
Welcome to
Yatesbury
Richard Gantlett
which is sequestering (capturing from the air)
10x more carbon
than it is emitting

Yatesbury

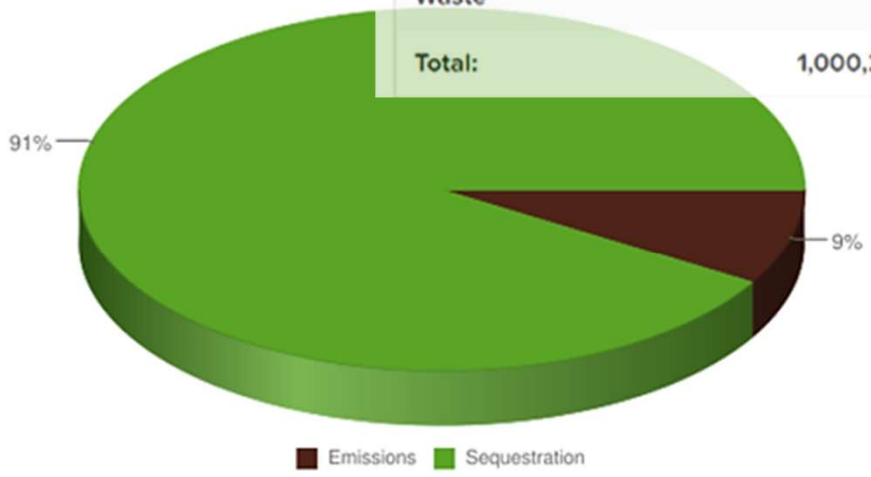
Emissions

	CO_2e (kg/year)	% total emissions
Fuel	97,581	9.76%
Materials	4,815	0.48%
Capital Items	31,988	3.20%
Livestock	727,836	72.76%
Fertility	136,360	13.63%
Agro-chemicals	0	0.00%
Distribution	1,557	0.16%
Waste	130	0.01%
Total:	**1,000,267**	**100%**

Sequestration

	CO_2 (kg/year)	% total sequestration
Field Margins	11,892	0.11%
Soil Organic Matter	10,273,747	96.71%
Orchards & Vineyard	0	0.00%
Wetland	0	0.00%
Woodland & Hedges	337,284	3.18%
Woodland (detailed analysis)	0	0.00%
Total	**10,622,923**	**100.00%**

Carbon Balance



650 ha

Farm Carbon Audit 2019

Farm Carbon Toolkit

TOTAL CARBON BALANCE: -9,622,657 CO_2 (kg/year)

On-farm PhD research Results 1

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The diverse ley cropping system in this study
Rotation 2 years in 7
Whether shredded crop residues were retained or not,
Resulted in increases in soil organic matter (SOM)
2-3 times Faster than difficult to achieve global target of 4 per 1000 (Minasny 2017)

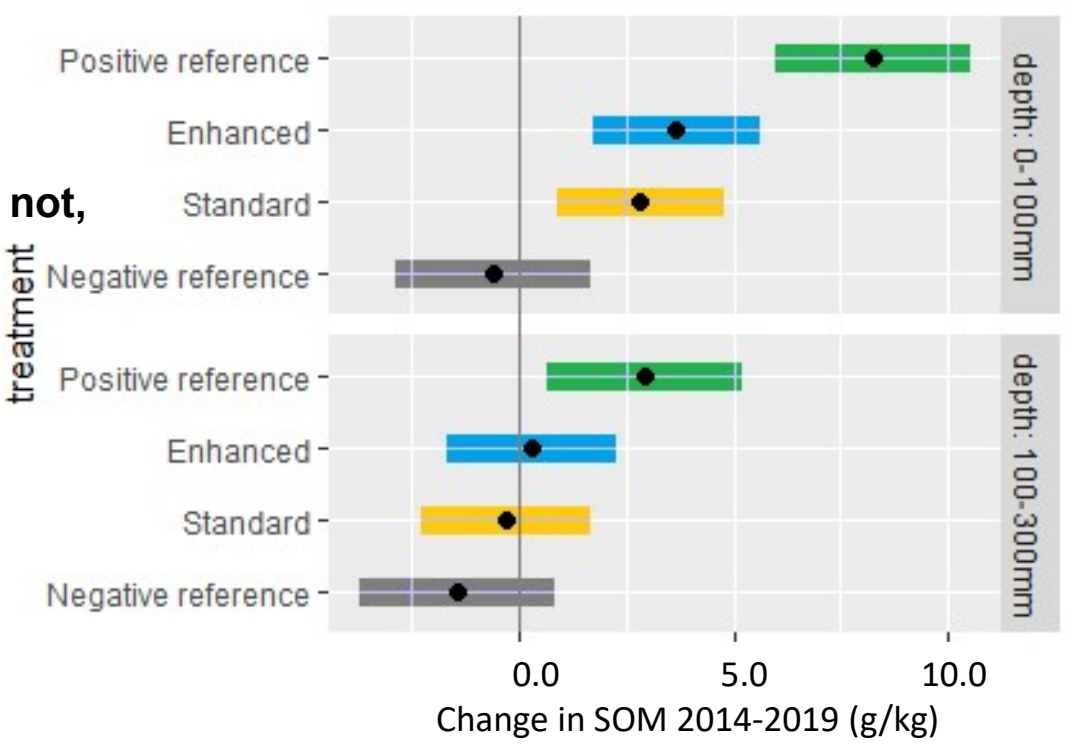

Figure 1
Change in SOM between 2014 to 2019 ($g.kg^{-1}$)

Dots show predicted means by treatments and depth, bars represent 95% confidence intervals

In four plant biomass treatments:
positive reference (5 year ley),
enhanced (retention of all crop residue in situ),
standard (removal of residues, business as usual),
and negative reference (fallow).

On-farm PhD research Results 2

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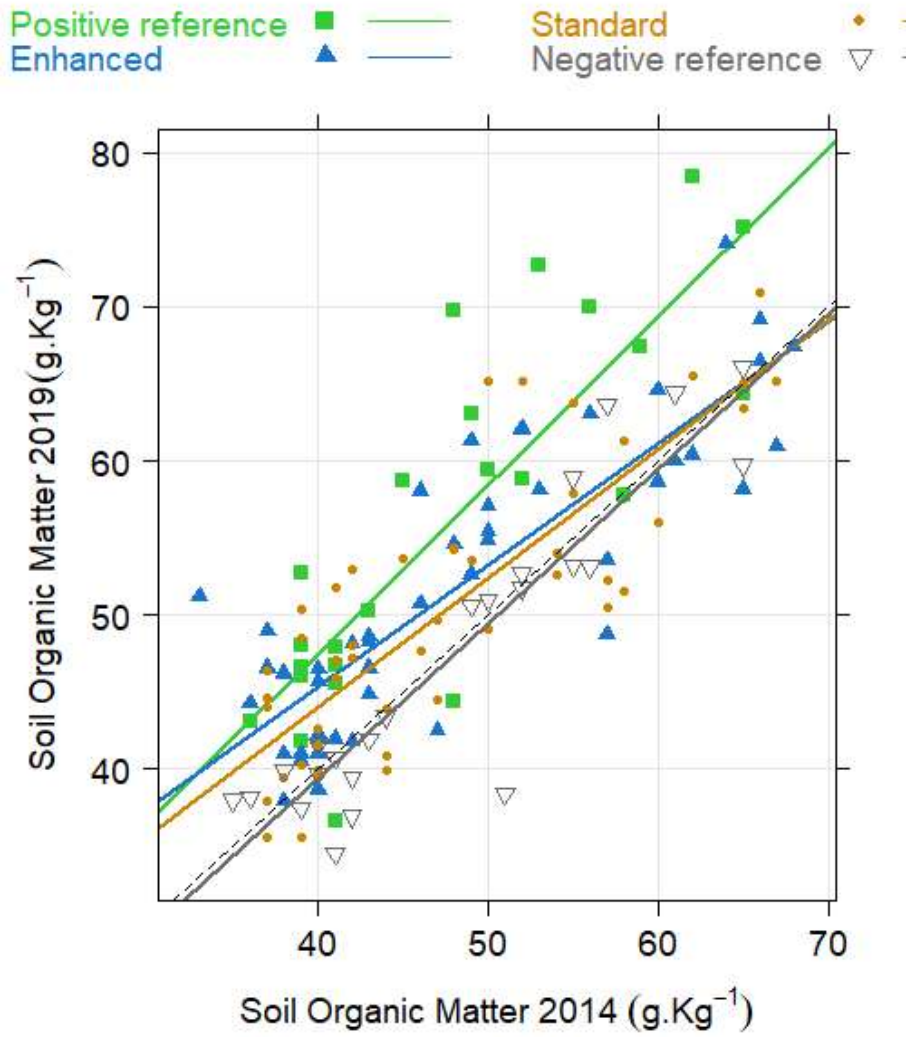
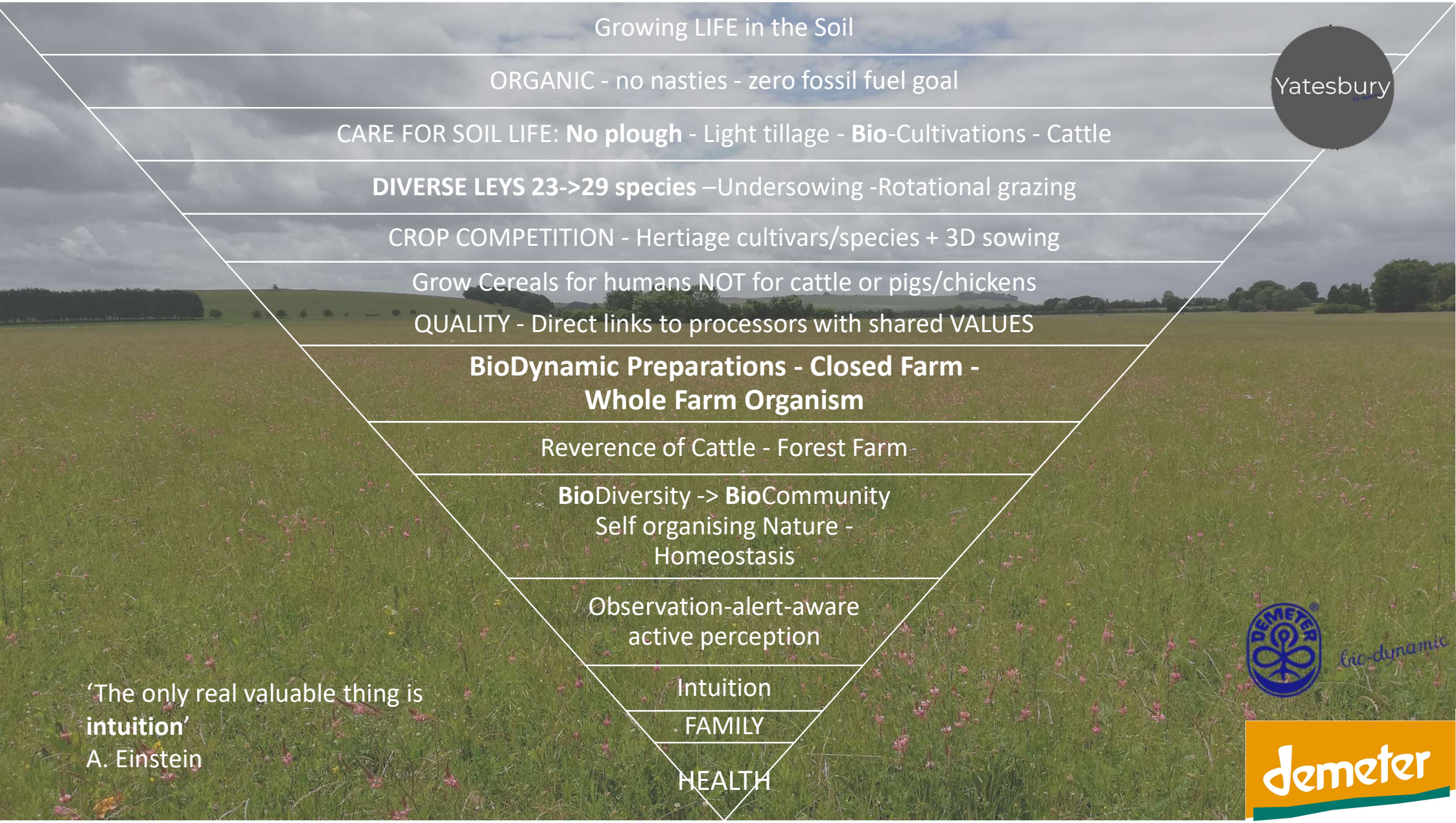


Lengthening the ley phase duration
1. increased carbon sequestration in soil organic matter
2. and increased its carbon sequestration potential.

Figure 2 Scatterplot of SOM 2014 against SOM 2019 at 0-100 mm soil depth with linear regression lines. Experimental treatments: positive reference (green squares and line), enhanced (blue triangles and line) standard (gold circles and line) and negative reference (grey diamonds and line). The dashed line represents the one-to-one line.

(Gantlett R, 2024)


Yatesbury
bio-dynamic
©Microsoft
"……We need not wait to see what others do" M. Gandhi
Be the change you want to see
Feedback
2500 feet
1 km


Growing LIFE in the Soil
ORGANIC - no nasties - zero fossil fuel goal
CARE FOR SOIL LIFE: **No plough** - Light tillage - **Bio**-Cultivations - Cattle
DIVERSE LEYS 23->29 species –Undersowing -Rotational grazing
CROP COMPETITION - Hertiage cultivars/species + 3D sowing
Grow Cereals for humans NOT for cattle or pigs/chickens
QUALITY - Direct links to processors with shared VALUES
BioDynamic Preparations - Closed Farm - Whole Farm Organism
Reverence of Cattle - Forest Farm
BioDiversity -> **Bio**Community
Self organising Nature - Homeostasis
Observation-alert-aware active perception
Intuition
FAMILY
HEALTH
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'The only real valuable thing is **intuition**'
A. Einstein
DEMETER
bio-dynamic
demeter


Health
is infectious


the health of
Soil, Plant, Animal, Human, Wildlife
& Planet
are one and indivisible (Balfour 1948)


Yatesbury
Yatesbury Diverse Ley
23->29 species
33->44 varieties

How Plants Feed (Alex Podolinsky, Bradshaw 2024)

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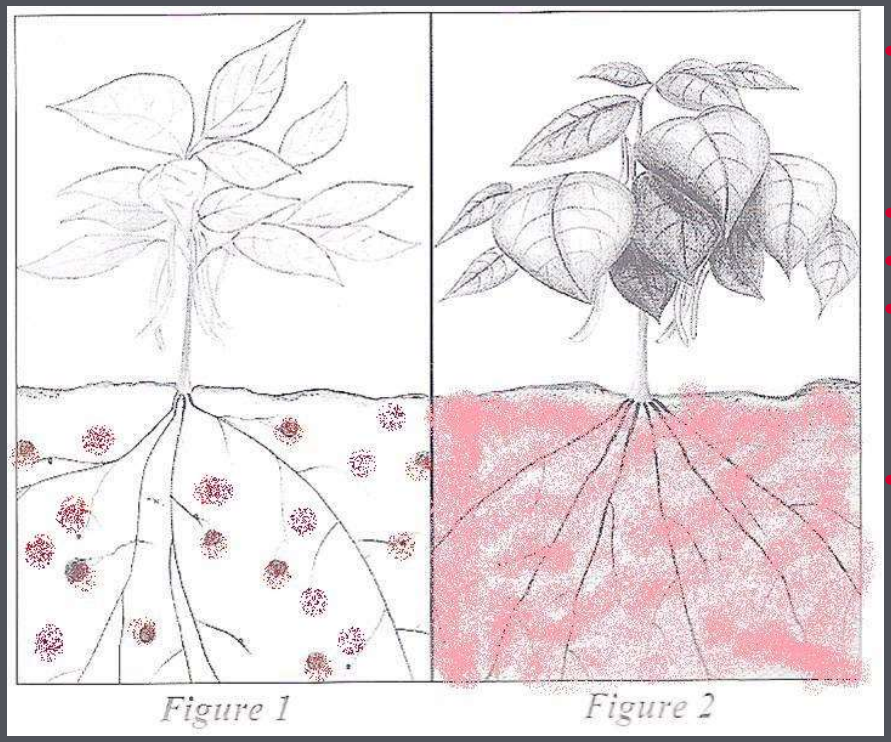
- Figure 1
- Nutrients held in stable soil material

- Plant drinking through transpiration
- Plant feeding through mycorrhizal exchange of nutrients
- Plants only take up as much nutient as they need and separately drink as much water as they need

- Balanced plants

- Red indicates nutrient location

Alex Podolinsky (2000)



- Figure 2
- Nutrients held in soil water

- When plants transpire, they drink taking up water, but they also take up food without choice at the same time
- i.e. Force fed
- This causes cell bloating
- Indicated by **blue green** leaf colour commonly seen in cereals/grasses

- Leads to:
  - pest and disease access
  - bitterness in fruits/leaves
  - (see area around cow pats
  - which cows won't eat).

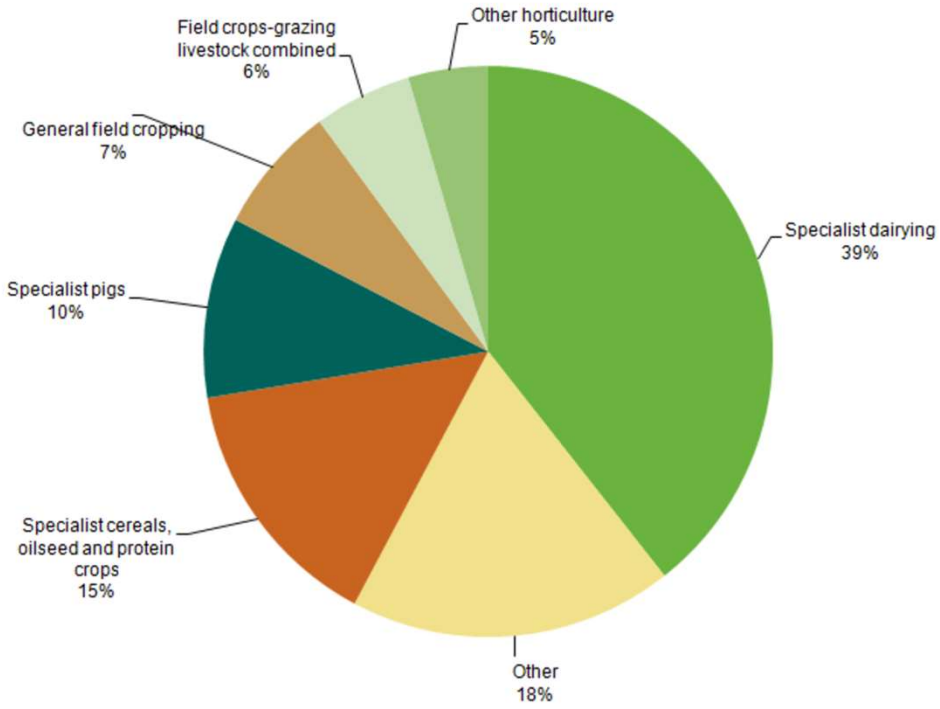

Everything
comes from the
soil
including
Climate Change

Context

- What are the problems that we are experiencing? Personal, Country, Global
- how can we make a positive contribution?
- can we be part of the solution?
- Can agri-techology solve the problems that we face?
- What is agritech?
- Agri-techniques?
- Estonian situation?

