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Modelling the impacts of seasonal drought on herbage growth under climate change

Pierluigi Calanca

LiveM 2016, 15-16 June 2016, Potsdam

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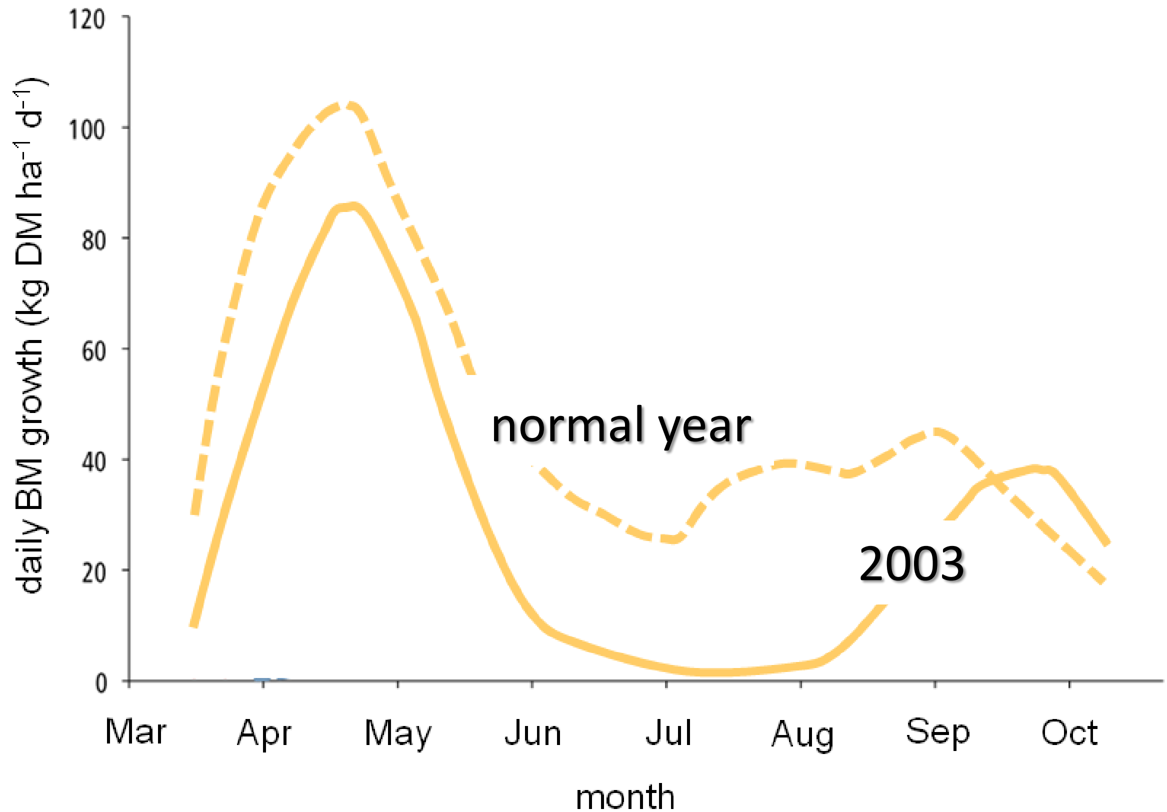
modextreme
agriculture facing extreme climatic events

Drought and growth



Mosimann et al. (2013)

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nature COMMUNICATIONS

ARTICLE

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OPEN

Long-term decline in grassland productivity driven by increasing dryness

E. N. J. Brookshire[1] & T. Weaver[2]

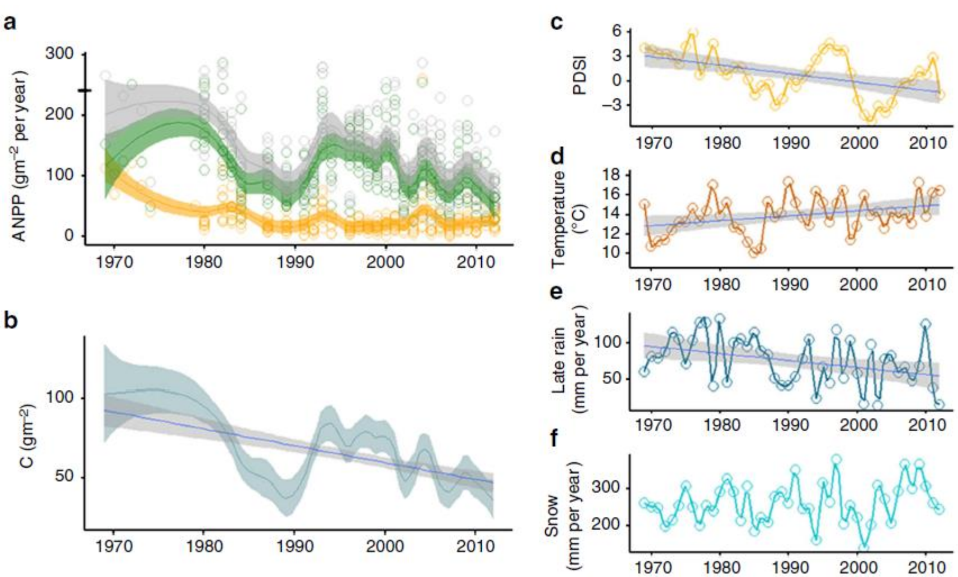

Figure 1 | Long-term pattern of grassland production and climate variation. (**a**) Above-ground net primary production in control plots showing all plot data (points) and locally weighted trend lines with 95% confidence bands for total (grey), grass (green) and forb (orange) production. The horizontal black bar on the *y* axis is ANPP for 1965-1967 at a nearby subalpine grassland (ref. 20). (**b**) Change in total above-ground carbon pools with 95% confidence bands. (**c**) Time series of the regional Palmer Drought Severity Index (PDSI, lower values indicate increasing dryness), (**d**) September temperature, (**e**) late-summer rainfall and (**f**) annual snowfall. All significant ($P<0.001$) trends in **b**-**f** are shown with a regression line (blue) and 95% confidence intervals.

