Resilient and healthy organic farming systems – concepts, measurements and applications

EPOK Seminar

Research for sustainable organic farming — System perspectives, stakeholder cooperation and communication

Stockholm, 9th December, 2015

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1. The role of health in organic agriculture

Health is central for organic (and non-organic) agriculture

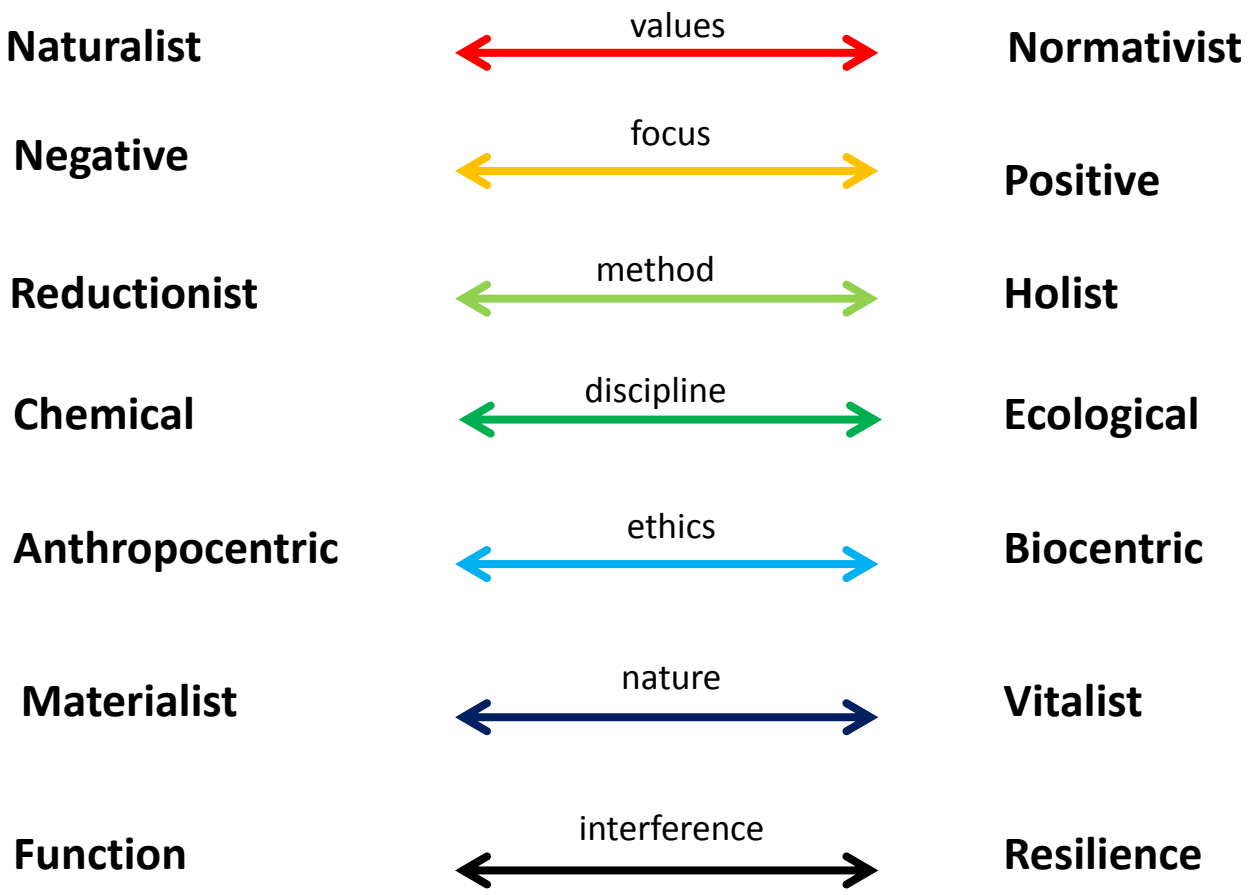
- IFOAM organic principle of health
- Healthy products as *consumers*‘ motivation to buy organic products
- Hot debate in academia and in public about health benefits of organic *products*
- Debate about wellbeing and health of conventional vs. organic *livestock*

So what is health (in the OF context)?

- We need to agree on the meaning(s) of health so that we can promote it

1. The role of health in organic agriculture

Seven dimensions of health concepts



‚Health' cannot be captured by a dictionary definition – it encompasses many different, **diverging concepts**.

Döring et al. 2012, *Plant Path*. 61:1-15

1. The role of health in organic agriculture

Terms used to define health

Growth Paradigm: primarily oriented towards continued growth	**Boundary Paradigm**: focus on maintaining or coming back to a status quo, recognising system boundaries.	**Further terms**
Function	**Maintenance**	**Wellbeing**
Productivity	**Resilience**	**Diversity**
Performance	**Resistance**	**Dynamic**
Provision	**Sustainability**	**Integrity**
Efficiency	**Adaptation**	**Complexity**
	Equilibrium	**Survival**
	Stability	**Vitality**
	Tolerance	**Naturalness**
	Balance	**Normality**
	Recovery	**Welfare**
	Immunity	
	Coping	
	Homeostasis	

In farming contexts, health concepts diverge most notably in how much they **recognise system boundaries**.

Vieweger & Döring 2015.
J Sci Food Agric 95: 438–446

1. The role of health in organic agriculture

An approach to farm health

Category	Metric	Source of case study data		
Species diversity	Planned vegetation richness	Farm questionnaire	Biodiversity score	Healthy farm Index
	Livestock richness	Farm questionnaire		
	Avian indicator species	Researcher and farmer observation		
	Native/total ratio	Researcher and farmer observation		
Ecosystem diversity	Richness of landscape elements	Farm maps/farm questionnaire		
	Percent non-crop	Farm maps/farm questionnaire		
	Percent rare landscape elements	Farm questionnaire		
Provisioning services	Yield average	Farm questionnaire	Ecosystem service score	
	Market opportunities	Farm questionnaire		
Regulating services	Percent of waterways buffered/ sheltered	Farm maps		
	Percent of farm fields protected	Farm maps		
	Percent continuous living cover	Farm questionnaire		
Cultural services	Satisfaction	Farm questionnaire		
	Tenure	Farm questionnaire		

Although biodiversity & ecosystem services are important in OF, **central elements are missing** from this approach.

Quinn et al. 2012. *Int J Agric Sust*

1. The role of health in organic agriculture

The IFOAM Principle of Health

Organic Agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible.

1. Health of individuals and communities cannot be separated from the health of ecosystems - healthy soils produce healthy crops that foster the health of animals and people. Health is the **wholeness** and **integrity** of living systems.
2. It is not simply the absence of illness, but the **maintenance of physical, mental, social and ecological well-being**. Immunity, **resilience** and regeneration are key characteristics of health. […]
3. Organic agriculture is intended to produce **high quality, nutritious food** that contributes to preventive health care and well-being.
4. […] it should **avoid** the use of **fertilizers**, **pesticides**, animal drugs and food additives that may have adverse health effects."

IFOAM 2005

Lady Eve Balfour (1898-1990)

1. The role of health in organic agriculture

Health in the domains of soil, plant, animal, man and ecosystem

- *Linking up* the domains: Indivisibility
  - Do not separate domains – always consider all domains together; or
  - ‚Healths' of different domains are physically or ecologically linked ('transmission of health')
- But the meaning of health may not be the same for the different domains.