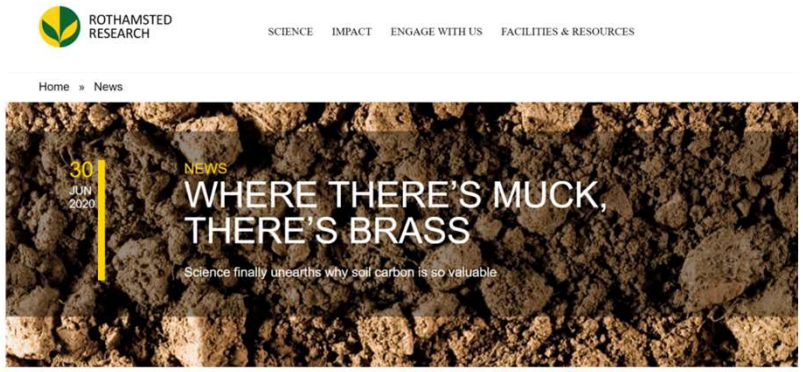
- Let's share our thoughts in a few minutes in the chat.

Figure 3: Standard output by main type of farming, Estonia, 2010 (%)
Source: Eurostat



Brown plumes of soil flowing into coastal zone (Jones 2016).

Need to learn about glyphosate watch this:
Here is the video https://youtu.be/NH_u57IJjKQ
from someone I met recently it is long but worth it.



Blanco-Canqui (2008)

Soil Science Society of America Journal
SSSA Soil Science Society of America

No-Tillage and Soil-Profile Carbon Sequestration: An On-Farm Assessment

Humberto Blanco-Canqui*
R. Lal
Carbon Management and Sequestration Center
FAES/OARDC, School of Natural Resources
2021 Coffey Rd.
Ohio State Univ.
Columbus, OH 43210-1085

No-tillage (NT) farming is superior to intensive tillage for conserving soil and water, yet its potential for sequestering soil organic carbon (SOC) in all environments as well as its impacts on soil profile SOC distribution are not well understood. Thus, we assessed the impacts of long-term NT-based cropping systems on SOC sequestration for the whole soil profile (0–60-cm soil depth) across 11 Major Land Resource Areas (MLRAs: 121, 122, and 125 in Kentucky; 99, 124, 139A in Ohio; and 139B, 139C, 140, 147, and 148 in Pennsylvania) in the eastern United States. Soil was sampled in paired NT and plow tillage (PT) based cropping systems and an adjacent woodlot (WL). No-tillage farming impacts on SOC and N were soil specific. The SOC and N concentrations in NT soils were greater than those in PT soils in 5 out of 11 MLRAs (121, 122, 124, 139A, and 148), but only within the 0- to 10-cm depth. Below 10 cm, NT soils had lower SOC than PT soils in MLRA 124. The total SOC with NT for the whole soil profile (0–60 cm) did not differ from that with PT ($P > 0.10$) in accord with several previous studies. In fact, total soil profile SOC in PT soils was 50% higher in MLRA 125, 21% in MLRA 99, and 41% in MLRA 124 compared with that in NT soils. Overall, this study shows that NT farming increases SOC concentrations in the upper layers of some soils, but it does not store SOC more than PT soils for the whole soil profile.

Abbreviations: MLRA, Major Land Resource Area; NT, no-tillage; PT, plow tillage; SOC, soil organic carbon; WL, woodlot.

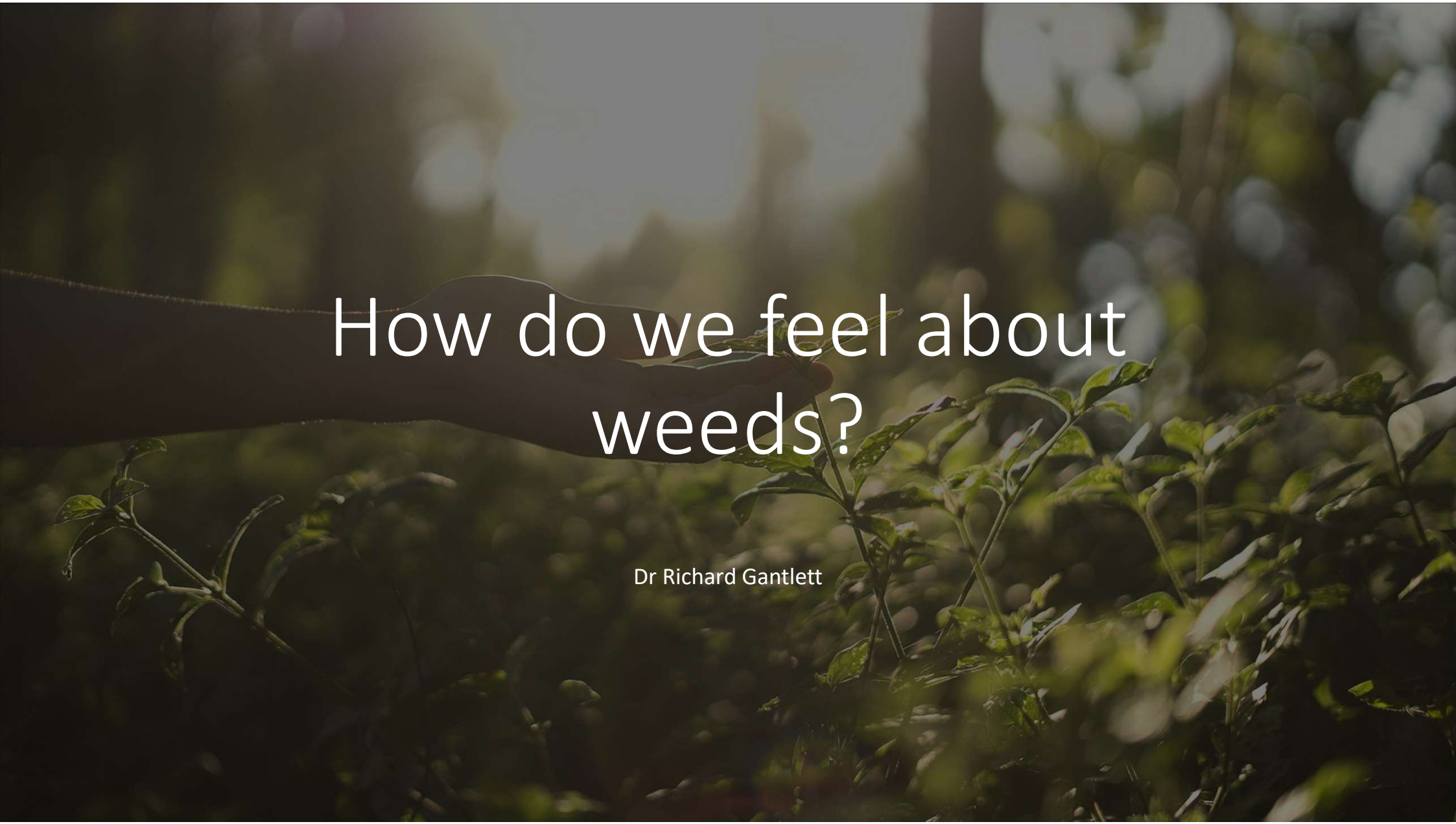
Neal (2020)

SCIENTIFIC REPORTS
nature research
Check for updates

Soil as an extended composite phenotype of the microbial metagenome

Andrew L. Neal[1]✉, Aurélie Bacq-Labreuil[2,4], Xiaoxian Zhang[3], Ian M. Clark[3], Kevin Coleman[3], Sacha J. Mooney[2], Karl Ritz[2] & John W. Crawford[3,5]

We use a unique set of terrestrial experiments to demonstrate how soil management practises result in emergence of distinct associations between physical structure and biological functions. These associations have a significant effect on the flux, resilience and efficiency of nutrient delivery to plants (including water). Physical structure, determining the air–water balance in soil as well as transport rates, is influenced by nutrient and physical interventions. Contrasting emergent soil structures exert selective pressures upon the microbiome metagenome. These selective pressures are associated with the quality of organic carbon inputs, the prevalence of anaerobic microsites and delivery of nutrients to microorganisms attached to soil surfaces. This variety results in distinctive gene assemblages characterising each state. The nature of the interactions provide evidence that soil behaves as an extended composite phenotype of the resident microbiome, responsive to the input and turnover of plant-derived organic carbon. We provide new evidence supporting the theory that soil-microbe systems are self-organising states with organic carbon acting as a critical determining parameter. This perspective leads us to propose carbon flux, rather than soil organic carbon content as the critical factor in soil systems, and we present evidence to support this view.



How do we feel about weeds?

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Weeds Science

1. Why do we worry about weeds?
2. Identification and classification
3. Context
4. Examples from the audience
5. Spread of weeds
6. History of weed control
7. Biodiversity
8. Weed ecology: Biology/physiology/phenology
9. Reproduction and Dispersal
10. Allelopathy
11. Understanding weeds

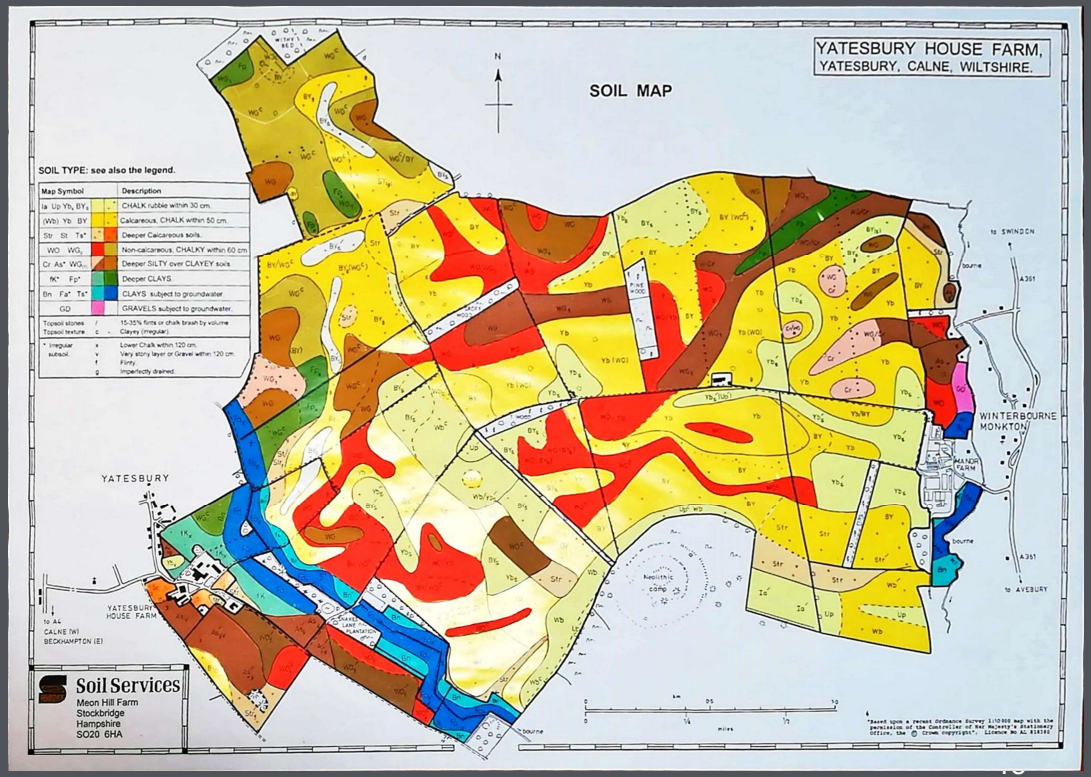
1. WHY DO WE WORRY ABOUT WEEDS?

- Economic impact
  - Difficulty harvesting
  - Difficulty separating saleable crop
    - Seed samples of oats
  - Reduction in yield
  - Taint food, e.g. sweet clover in malting barley
  - Toxic in food/forage, e.g. ragwort in hay

- Future impact, weed multiplication (“1 year’s seed, 7 year’s weed”)
- Visual impact (human need for order and control, roadside farmer)
- Environmental impact, invasive weeds (tor grass)
- Weedy - meaning= weak, feeble, frail!
  - Not the all weeds, but some are, perhaps the ones we want.

Maximum or optimum yield?

- What else has an impact on crop yield and quality? How do we know that it was weeds that had a significant impact?
  - Sunlight
  - Warmth
  - Soil quality
  - Fertility
  - Rainfall and soil water holding capacity
  - Competition from pests



Is yield loss from weeds exaggerated?

- “The mean yield loss in the 1691 trials was 5.4%(95% C.I.: 4.9–5.9) and the median 3.8. The average yield loss in Swedish cereals, confirmed in studies with hand-weeded plots (Bostro¨m, Milberg and Fogelfors, unpublished), was low (e.g. Friesen and Shebeski, 1960; Zanin et al., 1992; Oerke et al., 1994; Bourdot et al., 1996; Oerke and Dehne, 1997).
- This seems to suggest that, in a short-term economic perspective, there would sometimes be no justification for weed control.” **Milberg,** P. and E. Hallgren (2004).

- This will depend upon crop, and level of weed infestation (van Heemst 1985)

Crop	*Relative yield weedy crop*
Wheat	0·75
Peas	0·70
Potato	0·65
Soybean	0·64
Sugarcane	0·61
Cabbage	0·59
Maize	0·56
Sorghum	0·52
Transplanted rice	0·51
Sweet potato	0·45
Flax	0·42
Groundnut	0·39
Beans	0·39
Tobacco	0·34
Red beet	0·29
Okra	0·29
Cassava	0·28
Upland rice	0·25
Yam	0·25
Sugarbeet	0·23
Cotton	0·12
Garlic	0·12
Mungbean	0·10
Carrots	−0·13
Onions	−0·13

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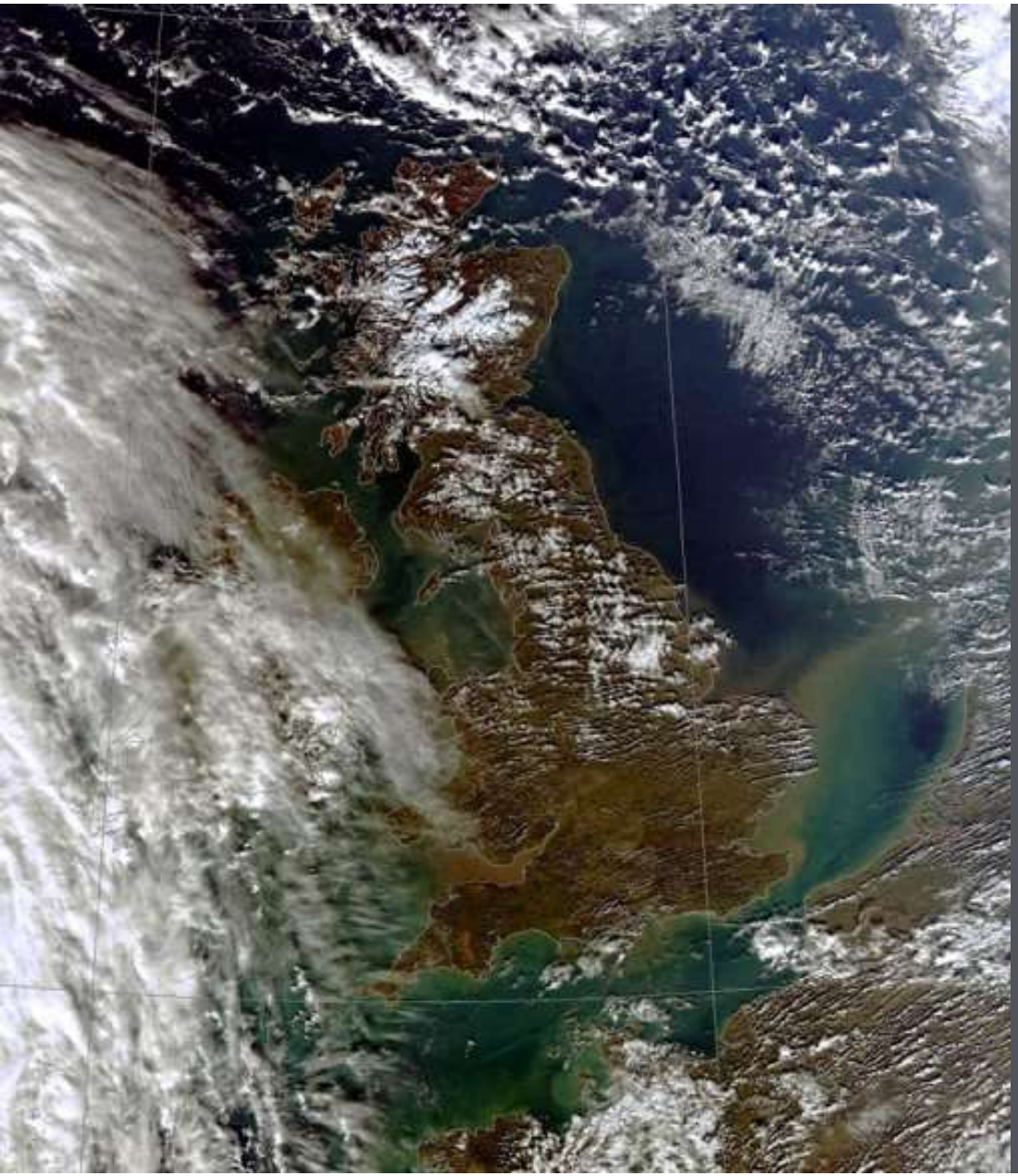
YIELD

- Quality v's Quantity/Volume
- If yield is to give up, what is being exchanged for high yield?
- What are the unintended consequences?
- Poor soil, lack of soil function, future fertility, soil water holding capacity and susceptibility to floods or drought,
- Exposure to stronger pioneer weeds, disease and pests even plagues of disease or pests where large monoculture exist.
- What does a field yield?
  - Food - public goods - ecosystem services - Nature



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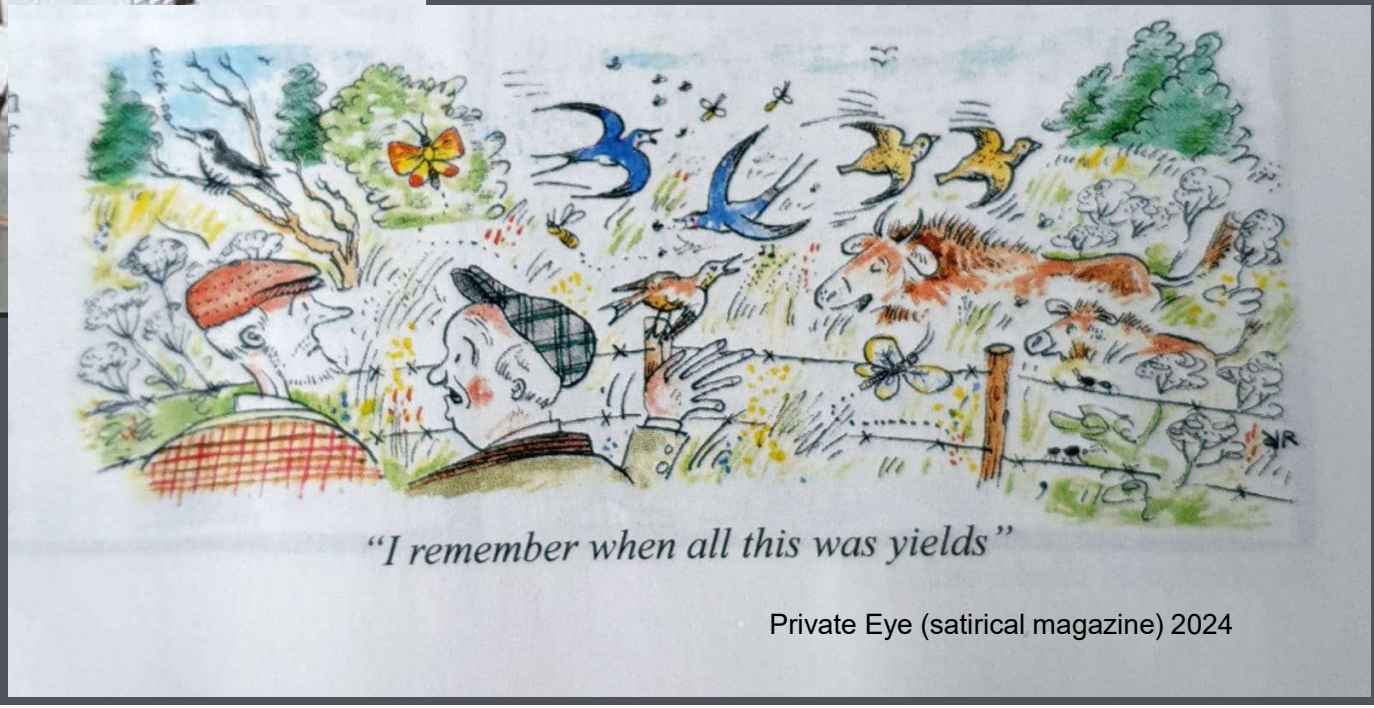
- Brown plumes seen flowing into the coastal zone
- (Jones 2016).