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The future

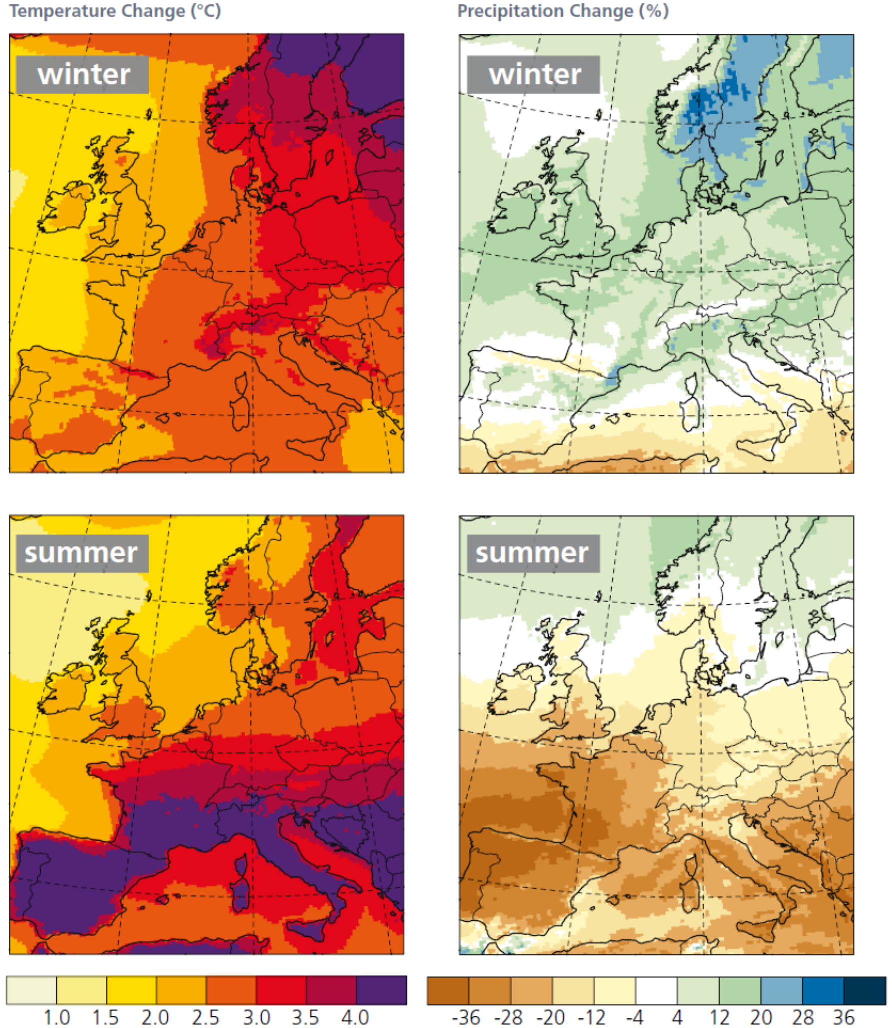
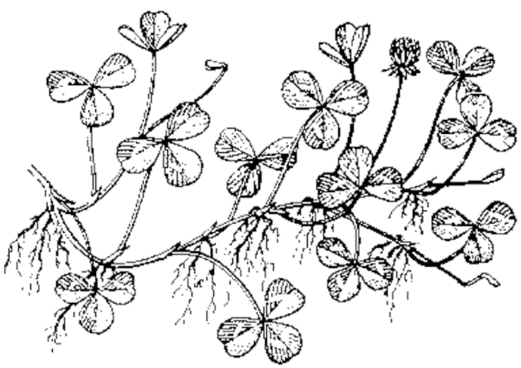


Figure 2: Change of temperature and precipitation for winter and summer as simulated by climate models. Large scale patterns are similar but details differ between models, time period and scenarios. The figure shows the multi-model mean change for 2070–2099 relative to 1980–2009, for an intermediate (A1B) greenhouse gas emission scenario.

CH2011 (2011)

Direct effects of water deficit on plant physiology

- Photosynthesis & assimilation ↓
- LAI, biomass ↓
- SLA ↓, leaf dry matter content ↑
- Leaf lifetime ↓
- Root machinery ↑
- BNF ↓



Meisser (2013)

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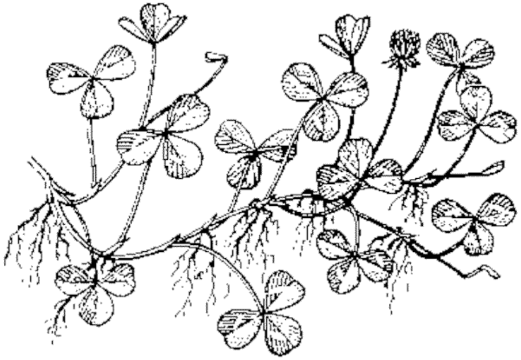
Other important effects

- Increasing temperature
  ⇒ growing season ↑
- Elevated CO_2 concentrations
  ⇒ water & N use efficiency ↑



Meisser (2013)

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Grassland models

Model complexity

low — gap — high

ModVege
(Jouven et al.)

PROGRASS
(Lazzarotto et al.)

ecosys
(Grant)

PaSim
(Riedo et al.)

