Productivity of an Australian mountain grassland is limited by temperature and dryness despite long growing seasons

Dr. Renée Marchin (Prokopavicius)
Dr. Ian McHugh
Dr. Robert Simpson
Dr. Lachlan Ingram
Damian Sebastian
Balas
Dr. Brad Evans
Dr. Mark Adams
Outline

• Flux sites in the Snowy Mountains
• Carbon fluxes at the warmer site, Nimmo
• The relationship between phenology and productivity
• Future directions

“A closer cooperation between atmospheric scientists and ecologists should produce meaningful results.”

Baldocchi et al. (1988) Ecology
Australia and New Zealand Flux Research

Google Earth, V 7.1.5.1557, 8 Mar 2016

## Paired Site Comparison

<table>
<thead>
<tr>
<th></th>
<th>Dargo High Plains</th>
<th>Nimmo High Plains</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Elevation</strong></td>
<td>1520 m</td>
<td>1340 m</td>
</tr>
<tr>
<td><strong>Annual temperature</strong></td>
<td>6.7 °C</td>
<td>7.5 °C</td>
</tr>
<tr>
<td><strong>Annual precipitation</strong></td>
<td>1250 mm</td>
<td>1100 mm</td>
</tr>
<tr>
<td><strong>Parent material</strong></td>
<td>Basalt</td>
<td>Granodiorite</td>
</tr>
<tr>
<td><strong>Soil organic content</strong></td>
<td>35 %</td>
<td>17 %</td>
</tr>
<tr>
<td><strong>Total soil N</strong></td>
<td>3.8 g m(^{-2})</td>
<td>3.8 g m(^{-2})</td>
</tr>
<tr>
<td><strong>Total soil P</strong></td>
<td>3.7 g m(^{-2})</td>
<td>1.2 g m(^{-2})</td>
</tr>
<tr>
<td><strong>Total phytomass</strong></td>
<td>704 g C m(^{-2})</td>
<td>347 g C m(^{-2})</td>
</tr>
</tbody>
</table>

* Data obtained from the nearest AGBoM station.

Nimmo High Plains, New South Wales

Photo by: R. Marchin
Eddy covariance equipment

Solar panels

PAR sensors

Temperature and RH

Radiation sensors

Datalogger

Soil heat flux plates

Soil moisture

Rainfall
Eddy covariance equipment

PhenoCam

Damian Sebastian Balas
Gaps in the 7-year datasets

[Images showing data plots for Dargo High Plains and Nimmo High Plains]

Figures produced with: OzFluxQC
Annual patterns of carbon uptake
NEE ranged from $-185$ to $-26$ g C m$^{-2}$ yr$^{-1}$
Temperature limits carbon fluxes at Nimmo

- **GPP (g C m\(^{-2}\) month\(^{-1}\))**: Soil T vs. GPP, with data points and trend lines. Soil T spans 0 to 20 °C.
- **ER (g C m\(^{-2}\) month\(^{-1}\))**: Soil T vs. ER, with data points and trend lines. Soil T spans 0 to 20 °C.
- **NEE (g C m\(^{-2}\) month\(^{-1}\))**: Soil T vs. NEE, with data points and trend lines. Soil T spans 0 to 20 °C.

Bar charts show the mean decrease in accuracy for different variables:
- **GPP**: Soil T, REW, Solar irradiance, VPD, Atmos Pressure, Precipitation
- **ER**: Soil T, REW, Solar irradiance, VPD, Atmos Pressure, Precipitation
- **NEE**: Solar irradiance, Soil T, REW, Precipitation, Atmos Pressure, VPD
Productivity is closely related to growing season length in many northern grasslands; less is known about southern grasslands.

- Churkina et al. (2005) Glob Chang Biol
- Hufkens et al. (2016) Nature Clim Chang

Shorter GSL  →  Longer GSL
Warming has advanced green-up

- **Green-up DOY:**
  - 240
  - 260
  - 280
  - 300

- **r^2 = 0.22**
  - p = 0.082

Peak NDVI day of Australian year:
- 150
- 180
- 210
- 240

Yellowing DOY:
- 50
- 100
- 150
- 200

Year:
- 2000
- 2004
- 2008
- 2012
- 2016

GSL (days):
- 150
- 200
- 250
- 300

August T (°C):
- 0
- 1
- 2
- 3
- 4

r^2 = 0.39
p = 0.012

August precipitation (mm):
- 0
- 50
- 100
- 150
- 200
- 250
- 300

r^2 = 0.42
p = 0.036

August VPD (kPa):
- 0.05
- 0.10
- 0.15
- 0.20
- 0.25
Grass yellowing is correlated with VPD
GSL of Nimmo is not correlated to productivity

Hufkens et al. (2016) Nature Clim Chang

Kansas, USA
Nimmo has a longer growing season than other high-elevation northern grasslands.
PhenoCam highlights the importance of rainfall during the growing season
Summary and Future Work

• Warming will likely increase carbon uptake of mountain grasslands in Australia, provided growing season precipitation does not decrease in the future.

• Australian mountain grasslands function differently than many northern grasslands.

• PhenoCams can be used to quantify vegetation dynamics of Australian grasslands.

• Future work will examine differences between Nimmo and the cooler site, Dargo.
Funding

- Bushfire CRC
- OzFlux, TERN, & NCRIS
- Coolringdon Pastoral Company

Thank you, Jim Treasure, for access to land.
Recent Climate Change at Nimmo
Climate Change Impacts on Snow in Victoria

Figure 12: Simulated snow depth profiles for 20-year periods centred on 1990 (black line) and 2050 (coloured lines) for 18 climate models and the medium (A1B) emissions scenario at Falls Creek and Mt Hotham.
Local Topography

The Dargo site is on a relatively flat plain, and the tower is located near snow gum woodlands.

The Nimmo site is located on a river valley floor, with stable atmospheric surface conditions frequently occurring at night.

Dargo High Plains, Victoria

Photo by: T. Salter
Carbon fluxes from 2007-2014

NEE: LT

CO₂ uptake

CO₂ release

Nimmo

Dargo
Climate change due to CO\textsubscript{2} emissions is irreversible for at least 1000 years

Solomon et al. (2009) PNAS
These long-term sites were established in 2007 and are still collecting data.

3D Sonic anemometer (CSAT3)

Open-path infrared gas analyzer (LI-7500)

Eddy Covariance Instrumentation
Field Data Collection

Raw 10-Hz Eddy Covariance Time Series

Flux data is collected 10 times per second and later converted to half-hourly averages for analysis.
Post-processing of data

Figure by: I. McHugh