Carbon Sources & Sinks, Global Livestock Systems

Measuring & Managing Livestock Farms Towards Net Zero

Prof. John Gilliland OBE

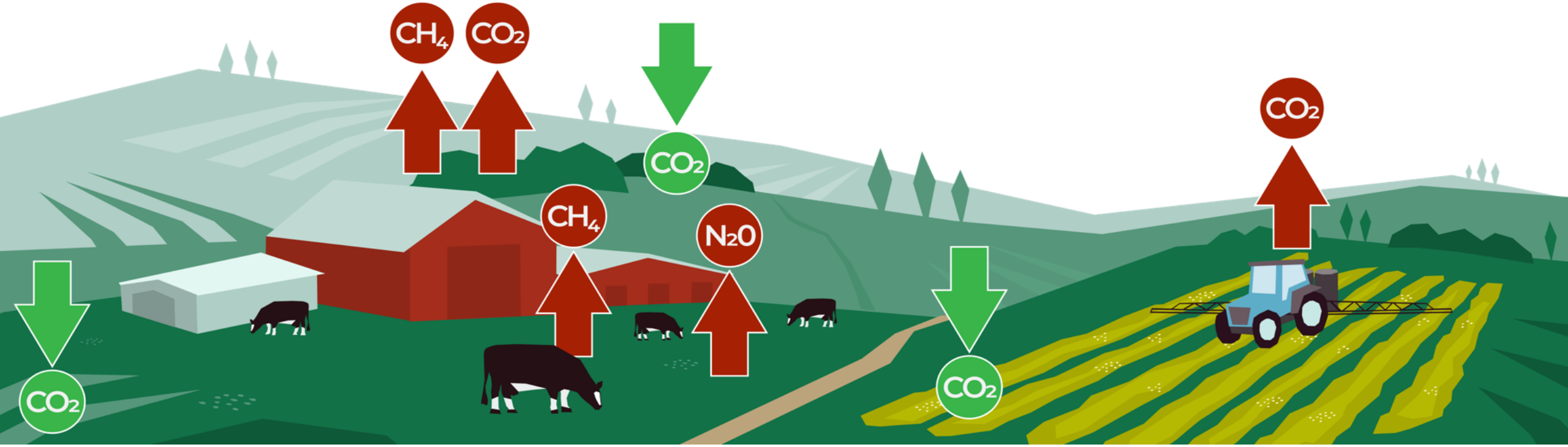
Professor of Practice, Queens University Belfast; Advisor, AHDB; Chair, ARC Zero

Owner, Brook Hall Estate.

31st August 2023

Net Zero Definition: Sum of Emissions equals Sum of Sequestration

Adjusted for any fossil fuel CO2 emissions displaced by Renewables
& for any methane emissions reduced by waste management



It is not about Zero Emissions……

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So How Do We Move Livestock Production Towards Net Zero?

- Measure & Manage….. Using Life Cycle Assessment Calculators (LCA)
- LCA "Factors," Emissions now to TIER 2 (An International Average)
  Sequestration only at TIER 1 (A National Average)
- Ideally, we need both to be at TIER 3 (Actual on farm data)

But…..

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- Ideally, we need both to be at TIER 3 (Actual on farm data)

But…..

The challenge of selecting an appropriate soil organic carbon simulation model: A comprehensive global review and validation assessment

Agata Garsia | Antoine Moinet | Carmen Vazquez | Rachel E. Creamer | Gabriel Y. K. Moinet

WUR, June 2023

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Delivering at the Farm Level

An EIP Operational Group - Accelerating Seven N. Irish Farms towards Net Zero

Roger & Hilary Bell *Sheep*

Simon Best *Arable & Beef*

Patrick Casement *Sheep & Sucklers*

John Egerton *Suckler Beef*

John Gilliland *Willow & Dry Stock*

Hugh Harbison *Dairy*

Ian McClelland *Dairy*

Department of Agriculture, Environment and Rural Affairs
www.daera-ni.gov.uk

The European Agricultural Fund for Rural Development: Europe investing in rural areas

rural Development Programme

AgriSearch Driving Excellence & Innovation

BIRNIE CONSULTANCY

DEVENISH Beyond Nutrition

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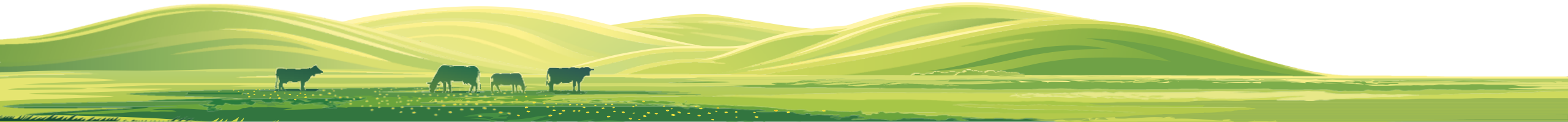
ACCELERATING FARMING TOWARDS CARBON NEUTRALITY

Where did we start…… We Learnt our Numbers…..

Baselined & Benchmarked…..



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Where did we start…… We Learnt our Numbers…..

Baselined & Benchmarked…..

- GHG Emissions
- Carbon Sequestration
- Carbon Stocks in Soil
- Carbon Stocks in Trees
- Net Carbon Position
- Behavioural Change
- Delivering other Public Goods

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Gross Emissions for the seven ARC Zero farms

Using agrecalc TIER 2 Emissions Module

2021 Agrecalc Analysis	Enterprises	Gross Emissions t CO2-e/yr
Ian McClelland	Dairy	1,101
Hugh Harbinson	Dairy	2,009
John Egerton	Beef & Sheep	1,475
Roger & Hilary Bell	Sheep with Beef	754
Simon Best	Arable with Beef	1,799
Patrick Casement & Trevor Butler	Beef & Sheep	492
John Gilliland	Willows with Dry Cows	151

Gross Emissions Variability within UK Livestock Systems

Recognising & Tackling a Huge Problem…..

