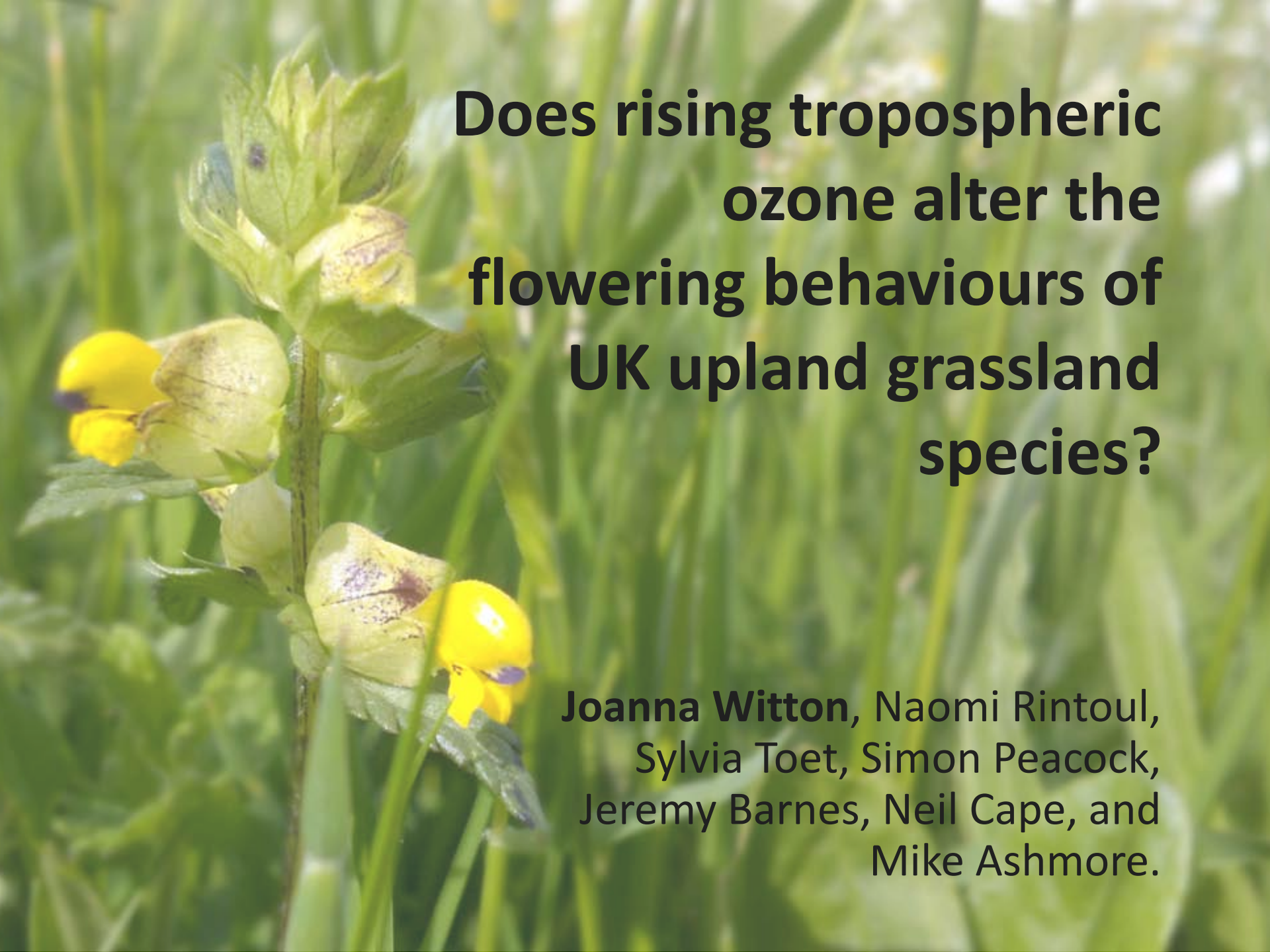


Does rising tropospheric ozone alter the flowering behaviours of UK upland grassland species?

Joanna Witton, Naomi Rintoul, Sylvia Toet, Simon Peacock, Jeremy Barnes, Neil Cape, and Mike Ashmore.

