Modelling the effects of rural land use and management change on hydrologically effective rainfall under climate change

Cranfield UNIVERSITY

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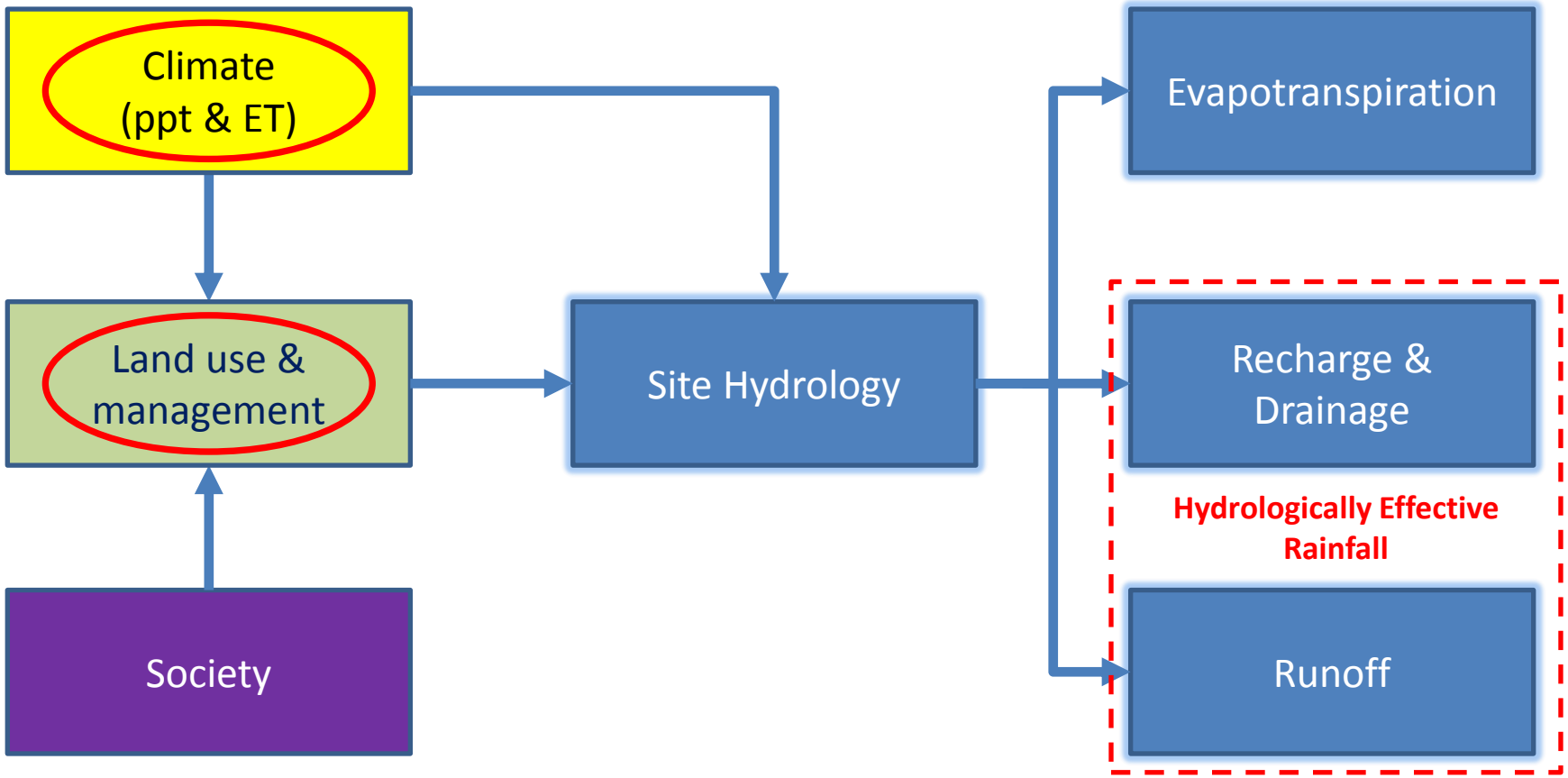
Background


Climate
(ppt & ET)
Land use &
management
Society
Site Hydrology
Evapotranspiration
Recharge &
Drainage
Hydrologically Effective
Rainfall
Runoff