1st Case Study - Milk Production	Nos. of Farms	Minimum Footprint kg CO2e/ kg FPC Milk	Average Footprint kg CO2e/kg FPC Milk	Maximum Footprint kg CO2e/kg FPC Milk
Cross Section of Dairy Systems	720	**0.69**	**1.31**	**5.71**

2nd Case Study - Beef Production	Nos. of Farms	Minimum Footprint kg CO2e/kg dwt	Average Footprint kg CO2e/kg dwt	Maximum Footprint kg CO2e/kg dwt
Spring Calving, Lowland Suckler	1,044	**7.56**	**37.77**	**395.18**

Source: Agrecalc.com; Period: 2018 -2022; August 2023

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Gross Sequestration for the seven ARC Zero farms

Using agrecalc TIER 1 Sequestration Module

2021 Agrecalc Analysis	Enterprises	Gross Sequestration t CO2-e/yr
Ian McClelland	Dairy	309
Hugh Harbinson	Dairy	549
John Egerton	Beef & Sheep	444
Roger & Hilary Bell	Sheep with Beef	456
Simon Best	Arable with Beef	738
Patrick Casement & Trevor Butler	Beef & Sheep	548
John Gilliland	Willows with Dry Cows	156

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Net Carbon as a Percentage of Gross Emissions

Using agrecalc TIER 1 Sequestration Module

2021 Agrecalc Analysis	Enterprises	Gross Emissions t CO2-e/yr	Gross Sequestration t CO2-e/yr	Net Emissions t CO2-e/yr	% Reduction
Ian McClelland	Dairy	1,101	309	792	28%
Hugh Harbinson	Dairy	2,009	549	1,459	27%
John Egerton	Beef & Sheep	1,475	444	1,031	30%
Roger & Hilary Bell	Sheep with Beef	754	456	298	60%
Simon Best	Arable with Beef	1,799	738	1,061	41%
Patrick Casement & Trevor Butler	Beef & Sheep	492	548	-56	111%
John Gilliland	Willows with Dry Cows	151	156	-4	103%

No two farms are the same…..

Some farms will find the journey easier than others……

agrecalc

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No two farms are the same…..

Some farms will find the journey easier than others……

Some farms are beyond Net Zero already…..

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Carbon Sequestration – New Measuring Technologies

When repeated every 5 yrs. measures actual change, essential for TIER 3

Aerial LiDAR Survey
at 40 scans per metre

Soil Sampling to one
metre deep

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Measuring Carbon in Trees & Hedges

Using Aerial LiDAR at Brook Hall

A. Higgins 2021

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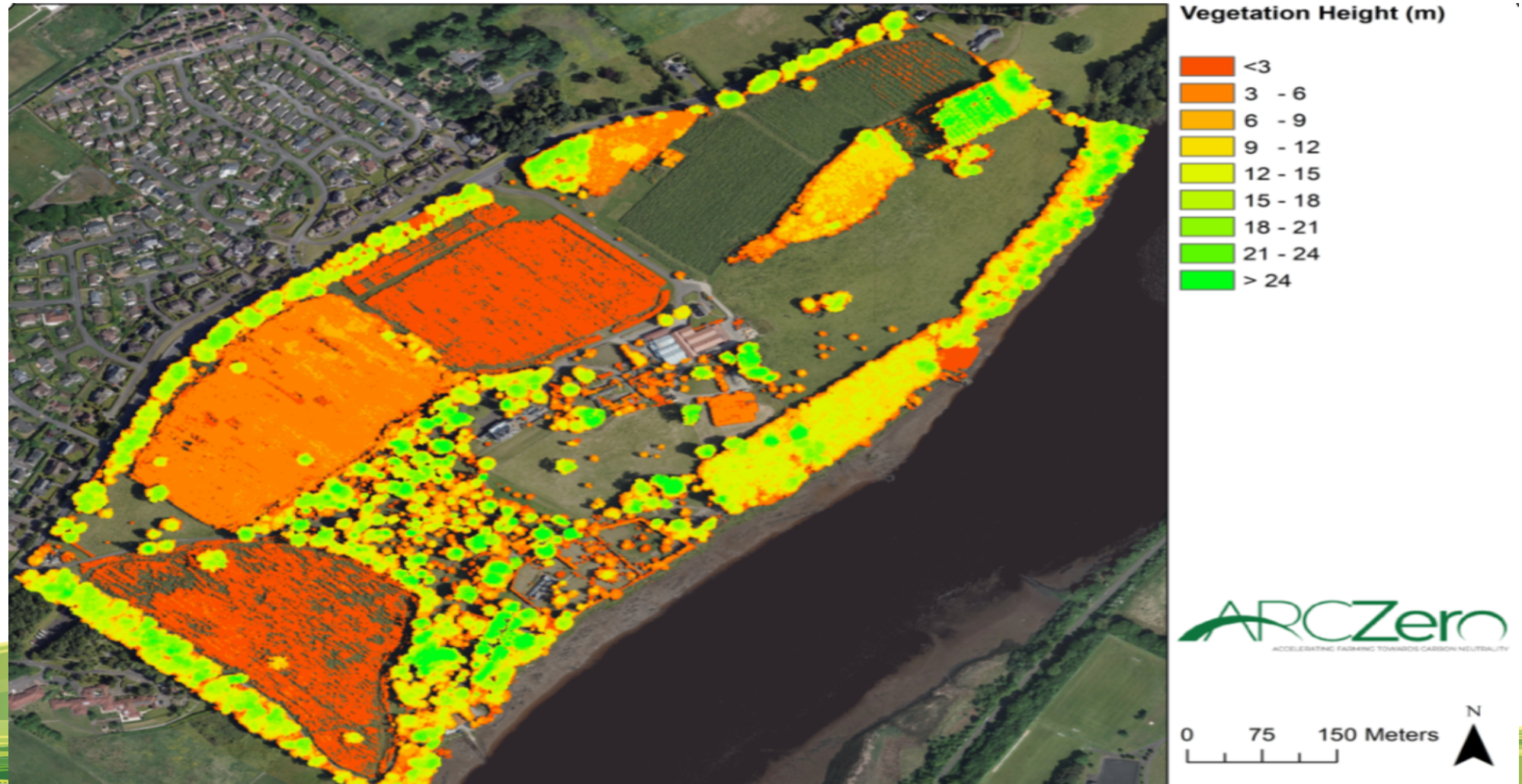

