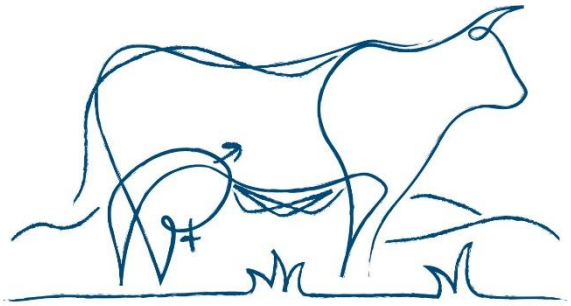
“What the hell do resilience and efficiency mean in the real world and what’s the underlying biology linking the two?”

Nic Friggens and Jonathan Statham



GENTORE

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research | advanced breeding | food futures | training

This project has received funding from the European Union’s Horizon 2020 research and innovation program under Grant Agreement No 727213

Resilience and Efficiency

- Real world perceptions
- Classical definitions
- Common ground (underlying biology)

(focus of this talk on adult producers, using bovine examples)

Resilience: Real-world views

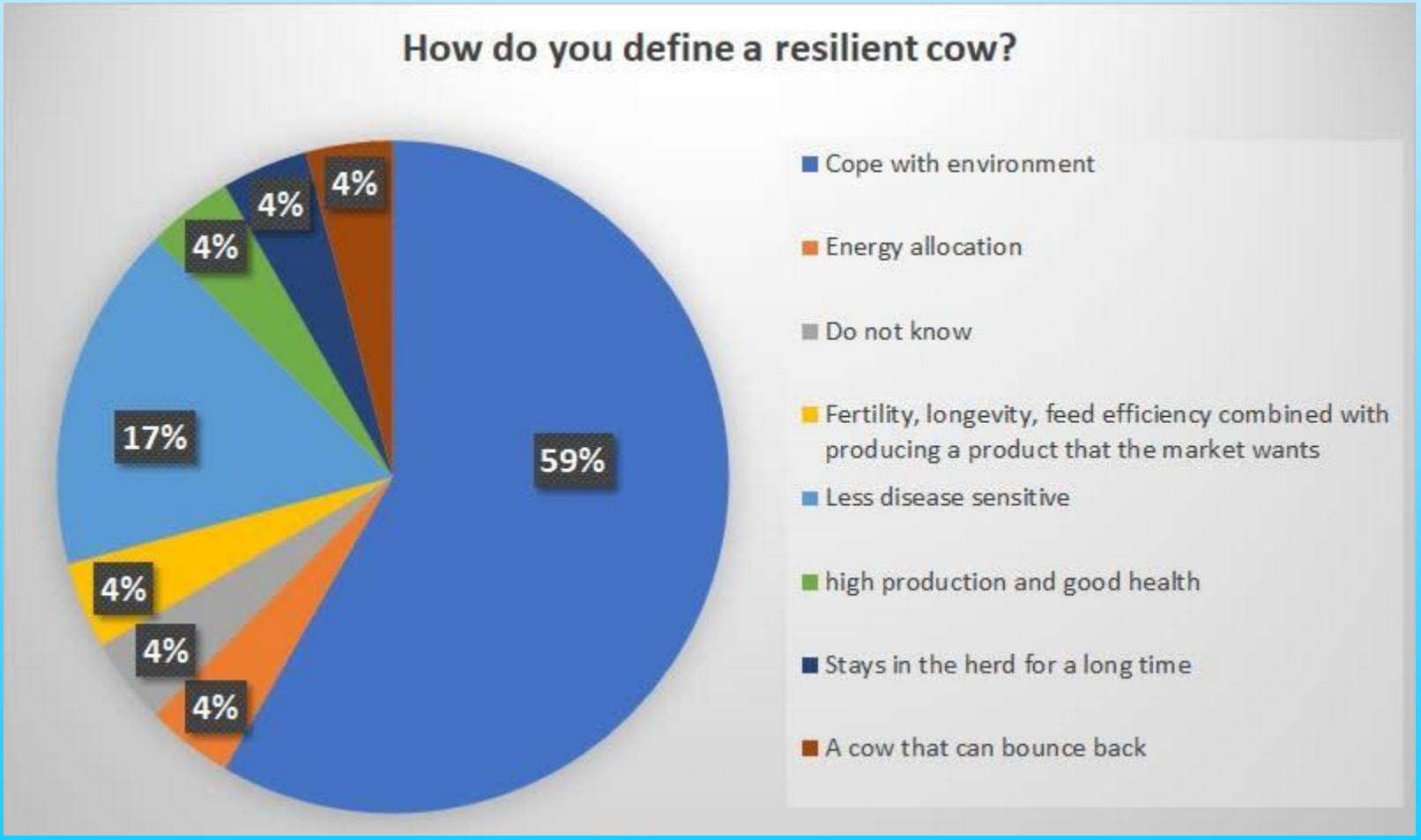
39 French Farmers

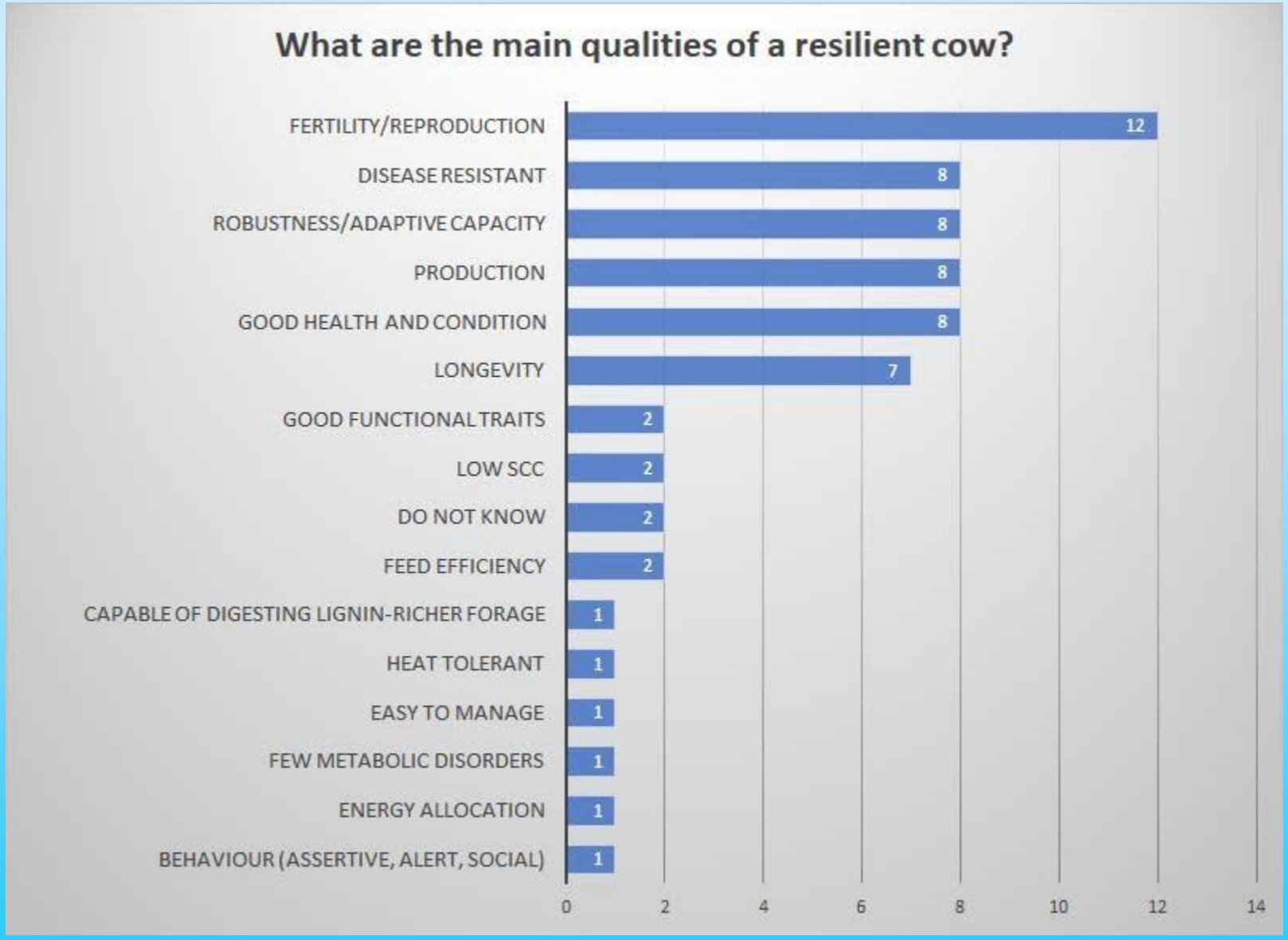
Trait	Number	Comment
Good legs	(23/39)	“Cows that start to hobble are those that come last…. to the feedbunk”
Disease resistance	(19/39)	“problem-free with no vet costs”
Longevity	(15/39)	“she doesn’t attract attention and thus keeps going”
Fertility	(13/39)	“easy to get back in calf, clear heats”
Udder	(11/39)	“low mastitis and good udder ligaments”
Behaviour	(10/39)	“takes care of herself, motivated to feed”