Research question

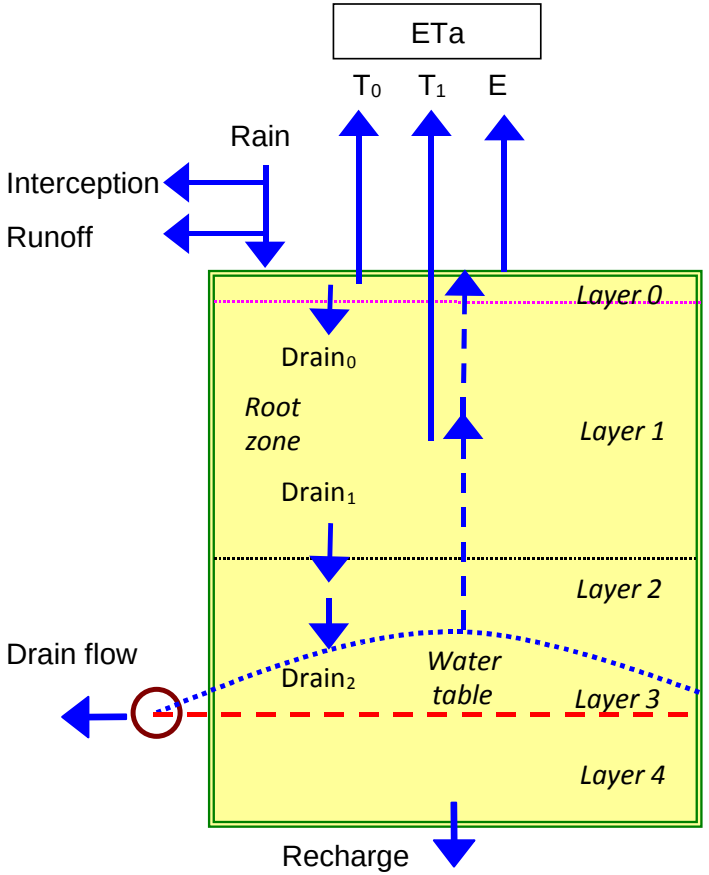
- How might plausible land use and management changes affect the hydrologically effective rainfall (HER) in rural areas under climate change?
- How sensitive are these changes to region (climate) and soil type?
  1. Determine plausible changes in land use & management.
  2. Model HER under alternative soil, land use & climates scenarios.

1. Plausible changes in land use & management

- Land use change
  - ⬇ agricultural area used for food production
  - ⬆ forested area
  - ⬆ agricultural land for bioenergy crops
  - Change is very sensitive to the socio-economic scenarios (policy, demand & prices)
- Change in cropping
  - Faster rates of crop development
  - Earlier sowing or planting
  - Change in crop type / variety
- ~~Biological changes~~
  - ~~Enriched CO_2, plant breeding, etc.~~

Model simulations

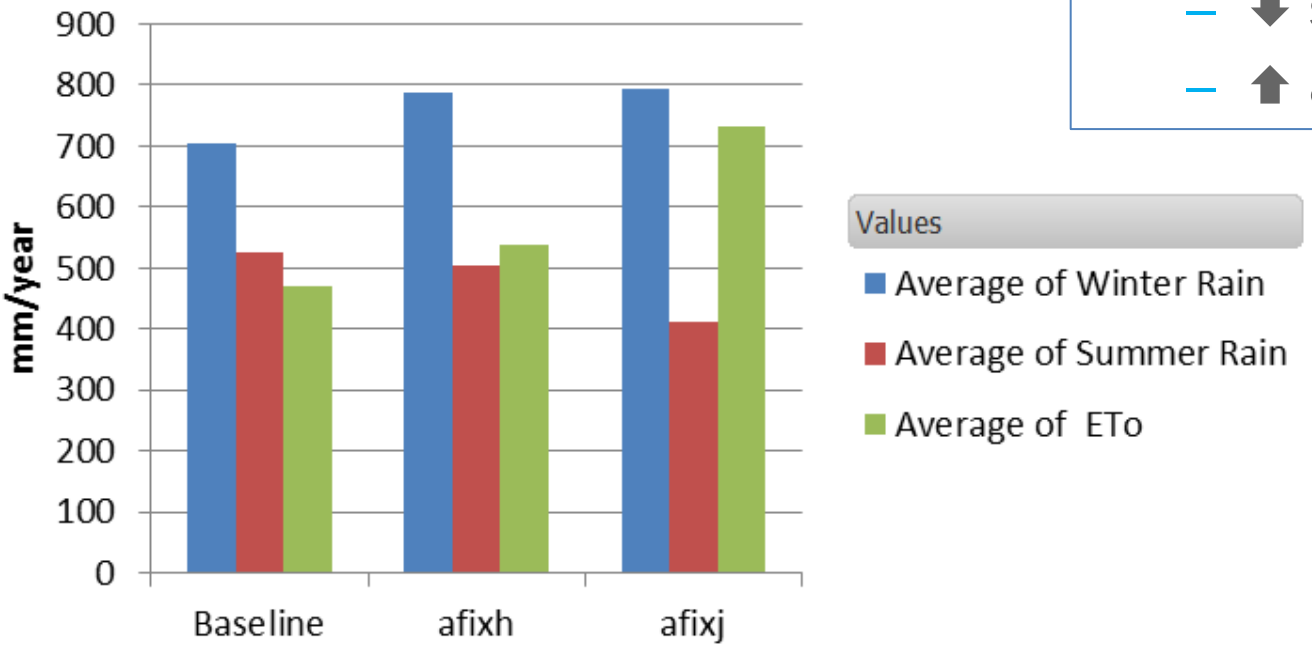
- 1D simulations using Wasim
  (Hess, et al., 2000; Holman et al. 2011)
  - 265 Locations in England & Wales
  - 28 Soil types
  - ~~5 soil "conditions"~~
  - 5 Land uses
    - Permanent grass
    - Semi-natural
    - Spring beans
    - Winter barley
    - Woodland



Holman, I.P., Hess, T.M. and Rose, S.C. (2011) A broad-scale assessment of the effect of improved soil management on catchment Baseflow Index. Hydrological Processes 25(16) 2563-2572.

