Prifysgol Aberystwyth

# Professor Athole Marshall

Aberystwyth University

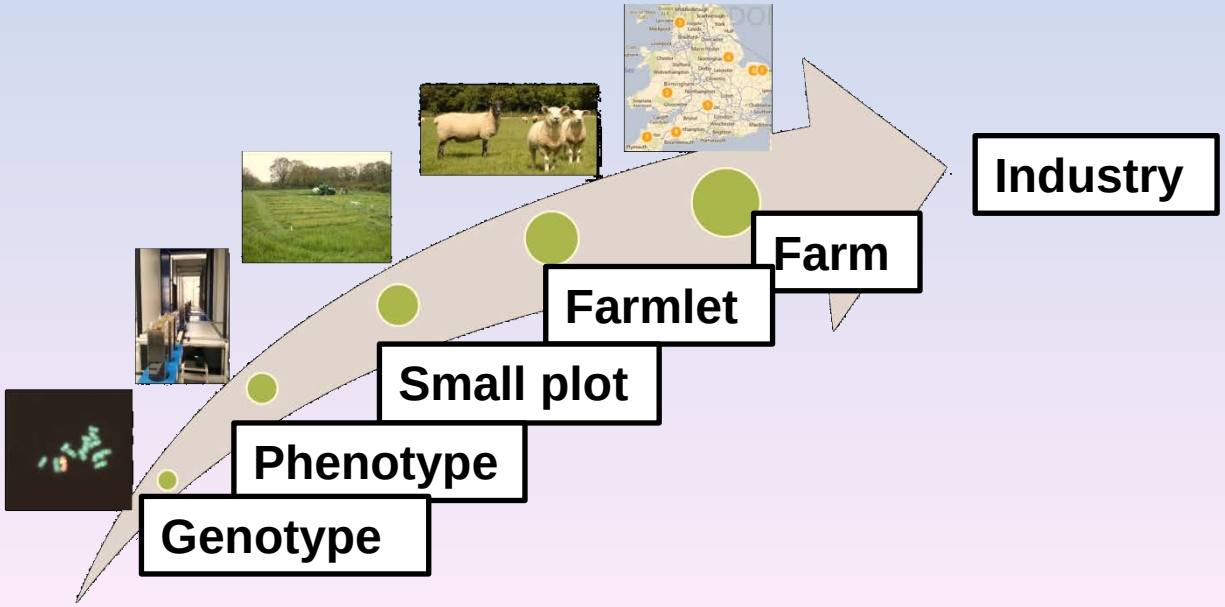
# *Introduction to the Sureroot Project*

Athole Marshall
Aberystwyth University-IBERS

# What is Sureroot?

A new, collaborative project funded jointly by BBSRC and industry, which started in 2014, brings together two **BBSRC National Capabilities**, the **North Wyke Farm Platform** at Rothamsted Research and the **National Plant Phenomics Centre** at IBERS.

The project applies multidisciplinary approaches to evaluate new grass and legume varieties for their agricultural and environmental properties at farm, landscape and catchment scales. These varieties will deliver benefits via improved root systems.



# Sureroot

**Project addresses the effects of climate change on grassland agriculture.**

**The hypothesis is that the effects of climate change can be mitigated by improving forage plant root systems.**

# Combatting Climate Change (1): Managing Hydrology

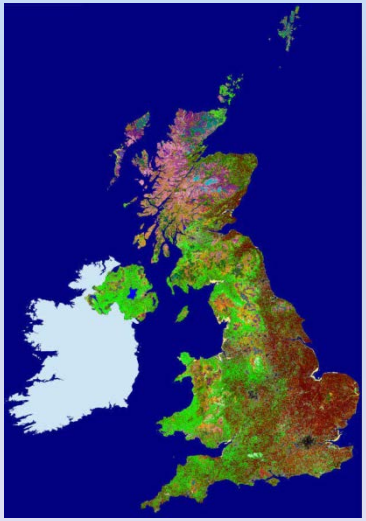
Problem: **Warmer winter temperatures and an increase in rainfall with more frequent high intensity events**

Potential: **Many UK grasslands are in the wettest river catchments**

Solution: **Slow down water movement through soils using large rooted forage species (grasses + legumes)**