- What are the unintended consequences of reaching higher yields?

YIELD



Private Eye (satirical magazine) 2024

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A weed is…

- A plant that has a (perceived) negative impact on a human being
- -beauty is in the eye of the beholder-it's subjective

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2. Classification and Identification

- Classification; Identification; and Recognition
  - » Monocotyledons/Dicotyledons
  - » Perennial/annual
  - » Volunteers- seedings emerging from a previous crop
  - » Pioneer weeds

3. Context in both space and time

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- Home garden
- Lawn
- Road side – building sites
- City
- Woodland
  - wildfire
- Agriculture/horticulture
  - Agroforestry
  - Pasture vs Wild flower meadow
  - Field scale root crops
  - Market garden
  - Combinable crops;
  - Fruits: top & soft;
  - Fibre production

4. Example from audience – post in the chat

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- Name 1 weed;
  - and why is it a weed?

5. Spread of weeds

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1. Seed purity; bought in with purchased seed/home saved seed
2. Us - Harvesting equipment, Cultivation equipment, irrigation,
3. Birds, wind, water, fir (Velcro)
4. **Legacy** (from an earlier time) - Opportunist/pioneer-plant density- from crop failure- flooding or fire-space/darkness
5. Weeds respond to fertility NPK, Butler (2012),
6. **Disease & Predators, ragwort- ; dock-; ergot**
7. **Injurous/Invasive (next 3 slides) ….pejorative**

<-**Galium aparine**-cleavers
Avena fatua-wild oats->

Injurous weeds: PINONEER WEEDS

- **Nature's cool tool to bring back life into damaged environments**
  - **Docks**
  - **Spear Thistles**
  - **Creeping Thistle**
  - **Couch**
  - **After wildfire; mining; building sites, industrial farm!**
- **They have their time.** **Wilding, Isabella Tree (2019)**
- **Weeds Demonstrate there is a problem……..**
- **And wild flowers, what do they indicate?**

Name	Botanical Name	Na	Io	Fl	B	Si	S	N	Mg	Ca	K	P	Mn	Fe	Cu	Co	Indicator of soil structure	Soil friability	Nutrient status	pH
Fumitory	Fumaria officinalis																well aerated, but moist		nutrient rich / high potassium	
Gallant soldier																		very friable - high humus	high nitrogen	
Garden mercury																		very friable - high humus		
Garlic	Allium sativum	x		x			x					x								
Goldenrod species	Solidago sp.											x					dry / low humus			
Goldenrod. narrow-leaved	Solidago graminifolia											x							nutrient rich	
Ground elder																			high nitrogen	
Ground pine																			nutrient deficient	calcareous soils
Groundsel	Senecio vulgaris													x				very friable - high humus	high nitrogen	
Hare's ear cabbage																				calcareous soils
Hawkbit	Leontodon taraxacoides																		acid soils	
Hawkweed (Hawksbeard)	Crepis capillaris																		acid soils	
Hawkweed. mouse ear	Hieracium pilosella																		acid soils	
Holly	Ilex aquifolium																			lime deficient
Horsetail. field	Equisetum arvense					x			x	x				x		x	poor drainage	very low	acid soils	
Horsetail. marsh						x			x	x				x		x				
Horsetails	Equisetum sp.					x			x	x				x		x				lime deficient
Iceland moss	Cetraria islandica		x																	
Irish moss														x						
Kelp		x	x				x	x	x					x						
Knapweed	Centaurea nigra																		acid soils / high potassium	
Knawel. annual																		low	nutrient deficient / acid soils	
Knotgrass (Wireweed)	Polygonum aviculare					x												friable		
Knotweed. asiatic	Polygonum cuspidatum																		acid soils	

5. Spread of weeds

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c.f. Covid
– travel
– globalisation
– population pressure
– monoculture->super weeds
Quarantine: Denmark wild oats

6. Recent History of weed control

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Why has IPM emerged?

- Why have some weeds become dominant, even flourished in modern systems?
  - » Weed **resistance** to herbicides:
    - » black grass
    - » GMO and Roundup Ready crops - leading to super weeds
  - » “Understanding weeds tells us pesticides will eventually fail” Prof. A. Murdock
  - » **Soil degradation** leading to weed specific environment e.g. polygonum <pH; pioneer weeds
  - » **Human health** operator-non Hodgkin's lymphoma, glyphosate- probably carcinogen (W.H.O.)
  - » Pesticide **residues**- glyphosate https://youtu.be/NH_u57lJjKQ
  - » **Environmental health** Silent Spring by Rachel Carson 1962
  - » **Socio-economic impacts**-on human health systems e.g. NHS- water companies-Propyzamide/Bentazone

7. Biodiversity

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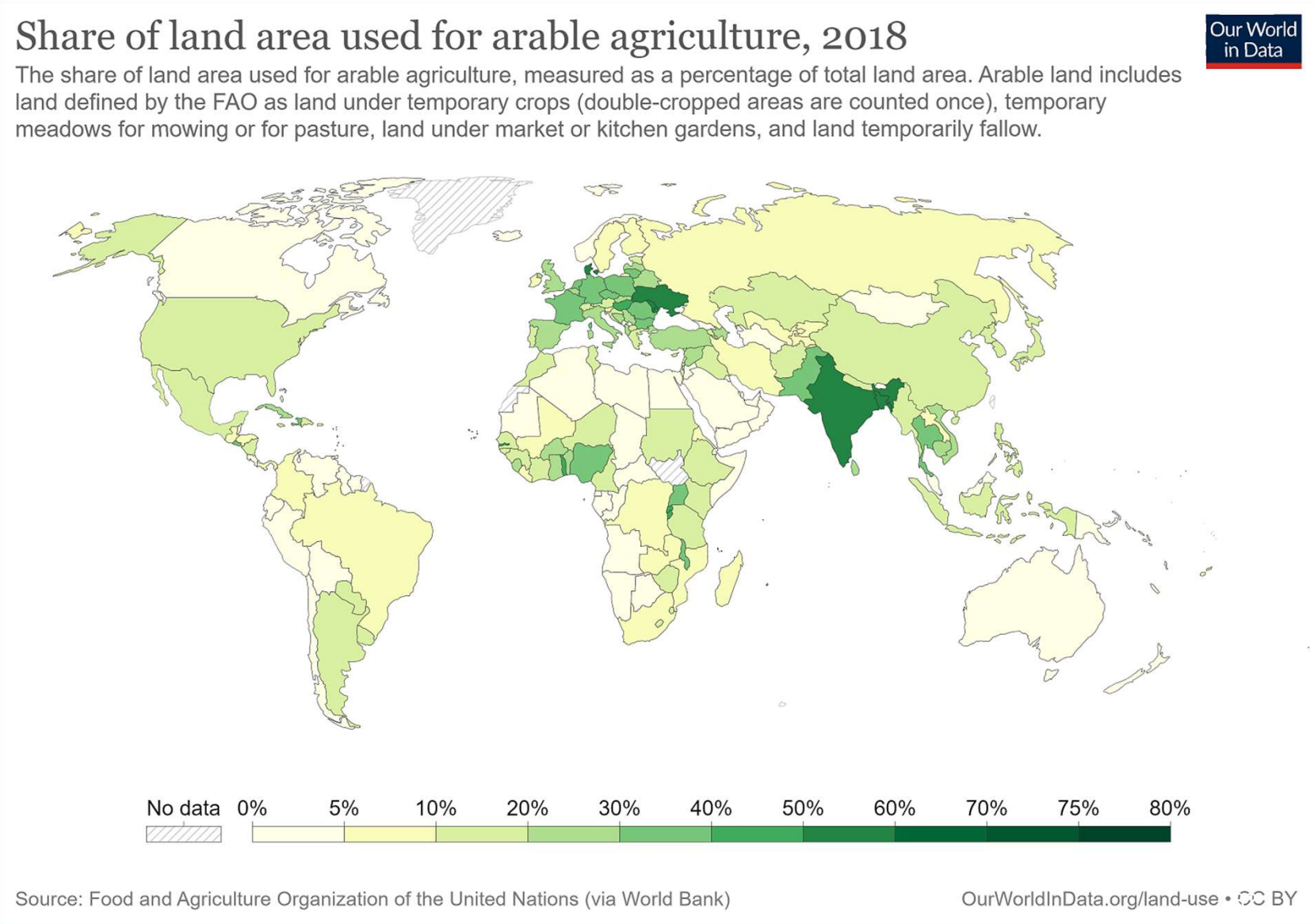
Flowering plant with cinnabar moth caterpillars

- What is biodiversity?
- Why is it important? **Shifting baseline syndrome** (Pauly 1995)
- Watch this review including a message from DA
- The Dasgupta Review: Economics of Biodiversity https://youtu.be/e2QDOeKH0DE

» Cinnabar catepillars and moths:

Farming occupies just under 40% of global land area (UNFAO).
Ellis et al. (2010) found that by 2000, 55% of Earth's ice-free (not simply habitable) land had been converted into cropland, pasture, and urban areas. This left only 45% as 'natural' or 'semi-natural' land.
If biodiversity is significant in buffering perturbations, is it prudent for farmers to increase biodiversity?
If we remove biodiversity in our fields is it any wonder that the fields become more vulnerable?



When considering weed control do we only consider food production?

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- What is the difference between biodiversity and weeds?
- When are weeds not biodiversity?
- Unintended consequences of removing weeds
  - They are hosts for insects, pollinators (Bretagnolle and Gaba 2015), food for farmland birds, food for soil biota
  - The role of uncultivated land in pests and beneficial insects (Van Emden, 1963)
  - Increased above ground biodiversity leads to increased below ground biodiversity and vice versa (Wagg, 2013)
  - Increased biodiversity leads to increased carbon sequestration (Gantlett, 2024).
  - Kremen (2018) Landscapes that work for biodiversity and people
  - Adeux (2019) Mitigating crop yield losses through weed diversity

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Land sharing or Land sparing?

Sustainable intensification - ecological intensification (Tittonell, 2014)

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8. Weed ecology: (Put yourself in their shoes/roots)

Biology; physiology; phenology (cycles and seasons)

- How weeds interact with their environment
- From the weed's point of view
- Invasive weeds, what, why, good to understand this
- Have weeds become worse?
  - Effect of fertilisation
    - » Where there's muck, there's brass | Rothamsted Research Neal (2020)
    - » Weed species change with fertilisation
  - Climate change effect on weed species diversity

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9. Weeds are smart – Weed reproduction and dispersal

- **1. Seed**
  - Seed numbers

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Docks in wheat,
-perennial
-reproduce from root or seed
-producing up to 60,000 seeds/year

Wild oats in field beans,
-annual
-seeds have already shed
-producing up to 2000 seeds/year

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9. Weeds are smart – Weed reproduction and dispersal

- **1. Seed**
  - Seed numbers
  - Spread of seed, as 5. above
  - **Indeterminate nature of seed maturation**
  - **Dormancy: signals; pioneers; fungi and collembola**
  - **Germination: needs dormancy release + correct conditions**

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Seed Dormancy-Germination

e.g. wild oats

- **Dormancy**: In Autumn the level of dormancy declines and is induced again in late Spring. Hot and dry conditions during seed maturation shorten the dormancy of the seed. **Summer fallow increases the number of seeds that break dormancy**. A new stand of wild oats will emerge after each tillage operation. Seed Autumn crops in the same year as the fallow to provide competition against wild oats that germinate in the spring. Beans encourages wild oats during their cropping and the year after.

- **Germination**: The optimum soil temperature for the germination of wild oats is between 16 and 22 degrees Celsius. Germination is slow at 4 degrees Celsius and very slow at 33 degrees Celsius. Most germination occurs at depths of 2 to 5 cm if soil moisture is adequate. However, if the surface layer is dry, germination can occur at depths up to 20 cm. Extreme cold weather can encourage a huge germination of seed in the spring, but the last time the required conditions occurred for an emergence on such a scale was in the mid-1980s. The wild oat seed will not germinate while exposed to light; it must be buried. Most wild oats **germinate and emerge in early to mid-spring mostly by the end of May.** Cool, moist conditions promote maximum emergence, so crops that are seeded early are usually the most heavily infested. Fall or early spring applications **of nitrogen fertilizer stimulate germination**. Growth of roots and shoot of wild oats is slow for the first two weeks,but increases quickly from then on. Most wild oats tiller within a month of emergence. Increases in soil nitrogen and oxygen can encourage germination

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9. Weeds are smart – Weed reproduction and dispersal

- **1. Seed**
  - Seed numbers
  - Spread of seed, as 5. above
  - Indeterminate nature of seed maturation
  - Dormancy: signals; pioneers; fungi and collembola
  - Germination: needs dormancy release + correct conditions
  - **Longevity: age; depth; predators including fungi which we call?**
  - **Weed life cycles and the Weed seed bank**

Location and life cycle

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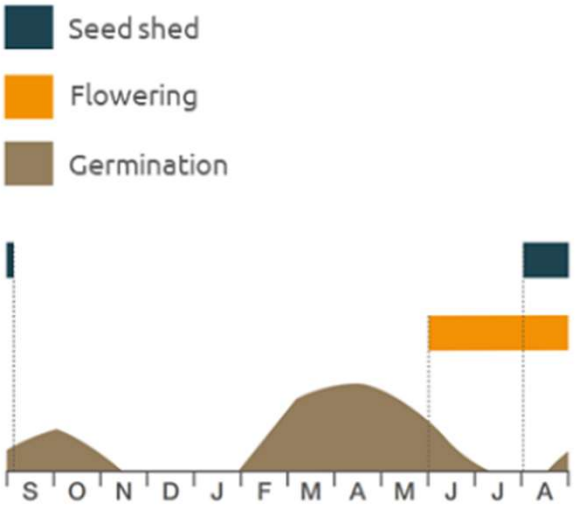
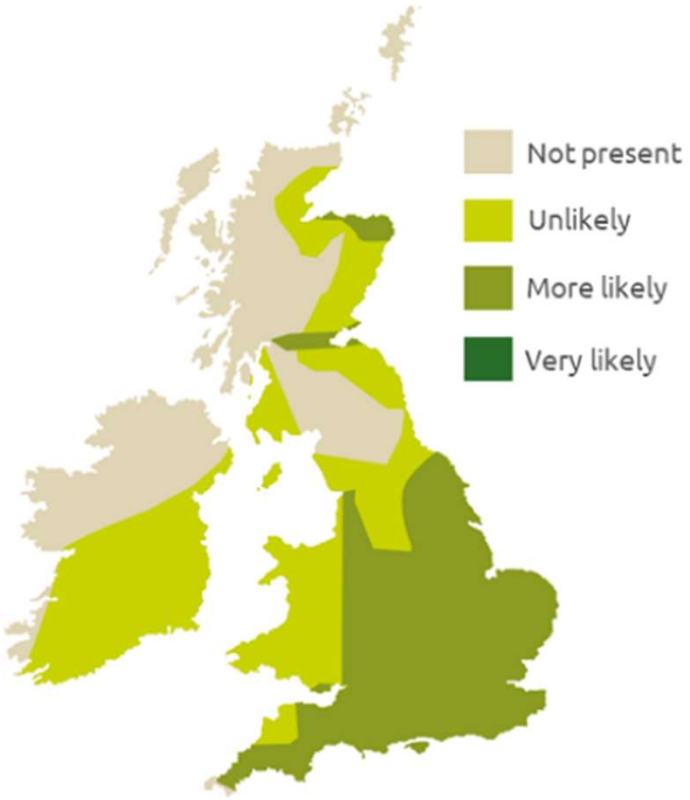
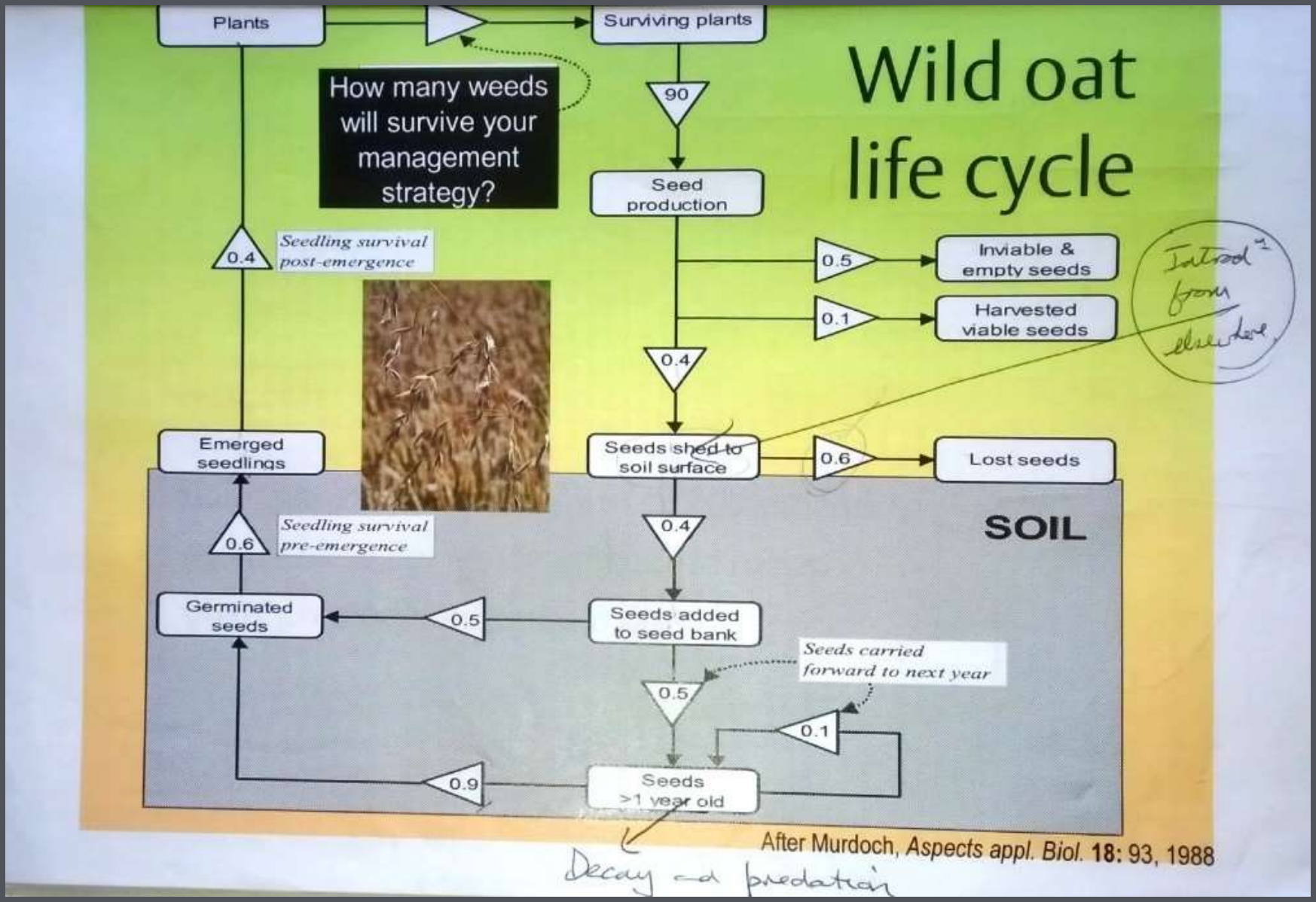
Wild-oat





» Distribution and biology of wild-oat in the UK | AHDB



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Weed seed bank management

- Those seeds that we have deposited for rainy day!
- 1 year's seed is 7 year's weed.