Climate scenarios

- Climates from “FutureFlows” projections
  - “Baseline” (1961 – 90)
  - “afixh” = best-case (2014 – 70)
  - “afixj” = worst-case (2014 – 70)



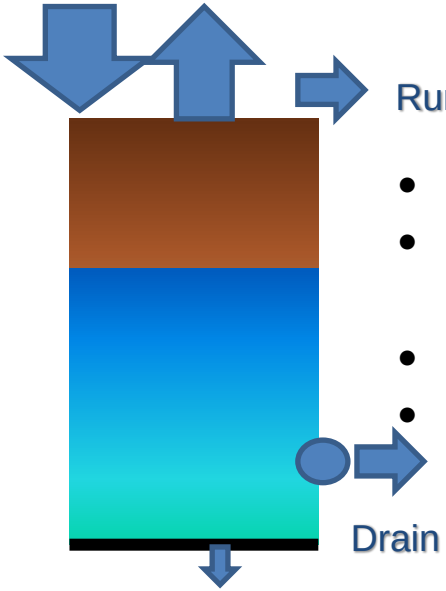
- Main features:
  - ≈ annual rainfall
  - ⬇ summer rainfall
  - ⬆ annual ET

Soils & hydrological indicators

Rivington

- Freely draining
- Low water holding capacity
- Rapid percolation

Blacktoft

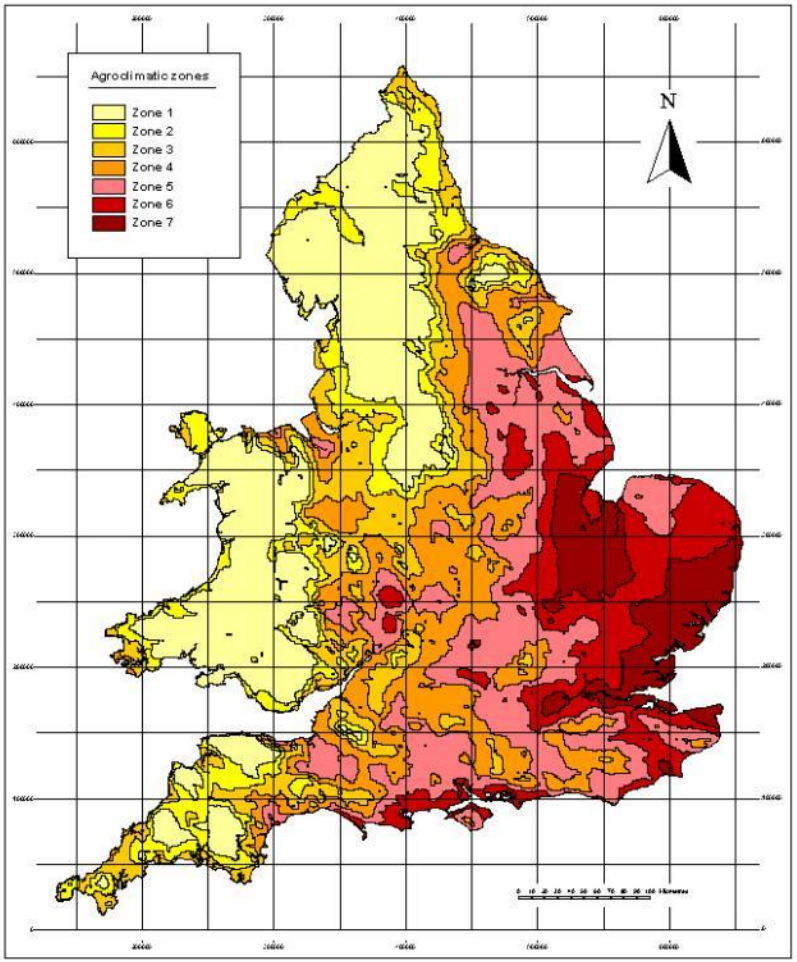


- Poorly drained
- High water holding capacity
- Slow percolation
- Drained for cropping

Hydrologically Effective Rainfall (HER) = ∑ (Runoff + Drain flow + Potential recharge)

Potential Baseflow (PB) = ∑ (Drain flow + Potential recharge)

Agroclimatic zones



Knox and Holman (2005)

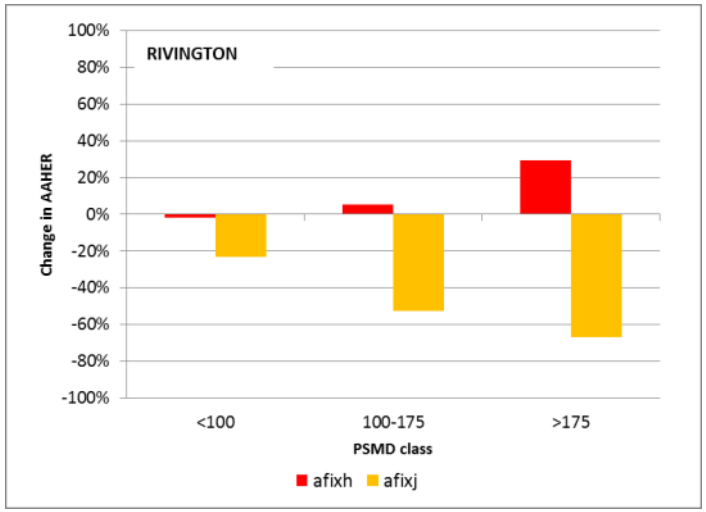
- 7 agroclimatic zones on the basis of baseline PSMD (summer dryness)
  - Zones 1 – 2 (<100mm)
  - Zones 3 – 5 (100 – 175mm)
  - Zones 6 – 7 (>175mm)