# Combatting Climate Change (2): Increasing Carbon Capture

Problem: **The agricultural sector accounts for around 9% of total UK greenhouse gas emissions**



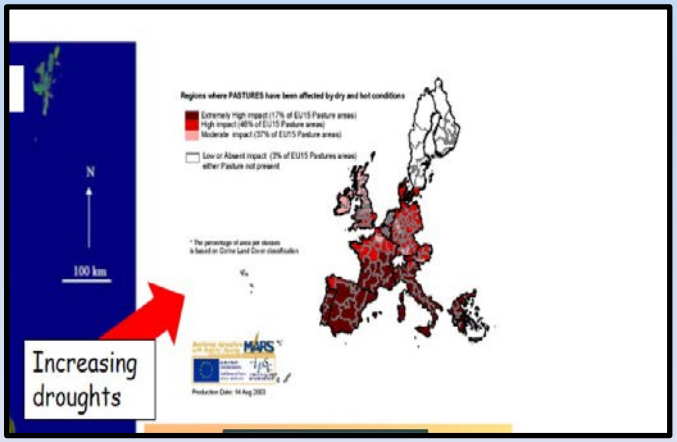
Bright green = areas of improved grassland

Potential: **65% UK agricultural land area is grassland**

Solution: **Increase C storage in grassland subsoils using plants with deep root architecture**

# Combatting Climate Change (3): Improving Drought Tolerance

Problem: **Soil water deficits are increasingly common in the UK and other parts of Europe, and can restrict forage production**




Potential: **Genetic resources for drought tolerance exist with grasses and legumes**

Solution: **Introduce these traits into agronomically useful germplasm**

**Sureroot project exploits the potential of forage grasses and legumes used in UK agriculture to tackle elements of climate change.**

**Three groups of forage species are used.**

# (i) Perennial ryegrass

**The most widely-grown forage grass species in temperate grassland.**

**Aim is to develop genetic tools to enable selection for root system architecture that can be incorporated into new perennial ryegrass**

***Development of specific populations***

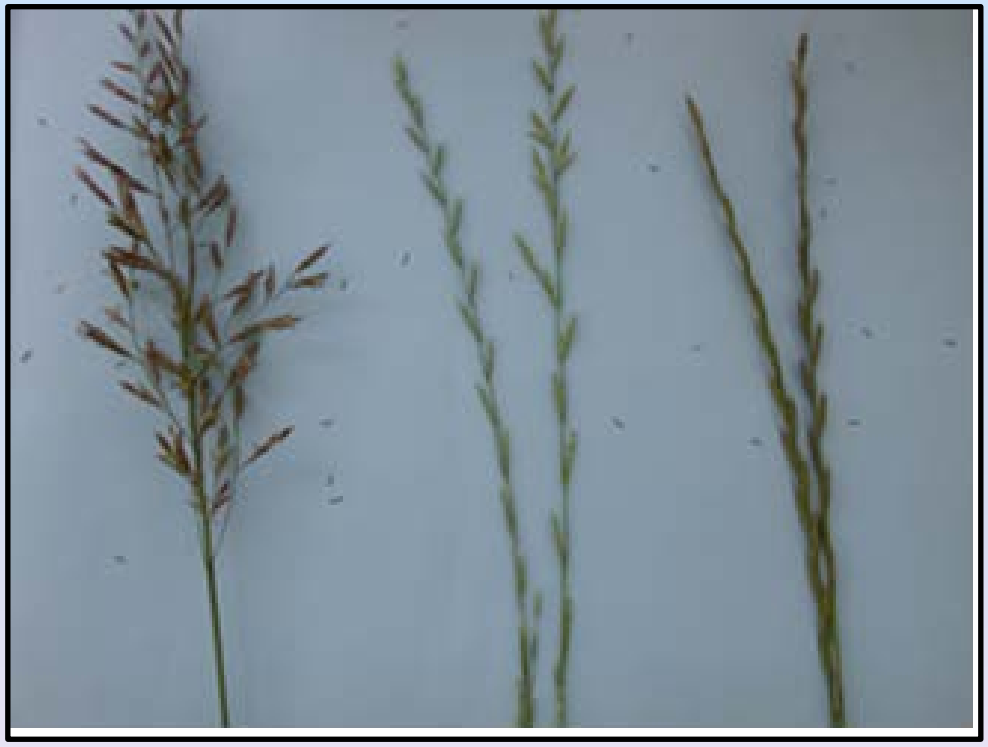
**<u>AberMagic</u>**
**(One of the latest IBERS cultivars)**

**X**

**<u>Aurora</u>**
**(an old un-adapted variety)**

**Segregating population of 189 $F_1$ cloned plants**

# (ii) Festuloliums: hybrids between *Festuca* and *Lolium* species



Meadow fescue *Festulolium loliaceum* Perennial ryegrass

There is increasing interest in Festuloliums in UK farming: high yielding and resilient to a range of environmental stresses.