Size and composition of soil seed banks

Vegetable/arable fields in England and Wales
Sampled to 15 cm depth

Years	No. of fields	Viable seeds m^{-2} Median	Min.	Max.	Species per field Mean	Min.	Max.	Species	Found in fields %	Fields with >n seeds m^{-2}
1. Commercial vegetables with minimal herbicide use										n=1000
								Stellaria media	100	28
								Poa annua	98	39
1958-62	58	10200	1600	86000	14	4	30	*Urtica urens*	93	30
								Senecio vulgaris	90	8
								Capsella bursa-pastoris	86	18
								Chenopodium album	84	18
								Veronica persica	71	10
2. Commercial vegetables with considerable herbicide use										n=250
								Poa annua	90	68
								Stellaria media	74	42
1968-75	89	4120	0	24330				*Matricaria matricarioides*	69	41
								Polygonum aviculare	53	27
								Urtica urens	49	22
								Chenopodium album	49	18
								Capsella bursa-pastoris	48	18
								Veronica persica	39	18
								Senecio vulgaris	39	13
3. Arable fields sampled 3 times										n=625
								Poa annua	100	35
1972/3	64	4360	1500	67000	17*	8*	32*	*Polygonum aviculare*	92	17
								Stellaria media	90	20
1974/5	64	4930						*Bilderdykia convolvulus*	70	2
								Aethusa cynapium	68	7
1976/7	64	2900						*Veronica persica*	67	19
								Alopecurus myosuroides	67	18
								Chenopodium album	66	7

1. Roberts and Stokes. 1966. (J appl Ecol, 3:181-190)
2. Roberts and Nielson 1982. (Weed Res, 22:13-16)
3. Roberts and Chancellor 1986. (Weed Res, 26:251-257) * in 32 of the fields

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9. Weeds are smart – Weed reproduction and dispersal

- **1. Seed**
  - Seed numbers
  - Spread of seed, as 5. above
  - Indeterminate nature of seed maturation
  - Dormancy: signals; pioneers; fungi and collembola
  - Germination: needs dormancy release + correct conditions
  - Longevity: age; depth; predators including fungi which we call?
  - Weed life cycles and the Weed seed bank

- 2. Also from **Roots**: Rhizome/tap root, perennials (couch, docks, creeping thistle, dandelion)- roots store energy for challenging times- and regrow from small fragments

- Beware: As farmers/gardeners we send them signals all the time
- Know thy enemy (Prof A. Murdock)...
- Further resource on individual weeds Weeds List | Garden Organic

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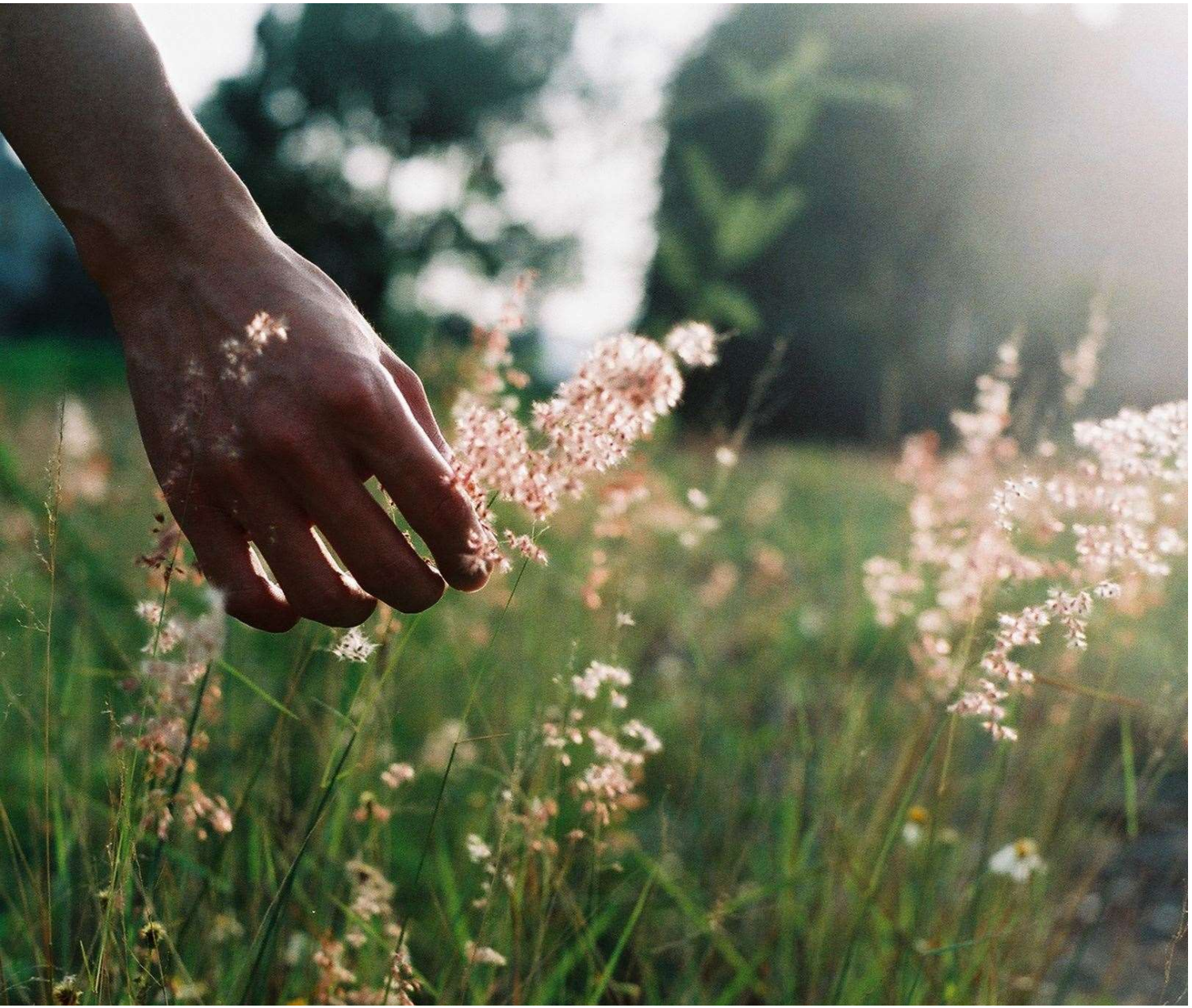
10. Allelopathy – a plant's defence

e.g. Oats, Rye, Barley,
Older wheat strains? (C.Clarke 2017)
Hemp, Buckwheat

Al-le-lop-athy

- **Leachate from the roots of wheat seedlings inhibit the germination** of winter wild-oat seed,
- however, post-harvest residues of wheat stimulate germination of the seed.
- OTHER defences? Shading, Fungi



11. Understanding weeds

- Do we now understand weeds?
- If so we can now try:
  - to manage them:
    - outsmart them?,
    - appreciate them,
    - Select the ones we want.
  - know their reason for being, understand why Nature has sent them:
    - their mode of action
    - their weakness.

How do we feel about weeds now?
Do Weeds have a value?

- Food for Soil Biota
- Food for Birds,
- Food for Insects
- Species richness
- Add Root diversity
- Nutrition for cows
- Aid soil recovery

- …Well…

some are welcome!

Weed Science

Robert L. Zimdahl, in Fundamentals of Weed Science (Fifth Edition), 2018

3.8.2.3 Goals

Weed science has made major contributions to increasing crop production over several decades. Herbicides have been the primary control technique. Because of their efficacy and ease of use there has been an overreliance on them at the expense of other weed-control methods (Blackshaw et al., 2008). If the only or primary goal is to increase production, then the quest for better herbicides must continue. If the goal is sustainable weed management in a sustainable environment and society, then other control techniques must be investigated. Farmers must be shown that adopting nonherbicidal weed management will not increase the risk of crop failure or reduce profit. The new goal should be development of successful weed-management systems that have minimal or no effect on the flora and fauna of soil, water, or air and have no adverse effects on people.

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Weed Control (Integrated Weed Management) -Tools, Systems and Selection

Weed control aims to **manage** plant vegetation, seed dormancy, seed germination and seed dispersal through understanding plant and seed ecology.

- Approaches: **1. Cure** **or** **2. Prevention**

- Cost: money or resources or time: Carbon; Fossil fuel: gas burning; diesel;
- Systems philosophy

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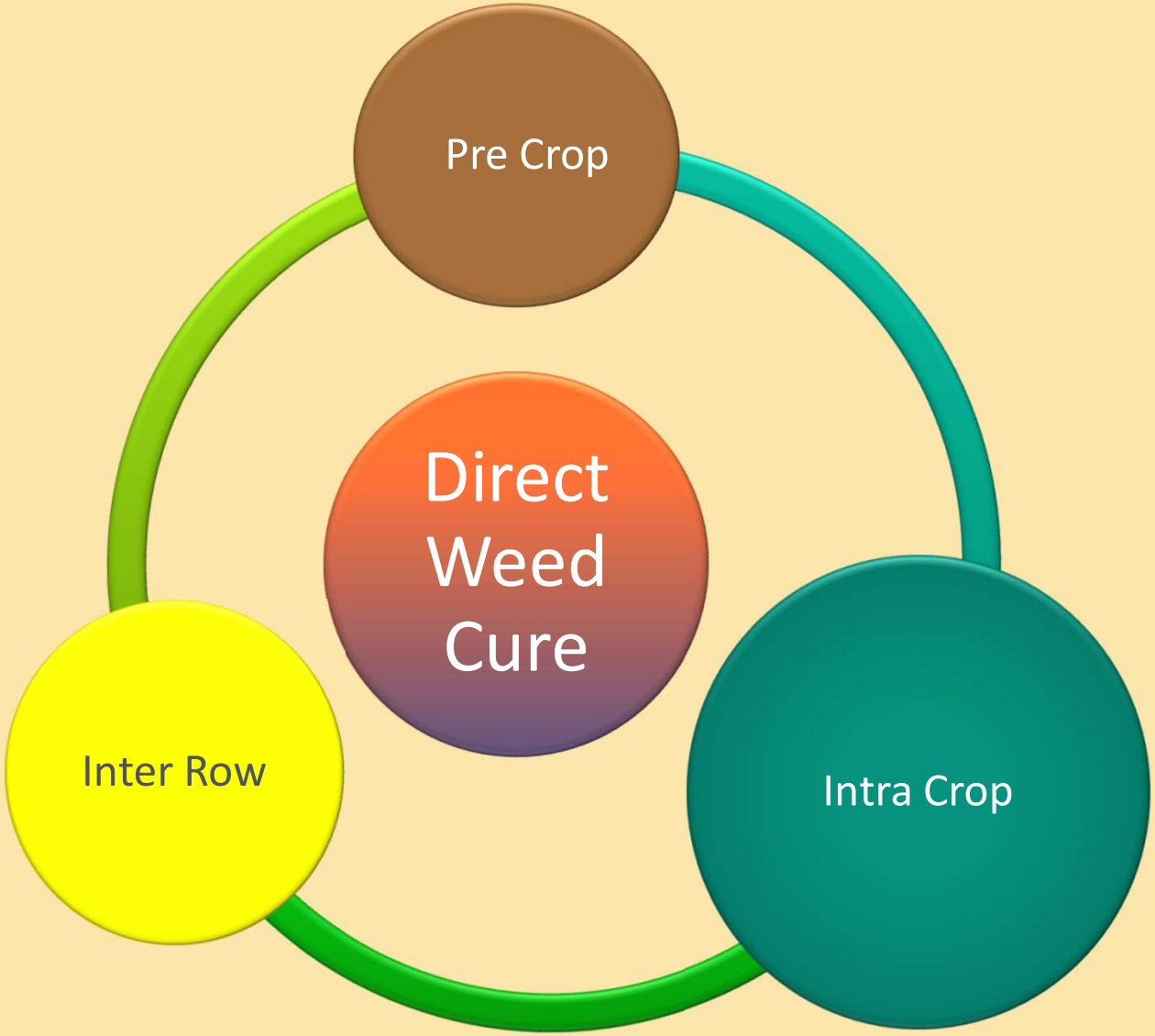
Approaches

- 1/2. Cure 😠🐑
  - » Bare/bastard fallow
  - » Biological weed control
  - » Hand weeding
  - » Tools



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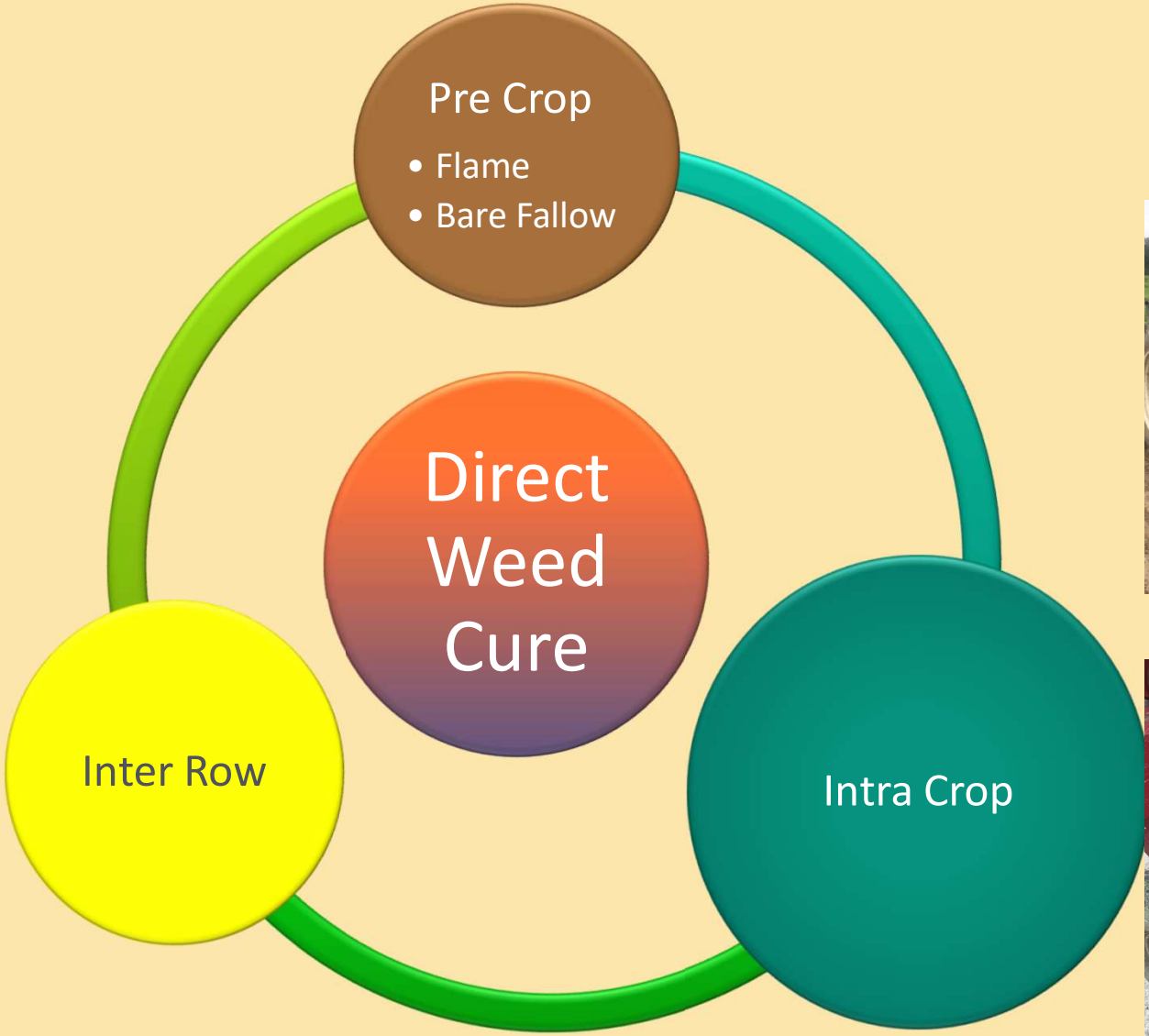
Tools to
cure weed problems



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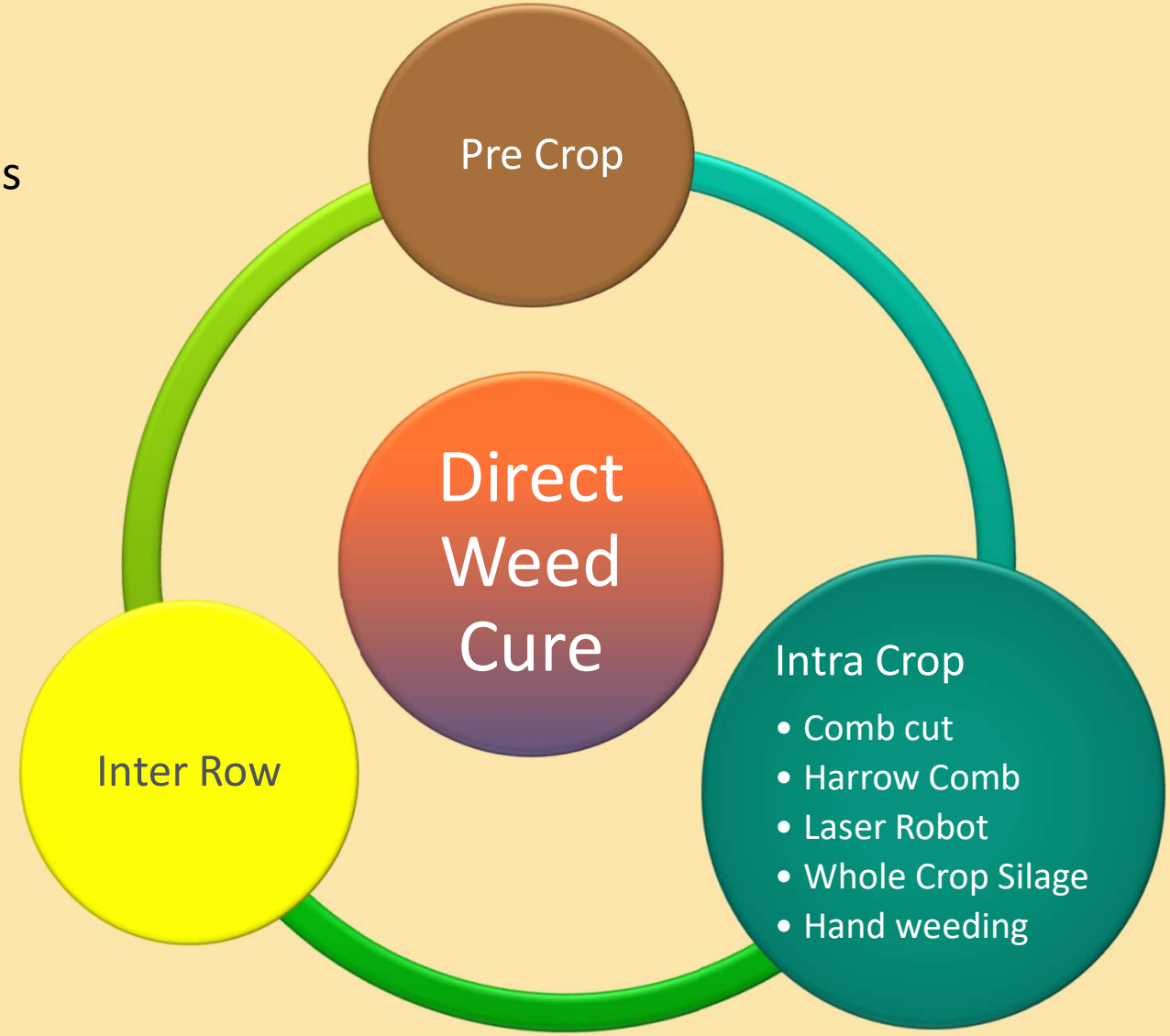
©Microsoft
Feedback
2500 feet
1 km

Tools to
cure weed problems



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Direct Weed Cure

Intra Crop

- Comb cut
- Harrow Comb
- Laser Robot
- Whole Crop Silage
- Hand weeding

CLAWS

Concentrated Light Autonomous Weeding & Scouting

Revolutionising the agricultural future with concentrated light weeding.