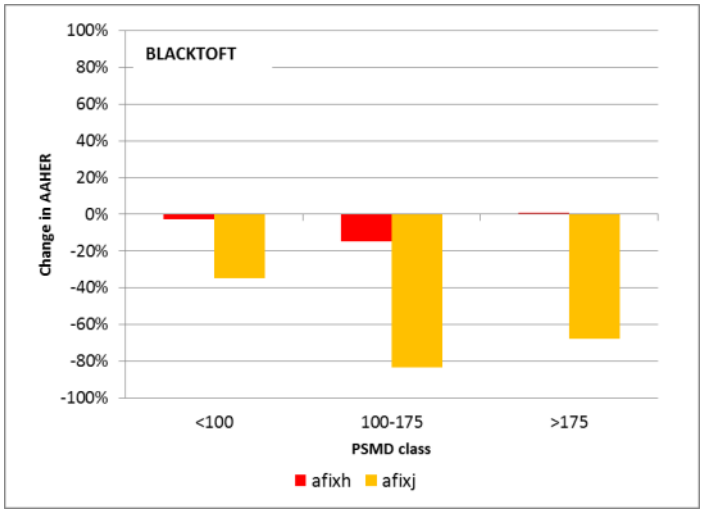
HER: Climate change

Rivington

Blacktoft

Permanent grass

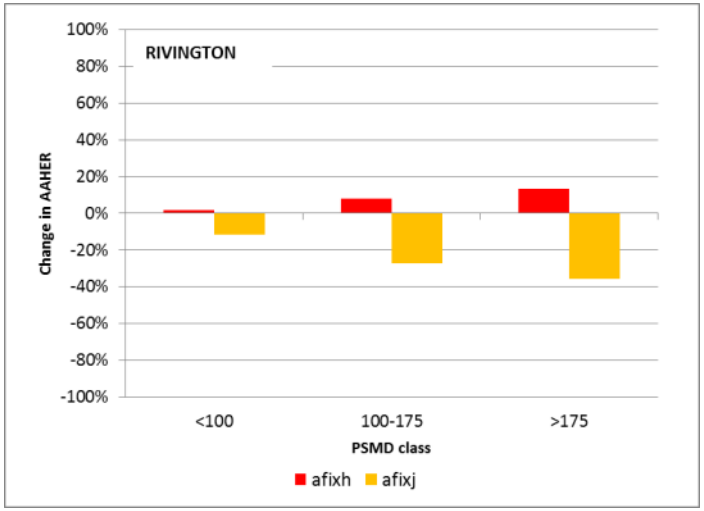


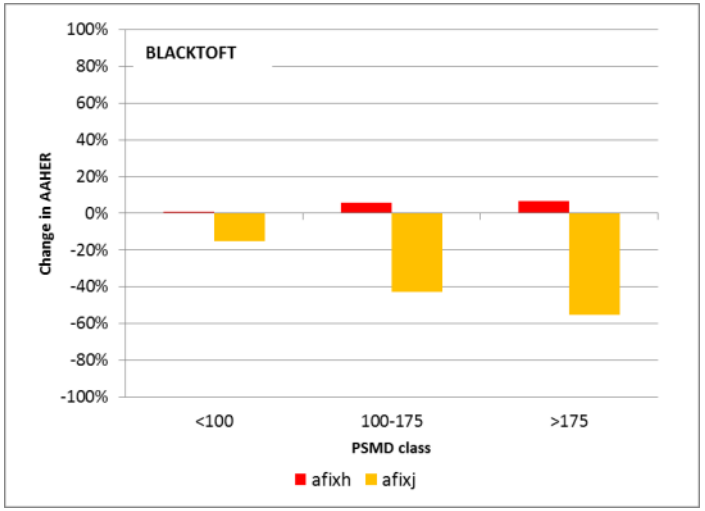


afixh (best case)

afixj (worst case)

Spring beans





Changes in crop calendar

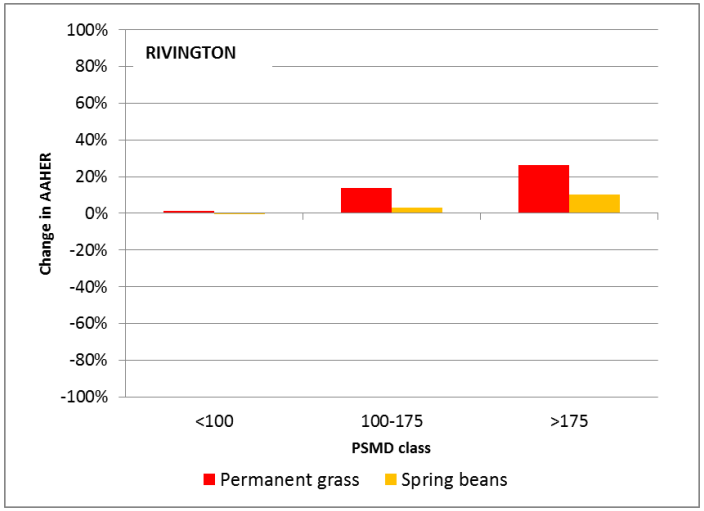
- Minor simulated effects on HER (with current varieties)
  - → earlier harvesting
  - → shortened growing season.
- Slightly greater simulated effects on recharge/drainage.
  - → reduced growing season ET
  - → reduced summer SMD
  - → earlier return to field capacity
  - → increased winter recharge/drainage.