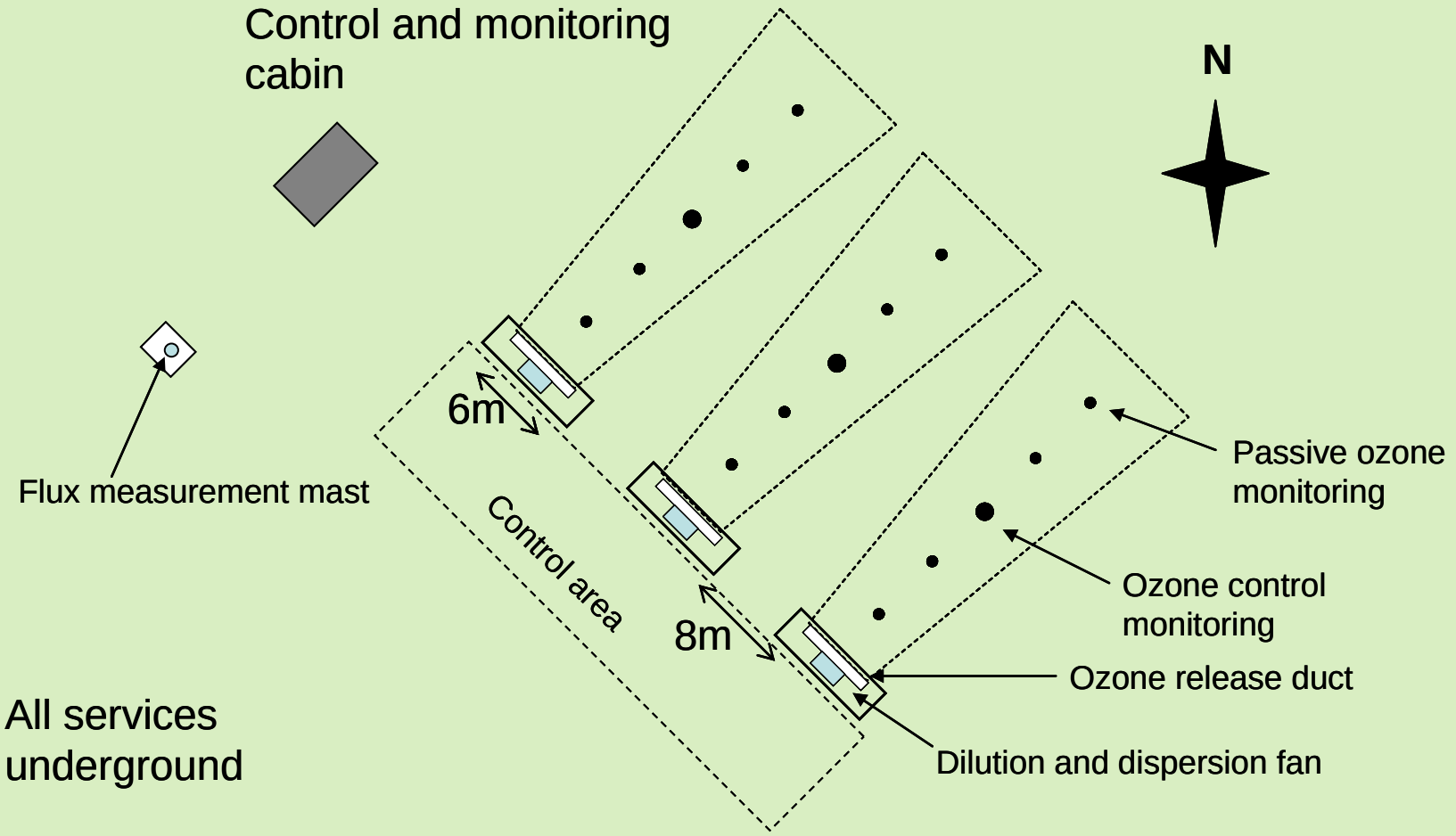
Background to Study

- Some knowledge of effects of rising ozone on biomass of UK grassland species
- Less known on flowering responses, especially in field conditions
- Long term field studies are necessary to gain stronger understanding
- Suggestion that changing climate will affect reproductive success of some species (Kudo *et al*., 2004; Leisner & Ainsworth, 2012)

Field Site – High Keenley Fell

- Upland hay meadow managed to Higher Level Stewardship objectives
- Upper Allendale (nr Hexham), Northumberland
- Actively grazed by livestock until 8 weeks before hay cut; livestock reintroduced post-cut
- Free-air fumigation system used on base of incline, facing NE