Keeping weeds at bay using farmer-led AI & robotics, creating a unique, revolutionary solution to a more sustainable and profitable future for farming.

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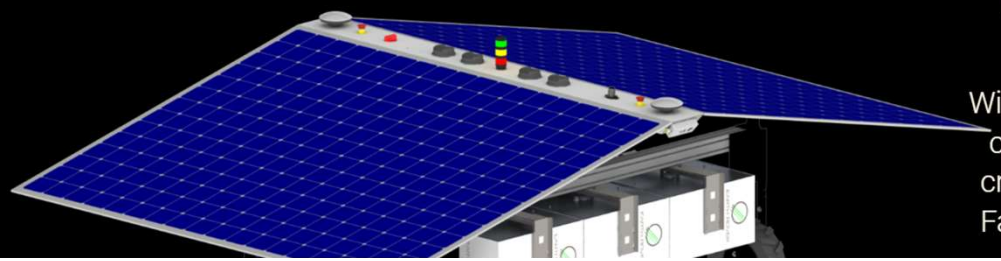
AGRIEPICENTRE

Engineering • Precision • Innovation

High-precision weeding control through concentrated beam technology



Its concentrated light technology doesn't require tilling, preventing root damage, improving soil health and avoiding greenhouse gases emissions.

With 6 built-in cameras, this rover is able to identify field components in space and time, and collect real-time crop data, sending this information to its Cloud Based Farm Intelligence System for farmer decision making.

Tools to cure weed problems

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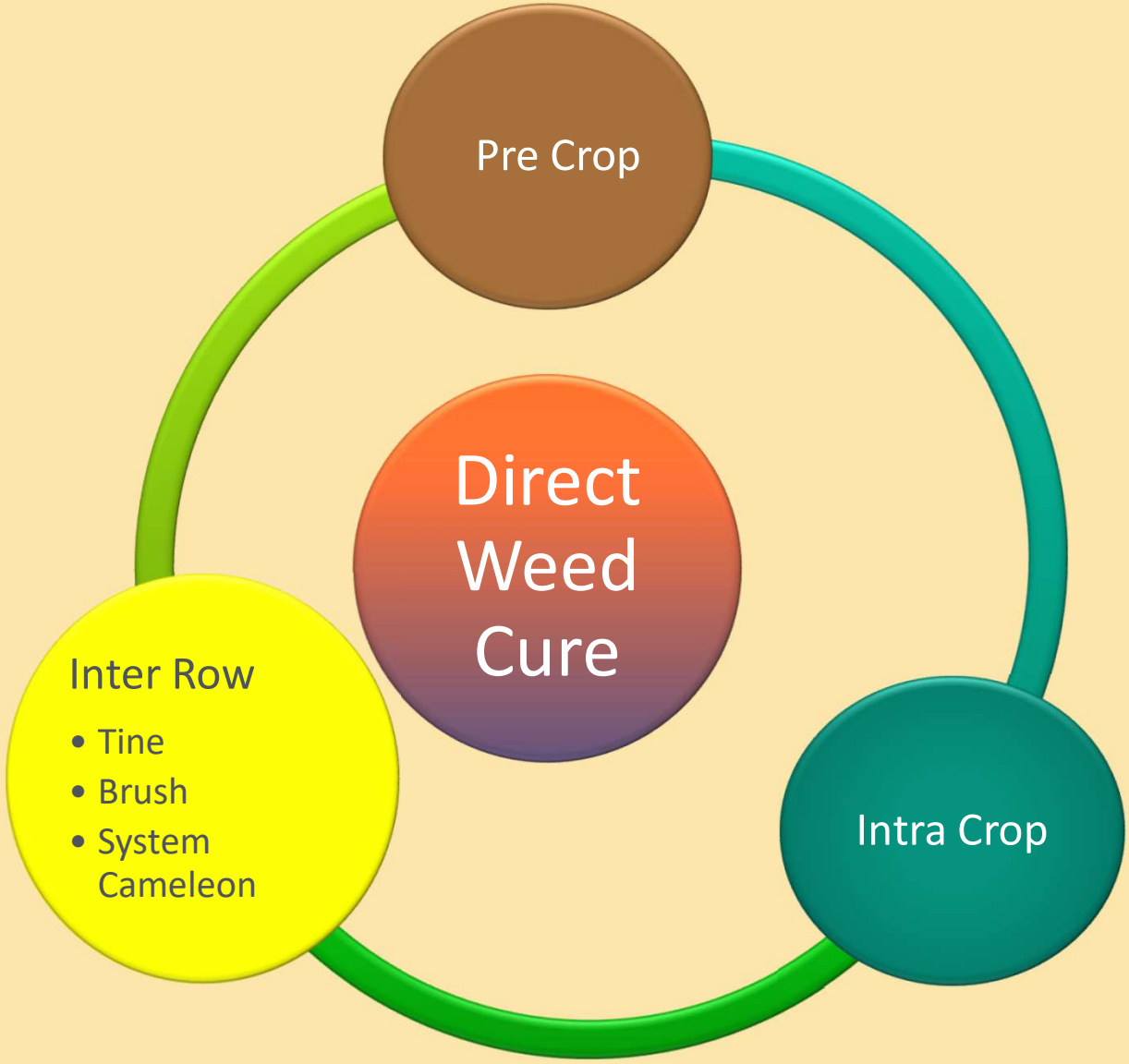

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Mertens (2002)

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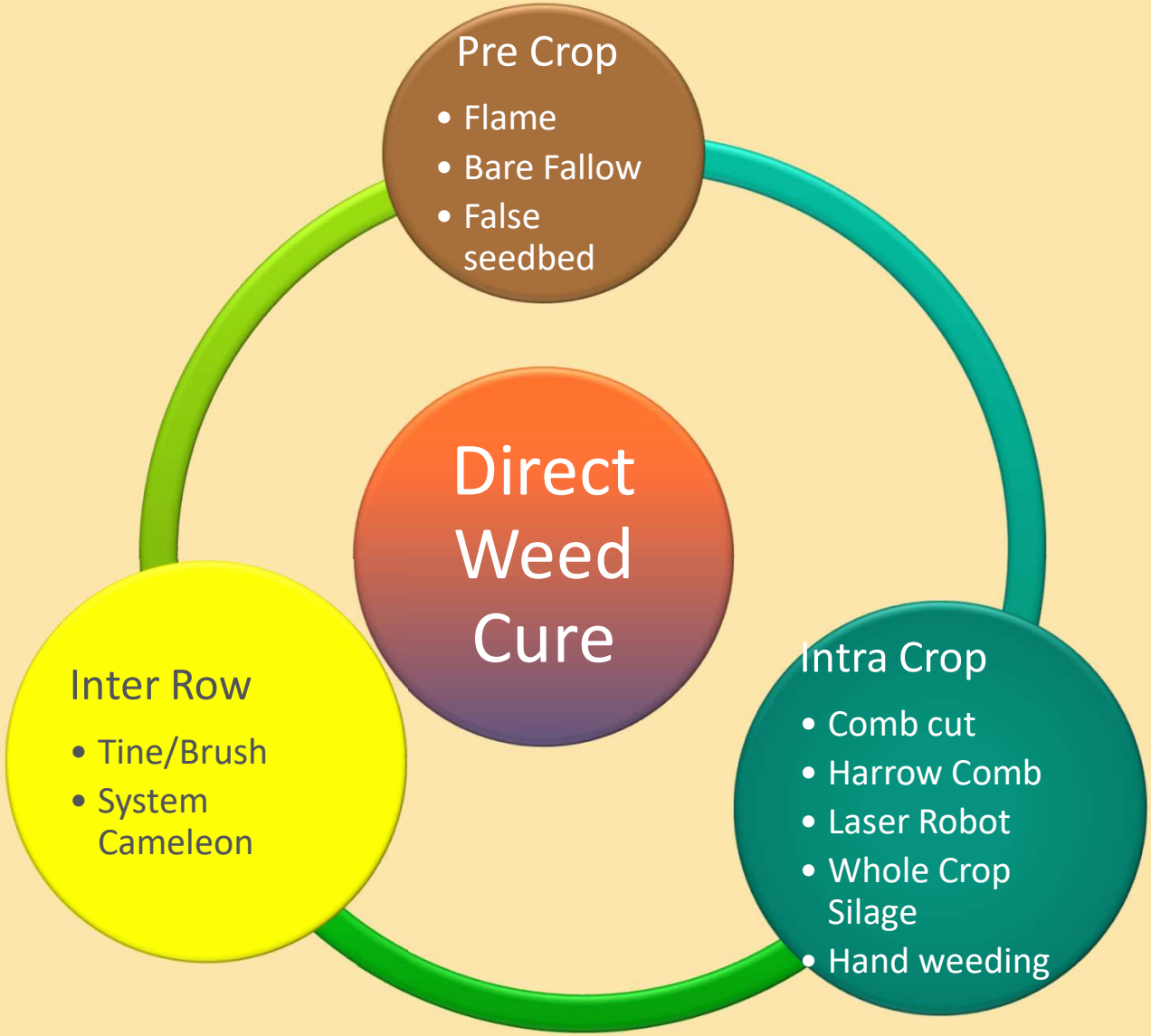

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Weed Control (Integrated Weed Management)

- 2/2. Prevention 🤩
  i. False seedbeds, (pretend to the weed seeds it's time to grow)
  ii. Cover crops
  iii. Late sowing
  iv. Rotations
  v. Undersowing
  vi. Living mulch
  vii. Soil disturbance
  viii. No-till, min-till, plough, crimper roller
  ix. Crop competition
  x. Soil Health improvement

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i. False seedbeds

- Germinate non-dormant seeds before sowing
- Including those volunteers (seedlings from previous crop left after harvest)
- Weed and sow at same time
- Tilling damages soil aggregation and releases nutrients

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ii. Cover Crops

(brassicas don't form associations with Arbuscular Mycorrhizal Fungi, AMF)

- Winter spelt sown before Spring crop of barley to develop AMF

- Field beans sown to encourage weed seed germination and fix nitrogen

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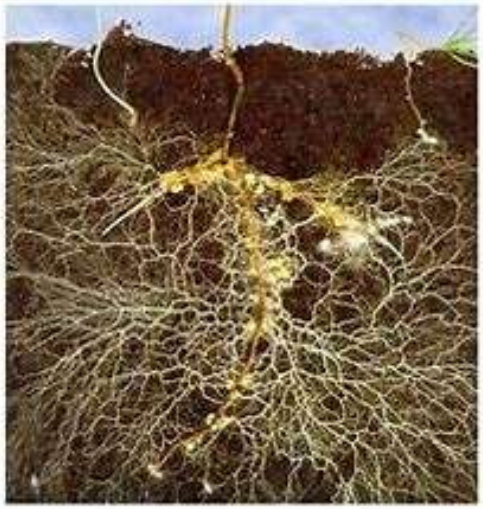
Soil-Root Biome

e.g. Fungi- Arbuscular Mycorrhizal Fungi, obligate symbionts

Mutualistic relationship

- Mycorrhizae = relationship with plant roots
- Fungal hyphae increase surface area of root
- Plant gets more water and minerals
- Fungus gets food from plant (from photosynthesis)



- Cheapest seed?
- ...weeds from your weed seed bank

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iii. Late sowing

(The difference between good and poor farmer is ????" Malcolm Stansfield)

- Soil cooler – less weeds germinate
- Less pest/disease?
- Danger of poor crop establishment
- Risk of soil damage

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iv. Crop rotation

- Over time and space?
- Build fertility
- Break the preferred life cycle of a particular weed (pest or disease)
- Spread farm workload (Winter/Spring)
- Biodiversity benefits on farm and beyond
- Bring benefits of animal esp. cattle

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v. Undersowing

- sow immediately,
- Spring cereals or beans or?
- shading,
- ley competes with weeds
- And a little with crop
- Ease of harvest?
- 1 seedbed for 2 crops
- graze 2wk-1mn after harvest

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vi. Living Mulch (opposite to undersowing

Yatesbury 2004
- Undersow yellow trefoil and white clover,
- into faba bean, harvest, then sow Winter wheat
- ½ yield of wheat plus
- ½ yield of yellow trefoil and clover

Yatesbury 2008
- White clover established,
- sow Winter wheat into it in November….
    - wheat disappeared

Italy
- Roots not competing with crop
- Tap root + shallow fibrous root
- 50% seed rate of durum wheat sown end Oct
- 15% yield reduction
- Wide rows to reduce competition between wheat and
    - Sub clover

Udine-Pisa, Paolo Barberi

Strip till

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vii. Soil disturbance

- Good or bad?
- Ploughing?
  - 🙃 it's death for much of the soil biota
  - It's a party for the docks and couch
  - We sold our plough in 2003☺
- Cereals have developed over thousands of years with tilled soil
- Different biota in tilled soil from no-til soil

viii. No-till, min-till, plough
No Till -Crimper Roller –Rodale Institute USA

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The concept of no-till organic farming was developed at the

Rodale Institute (where regenerative farming started)

to grow weed intolerant crops

on wide rows

such as soya beans, tomatoes and sweet corn.

Organic No-Till - Rodale Institute (US organic research center)

ix. Crop competition
Weeds are smart
- all plants are smart

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1. Seed spacing
2. Variable rate seeding
3. Species and varieties
4. Diversity

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1. Seed Spacing

- Row width
- Broadcast
- **3D seeding**
- Network seeding

Crops can do their own weed control

WEED CONTROL **Weeds are the enemy of crops and agricultural output worldwide. Organic and conventional farmers have their respective weed control strategies, either through the use of fuel guzzling, CO2 producing machines or environmentally harmful chemicals. Research from the University of Copenhagen now suggests that the war on weeds can be conducted more sustainably by asjusting sowing patterns and crop density.**

Wheat sowed in a field with high weed pressure provided by rapeseed. Left photo: Low crop density, crops sowed in rows. Middle photo: High crop density, crops sowed in rows. Right photo: High crop density, crops sowed in grid pattern.

http://plen.ku.dk/english/news/2015/crops/, (Olsen, Kristensen et al. 2005), (Weiner, Griepentrog et al. 2001)(Weiner, Andersen et al. 2010