1. The role of health in organic agriculture

Health links among the domains

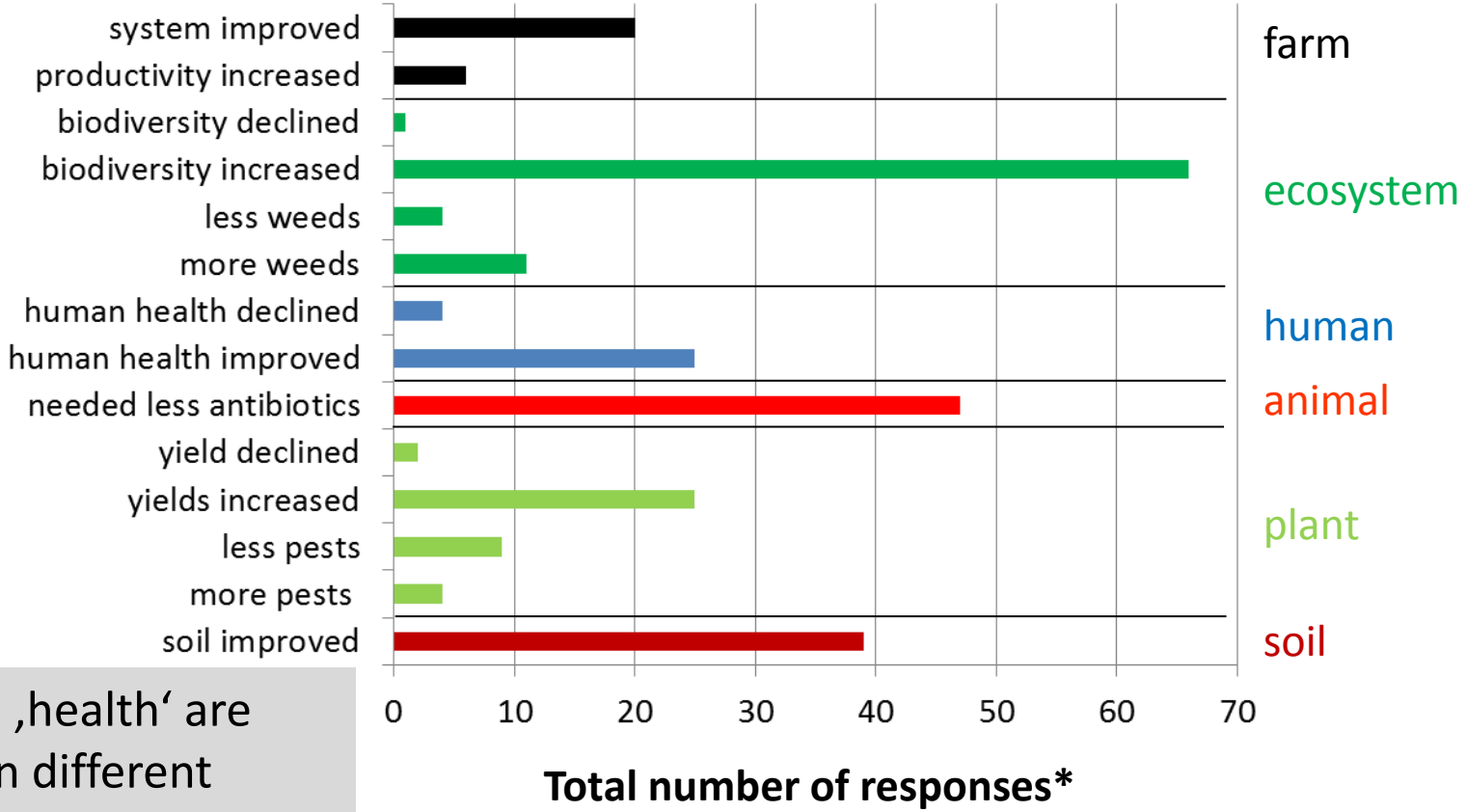
Approach	Links among domains
Physiological	• Nutrients (e.g. nitrogen) • Toxins (e.g. heavy metals) • Drugs
Microbiological	• Microbial communities inhabiting subjects of different domains • Transmittable diseases shared by farm animals and humans
Behavioural	• Health effects of relationship between livestock and humans
Cultural	• Health concepts, paradigms
Political	• Common policies and regulations • approaches to risk assessment
Economic	• Econometric methods

‚Health' **links** are present but **very diverse** and not based on one single transmission mechanism

adapted from Vieweger & Döring 2015, *J Sci Food Agric* 95: 438–446

1. The role of health in organic agriculture

Survey among organic farmers from the UK: How did the health in your system change over time?



Changes in ‚health' are observed in different domains - but criteria remain **incomplete**, **unconnected** and are **not validated**.

*multiple responses possible, post-hoc classification of responses; total number of responses: 237; total number of respondents: 28

unpublished data, A. Vieweger et al. 2015

1. The role of health in organic agriculture

Is organic farming really focussing on health?

- Research and practice are more focused on production and productivity:
  – **health is *secondary***: if it is not related to productivity, it is more or less neglected.
- This is particularly true for **(farm) system level**, i.e. where the different domains come together.
- **Concepts and criteria** of health in the organic community are vague.

All this **impedes promotion of health** on organic farms.

Renewed efforts are needed to promote health, both in research in practice

Multidisciplinary workshop on health in organic farming

Can resilience be used as a unifying criterion of health?

2. Measuring health through resilience

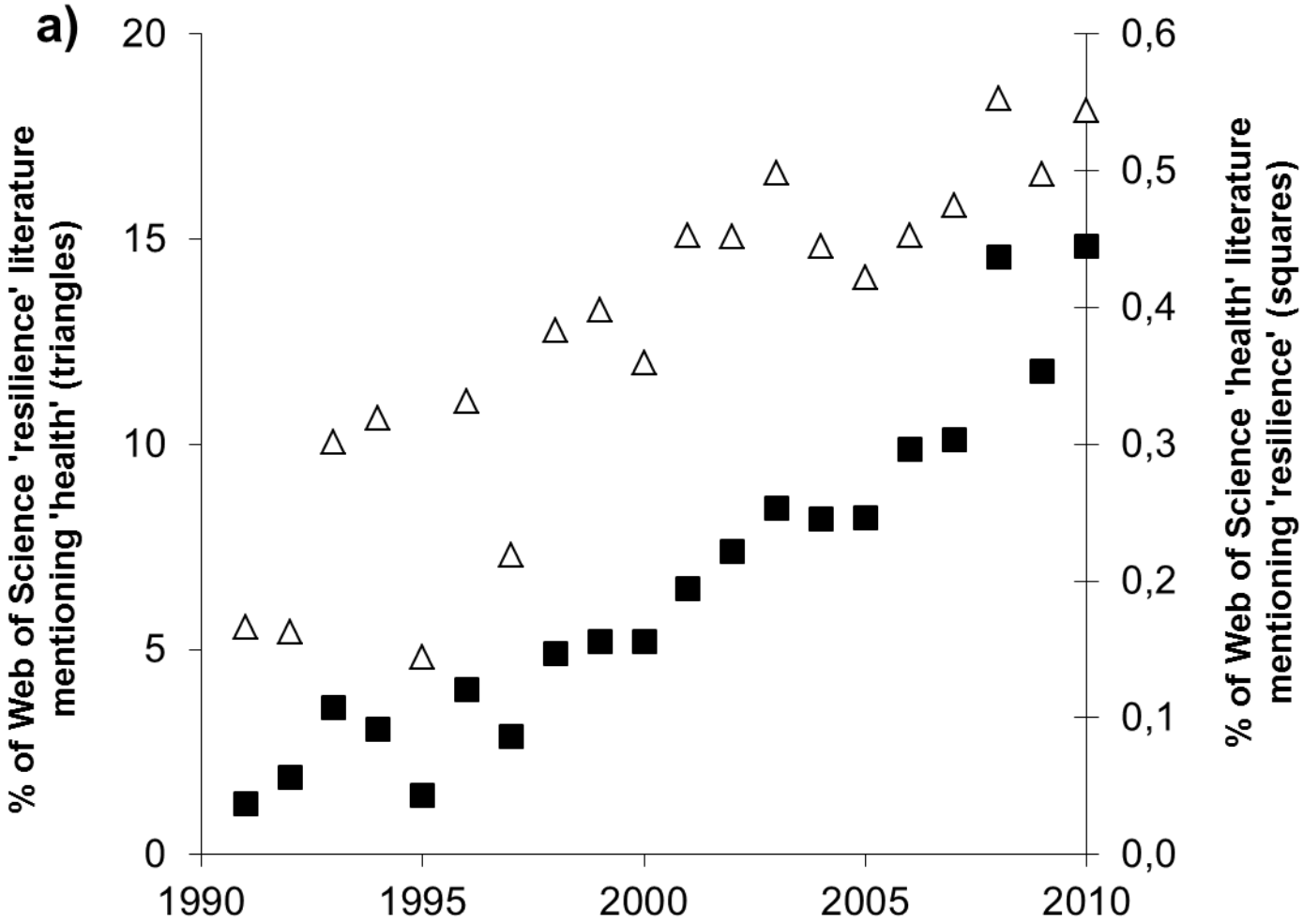
Can resilience be used as a unifying criterion of health?