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Measuring Carbon in Trees & Hedges

Using Aerial LiDAR at Brook Hall

A. Higgins 2021

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	Brook Hall Estate Totals					
Vegetation type	Hedge Length (km)	AGB (t)	C (t)	BGB* (t)	C (t)	Total C (t)
Hedge 0-4m	0.78	14.92	7.1	2.86	1.3	**8.5**
Hedge 4-7m	0.35	6.36	3.0	1.22	0.6	**3.6**
Hedge 7-10m	0.25	10.32	4.9	1.98	0.9	**5.9**
Hedge >10m	1.00	156.17	74.5	29.99	14.1	**88.6**
Total Hedges	**2.38**	**187.77**	**89.5**	**36.05**	**16.94**	**106.49**
	Canopy Area (ha)					
Single Trees	1.87	494.78	236.0	95.00	44.6	**280.6**
Deciduous Woodland	17	1352.74	645.1	259.73	122.1	**767.2**
Coniferous Woodland	0.09	6.17	2.9	1.27	0.6	**3.5**
Biomass	28.96	337.61	161.0	64.82	30.5	**191.5**
Total	**47.92**	**2,379.07**	**1,134.6**	**456.8**	**214.7**	**1,349.3**

AGB
Above Ground Biomass

BGB
Below Ground Biomass

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Measuring Carbon in the Soil

Stratified for different Land Uses & Land Managements at Brook Hall

Land Category	Total ha	Soil pH	Av. LOI/SOM	No. of Soil Cores	No. of Samples	Av. C. 0-10cm	Av. C. 0-30cm	Av. C/ha	Av. C/Category
<10% Soil Org. Matter, Short Rotation Willow Coppice	34.2ha	pH 6.2	7.60%	55	11	4.20%	3.20%	87.1t	2,978.8t
<10% Soil Org. Matter, Permanent Grass, no slurry/FYM, only grazed	1.4ha	pH 6.3	9.30%	15	3	4.90%	3.10%	87.3t	122.2t
<10% Soil Org. Matter, Decideous Woodland	0.5ha	pH 5.3	9.10%	15	3	5.80%	4.10%	114.7t	57.4t
10-20% Soil Org. Matter, Permanent Grass, no slurry/FYM, only grazed	12.9ha	pH 6.1	13.70%	30	6	5.50%	3.40%	93.7t	1,208.7t
10-20% Soil Org. Matter, Silvopasture, no slurry/FYM	4ha	pH 4.8	14.80%	25	5	5%	2.80%	81.6t	326.4t
10-20% Soil Org. Matter, Decideous Woodland	4.6ha	pH 5.3	13%	25	5	6.90%	4.90%	136t	625.6t
Totals	**57.6ha**			**165 Soil Cores**	**33 C. Samples**			**92.3t/ha**	**5,319.1t of C.**

Soil Carbon at Brook Hall = 5,319 t of C, or 19,468 of CO_2e

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Total Carbon Stocks across ARC Zero farms……

Total ARC Zero CO2e Stocks	Soil Carbon	Tree Carbon	Total Carbon	% C in Soil
Ian McClelland	31,813t	1,310t	33,123t	96%
Hugh Harbison	68,054t	1,969t	70,023t	97%
John Egerton	31,813t	1,310t	33,123t	96%
Roger & Hilary Bell	50,819t	688t	51,507t	98%
Simon Best	237,915t	6,493t	244,407t	97%
Patrick Casement & Trevor Butler	54,556t	4,022t	58,578t	93%
John Gilliland	19,468t	4,937t	24,405t	80%
		Total	515,166t	

ARC Zero farms manage 515,166t of CO2e, 97% is within the Soil

In 2027, Perhaps 540,000t? Who will reward the additional carbon stored?

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Empowered, ARC Zero Farmers made the following Changes

For both Mitigation & Building Carbon Stocks…

- Improving efficiency – genetics, age of slaughter, cow size, animal health
- Improving Soil pH – improving nutrient uptake & growth of clover
- Increasing the use of Legumes & Multi Species Pastures
- Reducing the use of Nitrogen fertiliser
- Planting trees & Hedgerow Management
- Grazing Willows

- Installing Renewables……..

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The Resultant Improvements Observed over two years…..

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Comparison between 2021 & 2023, gross emission/unit of output

GHG Reduction 2021 to 2023	Enterprises	2021	2023	% Reduction in GHGs
Ian McClelland	Dairy	1.3kg CO2e/kg FPC Milk	1.1kg CO2e/kg FPC Milk	13%
Hugh Harbison	Dairy	1.25kg CO2e/kg FPC Milk	1.2kg CO2e/kg FPC Milk	4%
John Egerton	Beef & Sheep	32.8kg CO2e/kg dwt	25.6kg CO2e/kg dwt	22%
Roger & Hilary Bell	Lamb	22kg CO2e/kg dwt	15.7kg CO2e/kg dwt	28%
Simon Best	Wheat	0.99kg CO2e/kg grain	0.47kg CO2e/kg grain	53%

Determining Factors – Price of Fertiliser

- Timing of sowing legumes
- Livestock ill health

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Reporting Methane using GWP*, as well as GWP100 Methodology

IOP Publishing Environ. Res. Lett. 18 (2023) 084014 https://doi.org/10.1088/1748-9326/ace204

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LETTER

Are single global warming potential impact assessments adequate for carbon footprints of agri-food systems?