HPM
(Thornley)

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Grassland models: ecosys

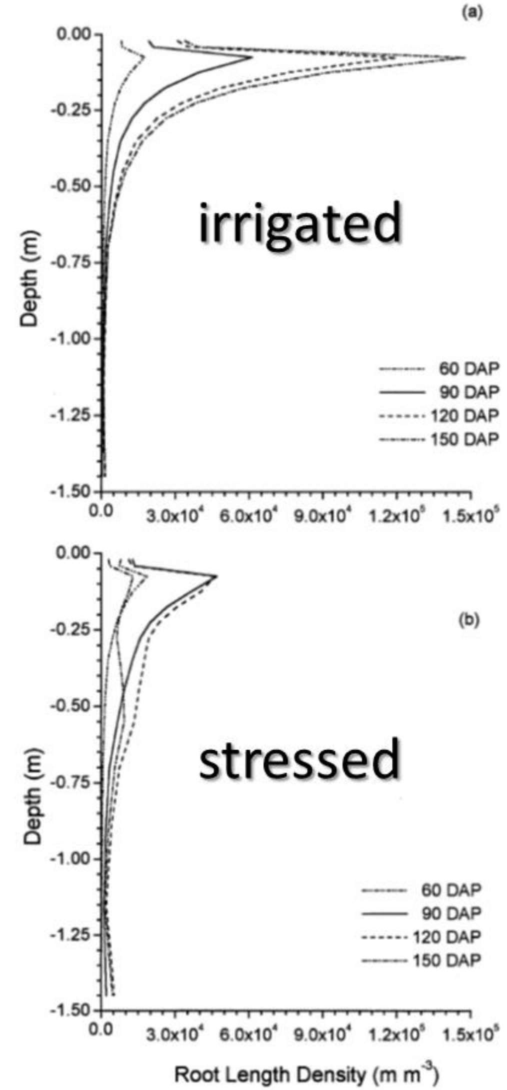

Fig. 5. Vertical profiles of root length density simulated 30, 60, 90, 120 and 150 days after planting (DAP) under 30 g N m^{-2} of fertilization and (a) 50 mm $week^{-1}$ of irrigation, or (b) zero irrigation.

Grant (1998)

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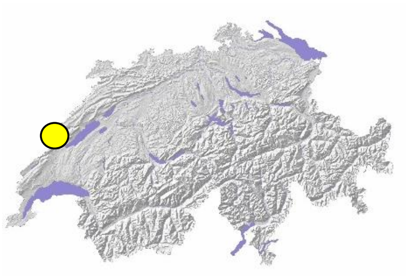
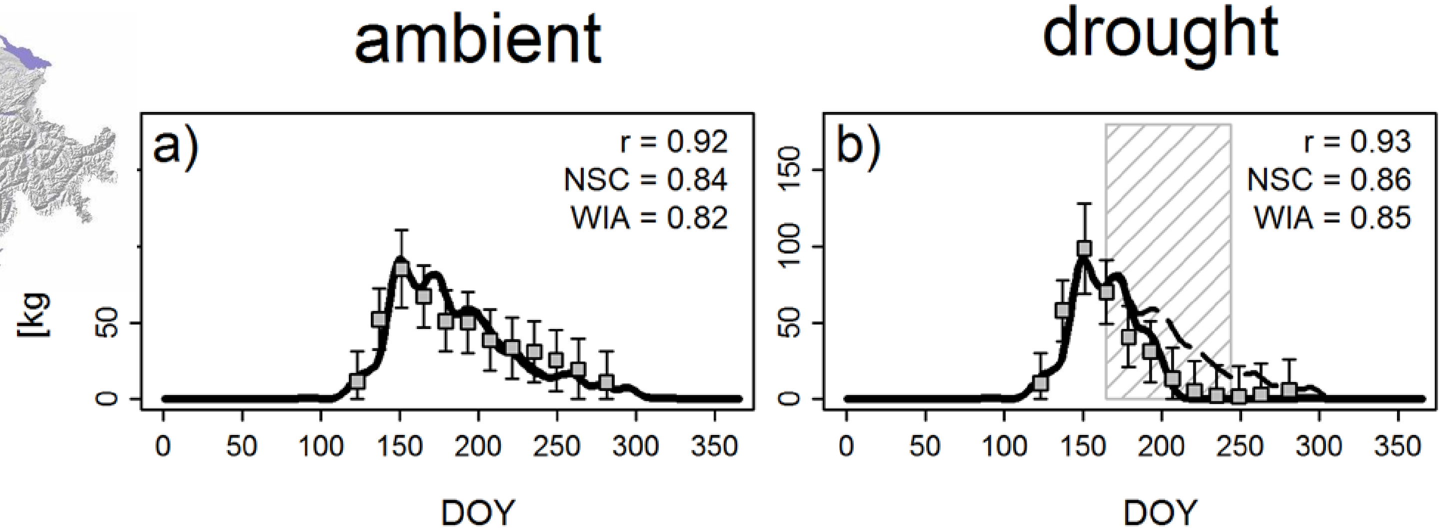
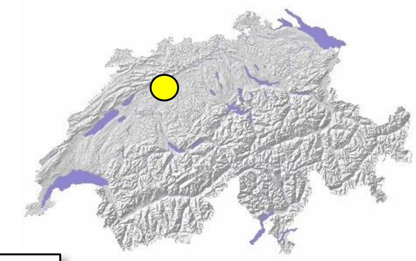
Model performance: ModVege