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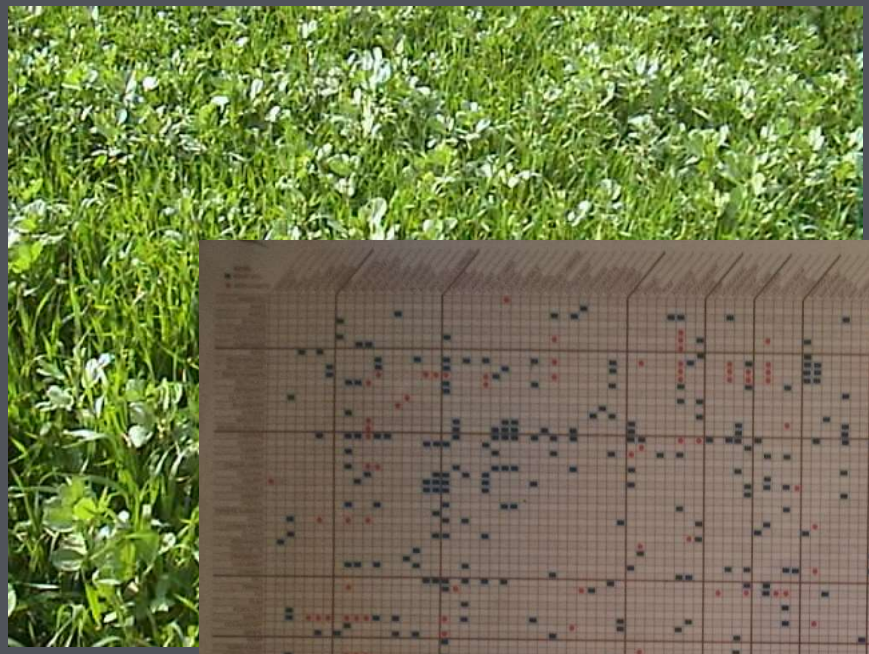
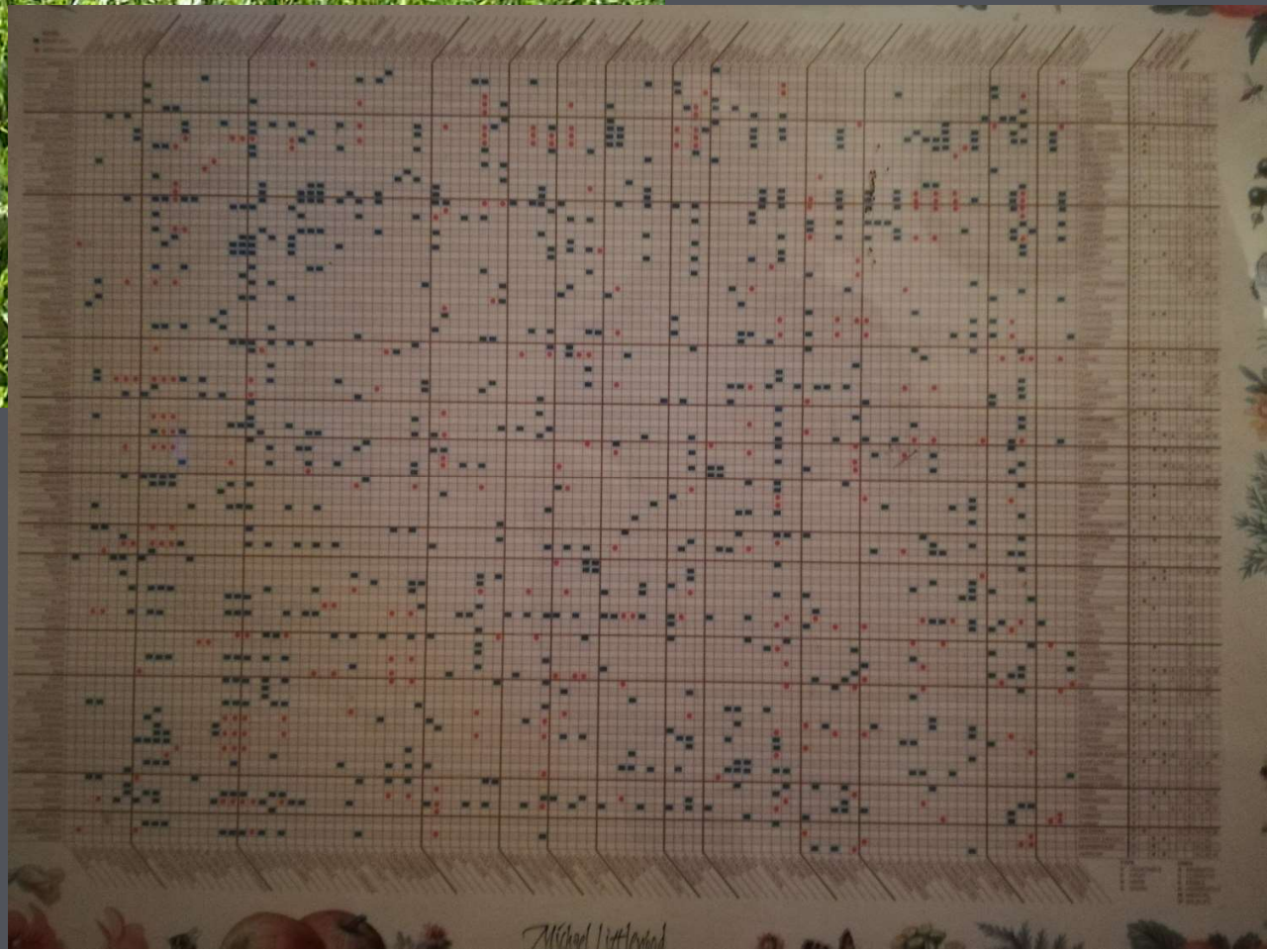
Choice of Species & Varieties

- Critical in both crops and covers/mulches/green manures
- What traits do we want?
  - Quality
  - Yield
  - Root development
  - Canopy development- shading
  - Allelopathy
  - Diverse mixtures provide community interaction,
    - > both sampling effect of having the best variety for a year/space
    - > And niche differential effect, always have the ones to fit a niche
    - > Crop cooperation for mutualistic benefit
    - > Simplicity in diversity
- Breeding - don’t bred out the smartness

Diversity





- Bi-cropping, intercropping
  - Wheat and beans
  - Barley and peas
- Companion Planting ->
- Weeds
- Multispecies…

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Yatesbury
Yatesbury Diverse Ley
23->29 species
33->44 varieties

Bio-diversity and Bio-cultivations
… Bio-diversity = Bio-Community

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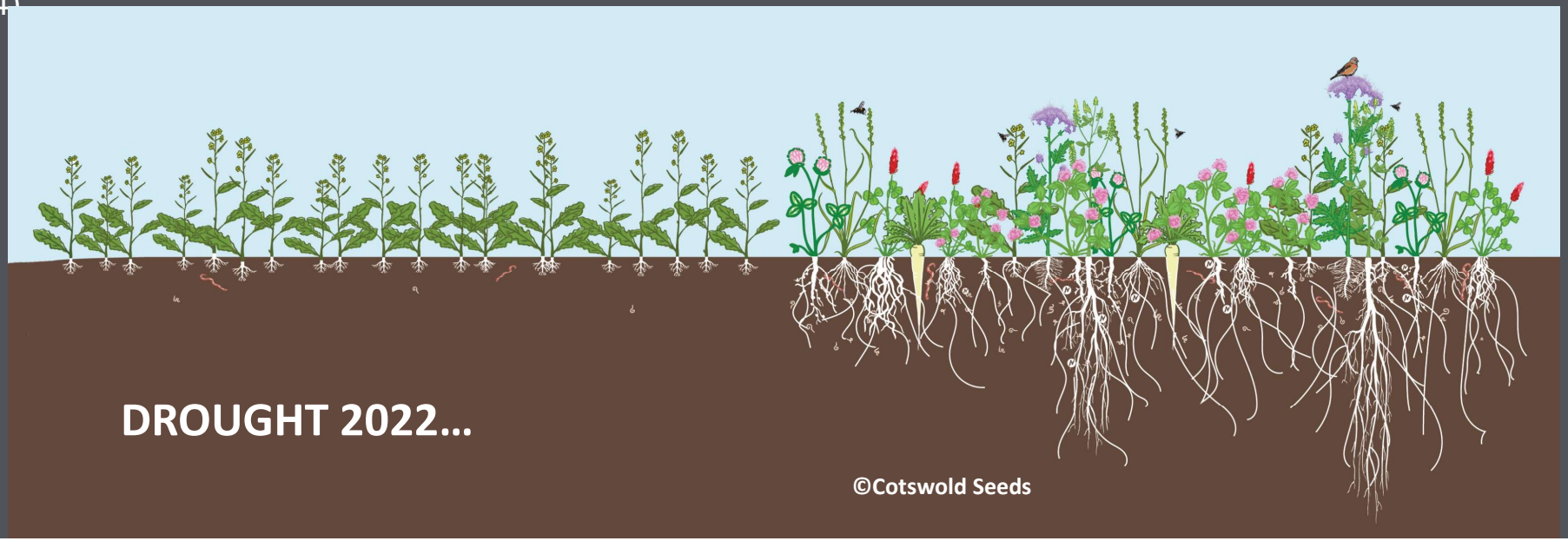
- Diverse mixtures provide benefits of the:

1. **Sampling effect -** the best mixture is always available for any given location/soil/time (Tilman 1999).
2. **Niche differential effect -** each species can occupy a different niche avoiding competition (Tilman 1999).
3. Highly diverse leys **ROOT TWICE AS DEEP** as expected from their monoculture traits, giving access to greater soil resource which can correlate with aboveground productivity (Mueller et al. 2013).
4. Plant species diversity declined strongly with reductions in soil biodiversity and simplification of the soil communities in pasture (Wagg 2014)



Yatesbury

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Soil-Root Biome

e.g. Fungi- Arbuscular Mycorrhizal Fungi, obligate symbionts

Mutualistic relationship

- Mycorrhizae = relationship with plant roots
- Fungal hyphae increase surface area of root
- Plant gets more water and minerals
- Fungus gets food from plant (from photosynthesis)

Brassicas?

How Plants Feed (Alex Podolinsky, Bradshaw 2024)

Yatesbury

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- Figure 1
- Nutrients held in stable soil material

- Plant drinking through transpiration
- Plant feeding through mycorrhizal exchange of nutrients
- Plants only take up as much nutient as they need and separately drink as much water as they need

- Balanced plants

- Red indicates nutrient location

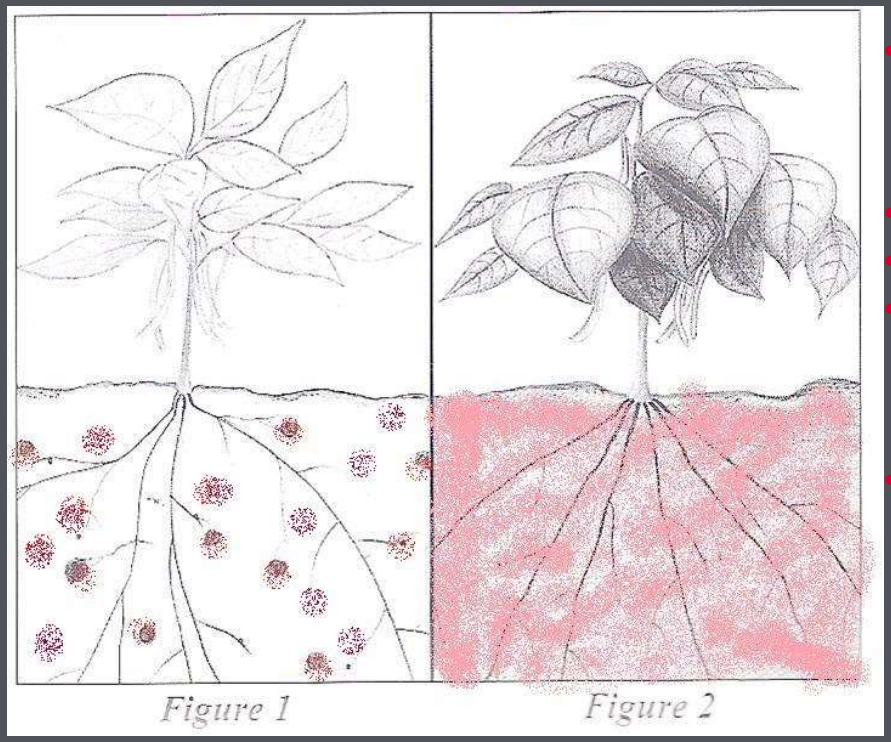


Figure 1 Figure 2

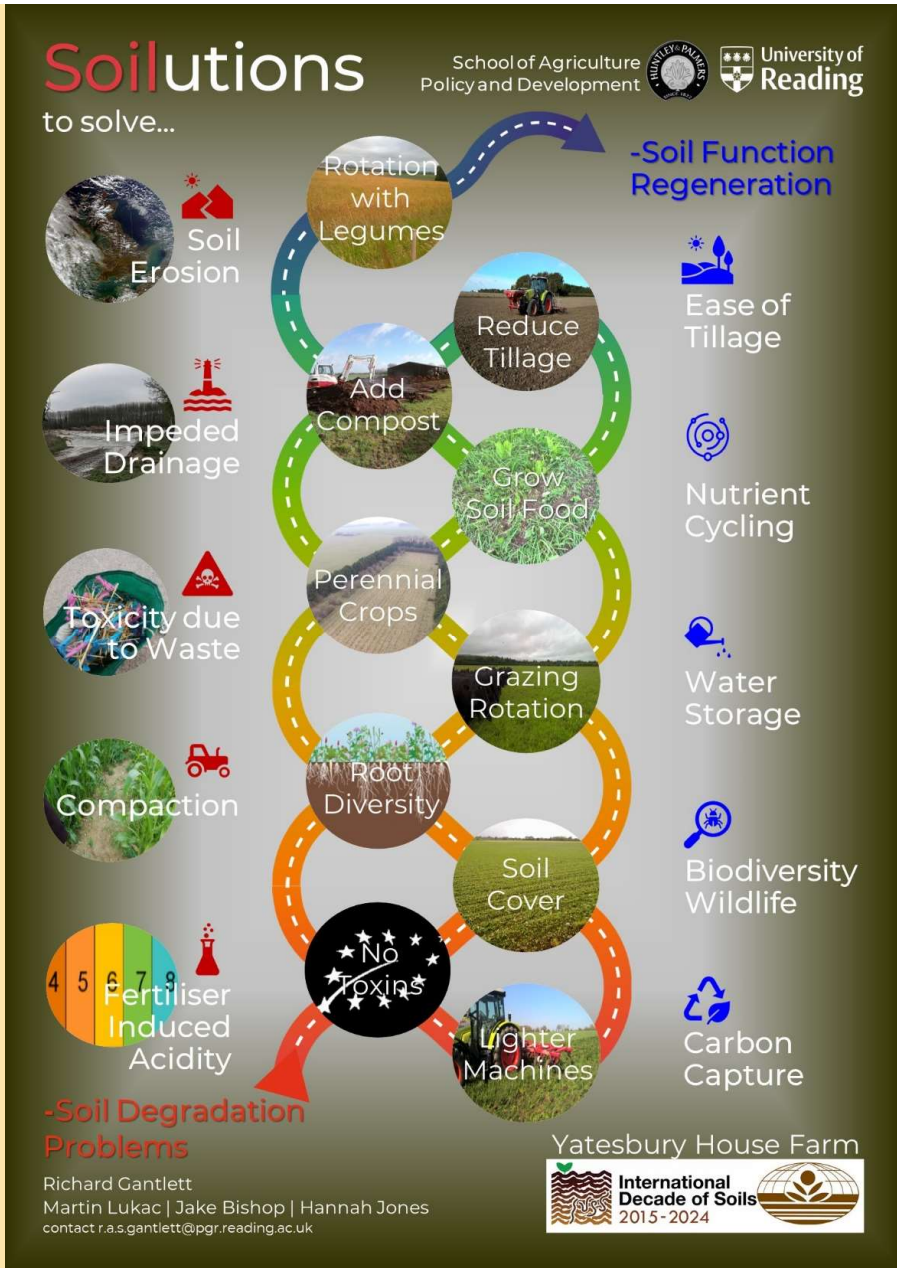
- Figure 2
- Nutrients held in soil water

- When plants transpire, they drink taking up water, but they also take up food without choice at the same time
- i.e. Force fed
- This causes cell bloating
- Indicated by **blue green** leaf colour commonly seen in cereals/grasses

- Leads to:
  - pest and disease access
  - bitterness in fruits/leaves
  - (see area around cow pats
  - which cows won't eat).

x. Soil Health

- Crops establish well
- Crops develop well
- Crops compete well
- Soil cycles nutrients
- Soil stores water and drains excess slowly
- Soil protects crops from flood and drought
- Pioneer weeds are not favoured



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Integrated Weed Management (Weed Control)

- 2/2. Prevention - recap
  i. False seedbeds
  ii. Cover crops
  iii. Late sowing
  iv. Rotations
  v. Undersowing
  vi. Living mulch
  vii. Soil disturbance
  viii. No-till, min-till, plough, crimper roller
  ix. Crop competition
  x. Soil Health improvement

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- MANY LITTLE HAMMERS

No one solution to weed control, use a combination of methods

And Maybe a hammer isn't always best?

Try a systems approach?

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A Systems approach is needed

- Central to the idea of a Systems Approach (Spedding 1979), is that

"one must understand the system before one can influence it in a predictable manner".

- Expect a consequence to any stimulus,
input or output from the system,
this involves understanding feedback loops,
thus avoiding **unintended consequences**

This also fits with
ecology
being the central science of agriculture in the 21st century (Weiner 2004).

Systems thinking or Whole Farm Approach
AMF priming

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Spelt ½ rate sown Oct 2017

Cultivations start 19th April 2018

Spring Barley sown 30nd April 2018

Undersown with Diverse Ley Mix 22th May 2018

Photo 28 June 2018

First Pass into Winter Cover
Spring 19th April 2018

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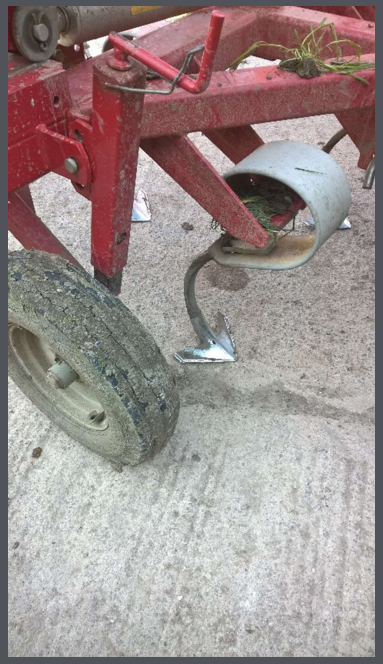
2nd Pass of cultivator next day



3rd Pass of cultivator with spring roller

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Systems thinking or Whole Farm Approach
AMF priming

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Spring barley undersown Photo 28 June 2018

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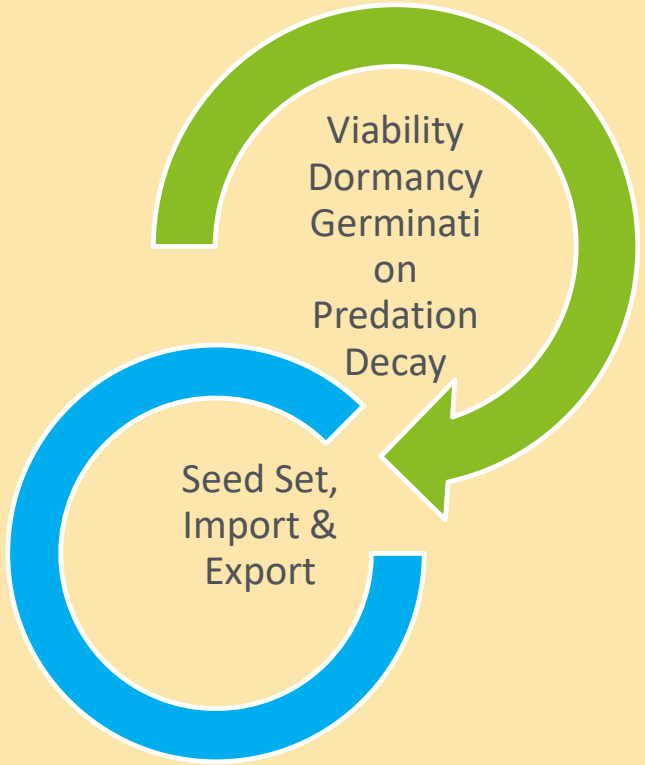
Weed seedbank management



1.Rotation(weeds are adapted ALREADY)

2.Ploughing v's Cultivation

3.Cover soil or fallow

4.Record weeds

5.Check crop seed

6.Adjust Combine Harvester to retain weed seeds?

