A meta-analysis on the impacts of climate change on the yield of European pastures

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Climate change in Europe

Changes from 1971–2000 to 2071–2100 (RCP4.5)
Climate change in Europe

Global atmospheric CO$_2$ concentration: 421 – 936 ppm by 2100
How do changes in atmospheric CO$_2$, temperature and water availability affect the yield of:

- pastures in different regions?
- different plant types?
Objective

Analyse the expected changes in pasture yield under elevated CO$_2$, elevated temperature and changes in water availability

- Shrubs
- Forbs
- Legumes
- Grasses
Meta-analysis

Finding studies

• Web of Science
• Grey literature
• Other meta-analyses
• Review articles

Criteria for inclusion

• In Europe or else laboratory conditions
• Common European forage species
• Plant above ground dry weight data under applied climatic change
• Inc. mean, sd (or equivalent) and sample size
### Summary of studies used

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. studies</th>
<th>No. observations</th>
<th>Average difference from control</th>
<th>Average duration (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevated CO₂</td>
<td>58</td>
<td>248</td>
<td>+289ppm</td>
<td>475</td>
</tr>
<tr>
<td>Elevated Temp.</td>
<td>34</td>
<td>178</td>
<td>+3.3°C</td>
<td>418</td>
</tr>
<tr>
<td>Elevated Water</td>
<td>7</td>
<td>29</td>
<td>76% more water than control</td>
<td>189</td>
</tr>
<tr>
<td>Reduced Water</td>
<td>43</td>
<td>207</td>
<td>81% less water than control</td>
<td>70</td>
</tr>
</tbody>
</table>

Almost exclusively C3 perennial species
Data analysis

Fixed and mixed effects models

Fixed effects included:

- Location
- Treatment conditions
- Methodology
- Management practices
- Plant types

Random effect: study ID (when significant)

Bayesian implementation using MCMC simulations
Yield change by region

Reduced water

Elevated water
Alpine, Continental and Atlantic: 
+57.1 ±19.9%
Yield change by region

Change in AGDW (%)

Elevated temperature

Alpine/Northern    Atlantic    Continental

Alpine  Atlantic  Continental
Northern  Southern
Yield change by plant type

Elevated CO$_2$

Elevated temperature
Combinations of climatic changes

↑C: Elevated CO₂
↑ T: Elevated temperature
↓ W: Reduced water availability
↑ W: Elevated water availability
Summary

• Northern and Alpine regions can expect improved yields
• Continental and southern Europe can expect decreased yields
• Different plant types respond in different ways leading to possible changes in pasture composition
Possible adaptation options

• Increase inputs
  – Concentrates
  – Water
  – Fertiliser

• Increase system robustness
  – Multi-species swards
  – Breed more resilient animals
  – Switch to hardier animal breeds or species
Acknowledgements
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