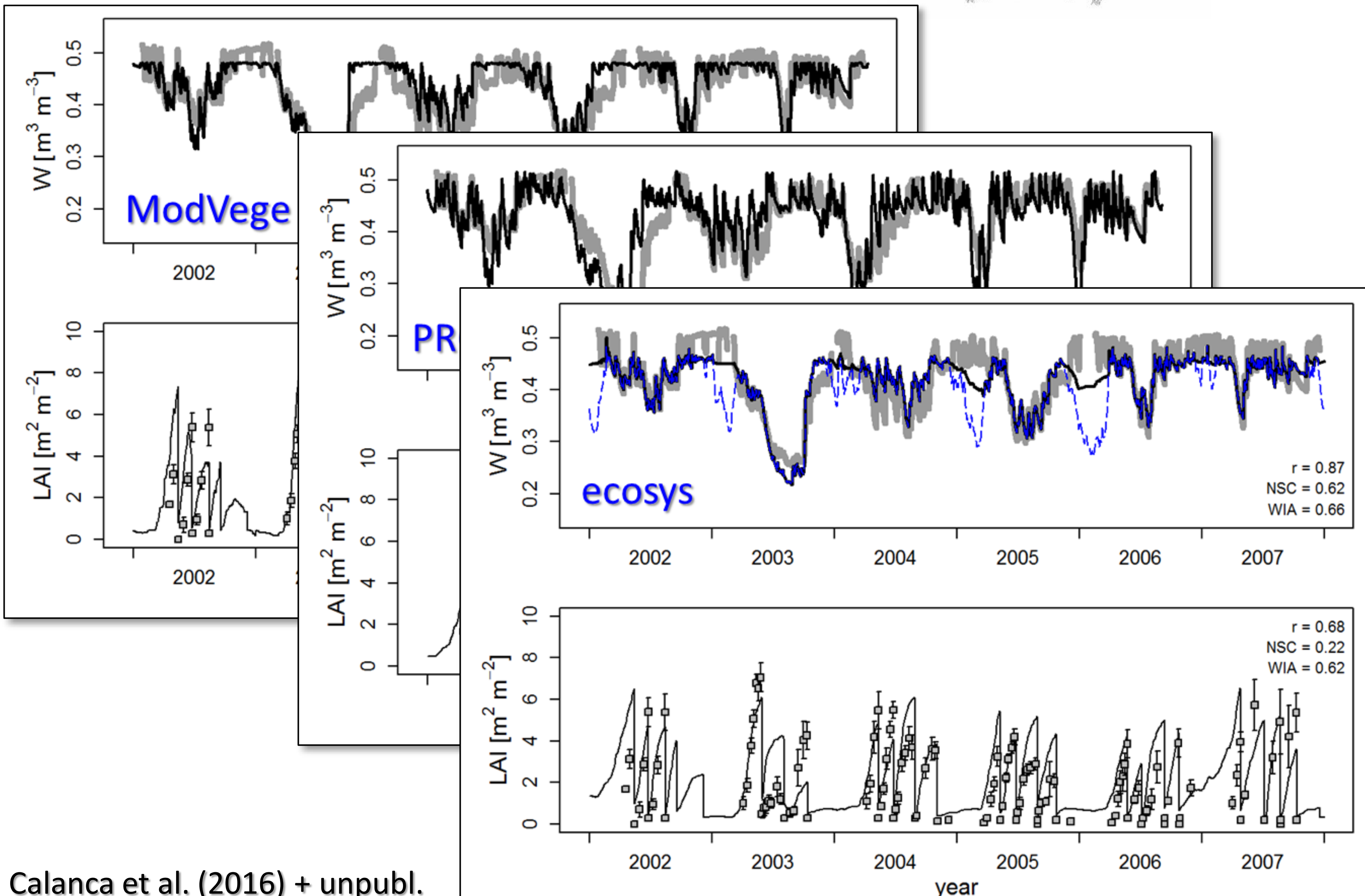




Calanca et al. (2016)

Model performance





Calanca et al. (2016) + unpubl.

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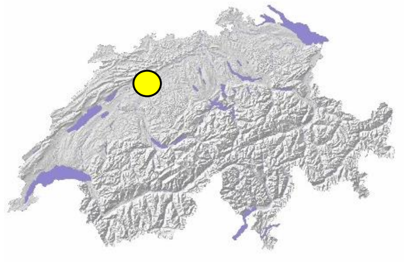
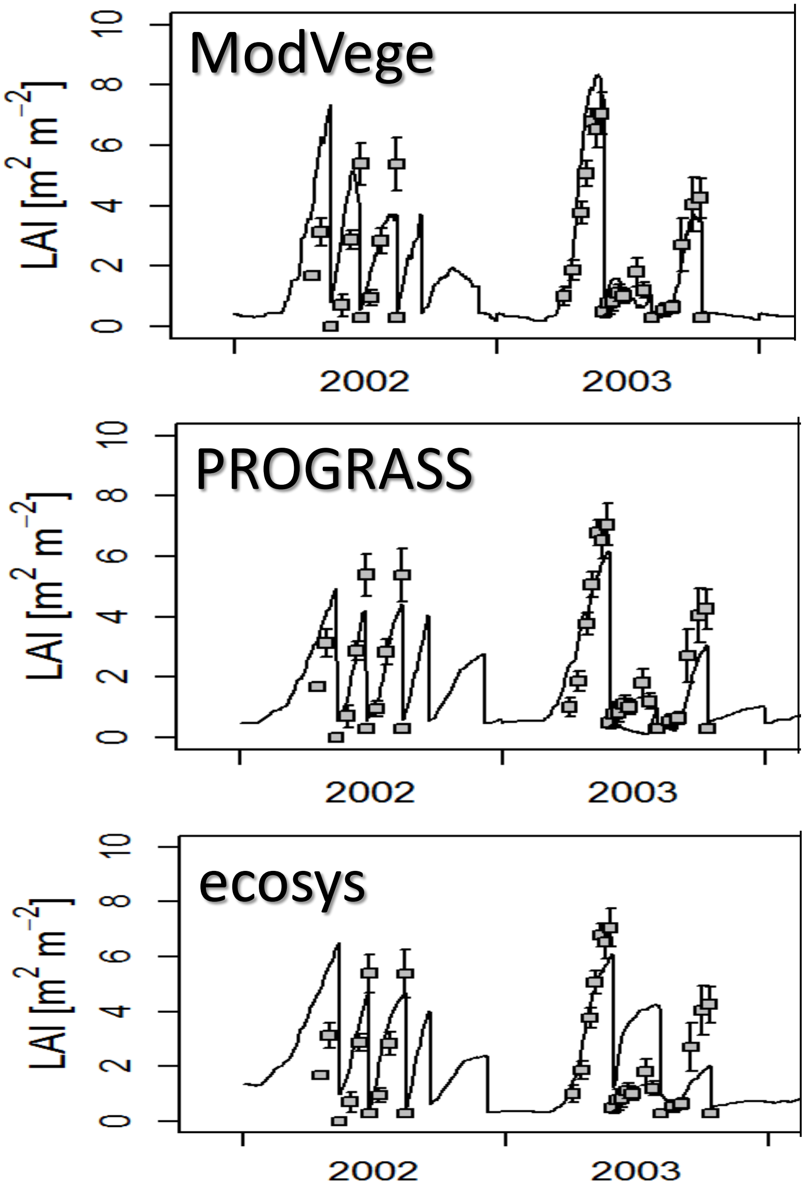
Model performance