7.Check for seeds in manure

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Summary of weed control

Prevention	Favour Prevention rather than Cure
Systems	Use a Systems Approach (C. Spedding)
Smart	Be smart-er, turnover is vanity, profit is sanity
Soil	Fill and Feed the soil with biodiversity, Healthy soil will grow competitive crops

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Rethinking Agricultural Systems

1. Value Biodiversity
2. Healthy Soil
3. Systems thinking
4. Homeostasis: organisation in living organisms
5. Observation skills-indicators
6. Overview
7. Long-term thinking and acting-game theory
8. Shifting goals
9. Impart Health

Health booklet.pdf (organic Research centre.com)

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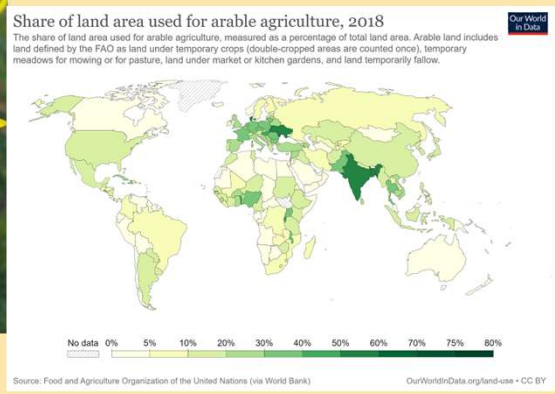
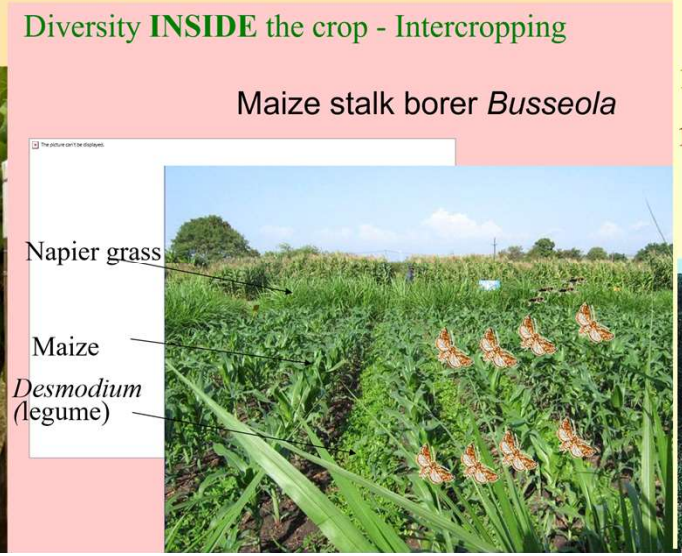
1. Biodiversity

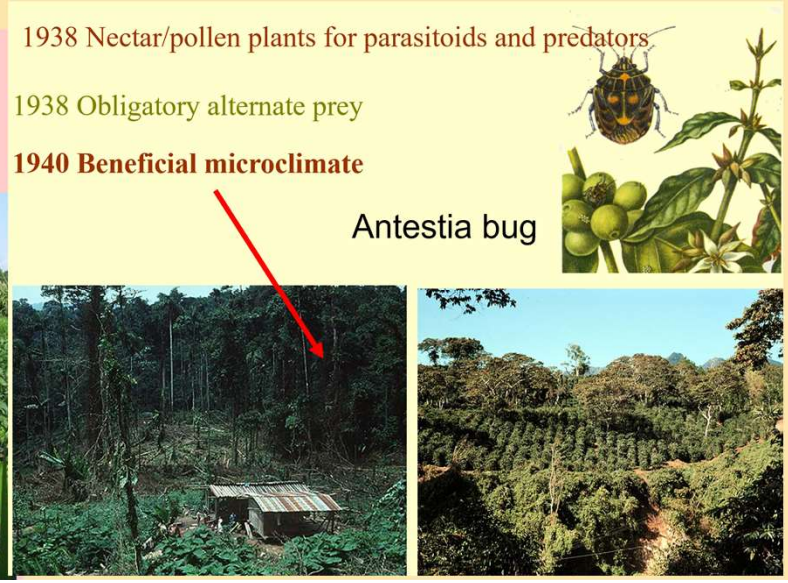
What is biodiversity?

Why is it important?

- The Dasgupta Review: Economics of Biodiversity







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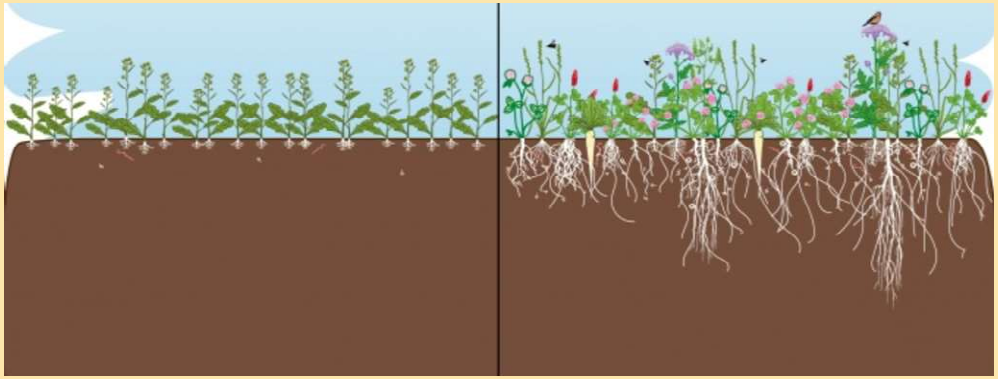
2. Healthy Soil

Mechanism: Bio-cultivations and biodiversity



- Diverse mixtures provide benefits of the **sampling effect and the niche differential effect** (Tilman 1999)
- Highly diverse leys **root twice as deep** as expected from their monoculture
- traits, **giving access to greater soil resource which can correlate with aboveground productivity**
- (Mueller et al. 2013).


Everything comes
from the soil
including
Climate Change
Ruddiman (2005) estimated the depletion of the terrestrial C stock (soil and vegetation) by 456 Pg (502.65 × 109 tn) since the onset of agriculture. Of this, the historic depletion of soil organic carbon (SOC) stock is estimated at 130 to 135 Pg (143.3 × 109 to 148.8 × 109 tn) (Sanderman et al. 2017; Lal 2018)

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3. A Systems approach is needed

- Central to the idea of a Systems Approach (Spedding 1979), is that

"one must understand the system before one can influence it in a predictable manner".

- Expect a consequence to any stimulus, input or output from the system, this involves understanding feedback loops, thus avoiding **unintended consequences**

This also fits with **ecology**
being the central science of agriculture in the 21st century (Weiner 2004).

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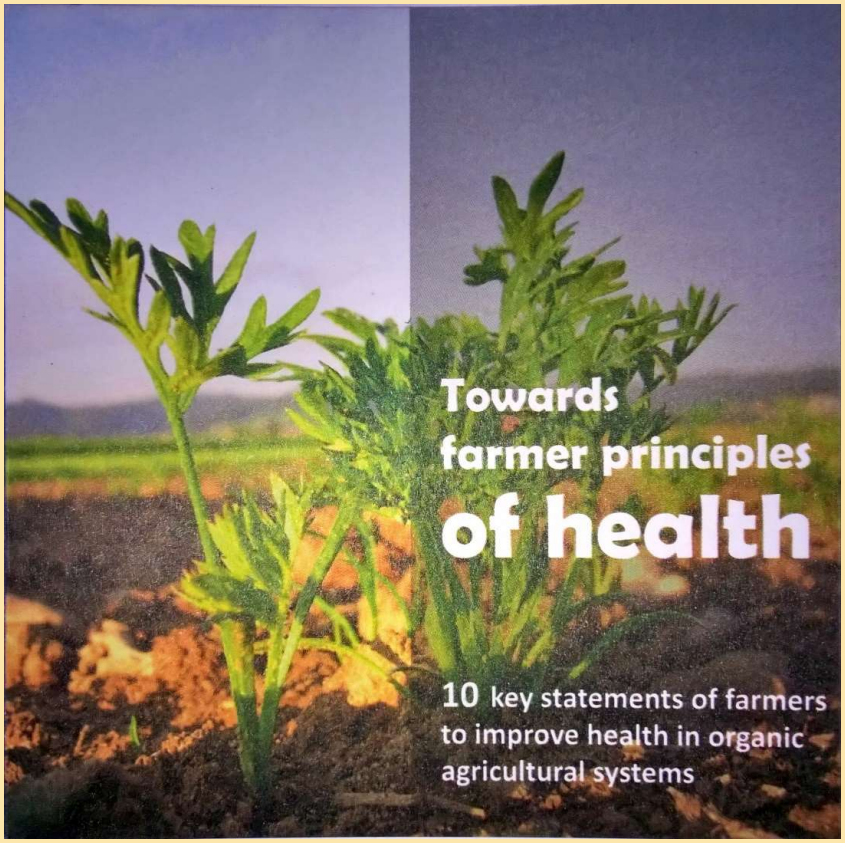
Whole Farm Organism/System

1. Soil Health
2. Biodiversity
3. Systems thinking
4. Observation skills
5. Intuition and self observation
6. Overview
7. Long-term thinking and acting
8. Shifting goals
9. Impart Health
10. Indicators



Health booklet.pdf (organic Research centre.com)

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Health, Stability, Resilience…

- Modern, industrial or chemical (conventional) farming seeks to stabilise (or maximize) production and income using artificial fertilisers, medicines and pesticides (Smith et al. 2007). These are used as, **targeted short-term solutions** (Watson et al. 2002), cures to problems relating to soil fertility, animal fertility, pests, disease and weeds. The conventional system uses these inputs to create a **perceived stability**. Perceived because the stability of simplified systems in modern agricultural landscapes is not self supporting - it relies on these outside inputs. These direct remedies often fail to address the systemic weakness that has caused the original symptom. They cause a systemic vacuum of communication between the biological organisms in the conventional system.
- A direct remedy cure may often cause unforeseen consequences despite short-term benefits. Some of the long-term consequences of this curative approach are a) the extensive use of fossil fuels and associated greenhouse gas emissions, b) pollution from leaching fertiliser and manures, agrochemicals or medicines and c) soil degradation; in particular through loss of carbon which impacts soil function and also contributes to carbon dioxide accumulation in the atmosphere (Power 2010).
- Resilience in biological systems implies an ability to bounce back or return to the original form following a challenge, it is the **ability to cope with a challenge** (Gunderson 2000, Doring et al. 2015). Resilience focuses on **recovery of a system after a shock** (Doring et al. 2015).

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4. Homeostasis (Cooper 2008)

- There is a **fundamental stabilisation principle** that governs natural systems that gives them a type of resistance or resilience to fluctuations.
- In biology this equilibrium is found in living organisms, but more than just coping with shock, living systems have an ability to adapt to new conditions or shocks with a constant rebalancing, this smart resilience is called homeostasis.
- Homeostasis is the act of an organism adapting to change. It is important to note that this adaptation, does not necessarily involve a return to the former equilibrium. We can take the development of an athlete as an example.
- **Rather than just bouncing back it is the ability to bounce forward.**
- Claude Bernard (1843) based his concept of active stabilisation of bodily states against disturbances from the outside on **negative feedback mechanisms**.
- **2 key notions:** There must be an overall conductor/orchestrator providing "**regulation"** and a ''**harmonious whole**.''
- Instinctive responses represent the basis of the regulatory behaviours animals use to maintain homeostasis, rather than learnt responses such as Pavlov's dog (Woods and Ramsay 2007).
- If homeostasis means life, then perhaps **optimum homeostasis is health**.

Homeostasis in communities

- The question is, does a community act like an organism or are the individual components competing?
- There is evidence for self-organisation in soils (Lavelle, Decaëns et al. 2006), and ant colonies, and perhaps herds of cattle or wildebeest.

- Can we describe or envisage a forest or a farm as an ecosystem homeostasis?

- Perhaps if we can enable joined up communities on farm we can enable self-organisation?
- Diverse root communities in Diverse Leys?
- Or even the whole farm biodiversity?

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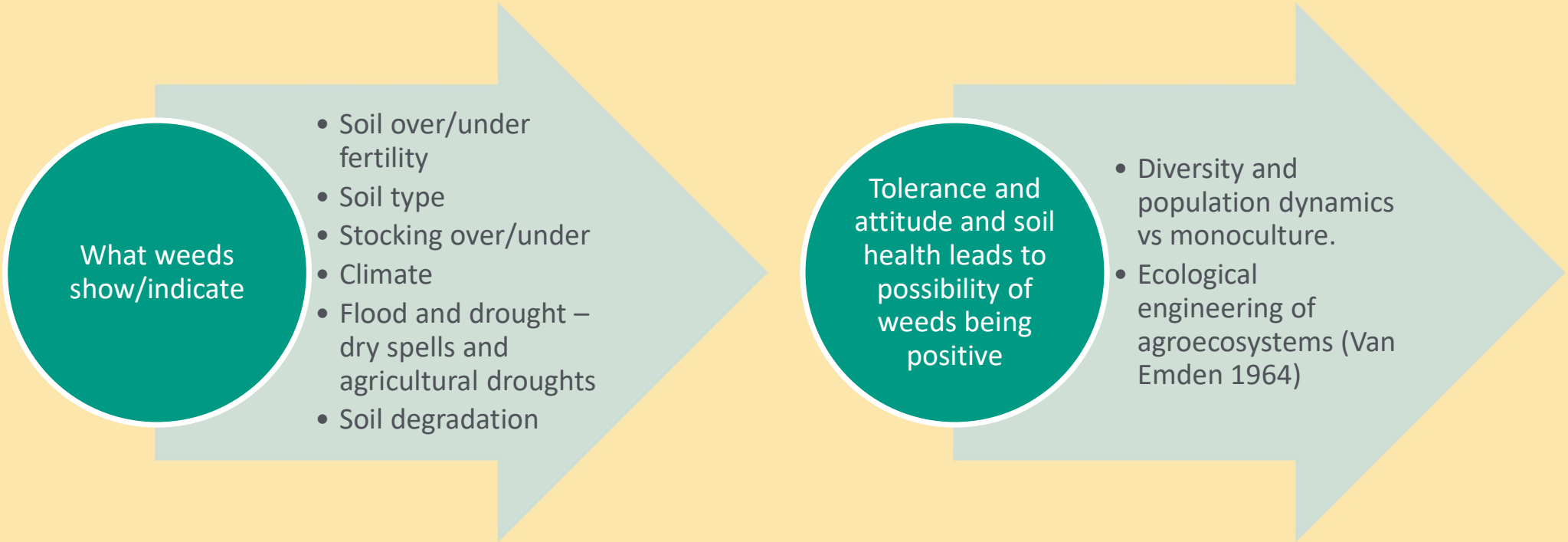
5. Observation Skills and indicators



Ian Davenport: In arid and semi-arid regions, cyanobacteria use light and water to grow filaments that bind soil particles together, forming a crust that helps to prevent erosion. Photo from Diamantina, Australia.

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The Monkey Business Illusion - Bing video

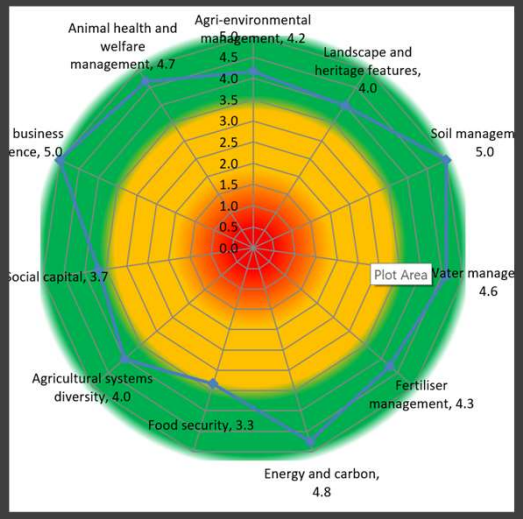
- Test your powers of observation

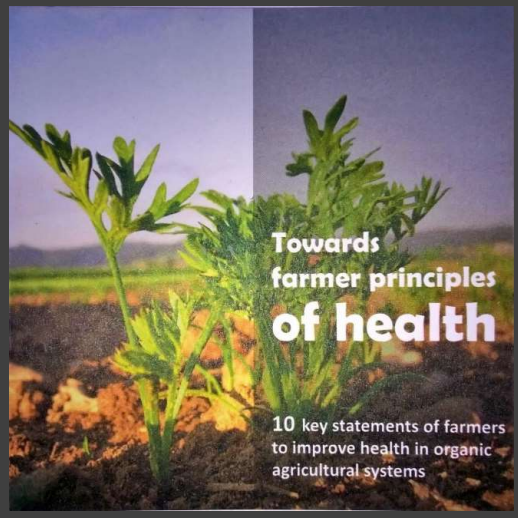
How to measure system/organism health?

Impact

using

B Corp. Impact Assessment - Public Goods tools - Health Principles





Governance, Environment, Workers, Community, Society, Business, Diversity

http://www.organicresearchcentre.com/manage/authincludes/article_uploads/project_outputs/Health_booklet.pdf

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Observation

- Athlete or body builder?

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Observation

See the Impact through **Active Perception**

- Conscious recognition
- Perceiving the process behind what one sees
- See a field of plants perceive the roots
  and life organisation in the plants and soil

Observe cow health through
rumen function

Obsalim®

Gut instinct

Good farmer or bad farmer?

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Rethinking Agricultural Systems

1. Value Biodiversity
2. Healthy Soil
3. Systems thinking
4. Homeostasis: organisation in living organisms
5. Observation skills-indicators
6. Overview
7. Long-term thinking and acting-game theory
8. Shifting goals
9. Impart Health

Health booklet.pdf (organic Research centre.com)

6. Overview

- It might sound obvious to say that **farmers are the key to the future of agriculture**.
- However, agriculture has not been led by farmers for many generations; government support has lead farming, most recently in the UK with the EU's Common Agricultural Policy.
- It is a farmer's job to ensure the manageability and overview of the land and processes (diversity, integrity and sustainability). Their responsible organisation, design and optimization of the capacities is essential so that the complexity and size of the farm does not negatively affect the overall health (Vieweger 2018).
- Different farm scales require different processes and organisational structures to achieve a healthy system. A healthy farm must be sustainable and profitable by implication.
- Farm optimization will be dependent therefore on the specific circumstances of the farm and the capabilities of the farmer. It is the farmer who is the key.
- Pfeiffer (1983) said "The human being who guides and directs the beginning, the course and the end of natural growth processes, is the strongest force in nature. His capacity is the final decisive factor." Of course, you might say, but most farmers underestimate the power and responsibility at their fingertips.

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7. Long-term thinking and acting

- **game theory**
  - **infinite players and finite players**
  - **John Nash's equilibrium, otherwise known as Governing Dynamics**

    -states that if each player cannot improve their situation given the other players keep their's constant then a Nash Equilibrium exists. This means that it is important not just what is best for the current crop, for the best total outcome one has to take into account the whole farm
- It demonstrates the principle where, if decisions are made on a collective approach rather than an individualistic approach, the outcomes will be greater than viewing each individual decision separately.
- Farm management training has led to the common practice of focusing on enterprise gross margins as the ultimate guide in assessing the contribution of each farm enterprise to farm profitability. If at the farm level the farm enterprises are viewed as a collective rather than the individual level of the enterprise gross margins, in economic terms the whole farm profit, a better cooperative systems outcome can be visualised.

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More on game theory

- Glimcher (2002) cites several applications of this game theory to biological questions, in a moose choosing grass or algae or a monkey choosing a mate.
- Take the example of cattle in a mixed farm, the simple equation of costs and income (enterprise gross margin) is far too simplistic to fully perceive the cattle contribution to the whole farm system.
- Cattle contribute to the soil organism community (Birkhofer et al. 2008); cattle spread the microorganisms that are developed in their gut around the farm and fields, they spread earthworm eggs, they encourage biodiversity through the food chain by feeding insects and birds, the cattle form a collective with the other farm organisms.
- Grazing of grassland by cattle increases sequestration of carbon in the soil, compared to un-grazed (Reeder and Schuman 2002).
- All these factors currently don’t form part of the business accounts, yet they contribute to the whole farm output or to public goods and services beyond the farm.