Experimental Setup



Aim of Study

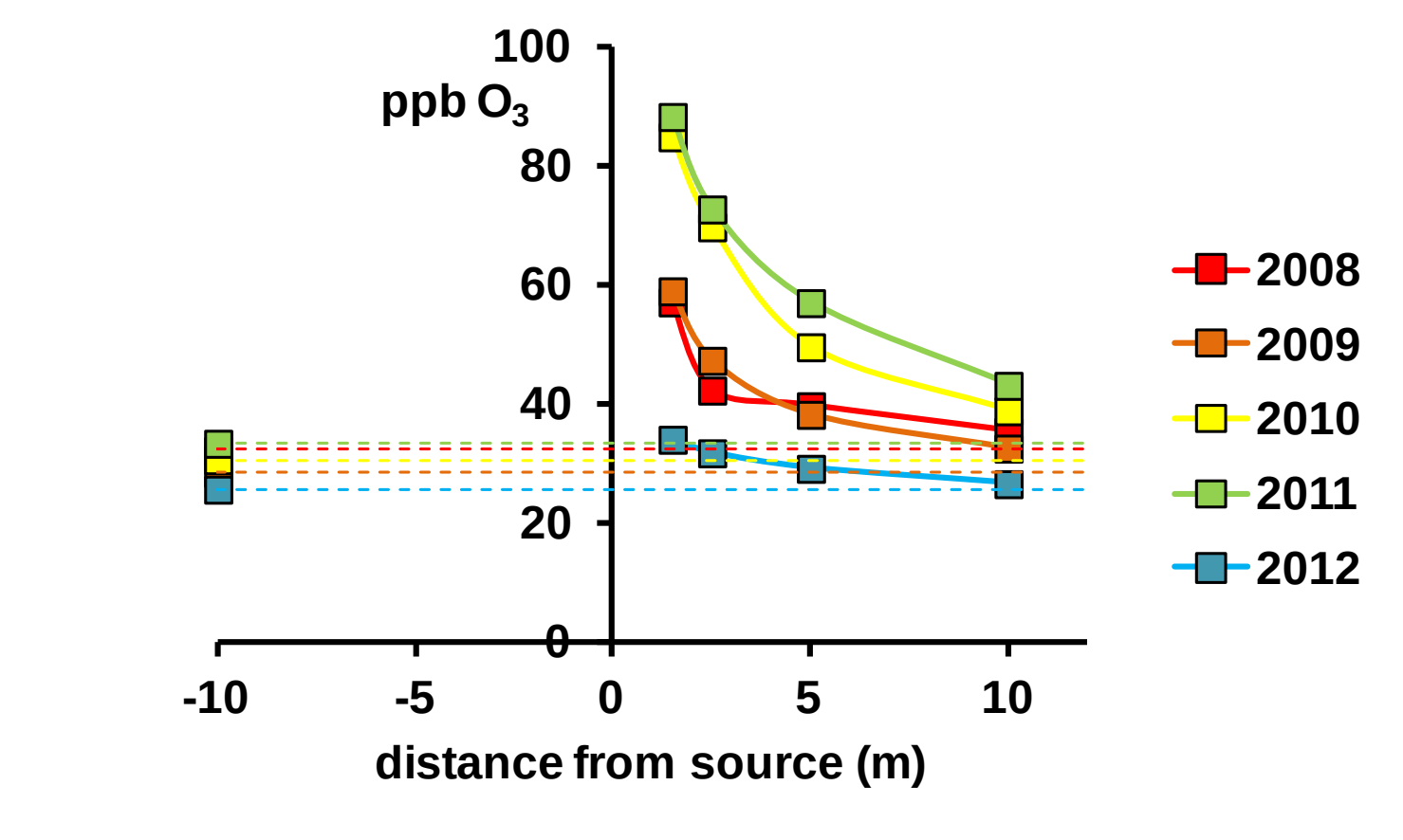
- To establish what effect future ozone scenarios will have upon the intensity and timing of the flowering of selected upland semi-natural grassland species.

- Will look at three year flowering trends – 2010-2012
- Flower timing 2010 vs 2012
- 2012 Flowering response vs biomass response