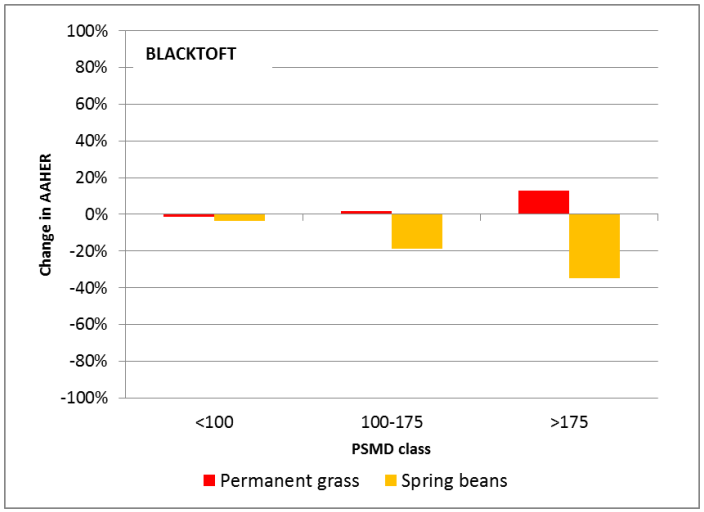
HER: Change to semi-natural

Rivington

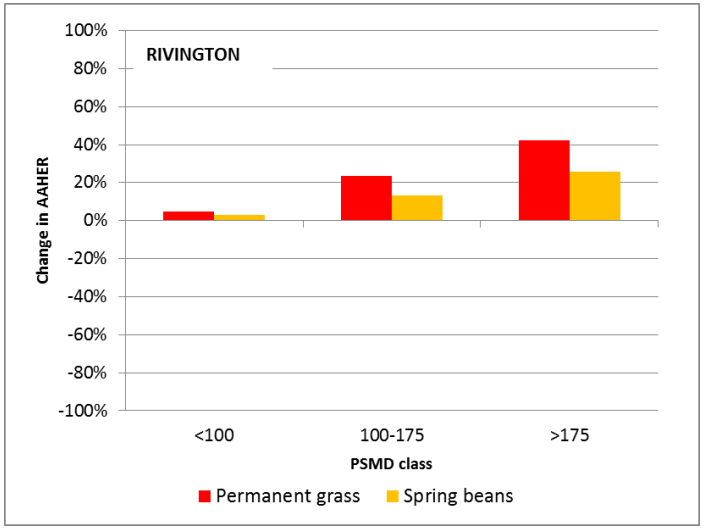
Blacktoft

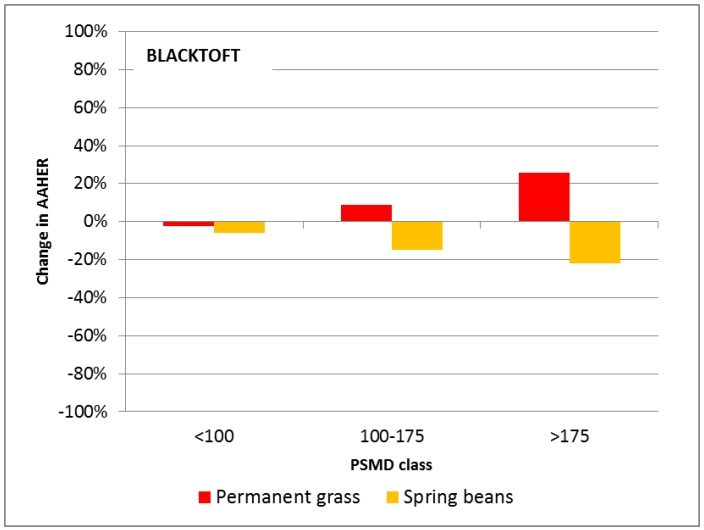
Baseline





afixh





From

P grass

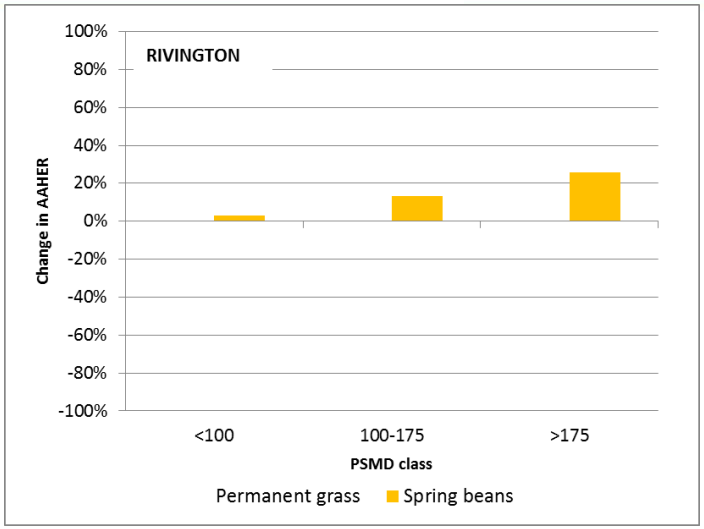
Sp beans

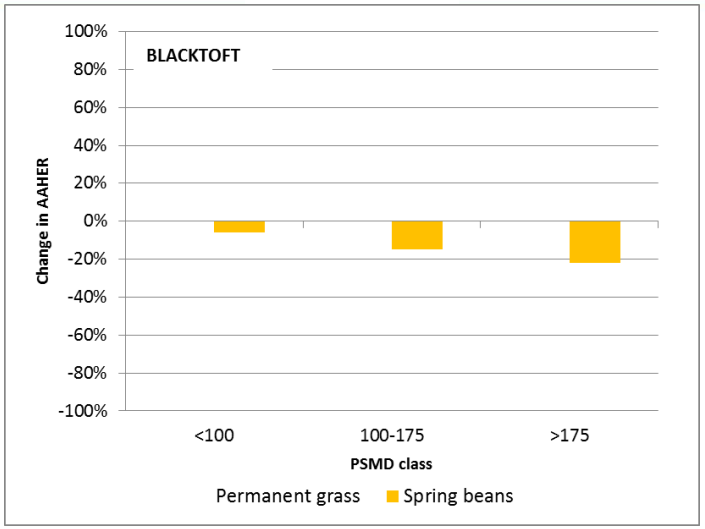
HER: Change to semi-natural

Rivington

Blacktoft

Sp beans (afixh)