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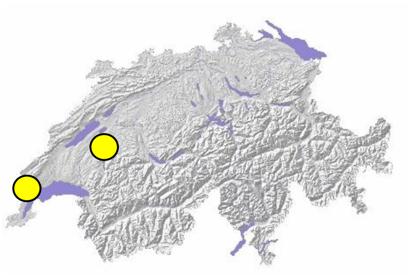
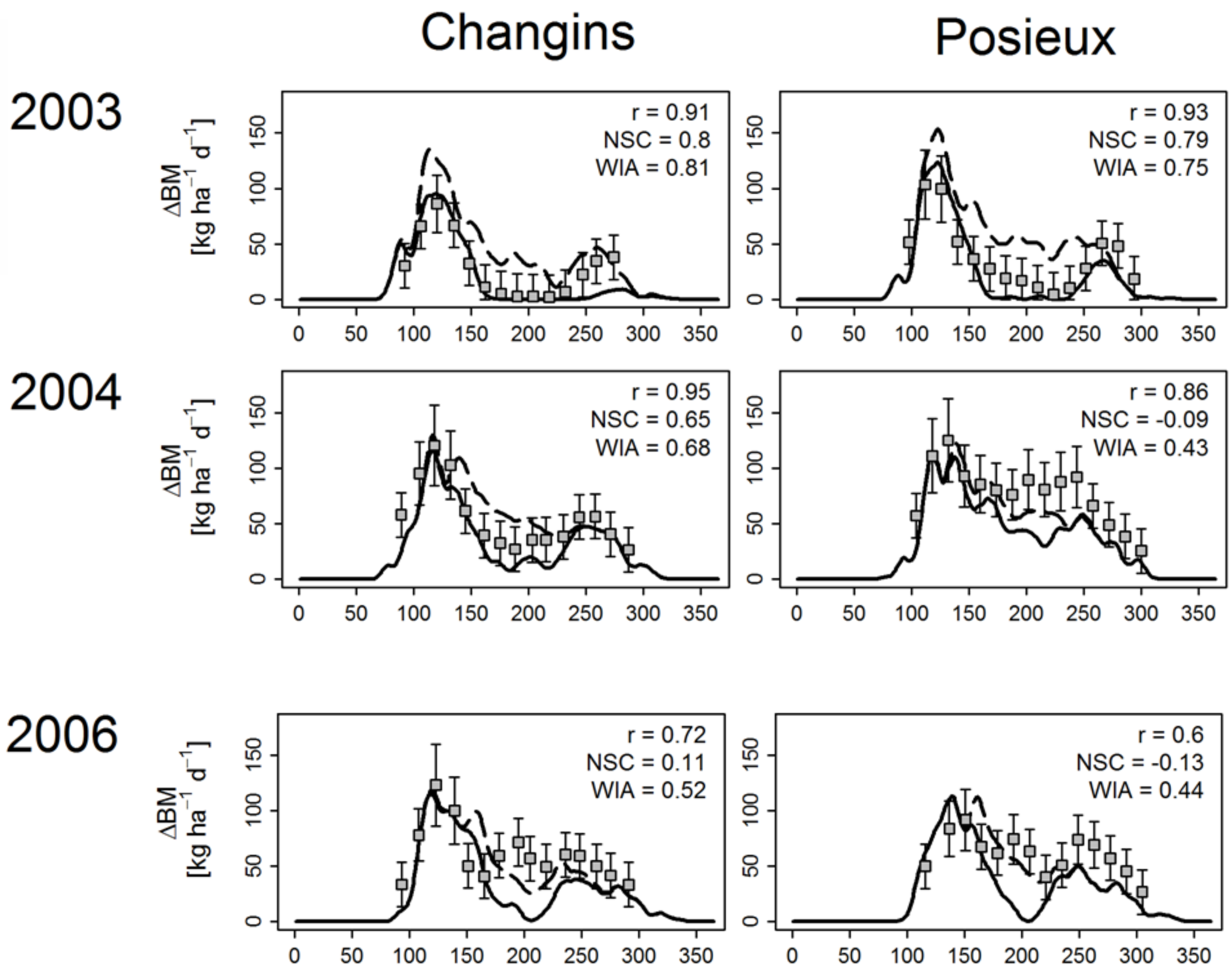
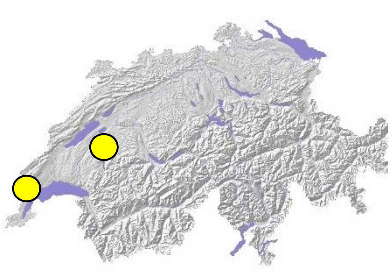
Model application: ModVege