# (iii) Forage legumes

Focus is on white clover, red clover and a drought tolerant hybrid between white clover and Caucasian clover.

Genetic information on root traits is lacking in forage legumes, so the initial phase analyses intra-specific variation in root architecture at the variety level.

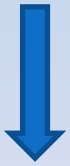
Subsequent phases will analyse root growth in mapping families, followed by marker identification.

# Background to Sureroot project

# Plants affect soil structure

There is an increasing body of evidence showing that plants differ in their effects on soil structure

DIRECT



Effects of plant root systems

INDIRECT

Effects on soil aggregate formation e.g. through microbial action

These effects can influence the way in which soil functions

# How plants can affect soil structure

10 cm diameter soil cores, sieved and homogenised

Greater aggregation = improved soil structure under white clover


Pictures from Holtham *et al*., (2007) *Geoderma* 142, 142-151.

**Ways of assessing soil structure: we need to measure it to quantify the effects of root systems**

# Examples of soil measurements on plots in Sureroot

Water infiltration rate

Soil water profile

Soil compaction

# Research plan for ‘Sureroot’

Detailed measurements of root system using phenomics scanning

Relate root traits to soil quality in field plots via measurements of porosity, compaction and water content

Develop genetic tools to enable these traits to be incorporated into plant breeding programmes

Evaluate the impact of variation in root system structure on performance in field plots in monocultures and mixtures with grasses (IBERS plots)

Measure large scale impacts on water drainage (North Wyke Farm Platform)

Look at impacts of improved varieties on commercial farms

# NPPC experiments (1): legumes

## White clover

- AberAce (small leaved)
- AberDai (medium leaved),
- Aran (very large leaved),
- TKPR (selection line: parent of the stolon mapping family),
- TNSP (selection line: parent of the stolon mapping family),
- AberLasting (hybrid with Caucasian clover - contains rhizomes)

## Red Clover

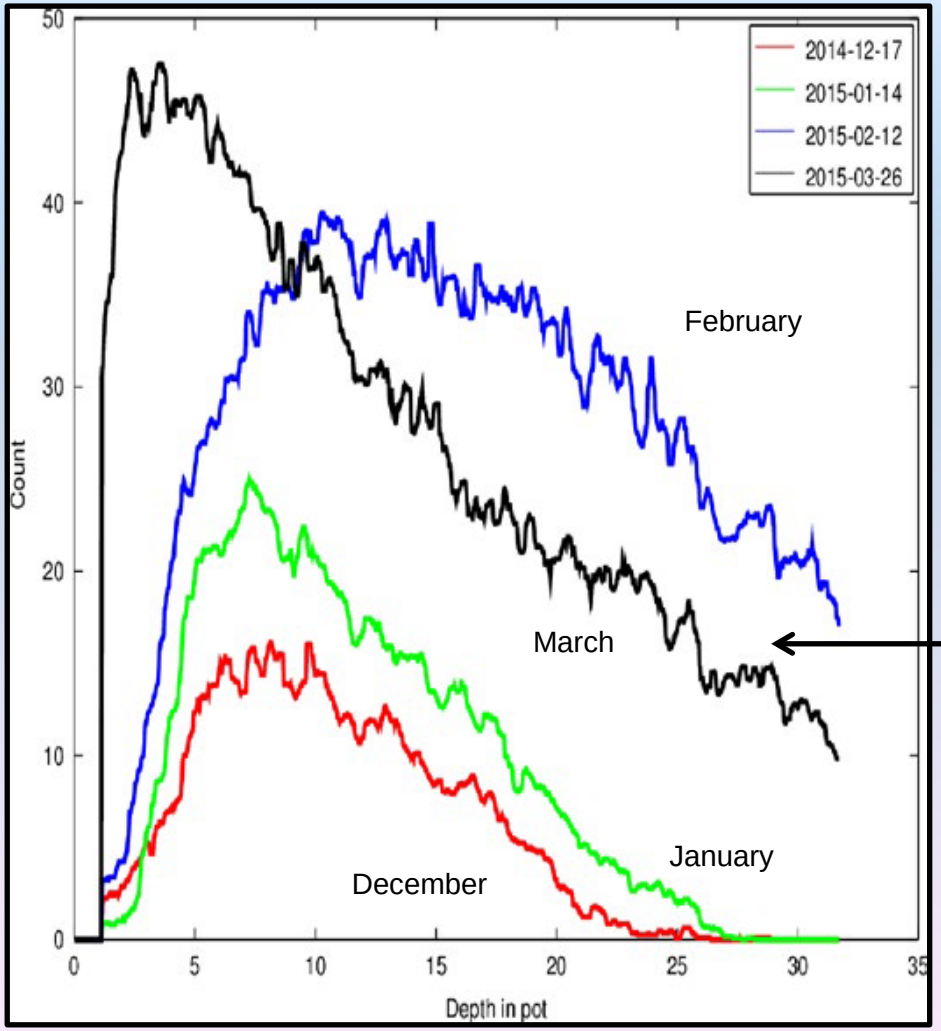
- AberClaret (UK variety selected for persistence)
- AberChianti (UK variety selected for persistence)
- Aa4559 (advanced line selected for persistence)
- Britta (Swedish variety selected for disease & pest resistance)
- Milvus (Swiss 'Mattenklee' variety)

