</th>
<th>Estimate</th>
<th>SE</th>
<th>Z</th>
<th>P</th>
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<td><strong>Rainy season intensification</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant production</td>
<td>$C_{\text{int}} - C = 0$</td>
<td>24.790</td>
<td>18.540</td>
<td>1.337</td>
<td>0.526</td>
</tr>
<tr>
<td></td>
<td>$\text{Int}_{1,2} - C = 0$</td>
<td>-10.360</td>
<td>22.440</td>
<td>-0.462</td>
<td>0.966</td>
</tr>
<tr>
<td></td>
<td>$\text{Int}_{3,10} - C = 0$</td>
<td>60.350</td>
<td>17.240</td>
<td>3.500</td>
<td>0.003</td>
</tr>
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<td></td>
<td>$\text{Int}<em>{1,2} - C</em>{\text{int}} = 0$</td>
<td>-35.140</td>
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<td>-1.319</td>
<td>0.537</td>
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<td>$\text{Int}<em>{3,10} - \text{Int}</em>{1,2} = 0$</td>
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<td>18.540</td>
<td>3.814</td>
<td>&lt;0.001</td>
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<td>Plant species richness</td>
<td>$C_{\text{int}} - C = 0$</td>
<td>-3.344</td>
<td>0.945</td>
<td>-3.537</td>
<td>0.002</td>
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<td>$\text{Int}_{1,2} - C = 0$</td>
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<td>1.354</td>
<td>0.115</td>
<td>0.999</td>
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<tr>
<td></td>
<td>$\text{Int}_{3,10} - C = 0$</td>
<td>0.521</td>
<td>1.138</td>
<td>0.457</td>
<td>0.966</td>
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<td>$\text{Int}<em>{1,2} - C</em>{\text{int}} = 0$</td>
<td>3.500</td>
<td>1.539</td>
<td>2.274</td>
<td>0.096</td>
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<td>$\text{Int}<em>{3,10} - C</em>{\text{int}} = 0$</td>
<td>3.856</td>
<td>1.354</td>
<td>2.855</td>
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<td>$\text{Int}<em>{3,10} - \text{Int}</em>{1,2} = 0$</td>
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<td>0.979</td>
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<tr>
<td>Herbivore abundance</td>
<td>$C_{\text{int}} - C = 0$</td>
<td>0.150</td>
<td>0.149</td>
<td>1.008</td>
<td>0.724</td>
</tr>
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<td>$\text{Int}_{1,2} - C = 0$</td>
<td>0.055</td>
<td>0.168</td>
<td>0.328</td>
<td>0.986</td>
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<td>0.148</td>
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<td>0.508</td>
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<td>0.114</td>
<td>1.265</td>
<td>0.561</td>
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<tr>
<td>Predator abundance</td>
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<td>0.233</td>
<td>-1.251</td>
<td>0.575</td>
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<td>$\text{Int}_{1,2} - C = 0$</td>
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<td>0.507</td>
<td>-2.278</td>
<td>0.091</td>
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<tr>
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<td>$\text{Int}_{3,10} - C = 0$</td>
<td>$\text{Int}<em>{1,2} - \text{Ext}</em>{1,2} = 0$</td>
<td>$\text{Int}<em>{3,10} - \text{Ext}</em>{1,2} = 0$</td>
<td>$\text{Int}<em>{3,10} - \text{Int}</em>{1,2} = 0$</td>
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<td>--------------------------</td>
<td>--------------------------</td>
<td>--------------------------</td>
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<td>0.996</td>
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<td>0.126</td>
<td>1.044</td>
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<tr>
<td><strong>Plant production</strong></td>
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<td></td>
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<td></td>
<td></td>
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<td>$C_{\text{ext}} - C = 0$</td>
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<td>1.177</td>
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<td>$\text{Ext}_{3,10} - C = 0$</td>
<td>152.135</td>
<td>26.698</td>
<td>5.698</td>
<td>$&lt;0.001$</td>
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<td>31.174</td>
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<td>0.000</td>
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<td>7.246</td>
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<td>$C_{\text{ext}} - C = 0$</td>
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<td>0.892</td>
<td>2.091</td>
<td>0.138</td>
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<tr>
<td>$\text{Ext}_{1,2} - C = 0$</td>
<td>3.156</td>
<td>1.632</td>
<td>1.934</td>
<td>0.192</td>
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<tr>
<td>$\text{Ext}_{3,10} - C = 0$</td>
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<td>1.478</td>
<td>-3.114</td>
<td>0.009</td>
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<td>1.772</td>
<td>0.729</td>
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<td>-3.964</td>
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<td>0.892</td>
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</tr>