1. **How is the term „resilience“ currently used in the literature on health?**
2. **How is resilience defined?**
3. **Is resilience a potentially useful criterion of health?** What are its advantages and disadvantages?
4. **Does resilience provide links between the different domains of soil, plant, animal, and man?**

Photo from the website of the First *International Symposium on Societal Resilience*, Virginia, 2010

2. Measuring health through resilience

Resilience in the health literature



Döring et al. 2015. *J Sci Food Agric* 95: 455–465.

2. Measuring health through resilience

What is resilience?

Latin '*resilire*' meaning 'to jump back'.

Some definitions

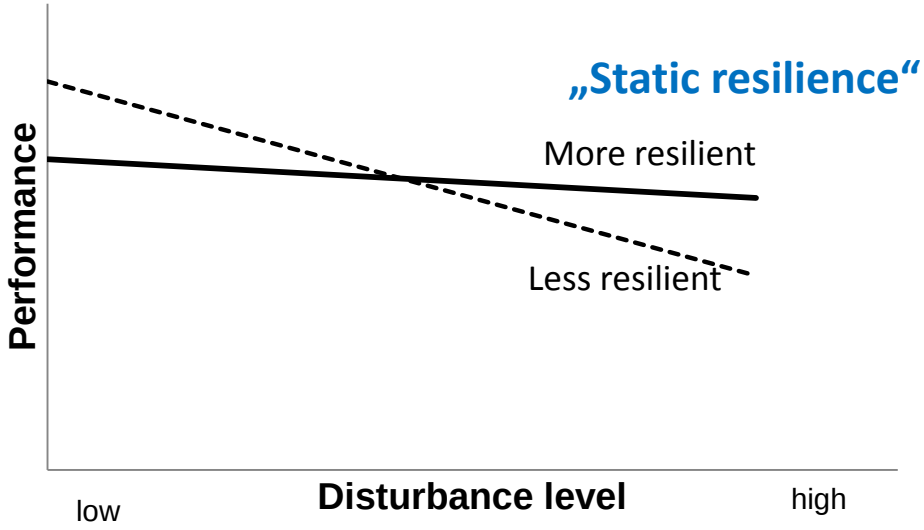
- **Materials:** The ability to return to the original form or position after being bent, compressed, or stretched.

- **Organisms**: The ability to recover readily from illness, depression, or adversity

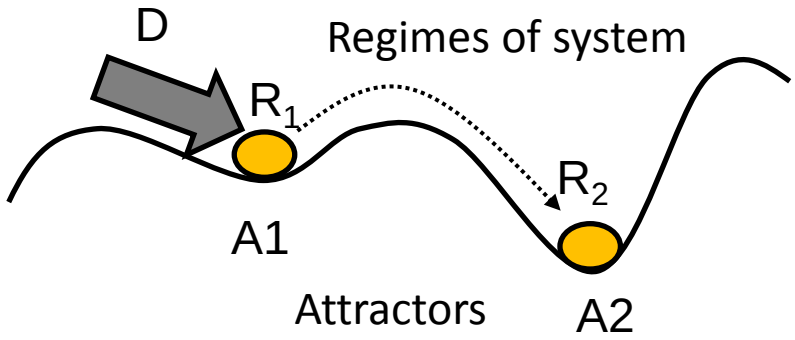
- **Soils and ecosystems**:
  - The ability of a system to return to its original state after being disturbed;
  - The amount of disturbance that a system can absorb before it changes its structure;
  - The ability of a system to remain functional when under external stress.

2. Measuring health through resilience

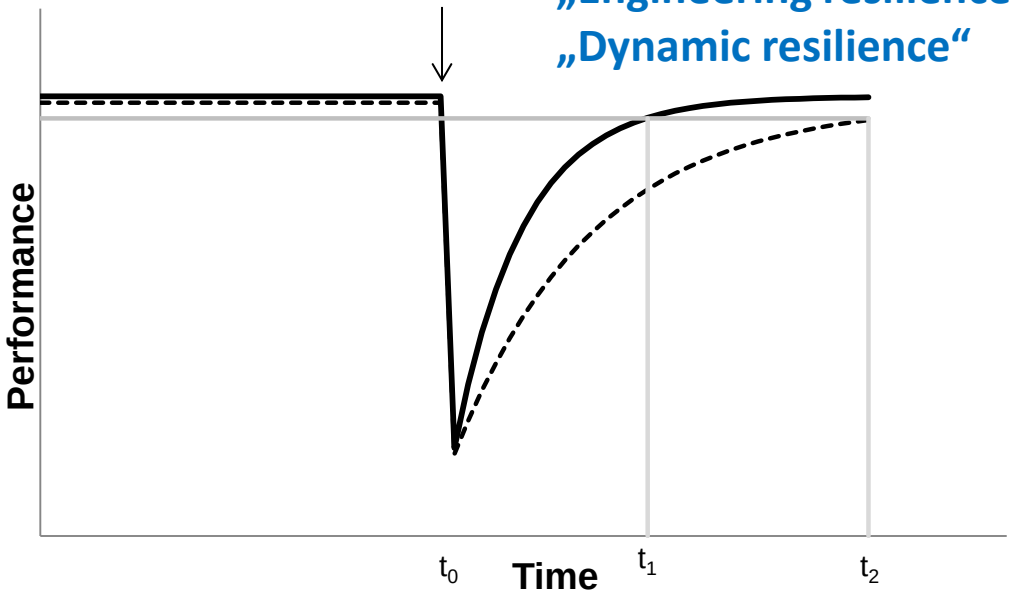
What is resilience?