# NPPC experiment (2): grasses

Improve perennial ryegrass by developing genetic markers for root traits

Build on previous data showing the potential of Festuloliums for reducing water run-off from soil surfaces. This resulted from deeper rooting, which also improved the plants' drought resistance.

# Root ontogeny in a Festulolium plant measured in the NPPC over 4 months




Possible evidence of root turnover, leading to improved carbon storage?

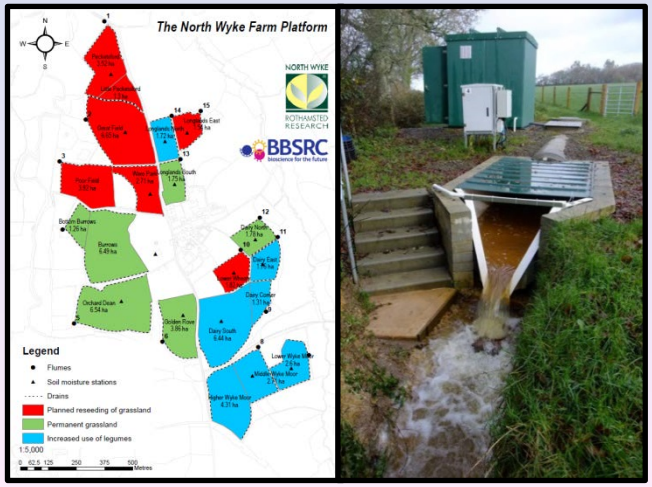
# But…..

**(i) we also need to quantify the impact of these traits on soil quality, and water + nutrient run-off**

**(ii) we also need to ensure that improvements in root systems are not at achieved at the expense of agronomic performance**

Field plots at IBERS

North Wyke Farm Platform




Commercial Farms

# Field experiments in IBERS

- Two expts have been established – **all species monos only (Expt. 1)** and **grass/legume mixtures + grass monos (Expt. 2)**

These plots contain all the legume populations tested in the root pipes and columns

- Aims are to monitor changes in soil quality in Expt 1 and to measure agronomic performance (DM yield + forage quality) in Expt 2

<u>Questions:</u>

- Do differences in root systems have measurable effects in the field?
- Are these grass/legume mixtures agronomically productive?