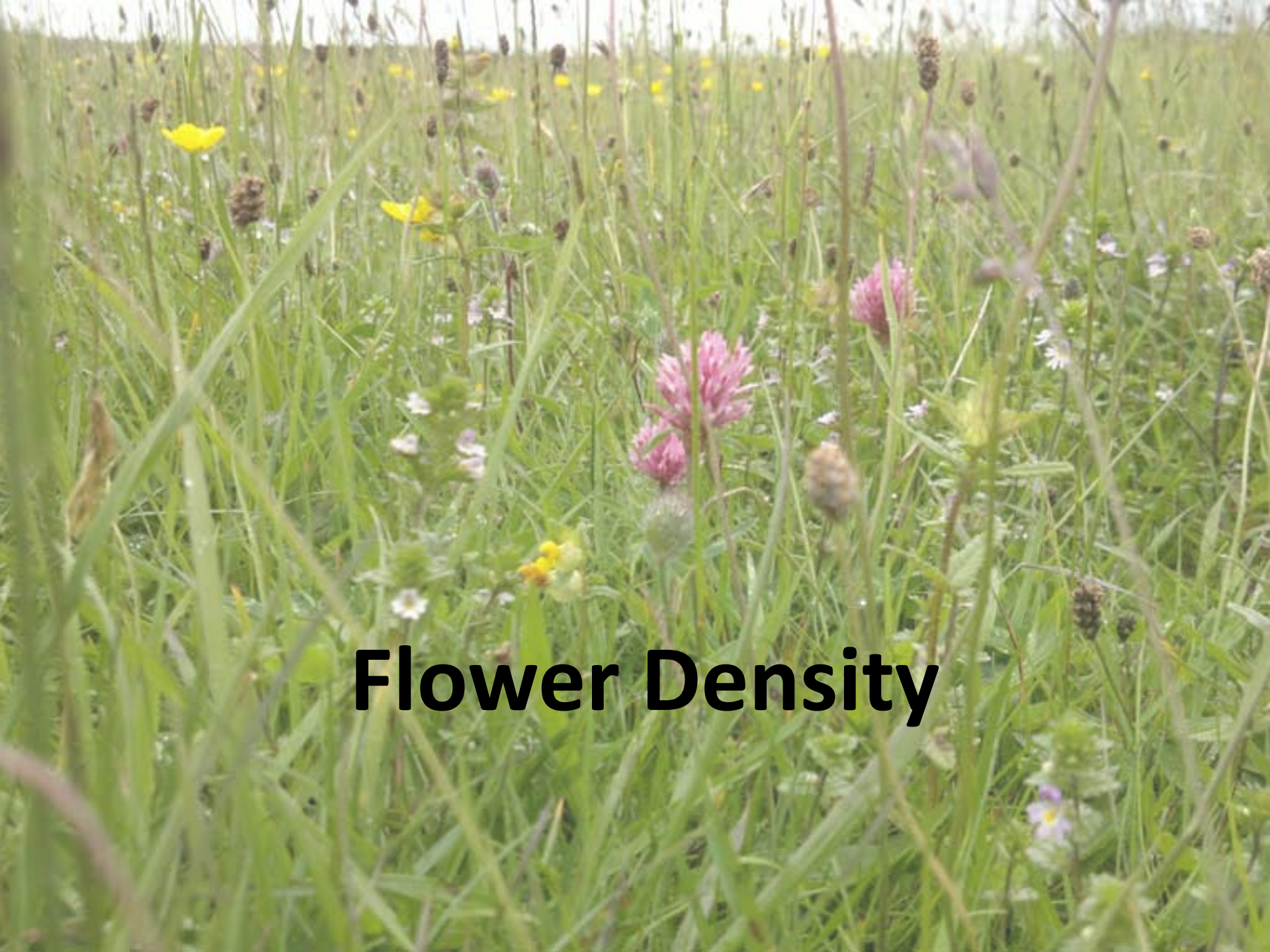
Methodology

- Plots fumigated with target increases of +10 ppb (10 m) and +25 ppb (5 m) above background ozone
  Flowering heads of 14 species (6 grass, 6 forb, 2 legume) counted over flowering season
  - Maximum flower density taken for season analysis
  - Mean flower density from each count used for timing analysis
- Above-ground biomass harvested annually in early August
- Nectar of *Rhinanthus minor* also collected to establish whether ozone affects nectar sugar composition