Graham A McAuliffe[1,*], John Lynch[2], Michelle Cain[3], Sarah Buckingham[4], Robert M Rees[4], Adrian L Collins[1], Myles Allen[5], Raymond Pierrehumbert[5], Michael R F Lee[6] and Taro Takahashi[1,7,8]

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Reporting Methane using GWP*, as well as GWP100 Methodology

2021 Agrecalc Analysis	Enterprises	GWP100 % Reduction	GWP* % Reduction
Ian McClelland	Dairy	28%	47%
Hugh Harbinson	Dairy	27%	51%
John Egerton	Beef & Sheep	30%	63%
Roger & Hilary Bell	Sheep with Beef	60%	126%
Simon Best	Arable with Beef	41%	50%
Patrick Casement & Trevor Butler	Beef & Sheep	111%	325%
John Gilliland	Willows with Dry Cows	103%	251%

Assumptions:

- Livestock Nos. Mirrored UK National Herd Trend over last 20 yrs
- IPCC AR4 CO2e & GWP* conversion values
- GWP* calculation is equation 3, Lynch et al. 2020

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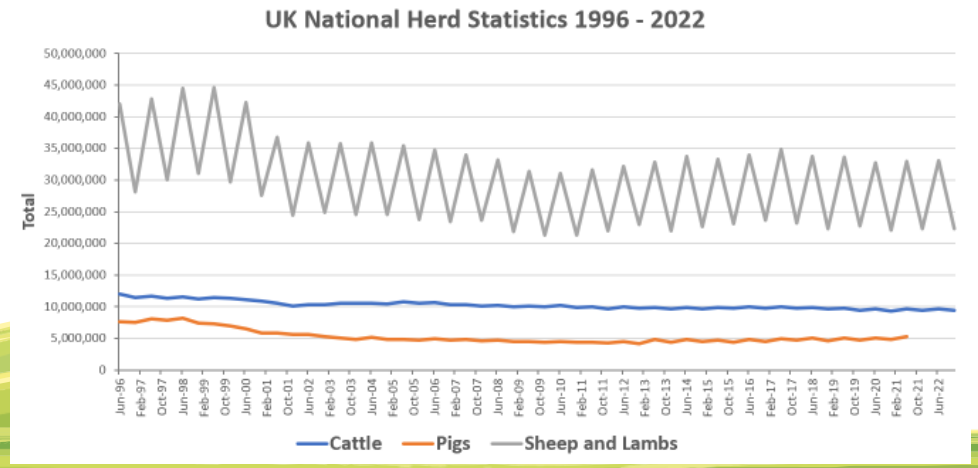

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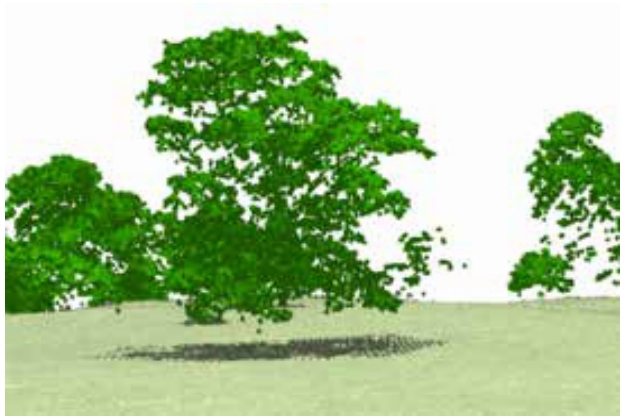
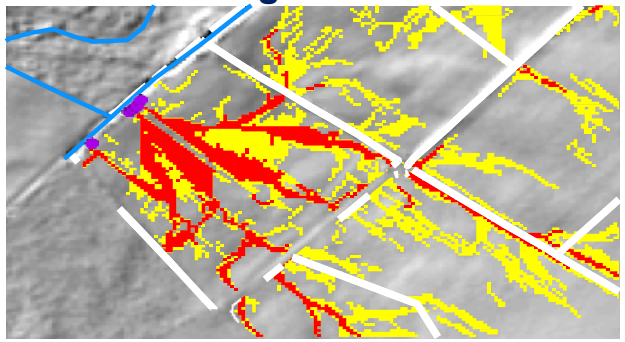
Delivering Multiple Public Goods - Not Single Agendas

Producing Nutritious Food & Tackling Malnutrition

Delivering Soil Improvement Both Fertility & Health



Accelerating Carbon Sequestration, Both Above & Below Ground



Improving Water Quality by Reducing Over Land Flow

Optimising Biodiversity, Especially Below Ground

Generating Profits

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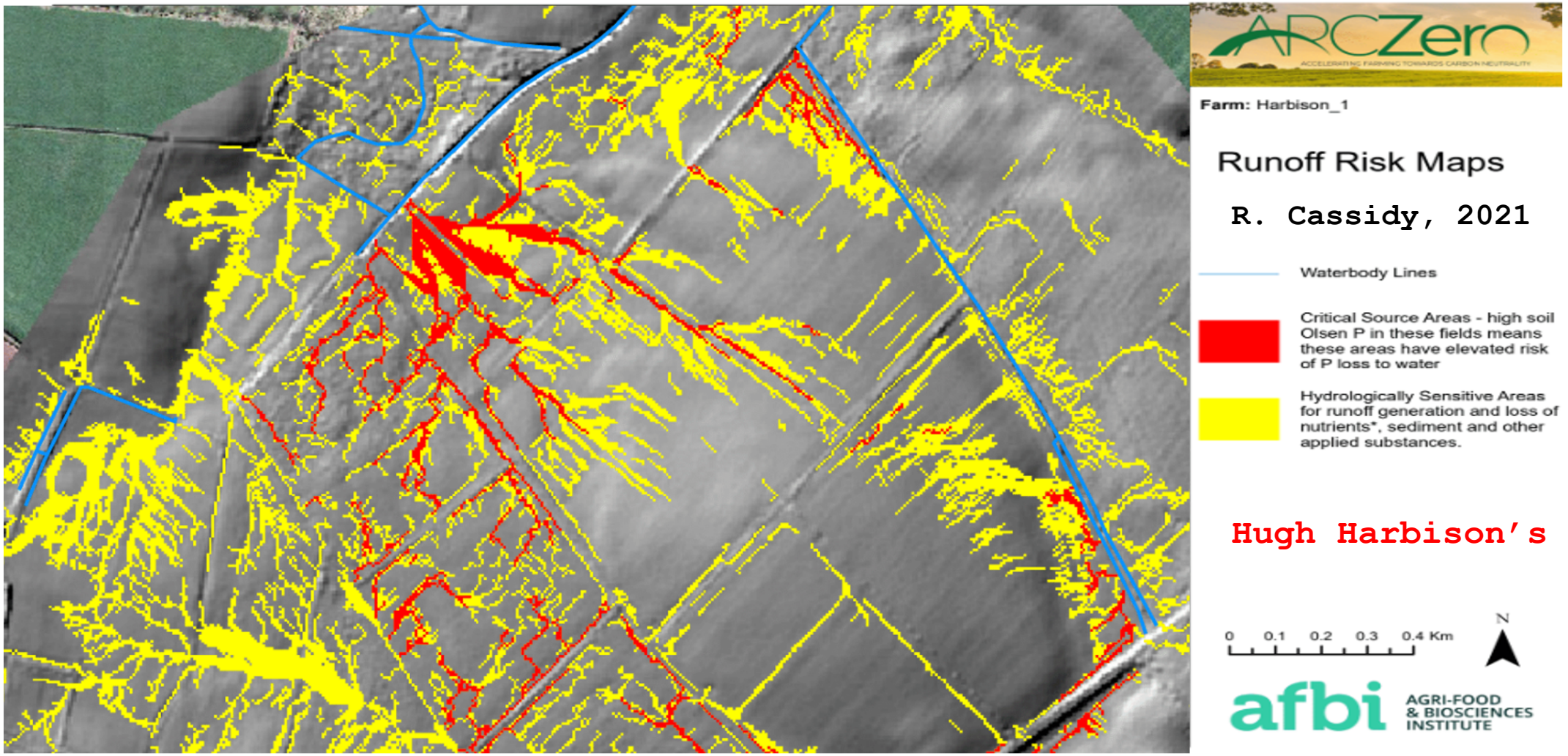
Delivering Multiple Public Goods Simultaneously