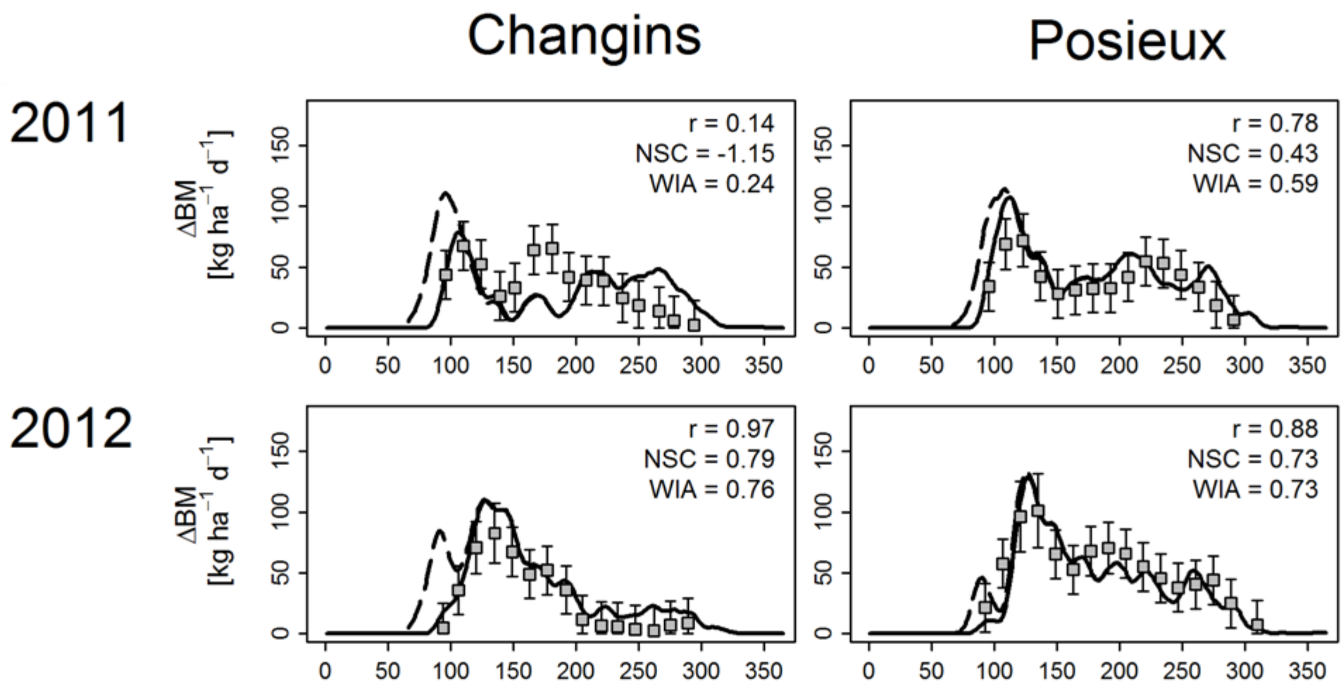




Calanca et al. (2016)