Field Ozone Fumigation

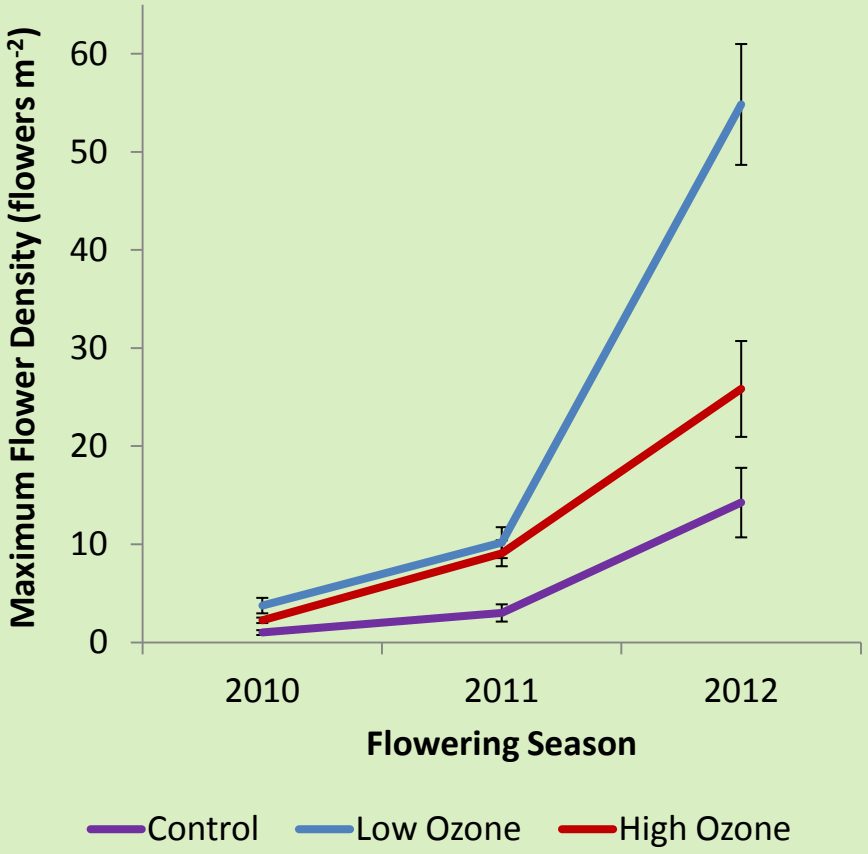


(Thanks to Kirsten, Neil and Simon at CEH Edinburgh and Newcastle University for the data)


Flower Density

Some species like ozone...

Dactylis glomerata

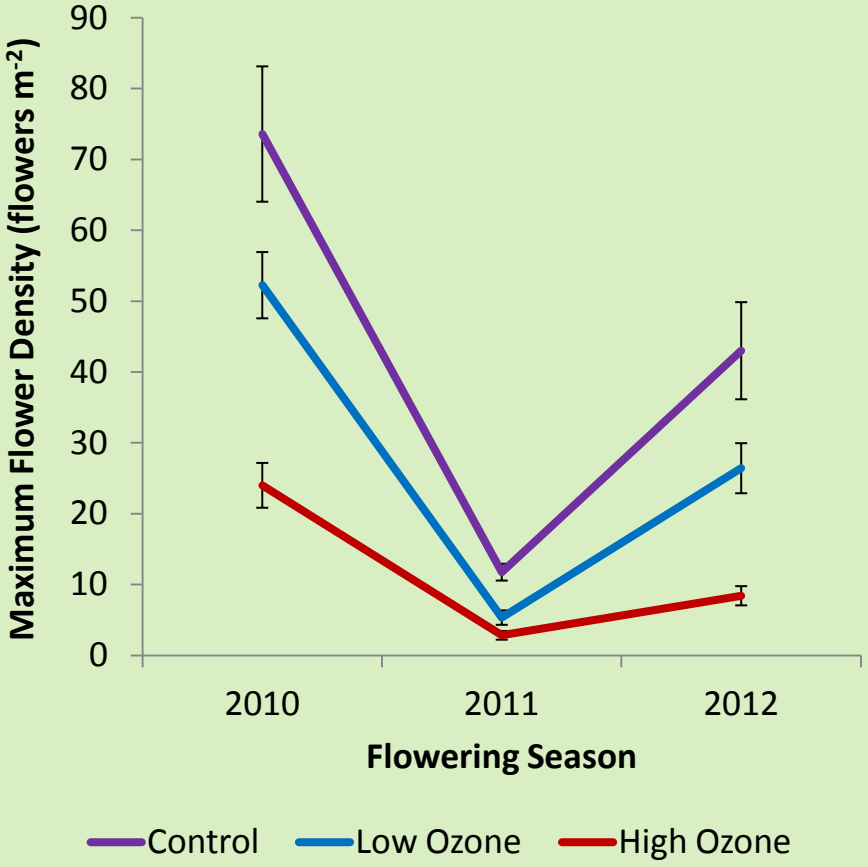


Year	Ozone Effect	Post-hoc
2010	ns	ns
2011	*	10 m, 5 m > control
2012	*	10 m > 5 m, control

** = P < 0.05; ns = not significant*

Some don’t…

Ranunculus acris



Year	Ozone Effect	Post-hoc
2010	*	control > 10 m > 5 m
2011	**	control > 10 m, 5 m
2012	ns	control > 10 m > 5 m