- Results of Ollion et al (2018) *Fourrages*. In press
- Interview Survey: what are the traits of a robust cow

Resilience: Real-world views

GenTORE Stakeholders survey (n=12)




What are the main qualities of a resilient cow?
FERTILITY/REPRODUCTION
DISEASE RESISTANT
ROBUSTNESS/ADAPTIVE CAPACITY
PRODUCTION
GOOD HEALTH AND CONDITION
LONGEVITY
GOOD FUNCTIONAL TRAITS
LOW SCC
DO NOT KNOW
FEED EFFICIENCY
CAPABLE OF DIGESTING LIGNIN-RICHER FORAGE
HEAT TOLERANT
EASY TO MANAGE
FEW METABOLIC DISORDERS
ENERGY ALLOCATION
BEHAVIOUR (ASSERTIVE, ALERT, SOCIAL)
12
8
8
8
8
7
2
2
2
2
1
1
1
1
1
1
0
2
4
6
8
10
12
14

Real world perception of resilience

- She never (or rarely) gets ill
- No problems getting back in calf
- The anonymous cow…

Real world perception of resilience

- She never (or rarely) gets ill
  - always bounces back
  - low recorded incidence of mastitis, lameness etc
- No problems getting back in calf

  -short calving-conception interval
- The anonymous cow…

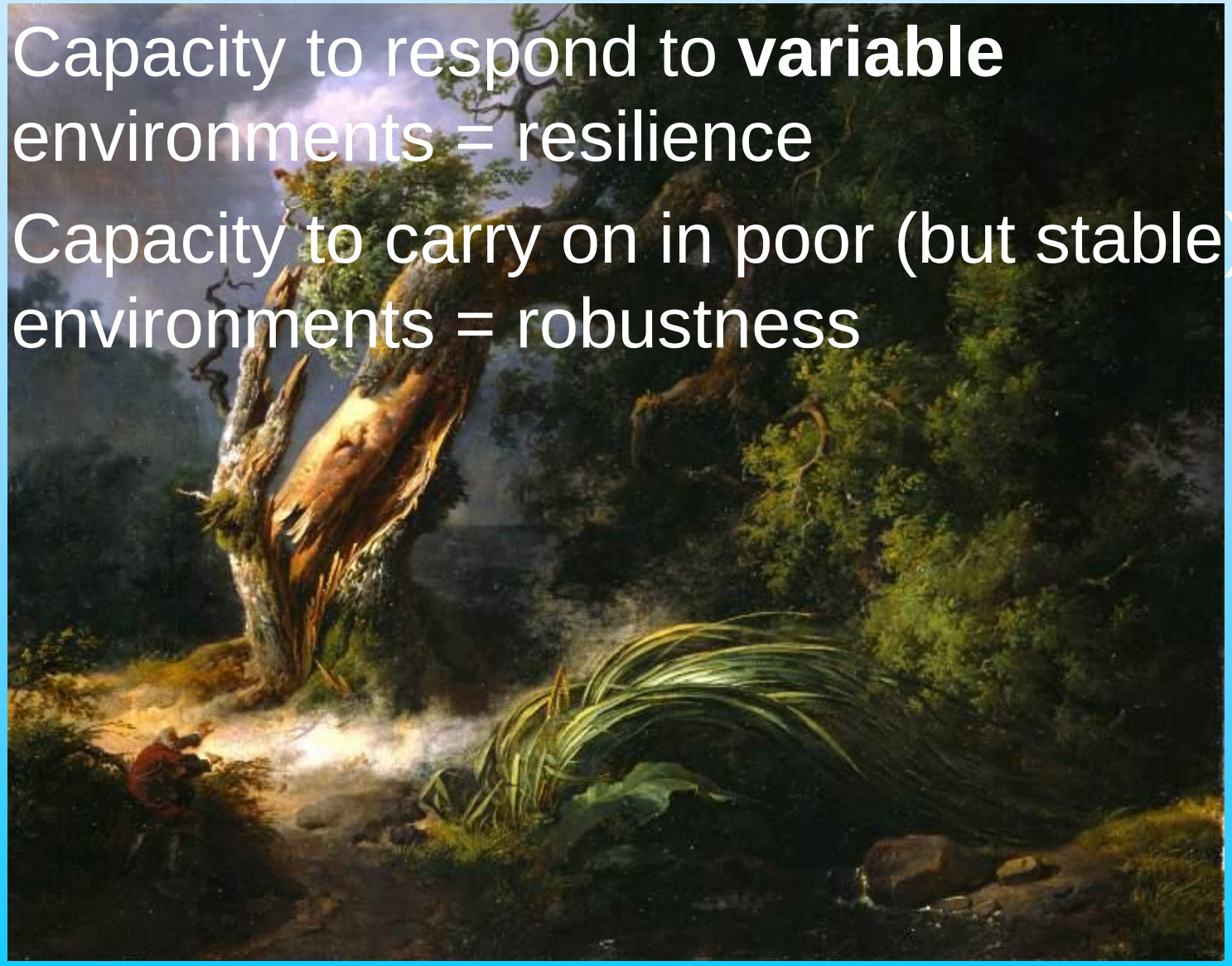
  -with lots of daughters in the herd

Resilience: classical definition

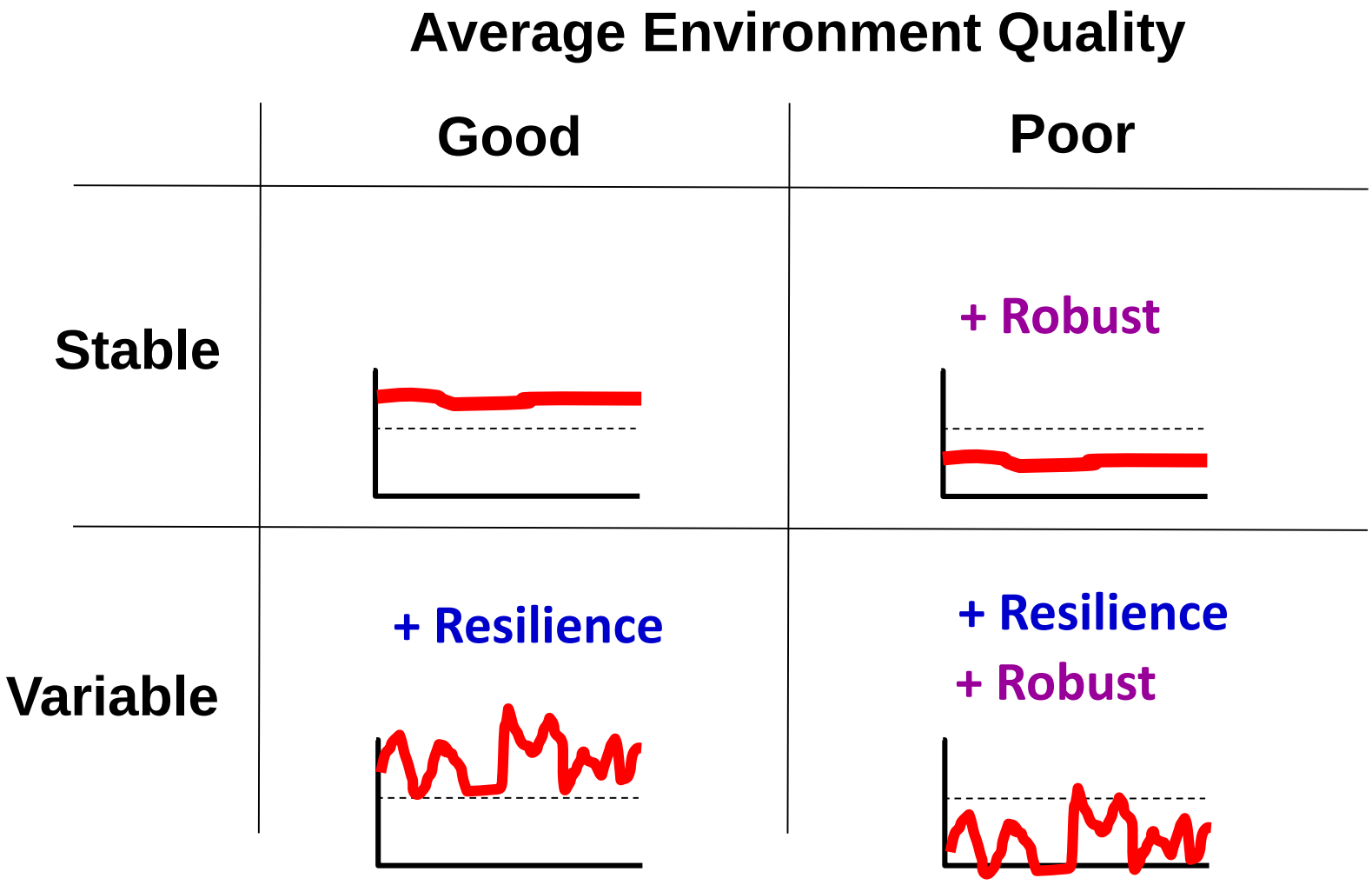
- The capacity to respond to environmental perturbations.
- Implies abilities to:
  - be able to absorb an environmental challenge through buffering mechanisms, and/or
  - modulate the allocation of available resources to life functions, down prioritizing those that are non-vital and up-prioritizing those that are needed to meet the challenge.
- Why?
  - to safeguard future ability to contribute genes to the next generation
  - includes both the ability to survive (or avoid being culled) until the next reproductive opportunity, and the ability to successfully reproduce (adequate nos of viable offspring).

Resilience *vs* Robustness

- Capacity to respond to **variable** environments = resilience
- Capacity to carry on in poor (but stable) environments = robustness



Resilience and Robustness



Resilience *vs* Robustness

High performance

-can adapt to cope with tough times

-but able to exploit better times with greater reproduction or production

Less high performing...

-set to cope with tough times as ‘normal’

-but less able to exploit better times...