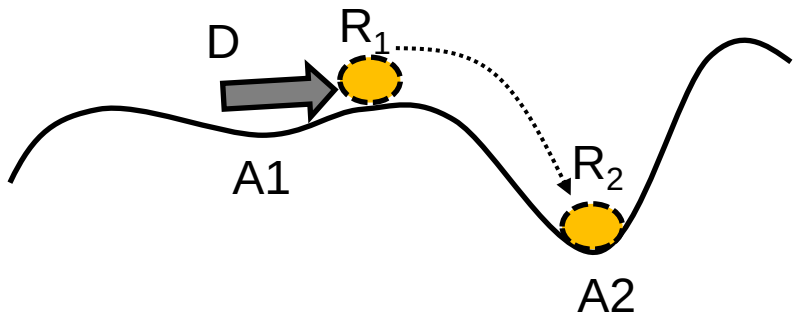


„Ecological resilience“
after Holling (1973)



„Engineering resilience“ or
„Dynamic resilience“





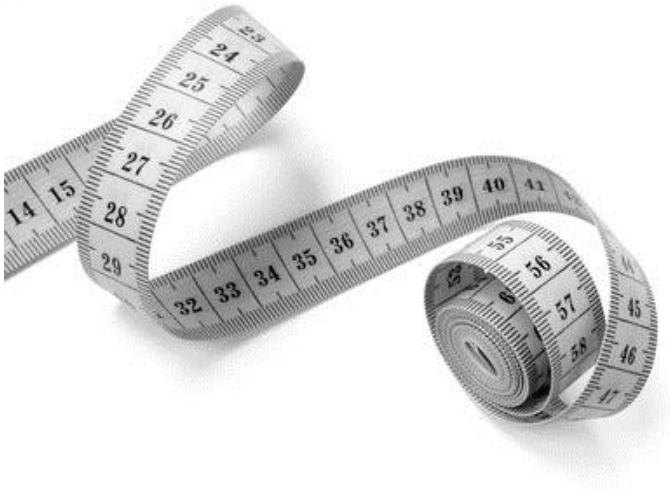
Holling C (1973) Ann. Rev. Ecol. Syst. 4:1-23

2. Measuring health through resilience

Can resilience be a useful criterion of health?

Advantages

1. Measureable
2. More concrete than fuzzy term of health
3. Is already shared among domains
4. Topical



Support to move towards a dynamic formulation of human health, "**based on the *resilience* or capacity to cope and maintain and restore one's integrity, equilibrium and sense of wellbeing**" (Huber et al. 2011 *BMC*)

Limitations?

1. Concept is not unified among disciplines.
2. It might become "too popular" (like *sustainability*).

2. Measuring health through resilience

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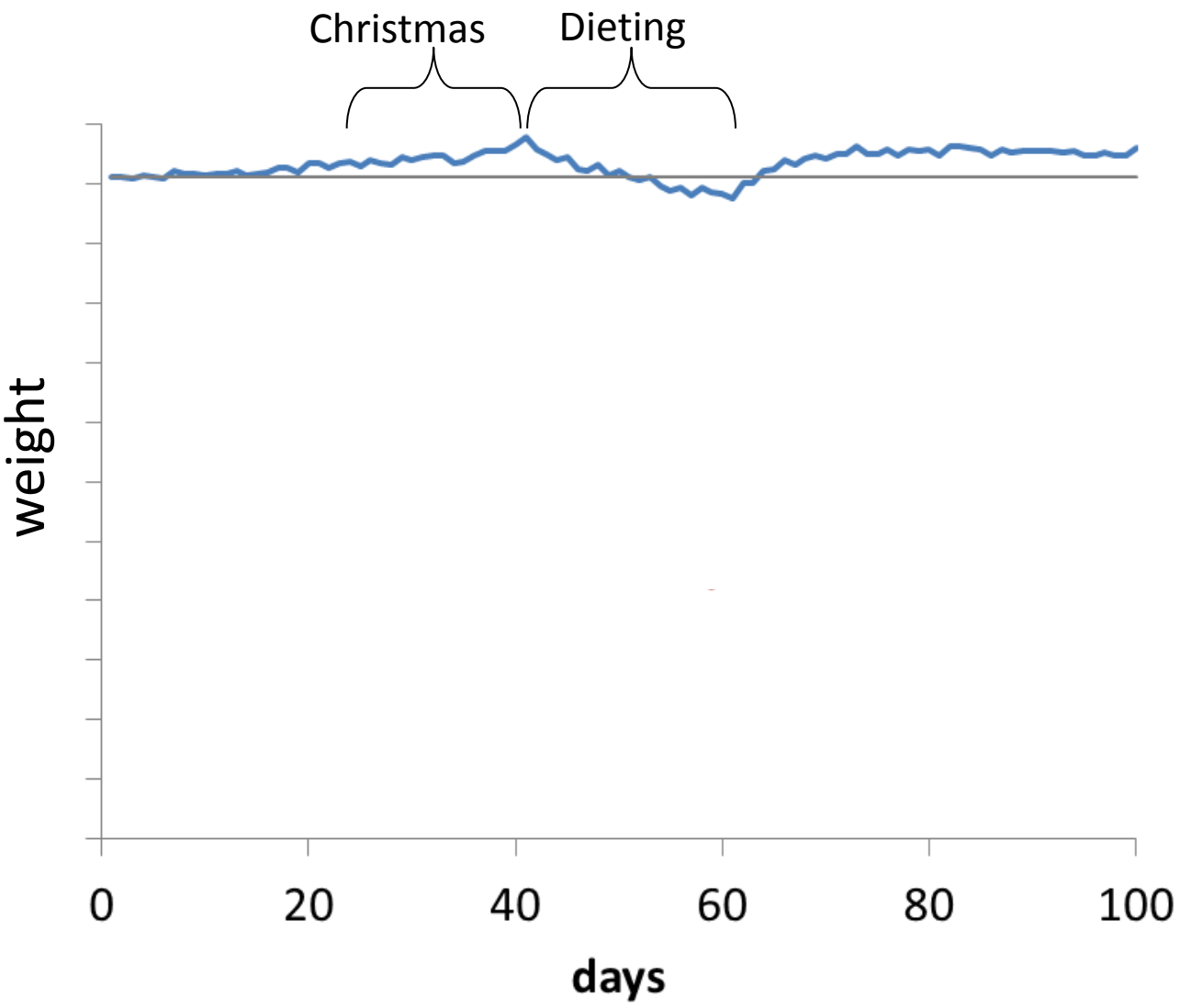
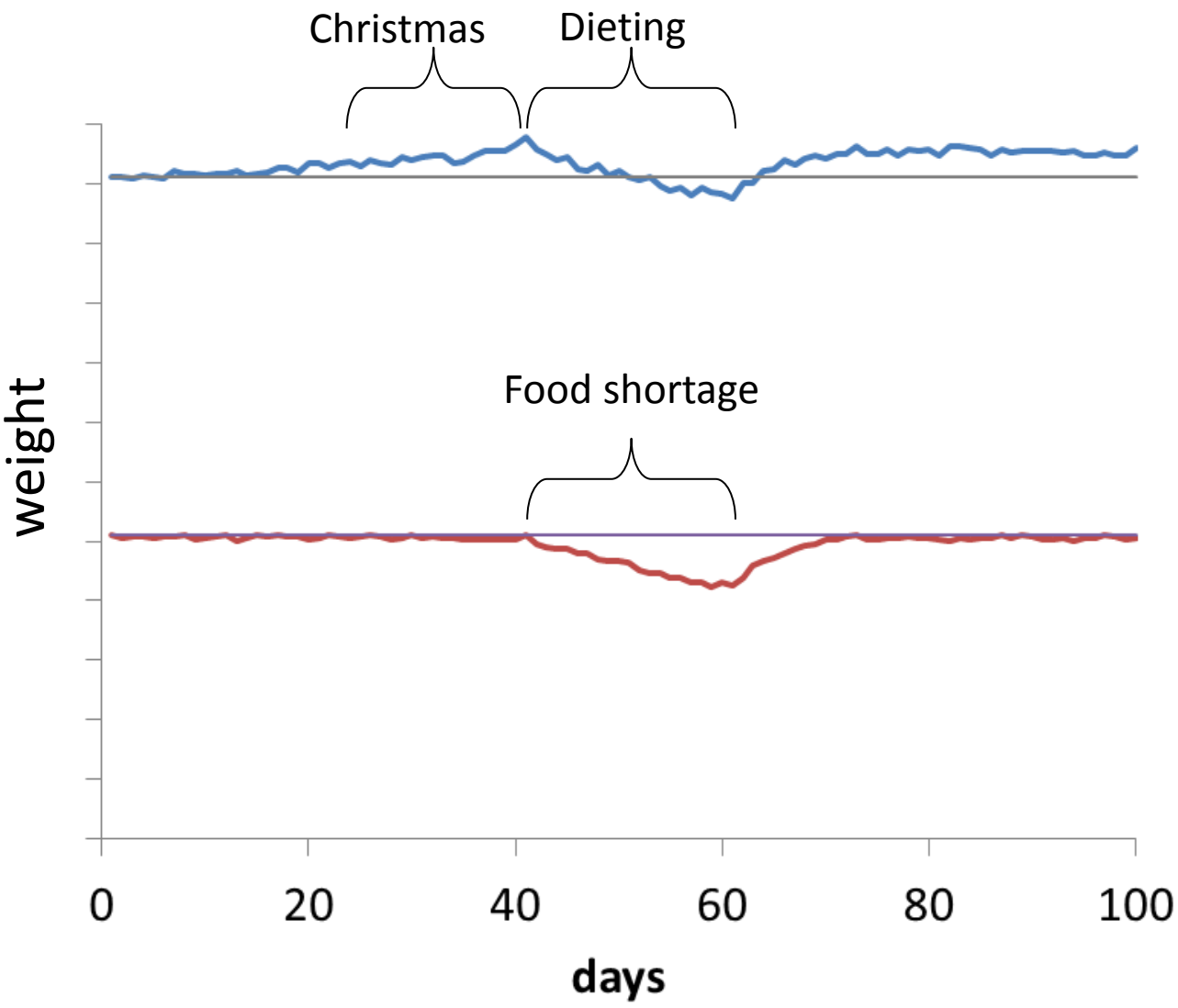