** = P < 0.05; ** = P < 0.01; ns = not significant*

And others unaffected…

	2010	2011	2012
Anthoxanthum odoratum	+ **	*ns*	*ns*
Dactylis glomerata	*ns*	+ *	+ *
Festuca pratensis		- **	*ns*
Holcus lanatus	*ns*	- *	*ns*
Lolium perenne	- .	*ns*	*ns*
Trisetum flavescens	+ *	*ns*	*ns*
Conopodium majus	+ *	+ x	+ ***
Ranunculus acris	- *	- **	*ns* †
Ranunculus bulbosus	- x	*ns*	- x
Rhinanthus minor	*ns*	*ns*	*ns*
Rumex acetosa	*ns*	- *	*ns*
Stellaria graminea	*ns*	*ns*	*ns*
Trifolium pratense	*ns*	*ns*	x
Trifolium repens	*ns*	*ns*	x

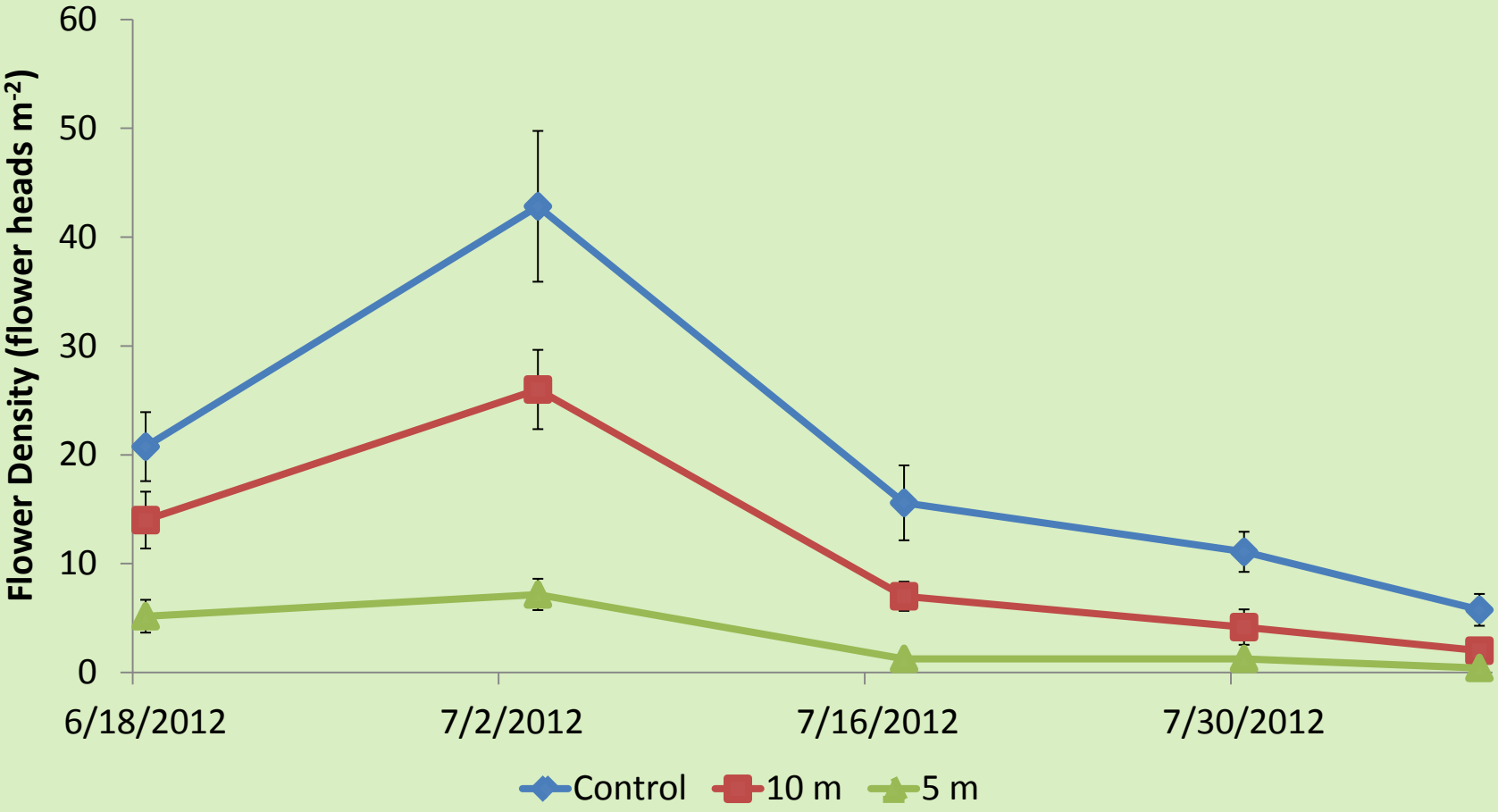
. = P < 0.1
** = P < 0.05*
*** = P < 0.01*
**** = P < 0.001*
ns = not significant
***x** = Species constancy between plots <80%*