Using LiDAR & Phosphate Soil Surveys to create “Run Off Risk” Maps



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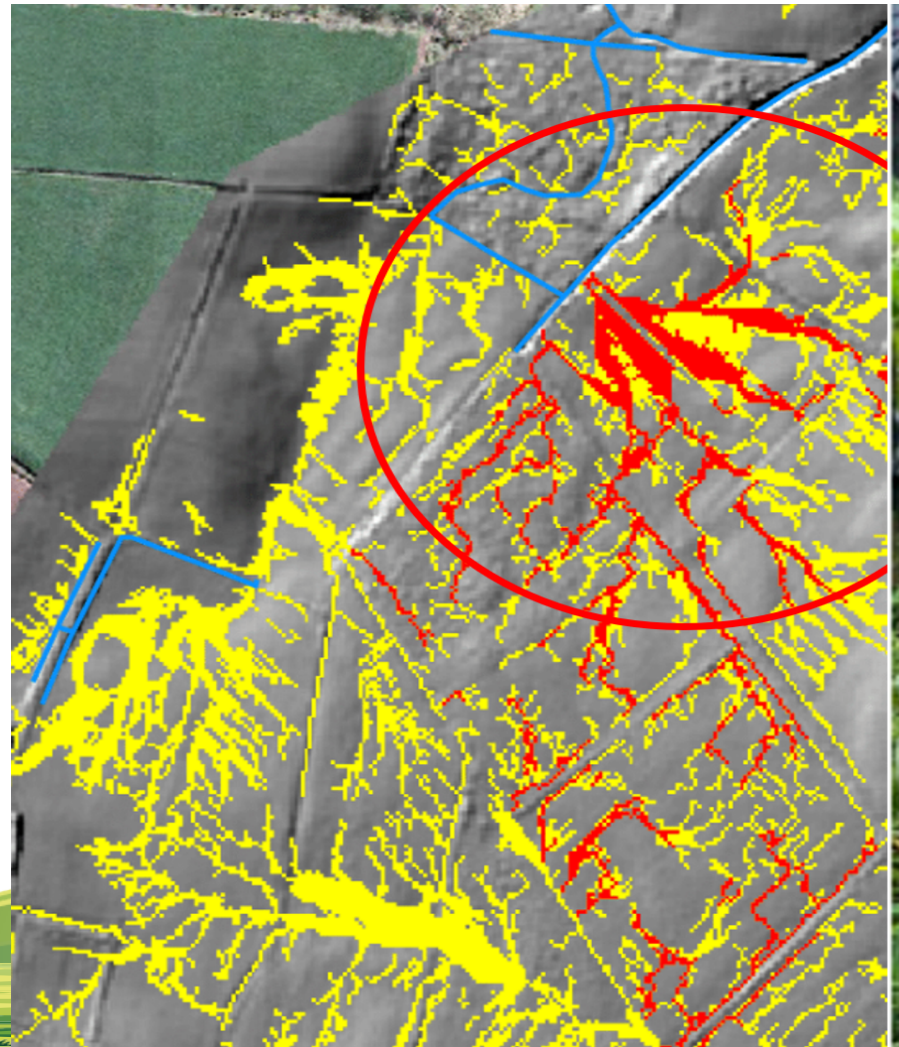
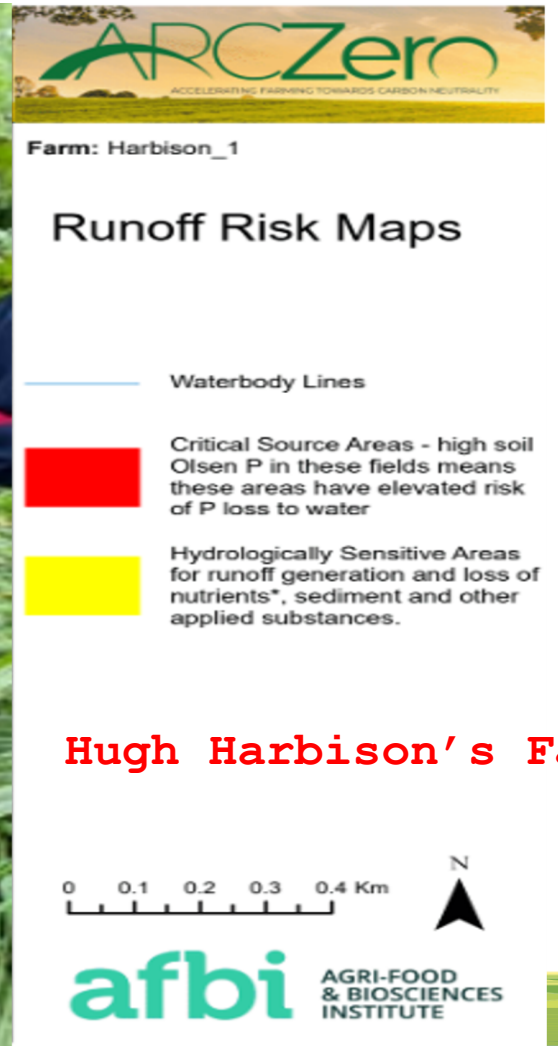
Delivering Multiple Public Goods Simultaneously