2. Measuring health through resilience

Can resilience be a useful criterion of health?



Resilience impeding health

Resilience supporting health

2. Measuring health through resilience

Does resilience provide a link between the domains?

Examples

- Soil functional recovery after compaction disturbance: improved plant health
- Healthy soil leads to quicker degradation of pesticides: lower health risk for humans

Counterexample

- Plants recover from climatic stress through compensatory growth: → yield secured but not necessarily any effects on animal or human health

Unclear

- Plants respond to fungal infection with higher level of defense (induced resistance): → effects on animal or human health currently not well known or debated

Resilience is a **useful** criterion for health in agricultural contexts but it has its **limitations** and it should **not be used as the sole criterion** of health.

3. Applications in farming systems

Determinants of resilience:

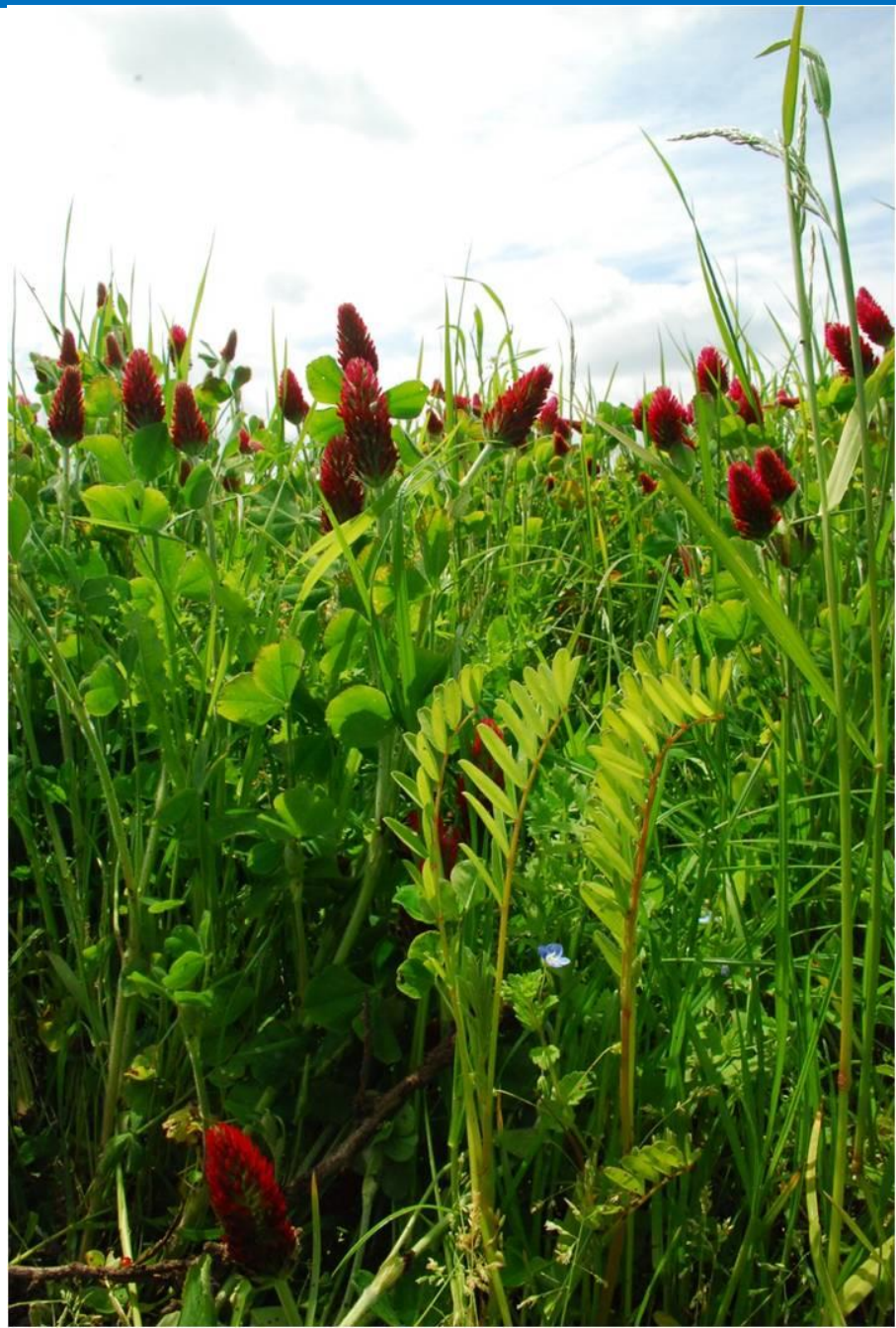
What can be done to promote resilience on organic farms?