† - R. acris *P <0.1, however inhomogeneous so deemed not significant.*


Flower Timing

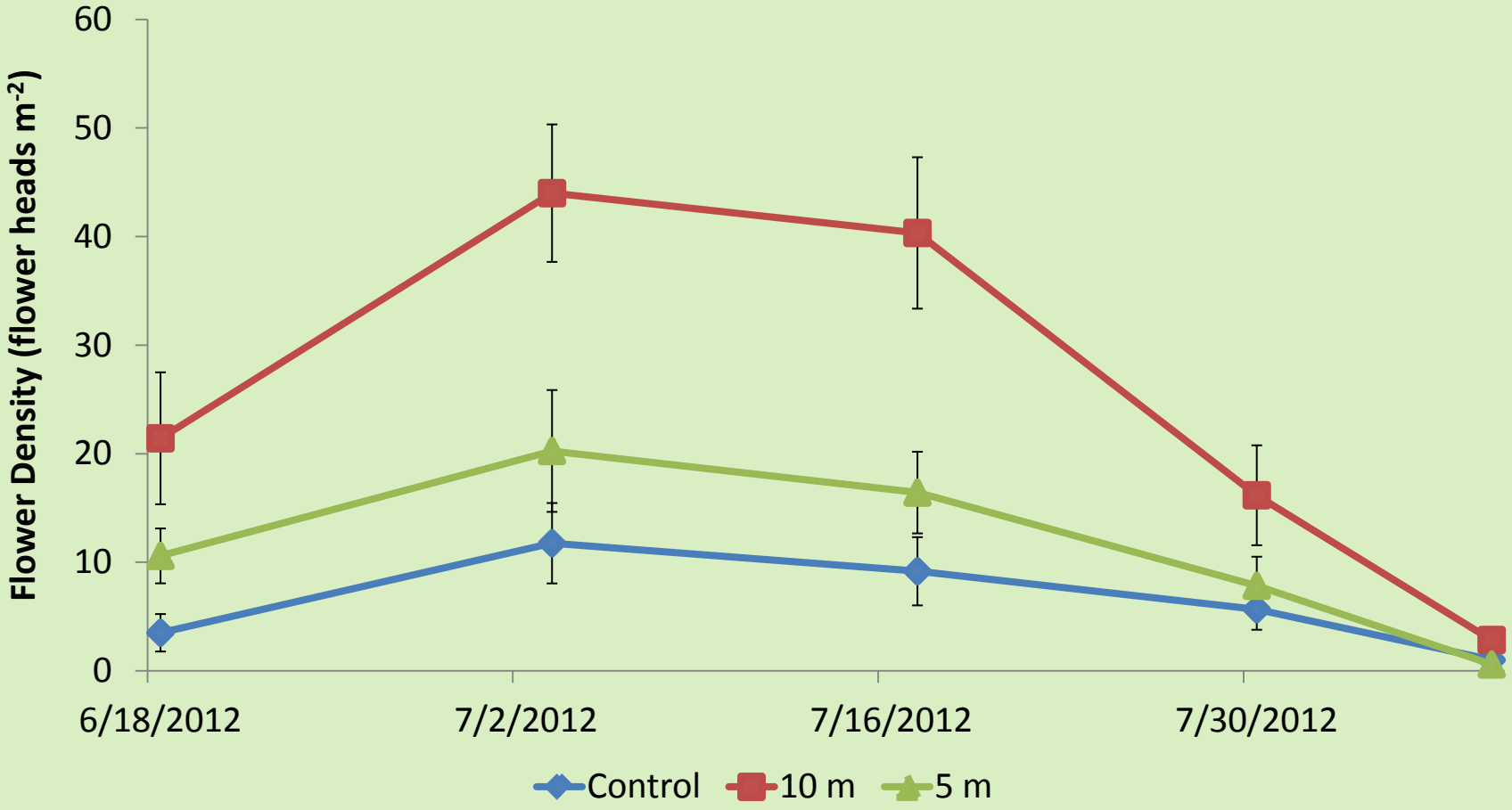
No change!