Multi Species Pastures – Water Infiltration, Biodiversity, Carbon Sequestration





COMPARING DIFFERENT LAND USES

Willow SRC (28 Yrs. Old)

Permanent Pastureland (200 Yrs. Old)

Silvopasture (120 Yrs. Old)

D. Woodland (30 Yrs. Old)

D. Woodland (250 Yrs. Old)

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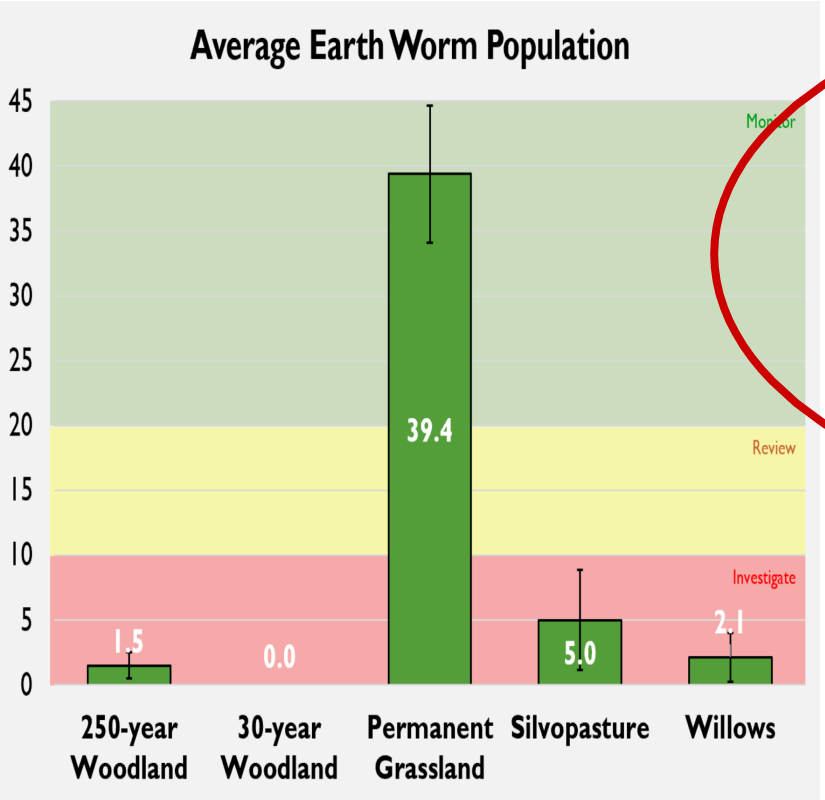
Delivering Multiple Public Goods Simultaneously

Increasing Biodiversity Under the Soil…. Role of Livestock Faeces….

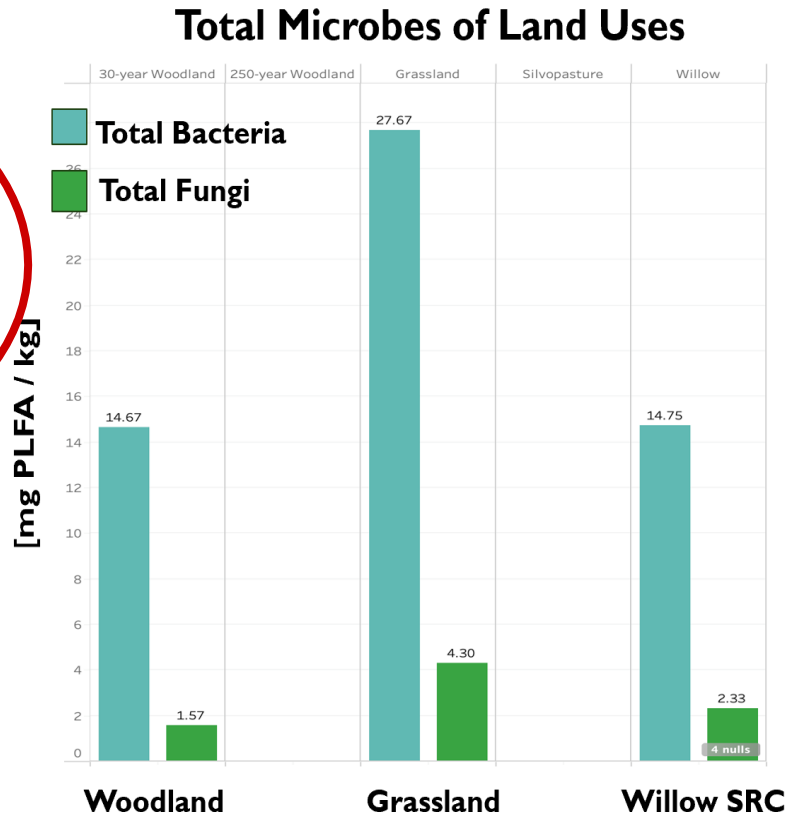


The age of extinction

More than half of Earth's species live in the soil, study finds

Soil estimated to be home to 90% of world's fungi, 85% of plants and more than 50% of bacteria, making it the world's most species-rich habitat