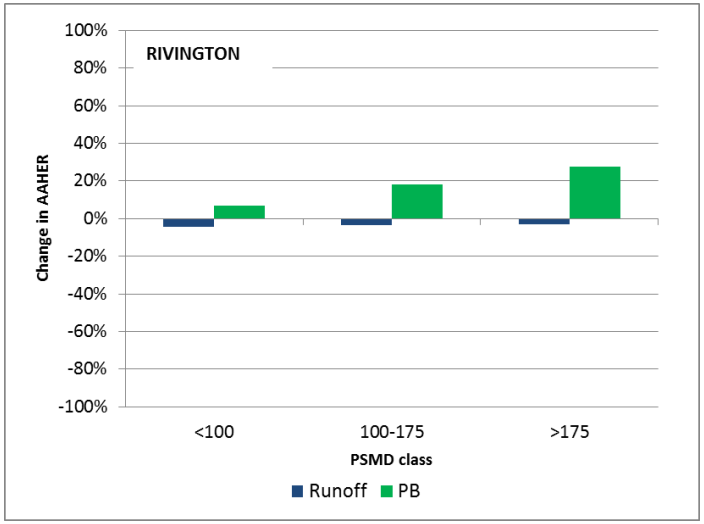


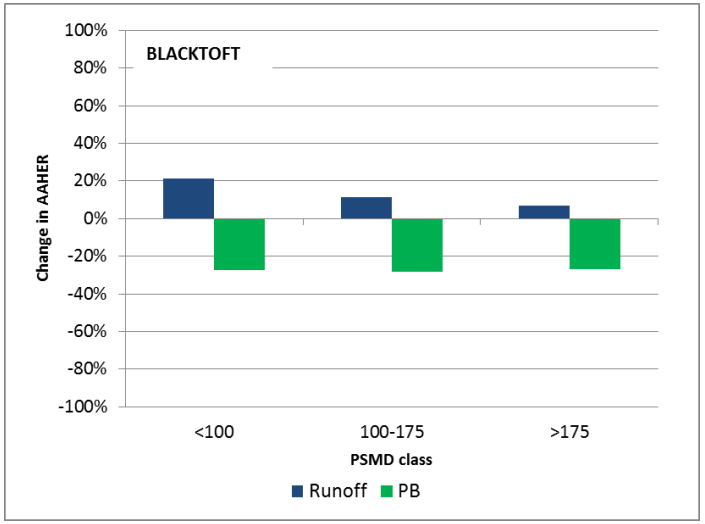
HER

Runoff

P Baseflow

Partitioning



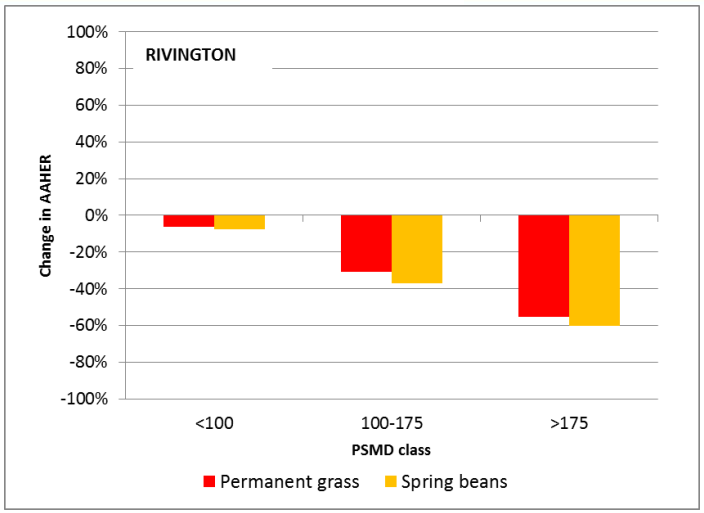


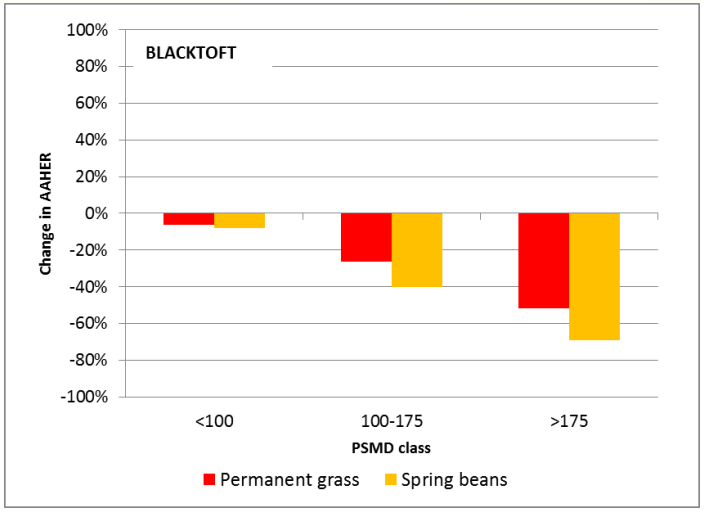
HER: Change to woodland

Rivington

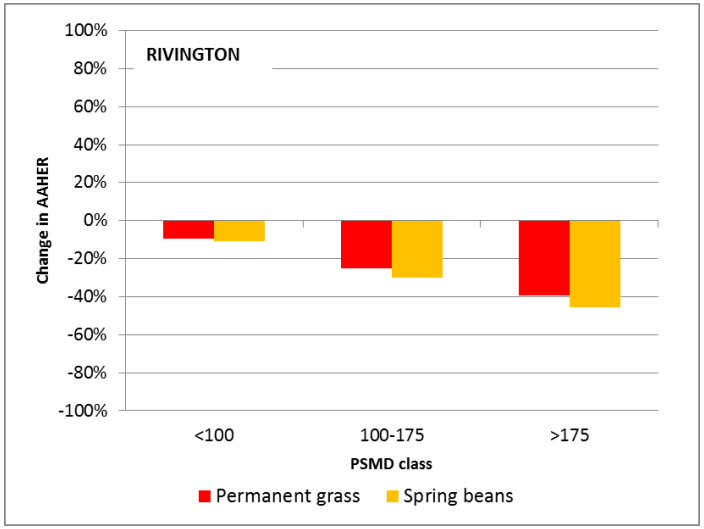
Blacktoft

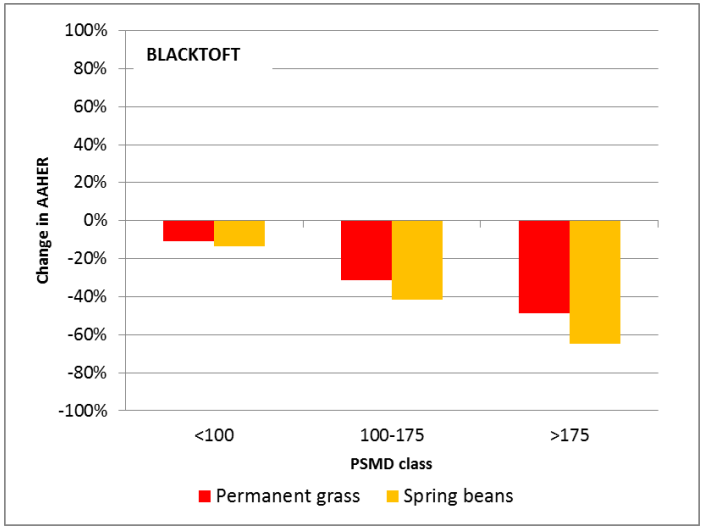
Baseline





afixh





From

P grass

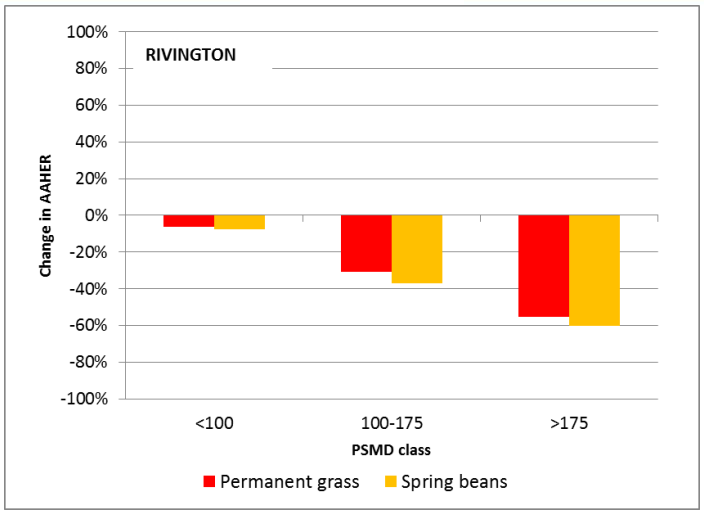
Sp beans

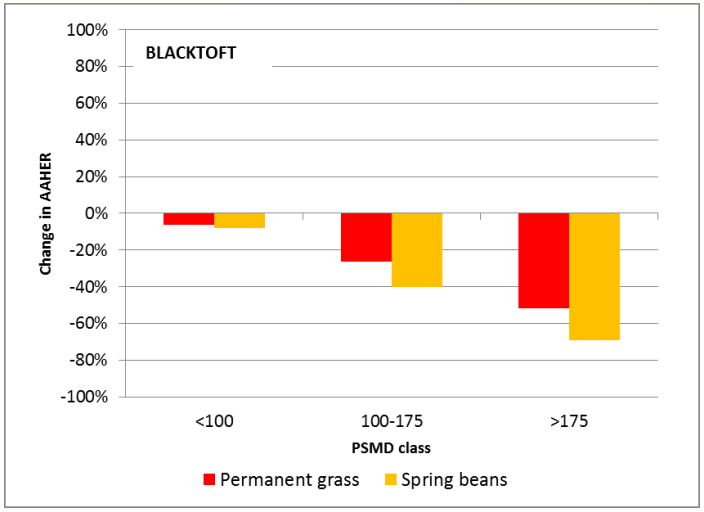
HER: Change to woodland

Rivington

Blacktoft

Baseline



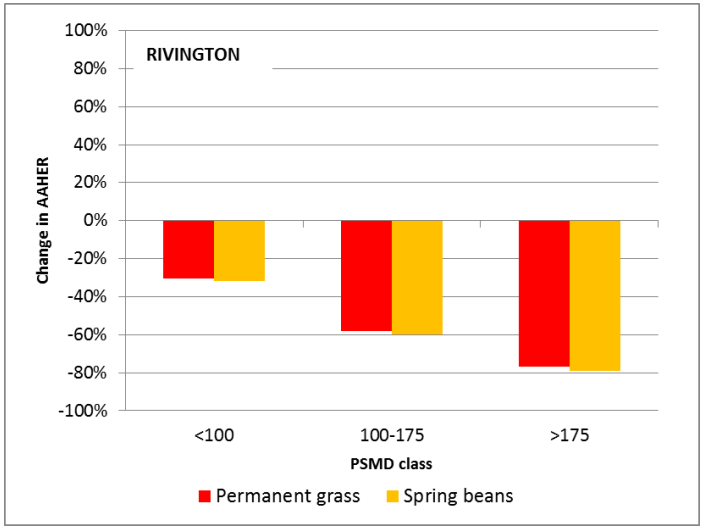