R. acris - 2012

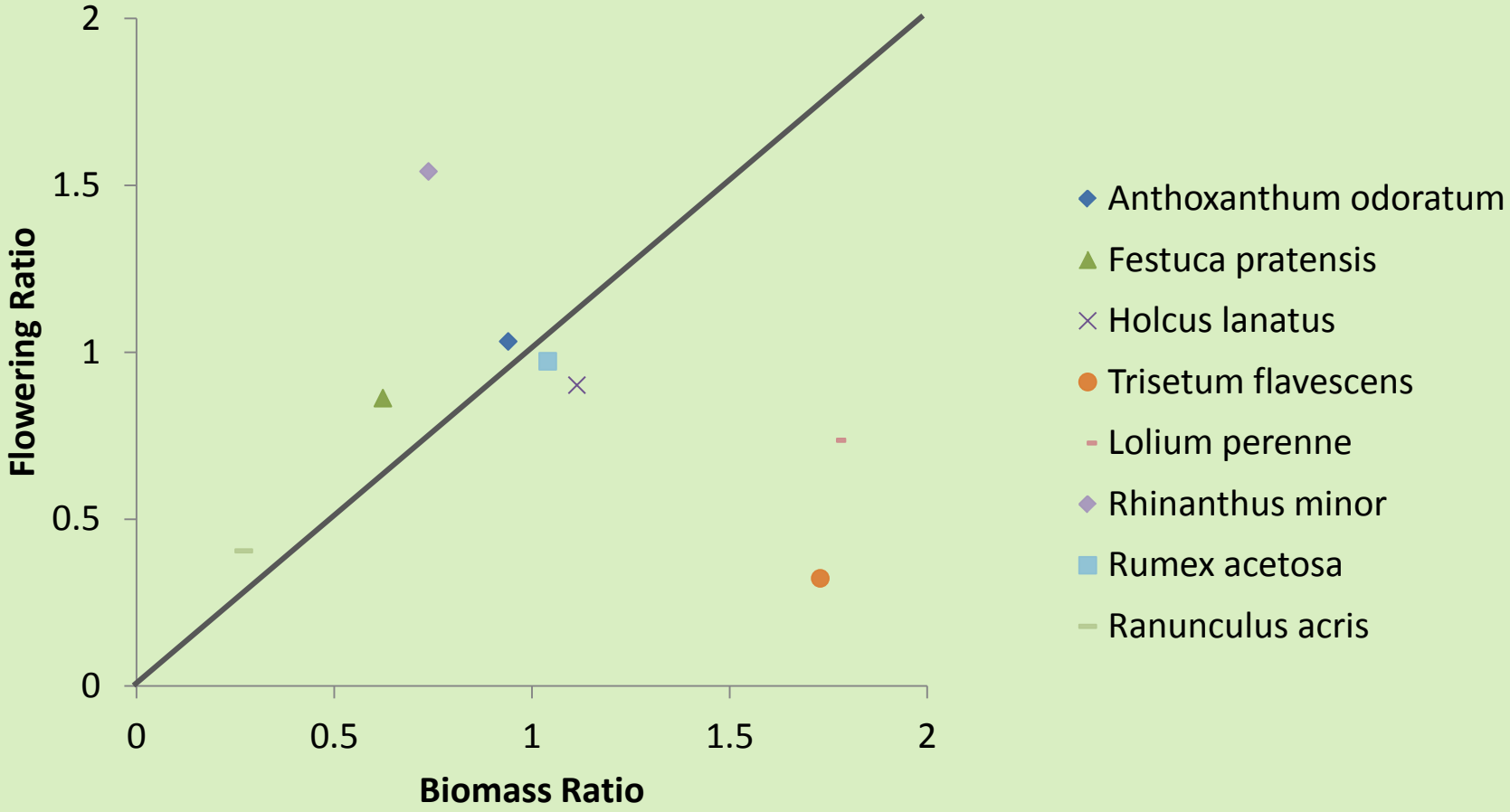


No change!

D. glomerata - 2012



Biomass vs. Flowering 2012 – treatment:control ratios



Policy Relevance

- Small increases in background ozone can have marked effects on flower density
  - Competitive species can increase (e.g. *D. glomerata*)
  - Valuable species can decrease (e.g. *R. acris*)
- Changes in flowering density could impact on pollination ecosystem services

Summary of Key Findings

- Ozone causes increases and decreases in flowering density of some species; some species resilient
- Ozone doesn’t change timing of peak flowering in the 4 species studied

Acknowledgements

- Project funded by Defra
- Sylvia Toet and Mike Ashmore
- Naomi Rintoul

Thank you!