National Academy of Science, Aug 23



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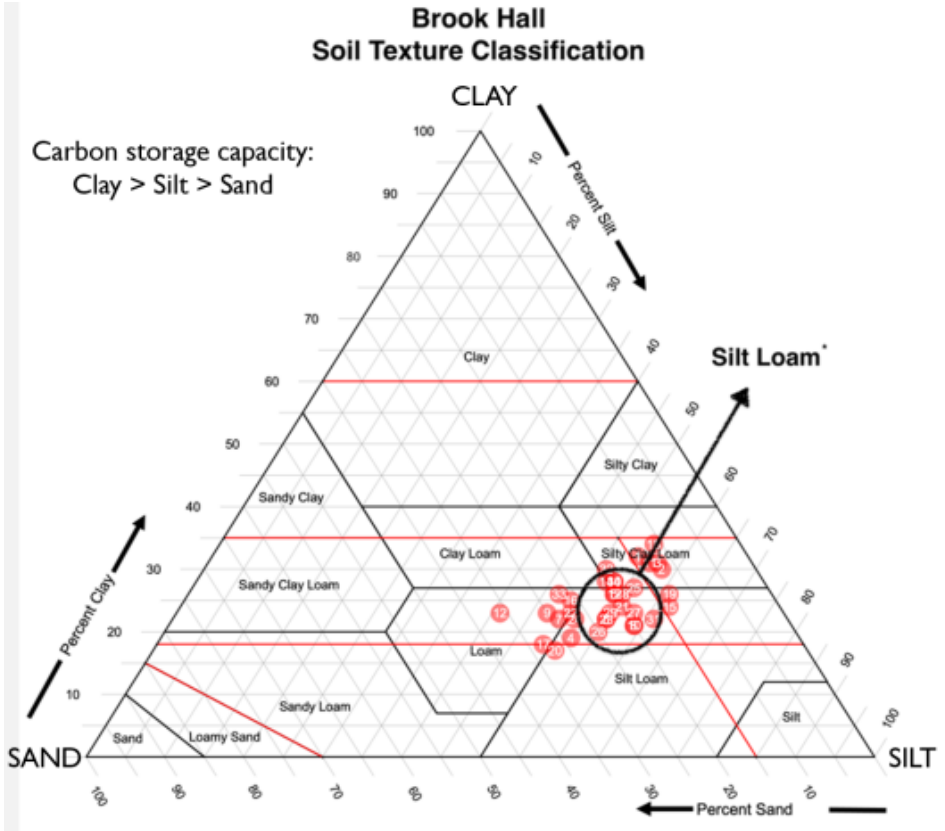
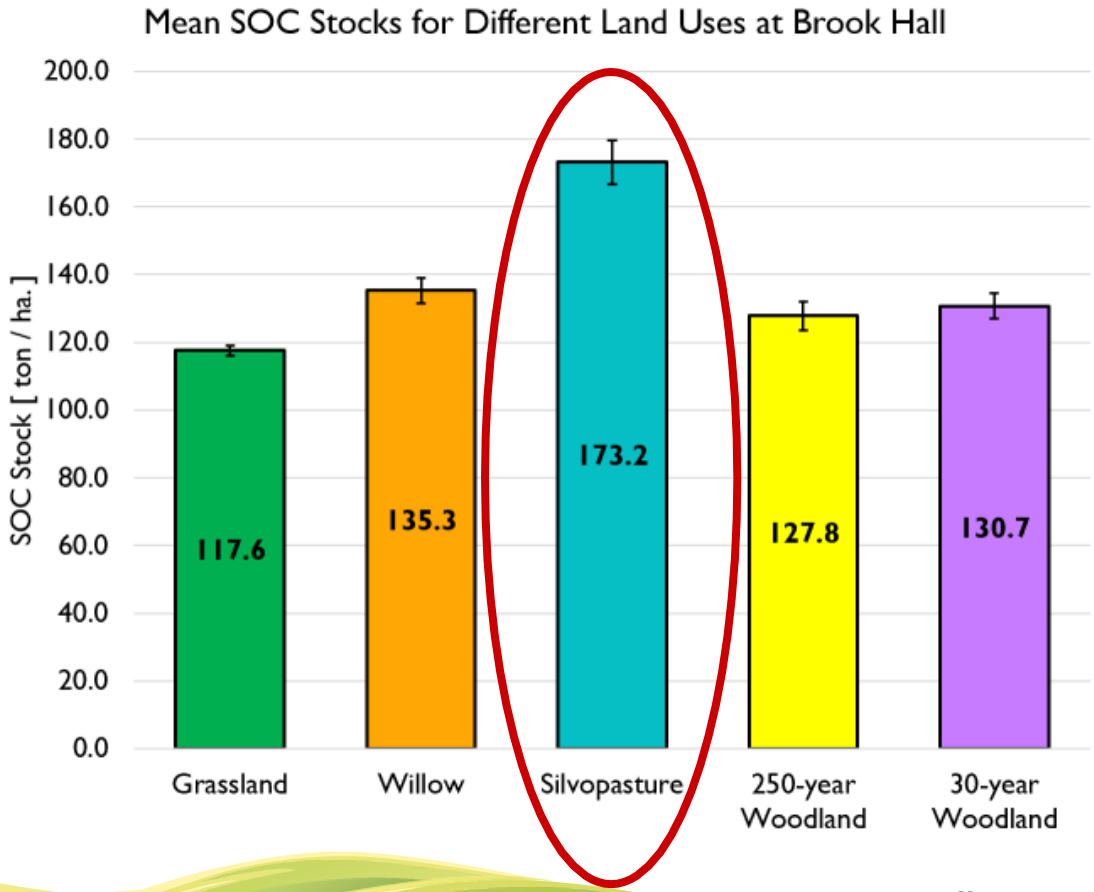
Role of different Land Uses in building Soil Organic Carbon

Diversity of root architecture is best…. Monocultures are not the right answer….