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<td><strong>Herbivore abundance</strong></td>
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<td></td>
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<td></td>
<td></td>
</tr>
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<td>$C_{\text{ext}} - C = 0$</td>
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<td>6.419</td>
<td>$&lt;0.001$</td>
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<td>0.850</td>
<td>0.106</td>
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<td>$\text{Ext}_{3,10} - C = 0$</td>
<td>0.215</td>
<td>0.098</td>
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<td>0.116</td>
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<td>$\text{Ext}<em>{1,2} - C</em>{\text{ext}} = 0$</td>
<td>0.105</td>
<td>0.156</td>
<td>0.676</td>
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<td><strong>Predator abundance</strong></td>
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<td>$C_{\text{ext}} - C = 0$</td>
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<td>0.216</td>
<td>1.625</td>
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<tr>
<td>$\text{Ext}_{3,10} - C = 0$</td>
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<td>Ext_{3-10} - Ext_{1,2} = 0</td>
<td>C_{ext} - C = 0</td>
<td>Ext_{1,2} - C = 0</td>
<td>Ext_{3-10} - C = 0</td>
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Table S3. Effect of precipitation treatment, year and their interaction on plant and invertebrate response variables. Plot identity was included as a random effect in all models, with year also included as a random effect for invertebrate responses.

<table>
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<tr>
<th>Response</th>
<th>Model term</th>
<th>$\beta$</th>
<th>SE</th>
<th>t*</th>
<th>P</th>
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<tr>
<td>Plant production</td>
<td>Intercept (Control)</td>
<td>148.464</td>
<td>22.879</td>
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<td>Extension</td>
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<td>32.355</td>
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<tr>
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<td>52.950</td>
<td>32.355</td>
<td>1.637</td>
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<tr>
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<td>Year</td>
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<td>2.838</td>
<td>2.230</td>
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</tr>
<tr>
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<td>Extension: Year</td>
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<td>-0.311</td>
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<tr>
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<tr>
<td>Plant species richness</td>
<td>Intercept (Control)</td>
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<tr>
<td></td>
<td>Extension</td>
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<tr>
<td>Herbivore abundance</td>
<td>Intercept (Control)</td>
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<td>0.362</td>
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<td>0.143</td>
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<td>0.037</td>
<td>1.378</td>
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<tr>
<td>Parasitoid abundance</td>
<td>Intercept (Control)</td>
<td>1.034</td>
<td>0.243</td>
<td>4.249</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>----------------------</td>
<td>---------------------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>---------</td>
</tr>
<tr>
<td></td>
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<td>0.059</td>
<td>1.636</td>
<td>0.102</td>
</tr>
</tbody>
</table>

* Z values for models of herbivore, predator and parasitoid abundance. Degrees of freedom for the t test statistic were estimated using the Kenwood-Roger approximation.
Figure S1. Experimental manipulation and sampling.
(a) Water is delivered evenly over the surface of each open 70m$^2$ plot from a sprinkler designed to mimic natural rainfall. (b) Plots are partitioned for simultaneous long-term measurement of multiple variables of plant and consumer response with minimal cross-interference among samples or year: plant production is measured from two pre-designated 900cm$^2$ subplots (small squares) three times per year, each subplot sampled once over the course of the experiment; plant diversity is measured in two central 2500cm$^2$ subplots (bolded large squares) across each year; foliar and flying invertebrates are sampled along perpendicular sweep-net transects (dashed arrows); ground-dwelling invertebrates are sampled in pitfall traps (filled circles).
Figure S2. Relationship between (a) plant species richness and plant productivity (ANPP) and (b) between plant productivity and consumer biomass in Ext treatment plots in each year of the experiment. Lines show bivariate regression fits using data from Ext treatment plots in each year.
Figure S3. Change in the contribution of forbs to annual net primary productivity (ANPP) over the course of the experiment. Data from control plots are shown by open circles, Int plots by grey squares, and Ext plots by black triangles.