- **Soil organic matter management**
- **Selection of crop species**
- **Increased plant diversity**

“Soil stability (resistance and resilience) [...] is related to soil properties such as organic matter, aggregation, the quantity and quality of carbon inputs and, to a lesser extent, clay content and soil pH.“

“There is no general soil response to disturbance because stability is particular to the disturbance and soil history.”

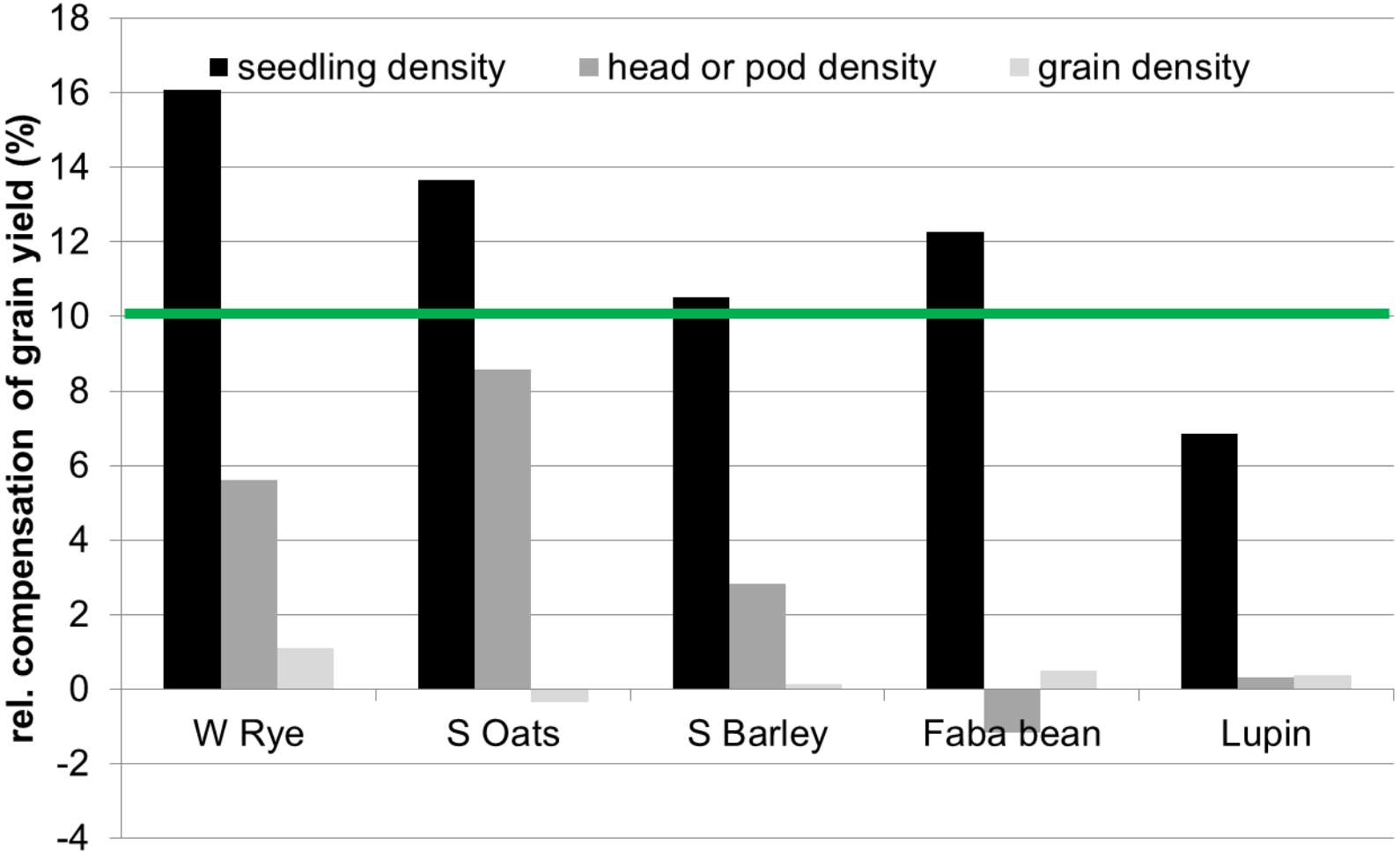
Griffiths & Philippot 2013. FEMS Microbiol Rev 37: 112–129



3. Applications in farming systems

Resilience in agronomy

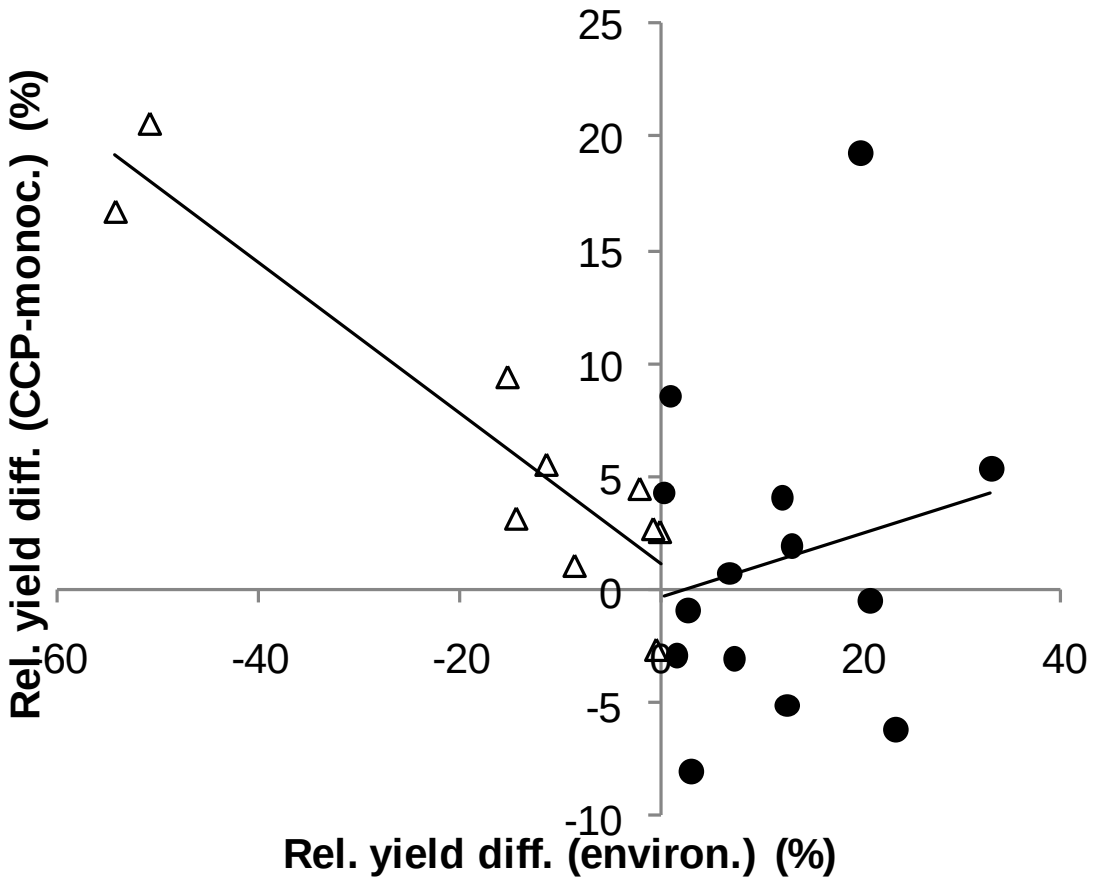
Compensatory growth through plasticity of yield components