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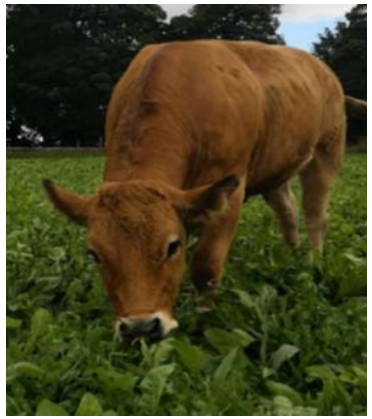
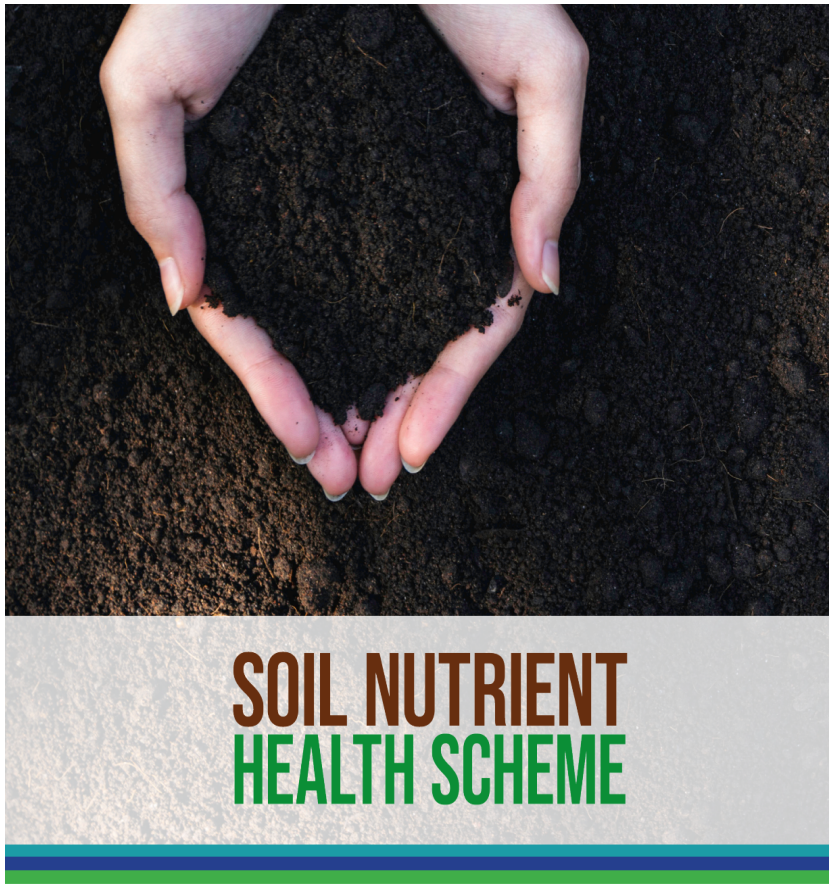
- ARC Zero registers as a Community Interest Company

- Co-op Foundation awards £97,000 to ARC Zero to reducing Soya Bean & Artificial Nitrogen Fertiliser



Is ARC Zero Ambition Possible at a Regional Level……



- £45m N. Ireland Scheme to base line every field, tree & hedge
- Carried out over four years, one Zone per year
- Online training, empowering farmers with their own Data
- Output - Soil Fertility, Carbon Stocks & Run off Risk Maps
- Opened May 2022, plan to repeat every five years
- 92% Farmer uptake in Zone One (25% of N. Ireland)
- Soil Nutrient Health Scheme | Agri-Food and Biosciences Institute (afbini.gov.uk)

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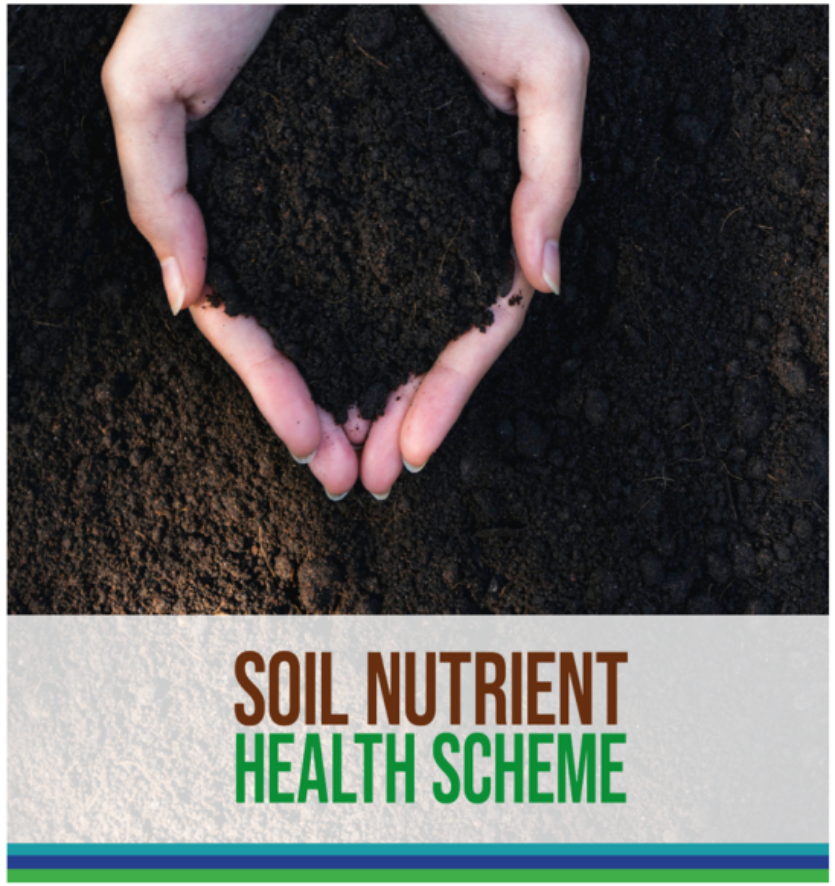

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Essential…… Government Recognition…….
Measuring, Reporting & Verification is a Public Good

Delivering At a National Scale…..
Australian Carbon Credit Units (ACCU)

ARCHER PASTORAL

AR

SOC measured to 1 metre, 7 years apart
53kg CO2e sequestered /kg of live weight grazed
Sold at a Premium for AUS$93/t

Carbon Sources & Sinks, Global Livestock Systems

Measuring & Managing Livestock Farms Towards Net Zero

Innovation, Precision Measurement, Management, Education & Empowerment

Key to Positive Behavioural Change & the Securing of the Future of Global Livestock Systems

john.gilliland@brookhall.org

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