# Field experiments: design

Expt 1: Monocultures (plots = 9 $m^2$)

**Grasses:**

PRG: cv. AberMagic

Festulolium: cv. Prior; novel lines: *L. perenne* x *F. glaucescens* (Bx514); *L. perenne* x *F. mairei* (Bx511)

**Legumes:**

White clover: TKPR; TNSP; cvs. AberDai; AberAce; Aran

Hybrid: cv. AberLasting

Red clover: Aa4559; cvs. AberClaret; AberChianti; Milvus; Britta

Expt 2: Mixtures (plots = 2.4 $m^2$)

All grasses + all legumes in binary mixtures; grass monos as controls

# Field plots: picture taken in mid-July 2015

Monocultures (Expt 1)

Mixtures (Expt 2)

After a weedy start the plots grew very well, and the annual DM yields of all sown species in mixtures and monocultures were high for the 2015 growing season.

# Soil measurements on mono plots in Expt. 1

Water infiltration rate

Soil water profile

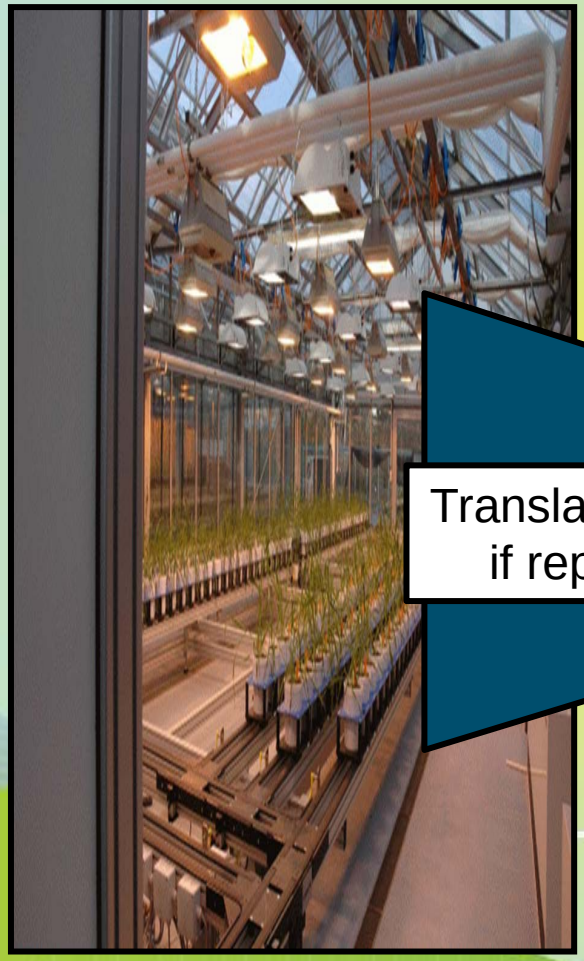
Soil compaction

# Expt.2: Grass/clover mixtures

- Yield
- Quality
(DMD, WSC, CP etc.)

# Measuring the effects of forage plants in larger-scale fields: hydrology and nutrient run-off

## National Plant Phenomics Centre (IBERS)



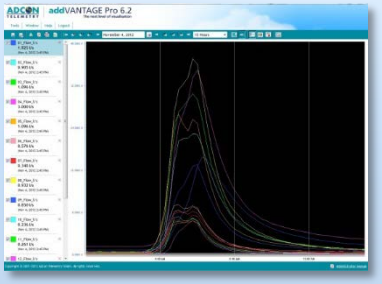
## North Wyke Farm Platform Rothamsted Research

Translating impacts of root redesign if reproduced at the field-scale

# North Wyke Farm Platform national capability

ROTHAMSTED RESEARCH

| Soil | Atmosphere | Farm Management |
|---|---|---|
| % Moisture | Rainfall | Field inputs/outputs |
| Temperature | $CO_2$ and $N_2O$ | Liveweight gain |
| pH | | Farm activities |
| Bulk density | | Labour hours |
| N, P & C status | | Machine hours |




| Water |
|---|
| Temperature |
| Conductivity |
| Turbidity |
| pH |
| Dissolved $O_2$ |
| Ammonium |
| Nitrate |
| Dissolved organic C |