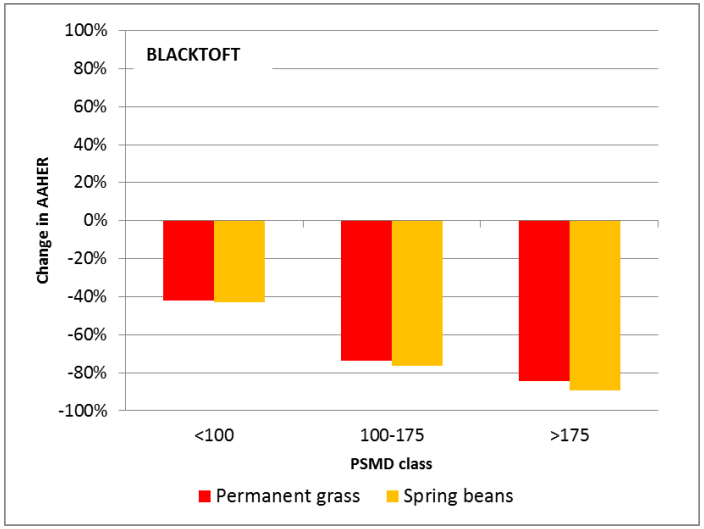
From

P grass

Sp beans

afixj





Conclusions

- Climate and land use / management change can have potentially significant impacts on water availability
- Effects of change of land use may be greater than due to climate change
- Effects differ (magnitude and direction) according to the interaction of:
  - Agroclimate (greatest in driest areas)
  - Soil type (depending on runoff behaviour, water holding capacity and drainage rate)

Land Use, Climate Change and Water Availability

- The *Land Use, Climate Change and Water Availability* project was commissioned and funded by the Department for Environment, Food and Rural Affairs

- Holman, I.P. and Hess, T.M. (2014). Land use, climate change and water availability (Phase 2a) - Task B: *Development of a range of plausible future land use, land management and growing season changes*. Unpubl. Cranfield Water Science Institute, Cranfield, UK

- Holman, I.P. and Hess, T.M. (2014). Land use, climate change and water availability (Phase 2a) - Task C: *Preliminary modelling of the effects of land use and management change on available water.* Unpubl. Cranfield Water Science Institute, Cranfield, UK