Data: Berlin Dahlem ‚E-Feld' Long-Term yield observations (non-organic), **unpublished**

3. Applications in farming systems

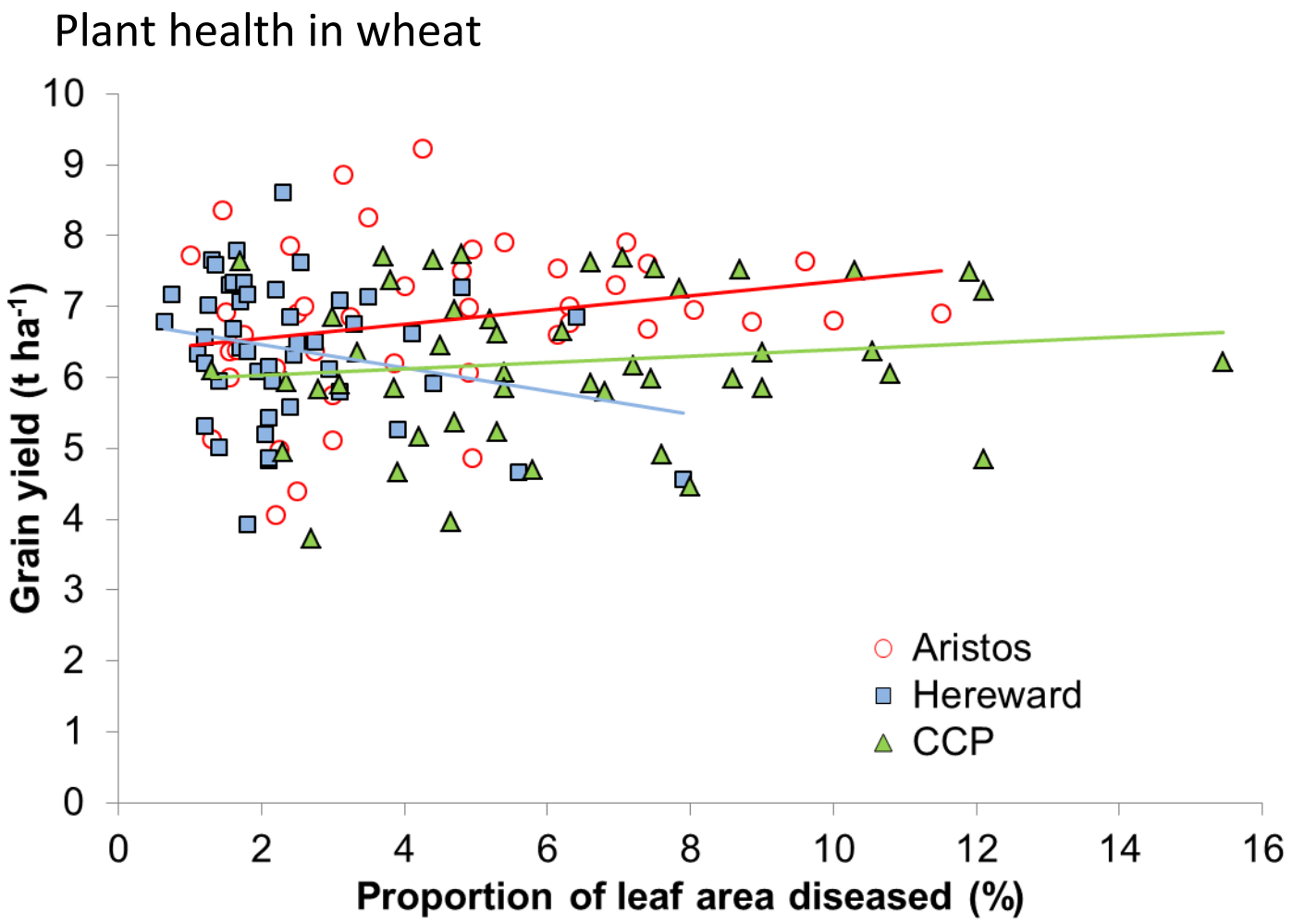
An example of ‘static’ resilience in wheat through genetic diversity



Döring et al. 2010. Eucarpia 2nd Conference of the Organic and Low-Input Agriculture Section, Paris.

3. Applications in farming systems

What can be done to promote health on organic farms?



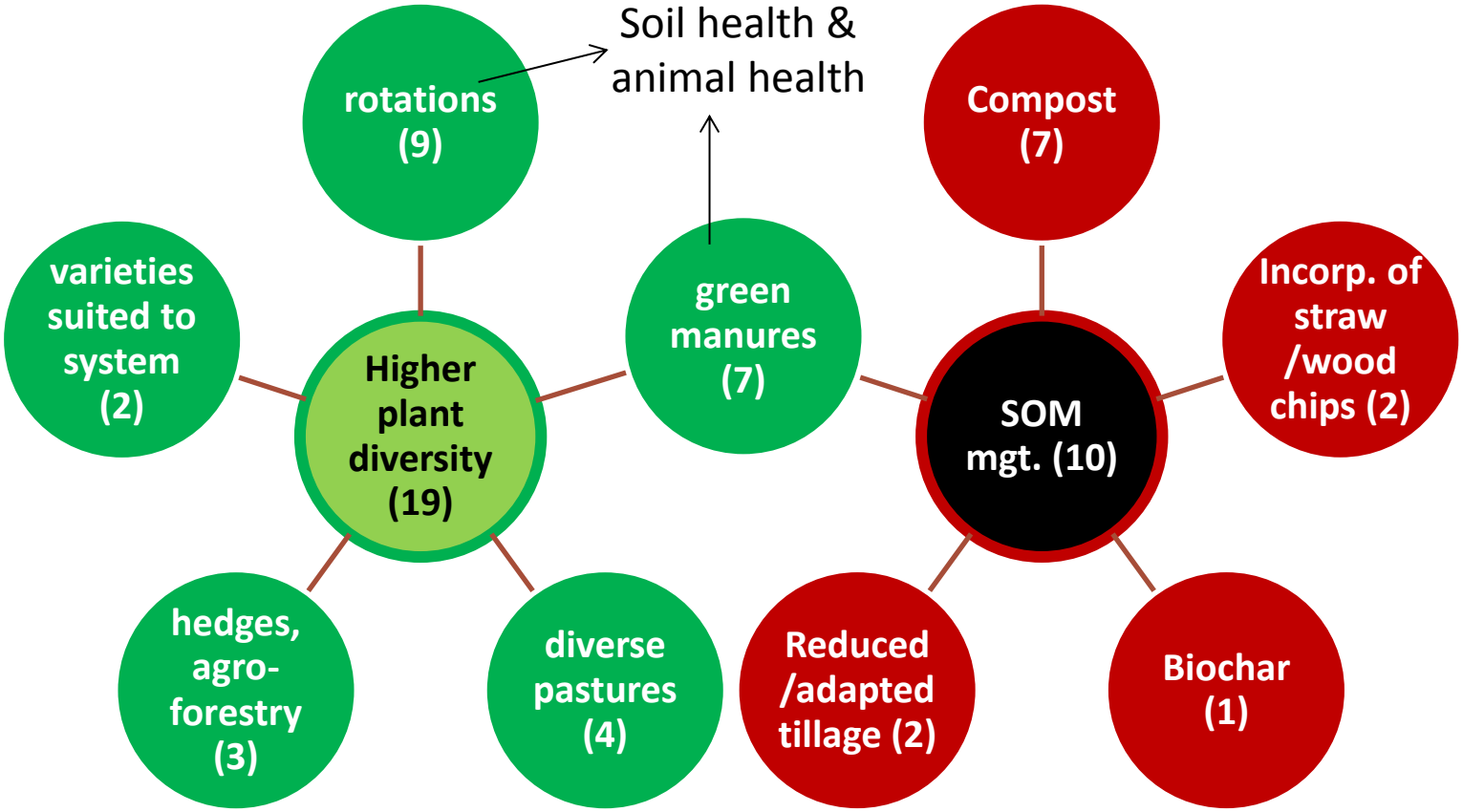
Winter wheat, Harvest 2008, Wakelyns Agroforestry