15 flume laboratories

Flow cell & sensors

Sequential/composite sampler



Total-P
Ortho-P

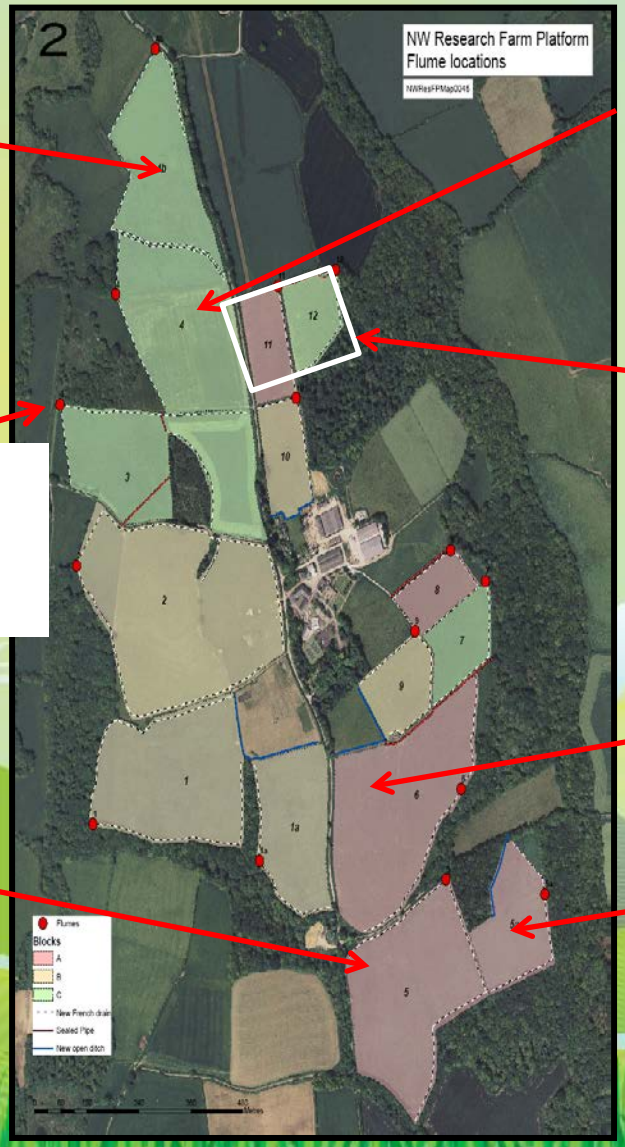
follow us on twitter @farmplatform

BBSRC bioscience for the future

# North Wyke Farm Platform

## Sustainable intensive grassland management

2014 AberMagic (high sugar grass)




2013 AberMagic (high sugar grass)

2013 Festulolium cv Prior (deep rooting grass) +/- white clover

Eucarpia *Festulolium* trial

2013 AberMagic (high sugar grass) + white clover

2014 AberMagic (high-sugar grass) + white clover

2013 AberChianti red clover + chicory

# High resolution hydrological data

ROTHAMSTED RESEARCH

BBSRC bioscience for the future

# The new germplasm is also tested at farm-scale

## Commercial Development Farms:

- Geographically spread
- All sectors represented
- Range of soil types
- Short term ley-silage system
- Grass a “ good fit” in rotation


Waitrose

DOVECOTE PARK

Coombe Farm

Dalehead Foods

Stonegate

BQP

DAIRY CREST

Gressingham Foods


1. Sheep SW
2. Sheep Wales
3. Beef
4. Eggs
5. Dairy
6. Pig
7. Turkey
8. Organic Dairy

# Commercial Development Farms

Phase1- 2014-2015 “ pilot”

- 2x 1 ha plots
- Single species leys
- Variety: Hybrid ryegrass AberNiche(FestX)/AberEve
- Establishment integrated into current farming system

Phase 2 -2015-2016

- Sowing of new material
- Marry practice with science
- Include animal measures


# BBSRC and industry funded science developing improved rooting systems in grasses and clover for sustainable livestock systems and for ecosystem service

Stonegate

Mole Valley Farmers

Waitrose

BQP

FINEST BRITISH BEEF
DOVECOTE PARK

ROTHAMSTED RESEARCH

PRIFYSGOL ABERYSTWYTH UNIVERSITY

IBERS
Athrofa y Gwyddorau Biolegol, Amgylcheddol a Gwledig
Institute of Biological, Environmental and Rural Sciences

DALEHEAD FOODS

Coombe Farm

müller Milk & Ingredients

HYBU CIG CYMRU
MEAT PROMOTION WALES

BGS

AHDB
AGRICULTURE & HORTICULTURE DEVELOPMENT BOARD

Gressingham
THE REMARKABLE DUCK PEOPLE