Robustness and resilience traits

Ollion, E. (2015) https://hal.archives-ouvertes.fr/tel-01312209v1

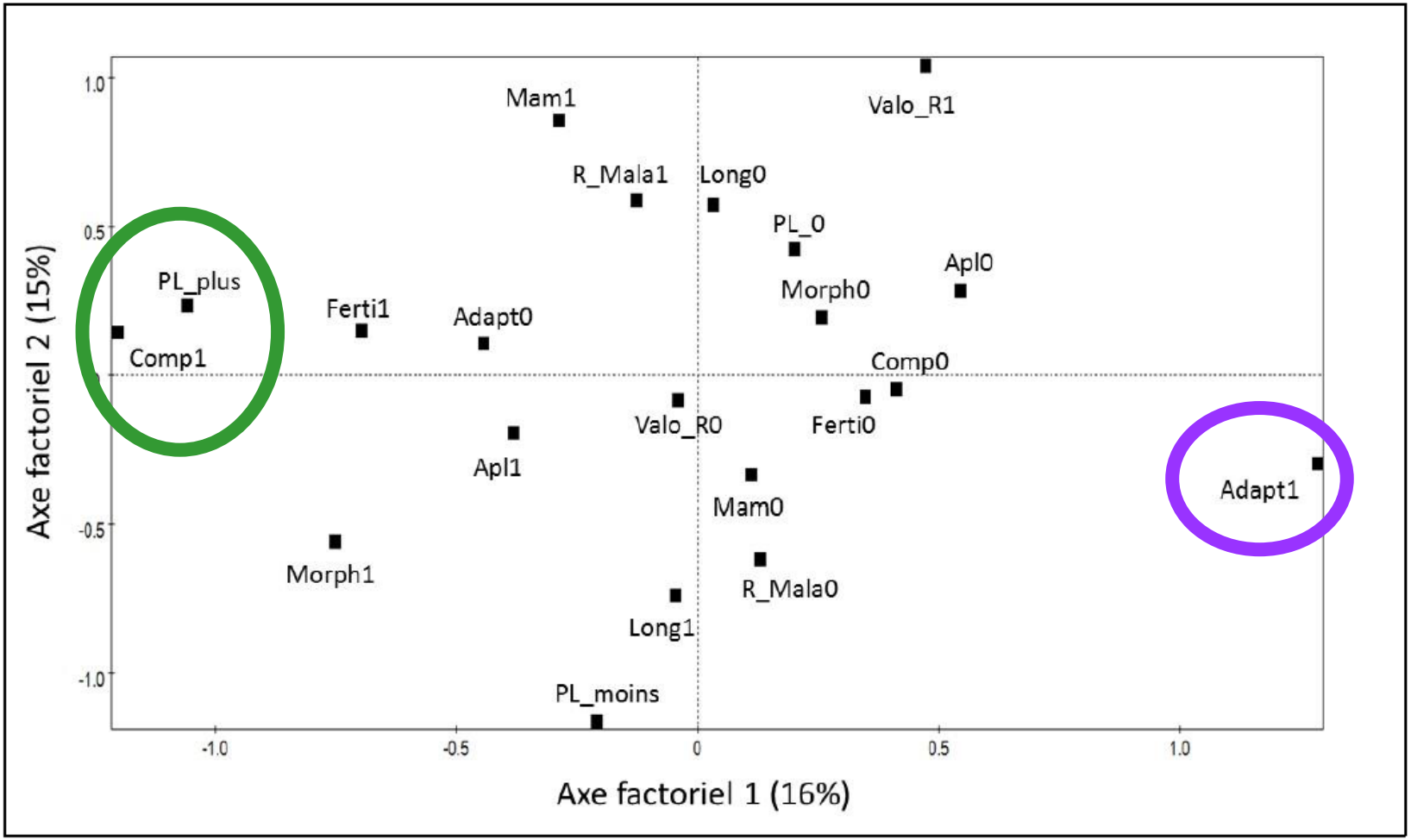


Figure 8 : Représentation des modalités des différentes variables dans l'espace factoriel résultant de l'analyse de correspondances multiples. Pour la liste des abréviations, se référer au Tableau 2