Döring et al. 2010. Organic Research Centre Bulletin 99: 4

3. Applications in farming systems

What can be done to promote health on organic farms?

Organic farmers' survey: „Please describe how you made your farm healthier over the years. Which methods or strategies did you use?"



Numbers in brackets show number of respondents out of 28; post-hoc classification of responses; data from Vieweger et al. 2015, **unpublished**

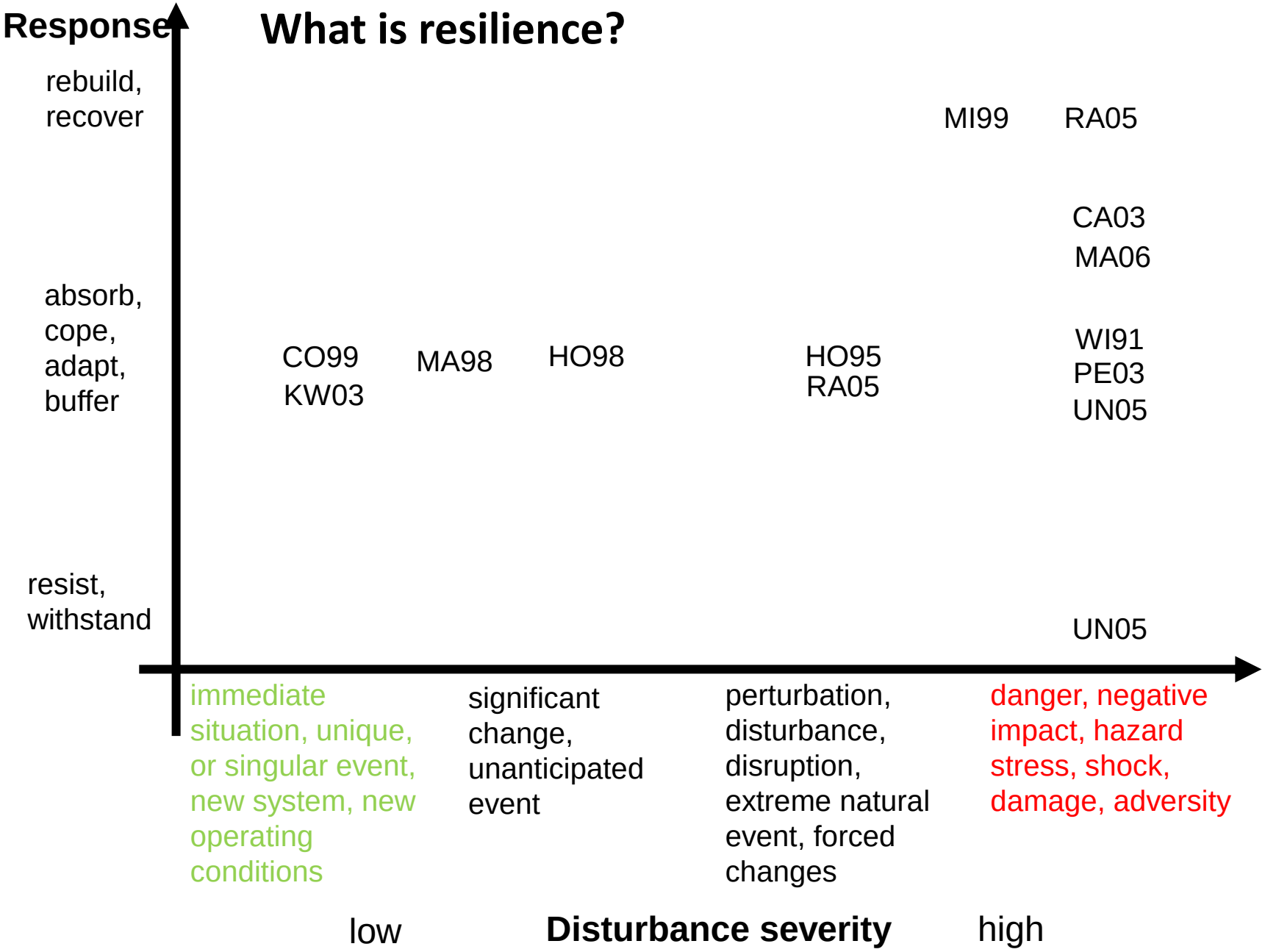
4. Conclusions

1. Health is a central proclaimed aim of organic farming but currently not (very) high on the agenda.
2. Resilience, like health, has many meanings but it has a common conceptual core among all domains and can be used a one criterion of health.
3. There is already good understanding of how to promote health on (organic) farms in separate domains.
4. However, health at the farming system level – bridging the domains – is not well understood.
5. Research is needed to investigate the links between the 'healths' of different domains.

Thank you for your attention!

The research presented was supported by Ekhaga foundation, Sweden

Measuring health through resilience



Measuring health through resilience

What is resilience?

Table 2. Calculation of resistance and resilience indices

Resistance	Resilience	Reference
$\frac{D_0}{C_0}$	$\frac{D_x}{C_0}$	Kaufman (1982)
$\frac{D_0}{C_0} \times 100$	$\frac{D_x}{C_0}$	Sousa (1980)
$\left(C_x - \frac{C_x}{D_x}\right) \times 100$	$\left(C_x - \frac{C_x}{D_x}\right) \times 100$	Griffiths *et al.* (2000)
$\left\|\left(\frac{D_x}{C_x}\right) - 1\right\| \times 100$	NC	Chaer *et al.* (2009)
$1 - \left(\frac{2\lvert C_0 - D_0\rvert}{C_0 + \lvert C_0 - D_0\rvert}\right)$	$\left(\frac{2\lvert C_0 - D_0\rvert}{\lvert C_0 - D_0\rvert + \lvert C_x - D_x\rvert}\right) - 1$	Orwin & Wardle (2004)
$\int_0^x f(t)\frac{dt}{x}$	$\int_x^j f(t)\frac{dt}{(j-x)}$	Zhang *et al.* (2010)
NC	$\sqrt{\sum_{t=i}(D_x)^2/C_x}$	O'Neill (1976)

C, variable measured in the control soil (undisturbed) at time 0 (immediately after disturbance) or at time *x* after disturbance; *D*, variable measured in disturbed soil at time 0 (immediately after disturbance) or at time *x* after disturbance; NC, not calculated.

Griffiths & Philippot 2013. FEMS Microbiol Rev 37: 112–129