Climate Change Impact Assessment on Mediterranean Natural Pastures

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Introduction

- In Italy permanent grassland represent 26.7% of the agricultural area (3.4 millions of hectares).
- Sardinia is the region with the largest area covered by grassland and pasture (693,000 ha), covering areas where the ground morphology, weather, and soil make them unsuitable for intensive agricultural use.
Introduction: studied area

- North-West Sardinia
  - Flat area
  - Soil texture: Clay-Loam
  - Average soil depth: 35-40 cm

- Mediterranean climate
  - Weather data: 1951 – 2010
  - Average annual max temp.: 20.6 °C (69 °F)
  - Average annual min temp.: 11.4 °C (52 °F)
  - Average precipitation: 569 mm (70% Sep. - Feb.)
Introduction: studied area

pasture characteristics

- Spring (60-70%) and autumn (30-40%) growth
- Annual species
  - Grasses (Avena sp. pl., Lagurus sp. pl.)
  - Legumes (Trifolium sp. pl., Medicago sp. pl.)
Objective

Productivity assessment as affected by climate change and climate variability

- Tool used: EPIC simulation model
Methods:

Data collected for the model calibration

- Period of observation: 1983 - 1988
- Corrall and Fenlon methodology
- Samples collected in each plot (4)
- Above ground biomass harvested
Methods:

Model calibration

- **Calibration**: 1984 – 1986
  - Validation: 1987 – 1988
  - General “winter pasture” was used
  - Management based on the experimental protocol
Methods:
Weather scenario 1: 2031-2090 present conditions

- Generated weather data (MarkSim™)
  - Present climate
  - Weather data: 2031-2090
    Generated 60-year weather data
    Yearly average max temp.: 20.0 °C (-0.6)
    Yearly average min temp.: 12.5 °C (+1.1)
    Yearly precipitation: 593 mm (+4%)
    CO₂ concentration: 390 ppm
Methods:
Weather scenario 2: 2031-2090 B1

- Generated weather data (MarkSim™)
  - Ensemble mean of CNRM-CM3; CSIRO-Mk3.5; ECHam5; MIROC 3.2
  - Emission scenario: B1
  - Weather data: 2031 - 2090
    Generated 60-year weather data
    Yearly average max temp.: 22.1 °C (+1.5)
    Yearly average min temp.: 14.0 °C (+2.7)
    Yearly precipitation: 372 mm (-35%)
    CO₂ concentration: 434 – 541 ppm
Methods:
Weather scenario 3: 2031-2090 A1b

- Generated weather data (MarkSim™)
- Ensemble mean of CNRM-CM3; CSIRO-Mk3_5; ECHam5; MIROC 3.2
- Emission scenario: A1b
- Weather data: 2031 - 2090
  Generated 60-year weather data
  Yearly average max temp.: 22.7 °C (+2.1)
  Yearly average min temp.: 14.6 °C (+3.2)
  Yearly precipitation: 329 mm (-42%)
  CO₂ concentration: 450 – 679 ppm
Methods:

Weather scenarios

<table>
<thead>
<tr>
<th></th>
<th>TMAX (°C)</th>
<th>TMIN (°C)</th>
<th>PREC (mm)</th>
<th>CO2 (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed</td>
<td>20.6</td>
<td>11.4</td>
<td>569</td>
<td>316 - 390</td>
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<tr>
<td>2031-2090 present conditions</td>
<td>-0.6</td>
<td>+1.1</td>
<td>+24.0</td>
<td>390</td>
</tr>
<tr>
<td>2031-2090 B1</td>
<td>+1.5</td>
<td>+2.7</td>
<td>-197.0</td>
<td>434 - 541</td>
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<td>2031-2090 A1b</td>
<td>+2.1</td>
<td>+3.2</td>
<td>-240.0</td>
<td>450 - 679</td>
</tr>
</tbody>
</table>
Results:

Model calibration

### Crop Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Default</th>
<th>Calibrated</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOP</td>
<td>15.0</td>
<td>18.0</td>
</tr>
<tr>
<td>TBS</td>
<td>0.0</td>
<td>5.0</td>
</tr>
<tr>
<td>DLAI</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>DLAP1</td>
<td>15.05</td>
<td>3.01</td>
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<tr>
<td>DLAP2</td>
<td>50.95</td>
<td>60.95</td>
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<tr>
<td>HMX</td>
<td>1.0</td>
<td>0.45</td>
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<tr>
<td>RDMX</td>
<td>2.0</td>
<td>0.3</td>
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<tr>
<td>IDC</td>
<td>6</td>
<td>5</td>
</tr>
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</table>

### Global Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Default</th>
<th>Calibrated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root growth-soil strength</td>
<td>1.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Soil water lower limit</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Moisture required for seed germination</td>
<td>(0.3 – 0.9)</td>
<td>0.5</td>
</tr>
<tr>
<td>Fraction of maturity at spring growth initiation</td>
<td>0.0</td>
<td>0.38</td>
</tr>
<tr>
<td>Weighting factor for estimating soil evaporation</td>
<td>1.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Heat unit adjustment at harvest</td>
<td>0.0</td>
<td>0.4</td>
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Results:
Calibration and Validation

<table>
<thead>
<tr>
<th></th>
<th>MAE</th>
<th>RRMSE</th>
<th>EF</th>
<th>d</th>
<th>CD</th>
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</thead>
<tbody>
<tr>
<td>Min</td>
<td>0.00</td>
<td>0.00</td>
<td>-inf.</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>Max</td>
<td>+inf.</td>
<td>+inf.</td>
<td>1.00</td>
<td>1.00</td>
<td>+inf.</td>
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<tr>
<td>Best</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
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<tr>
<td>Calibration</td>
<td>0.76</td>
<td>22.42</td>
<td>0.87</td>
<td>0.96</td>
<td>1.28</td>
</tr>
<tr>
<td>Validation</td>
<td>0.69</td>
<td>21.74</td>
<td>0.64</td>
<td>0.89</td>
<td>1.24</td>
</tr>
</tbody>
</table>

Calibration (3-yr)

Validation (2-yr)

Obs. yield (Mg ha⁻¹)

Sim. yield (Mg ha⁻¹)
Results:

Calibration and validation

![Graph showing calibration and validation results over time. The graph displays data for Mg ha⁻¹ DM, with separate lines for Sim. AGB and Obs. AGB.]
Results:
Impacts of weather scenarios
Conclusions

- The EPIC model is suitable to simulate Mediterranean natural pastures
- The model is sensitive to different weather scenarios
  - Slight yield reduction with the stable future weather (no statistical difference)
  - Slight yield reduction with B1 scenario (no statistical difference)
  - Severe yield reduction with A1b scenario

- Possible future development
  - Simulation based on functional groups/plants community approach
  - Improve simulation of crop growth after cutting/grazing
Grazie per l'attenzione

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