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8. Shift goals

- **-can we feed the world?**
  - **Do we feed the world?**
  - **Will we feed the world?**
- **Agricultural intensification or ecological intensification**
- Small farms can have higher yields and higher biodiversity (Ricciardi, Mehrabi et al. 2021)
- Landscape view
  - » Land sparing land sharing
  - » Shifting baseline syndrome Paully (1995)
  - » (van Emden 1964)

Can organic farming feed the world?

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1. 1/3 of food produced is wasted
   •
2. 3 times more Obese people than hungry (W.H.O.)
   •
3. Does conventional farming feed the world? Does conventional farmed food feed people well?
   - What does the overyielding go to feed? The extra yield in conventional farming goes to feed pigs and chickens which are intensively reared. We need grass fed beef and dairy
   - Modern ag is based on fossil fuels that has to change. Will conventional farming continue?
     - Agro fertilisers – Fungicides - Anti biotics – Glyphosate - Weed killers – insecticides - Animal welfare - Soil quality - Water quality - Air quality
   - Chemical farming feeds the privileged!
   - Farming needs a system change, It is not a question of if, it will have to, and already is. But using a little less is green wash.
   - (In 2 minutes there is the same amount of energy arriving from the sun as man takes a whole year to produce)
   - Agriculture has caused much of the modern problems on earth, organic farming needs to lead the way to a new farming system,

5. Oliver Walston once said to a conference of organic farmers you are farming for the planet, I am farming for the people!
   - A friend recently said she is producing food, that food production is their focus.
   -
   - How short sighted it is not to realise that the health of the soil, plant, animal, wildlife, human and planet are one and indivisible (Balfour 1948). If you don't look after the means of production then future production is jeopardised.

6. We need to have the infinite view- see Game theory in Mathematics

7. Mitigation and adapt for climate change - Reverse the biodiversity decline - Ensure food production for our children

More on yield

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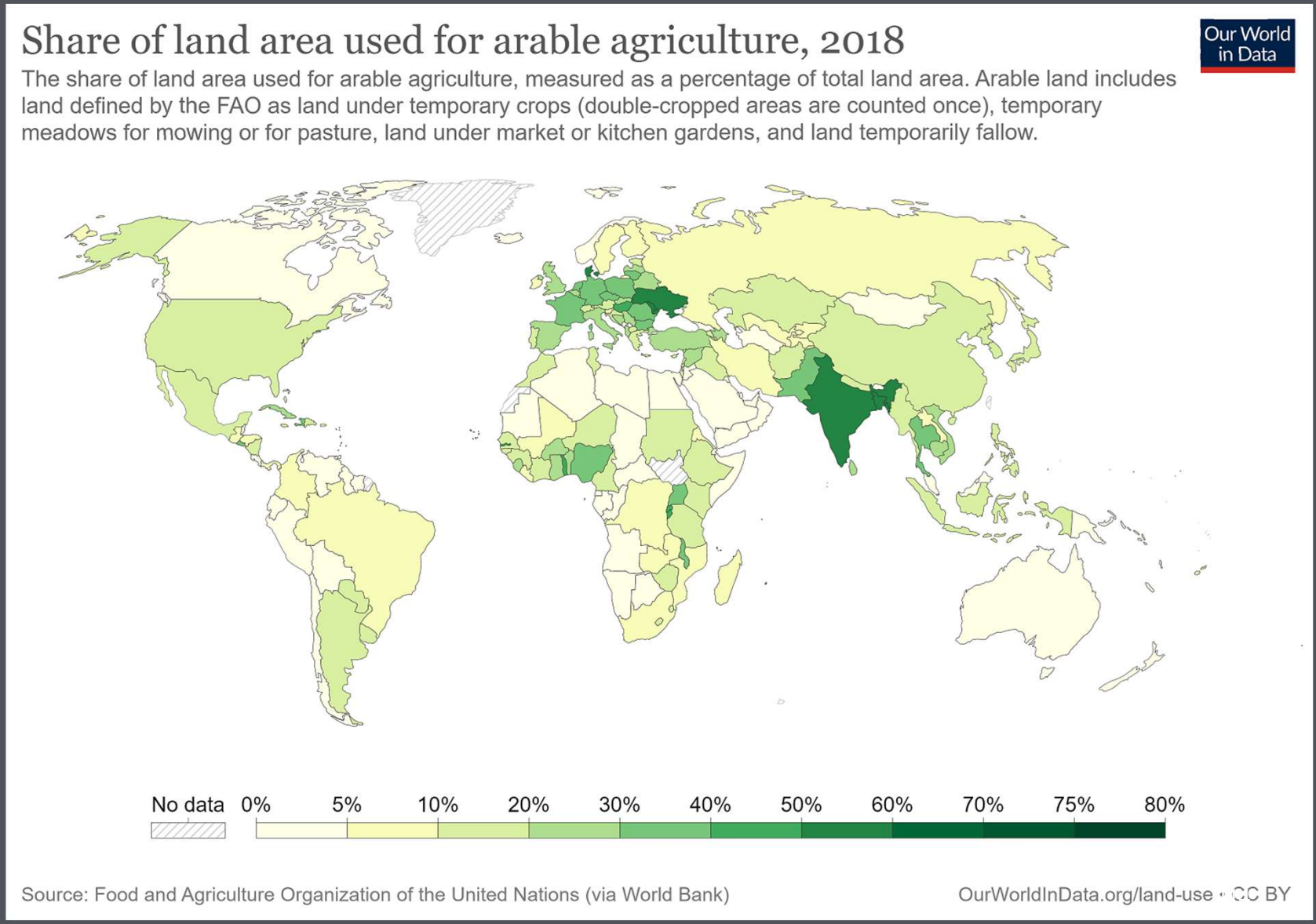
- Notwithstanding that, the adoption of alternative farming approaches in temperate climate systems is typically associated with a general yield penalty (Mader et al. 2002, de Ponti et al. 2012, Seufert et al. 2012), though this can be compensated for by increases in crop **quality** (Lairon 2011).
- …in **climate extremes** organic systems have been shown to out yield intensive input based systems (Lotter et al. 2003). In their experiment at the Rodale institute in the USA, Lotter et al. (2003) found that in four out of five drought years through 1984-1998, the organically managed plots yielded better than the conventional ones. Their organically managed soils retained more water and captured more than the conventionally managed plots and in "torrential rains" the organic soils captured approximately 100% more than in the conventionally manged soils. They propose that this improvement in water holding capacity accounted for the improved yields. In a 7-year experiment Smolik et al. (1995) showed less variability of net income for organic than conventional farms, interestingly they also found their reduced tillage conventional system was the least energy efficient system.
- Two more authors have shown that organically managed crop systems have **lower long-term yield variability** (higher stability), (Henning 1994, Peters 1994) as cited in (Lotter et al. 2003).
- Organic farming food outcomes are different to conventional farming ones
- Climate change is real, carbon needs fixing in our living soil. The world needs more organic.
- Organic farming empowers subsistance farmers to provide food and other public goods without getting into suicidal debt


SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS

Farming occupies just under 40% of global land area (UNFAO).
Ellis et al. (2010) found that by 2000, 55% of Earth's ice-free (not simply habitable) land had been converted into cropland, pasture, and urban areas. This left only 45% as 'natural' or 'semi-natural' land.
If biodiversity is significant in buffering perturbations, is it prudent for farmers to increase biodiversity?
If we remove biodiversity in our fields is it any wonder that the fields become more vulnerable?



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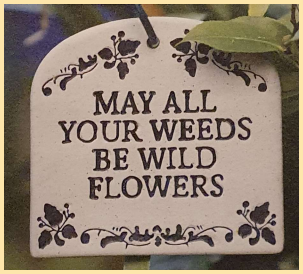
9. Impart Health – with IWM, WFO (philosophy)

- What next
  - Will pests become resistant to IPM
    - » Diversity and population dynamics
- **What if-**
  - Plant the weeds we want
    - Companion plants
    - Wild flowers
  - share all land with nature in a smart way



- **Why- Because our best way to cope with weeds is with a healthy soil**

How Plants Feed (Alex Podolinsky, Bradshaw 2024)

Yatesbury

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- Figure 1
- Nutrients held in stable soil material

- Plant drinking through transpiration
- Plant feeding through mycorrhizal exchange of nutrients
- Plants only take up as much nutient as they need and separately drink as much water as they need

- Balanced plants

- Red indicates nutrient location

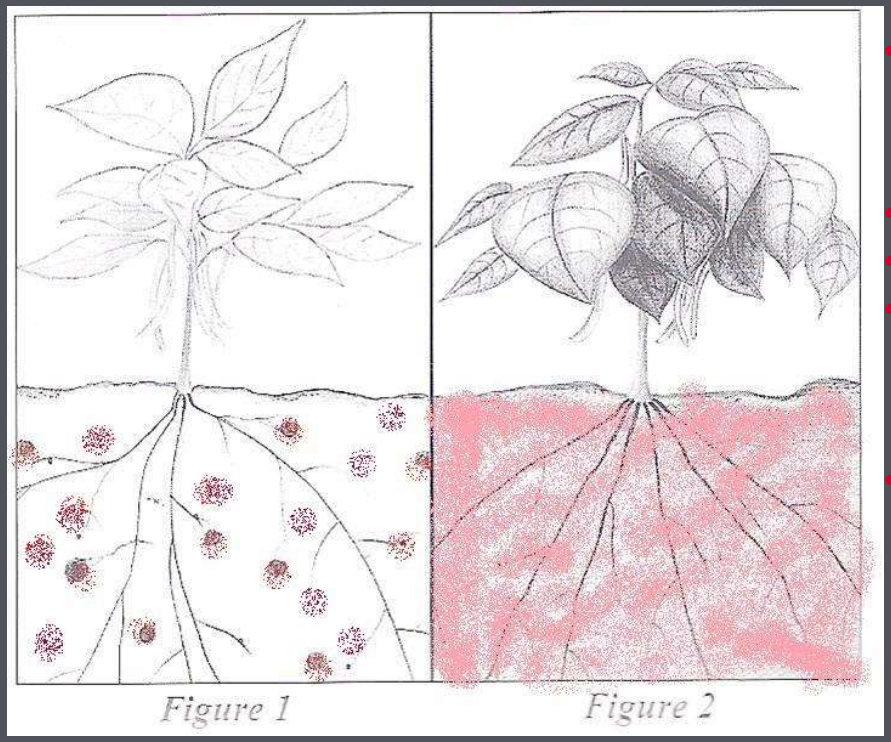
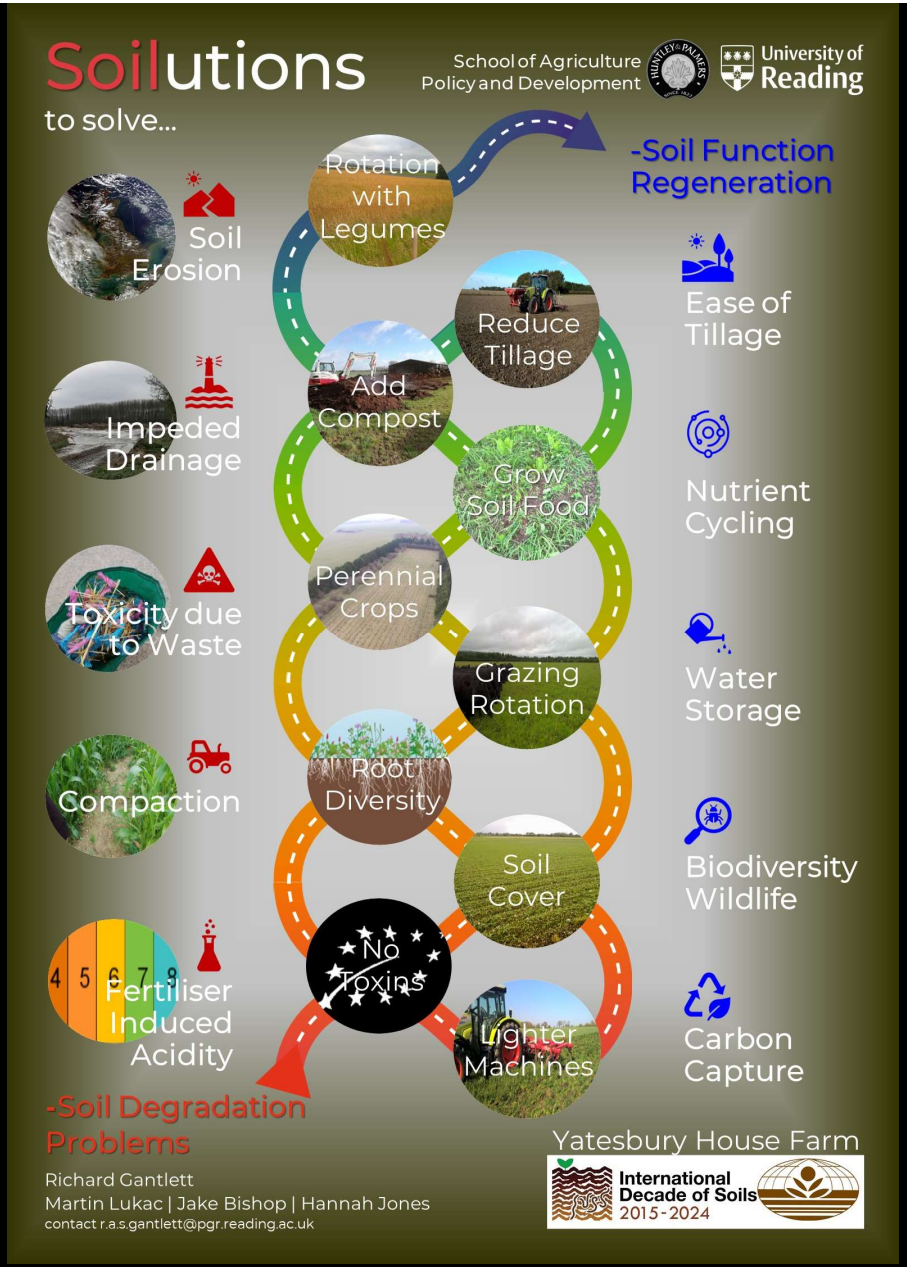


Figure 1 Figure 2

- Figure 2
- Nutrients held in soil water

- When plants transpire, they drink taking up water, but they also take up food without choice at the same time
- i.e. Force fed
- This causes cell bloating
- Indicated by **blue green** leaf colour commonly seen in cereals/grasses

- Leads to:
  - pest and disease access
  - bitterness in fruits/leaves
  - (see area around cow pats
  - which cows won't eat).



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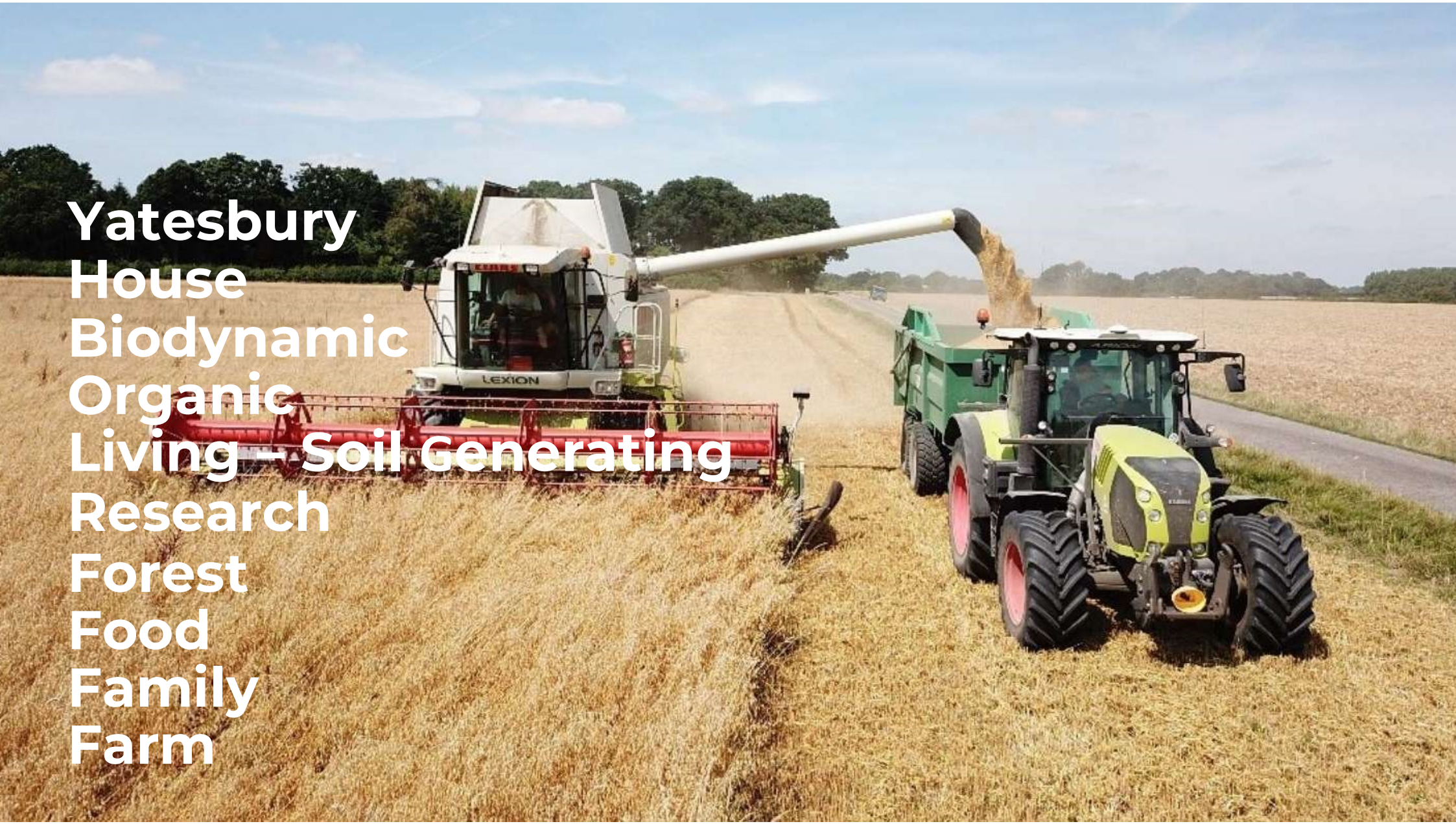
Instagram Yatesbury Farm

Dr Richard Gantlett: LinkedIn, Researchgate, Orchid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Videos:
Yatesbury House Farm **intro 4 mins**
Yatesbury Forest Farm **11 mins**

From others:
The Dasgupta Review: Economics of Biodiversity
Biodynamic Agriculture: Farming in Service of Life | Kiss the Ground - Bing video 5 mins
What's good about Glyphosate?
Where there's muck, there's brass | Rothamsted Research
The Monkey Business Illusion - Bing video

Integrated Pest Management reading/viewing list

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- Weeds in practice -health, homeostasis and active perception
  - Adeux, G., E. Vieren, S. Carlesi, P. Bàrberi, N. Munier-Jolain and S. Cordeau (2019). "Mitigating crop yield losses through weed diversity."
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- Weeds in practice -health, homeostasis and active perception

Cont.

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