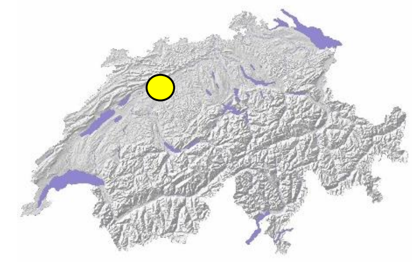
Model application: ModVege

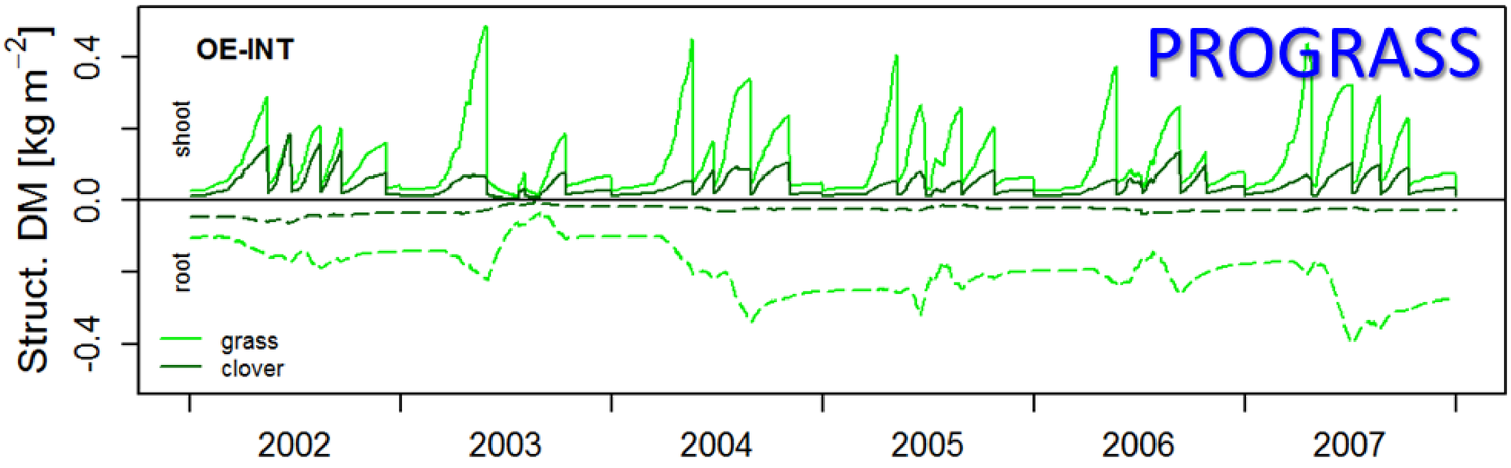


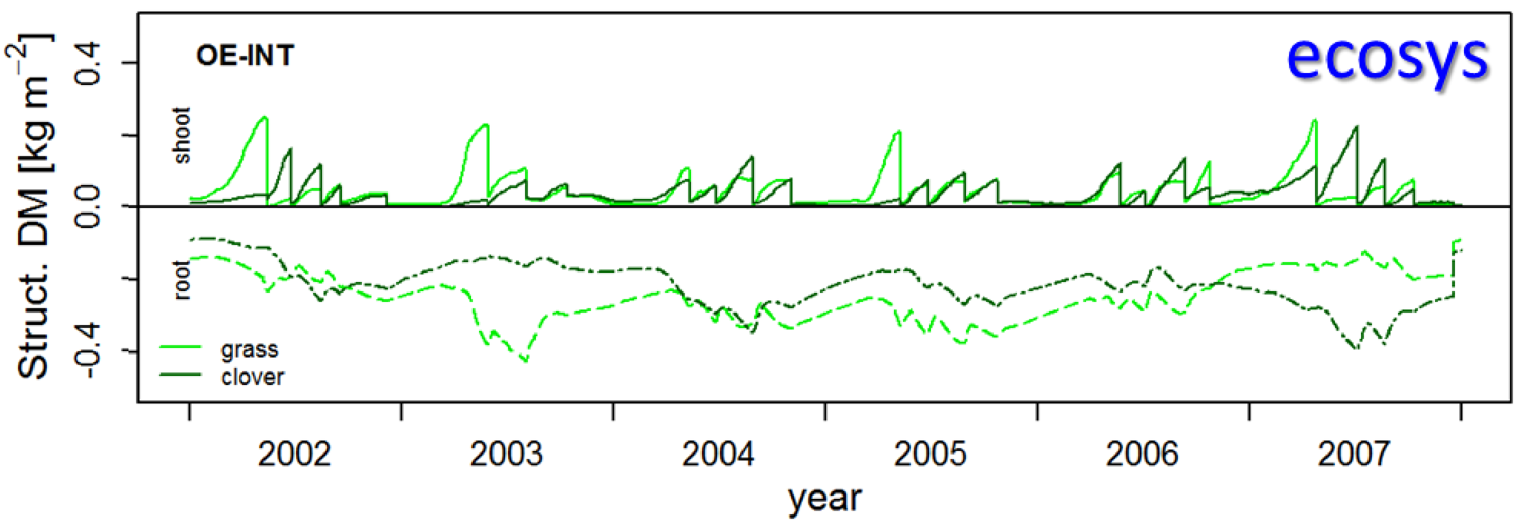


Calanca et al. (2016)

Root dynamics







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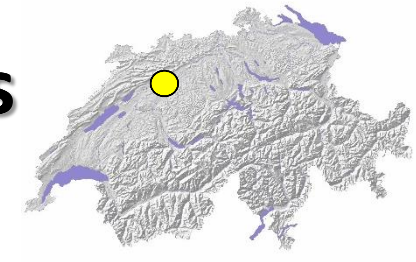
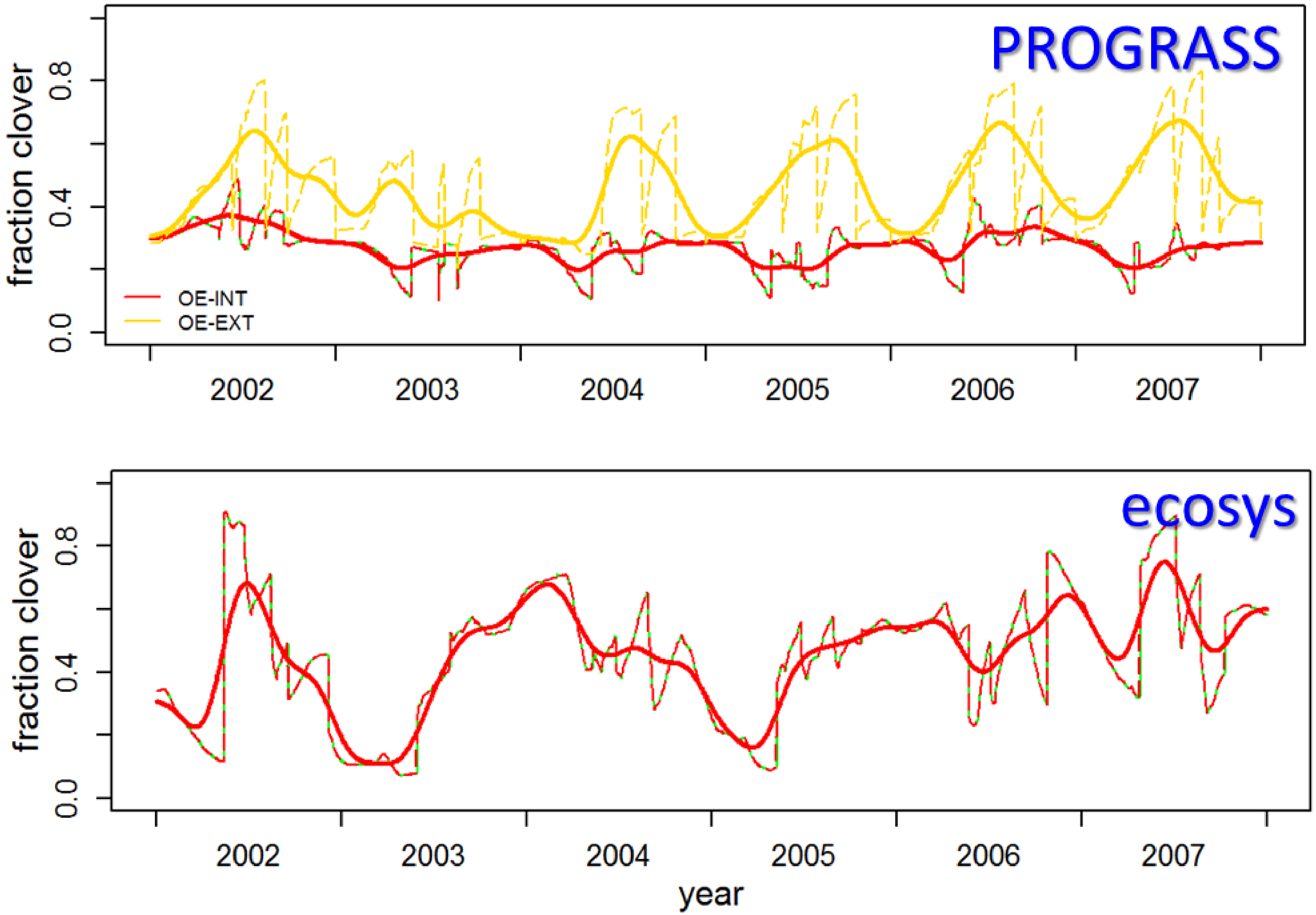
Co-existence & interactions





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Conclusions

The sensitivity of grasslands with respect to drought depends on

- Phenology, overwintering & winter mortality
- Root dynamics
- Community dynamics & species interactions
- Short-term effects of management
- Long-term effects of management

There is room for improving the formulation of these processes in current grassland models

Moreover …

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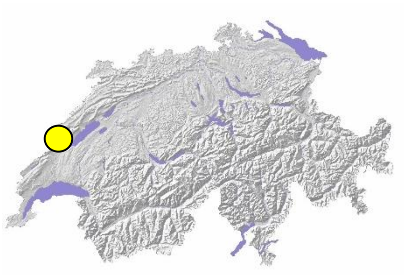
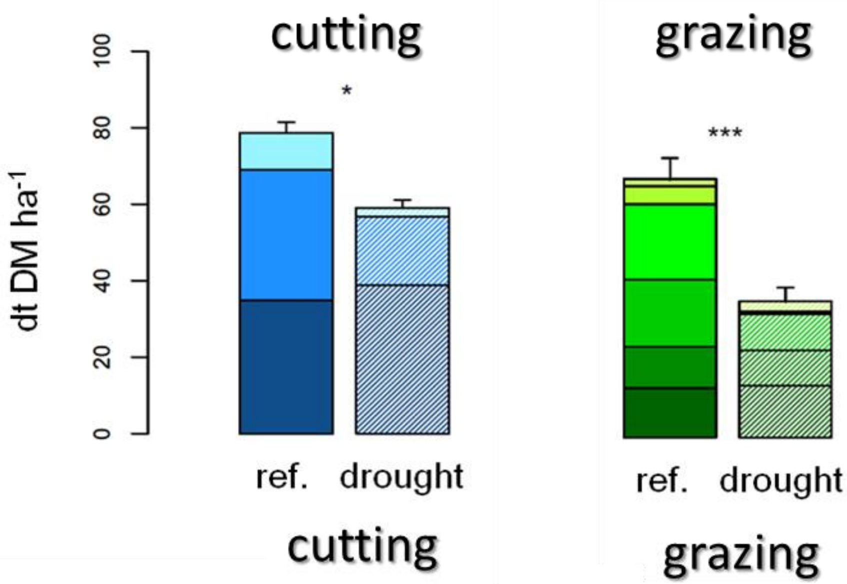
Complicating factors



Jun

Aug



Meisser et al. (2013)

Complicating factors

Journal of Ecology 2006
94, 801–814

ESSAY REVIEW

The Park Grass Experiment 1856–2006: its contribution to ecology

JONATHAN SILVERTOWN, PAUL POULTON*, EDWARD JOHNSTON*, GRANT EDWARDS†, MATTHEW HEARD‡ and PAMELA M. BISS

Fig. 1 An aerial view of the Park Grass Experiment looking due north, taken on 23 May 2005. Note the sharp plot boundaries, many of which are clearly demarcated by differences in vegetation.

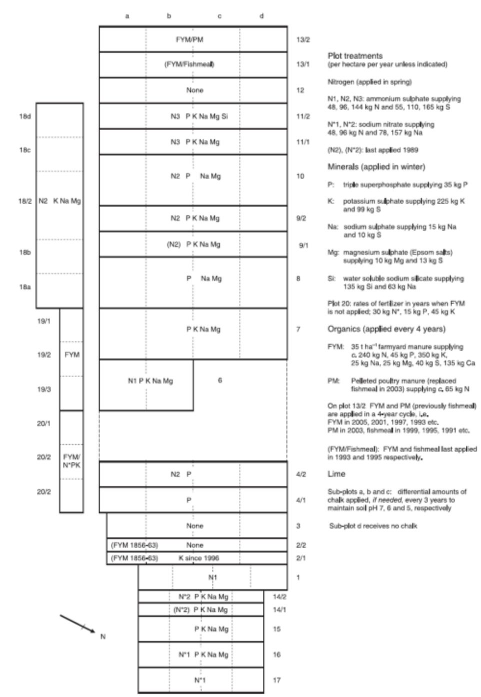


Fig. 2 Plot layout and current treatments of the Park Grass Experiment.

Complicating factors

LETTER

doi:10.1038/nature16444

Grassland biodiversity bounces back from long-term nitrogen addition

J. Storkey[1], A. J. Macdonald[1], P. R. Poulton[1], T. Scott[1], I. H. Köhler[2]†, H. Schnyder[2], K. W. T. Goulding[1] & M. J. Crawley[3]

PROCEEDINGS OF THE ROYAL SOCIETY B

Proc. R. Soc. B (2006) 273, 1149–1154
doi:10.1098/rspb.2005.3428
Published online 24 January 2006

Soil moisture mediates association between the winter North Atlantic Oscillation and summer growth in the Park Grass Experiment

P. S. Kettlewell[1,*], J. Easey[1], D. B. Stephenson[2] and P. R. Poulton[3]

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