Resilience and robustness

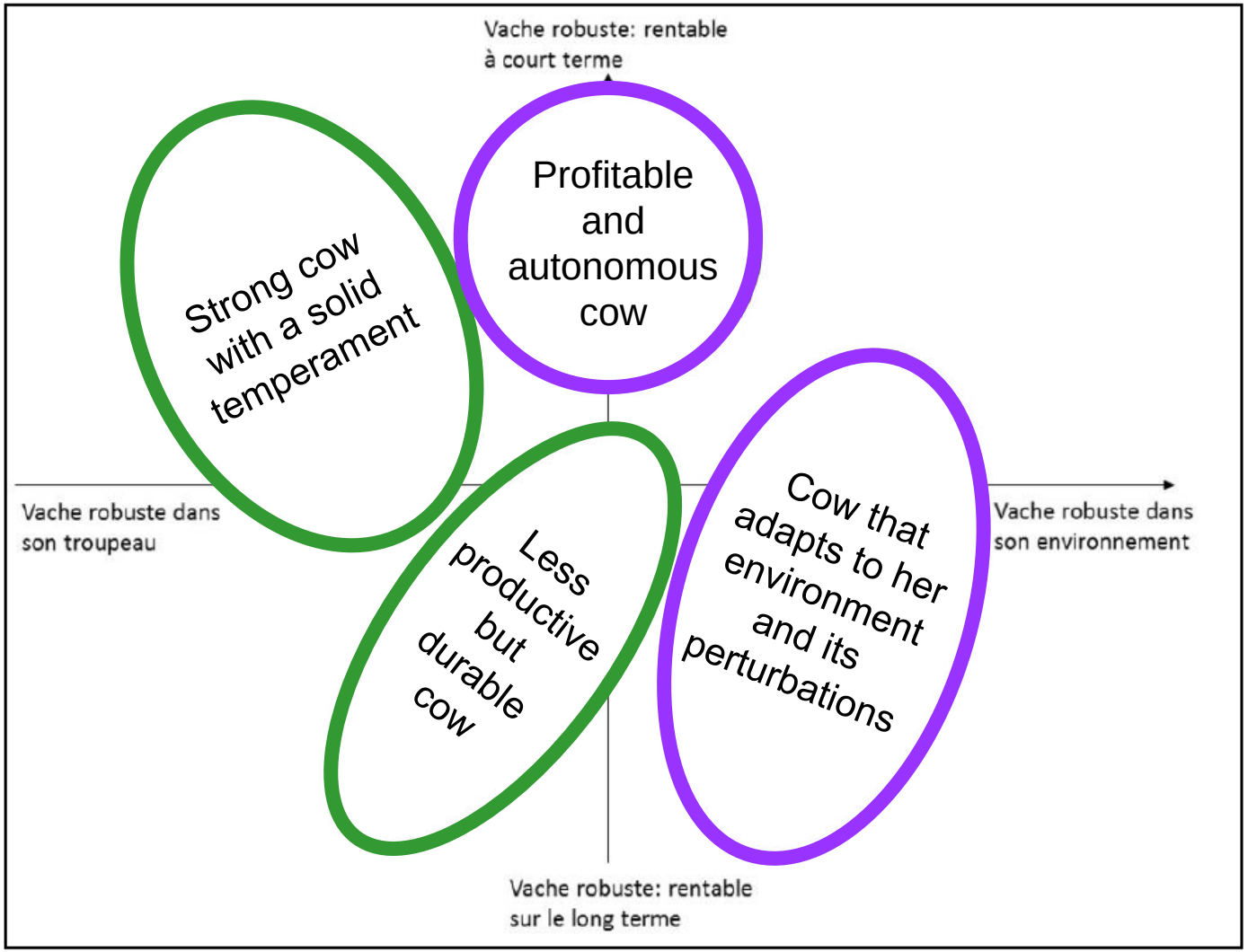
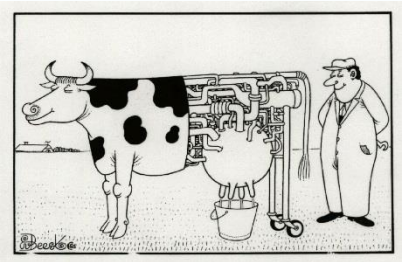


Figure 9 : Quatre définitions principales de la vache robuste, différenciées selon les deux axes factoriels obtenus par analyse des correspondances multiples.

Ollion, E. (2018)

Real world perceptions

- Resilience and robustness are recognized as being different
- Resilience underpins a cows ability to carry on
- i.e. it contributes to its overall robustness



Efficiency: classical definition

- The ratio energy in the product:energy ingested to achieve that production

(This definition does not preclude the measurement of efficiency via residual feed intake type approaches.)

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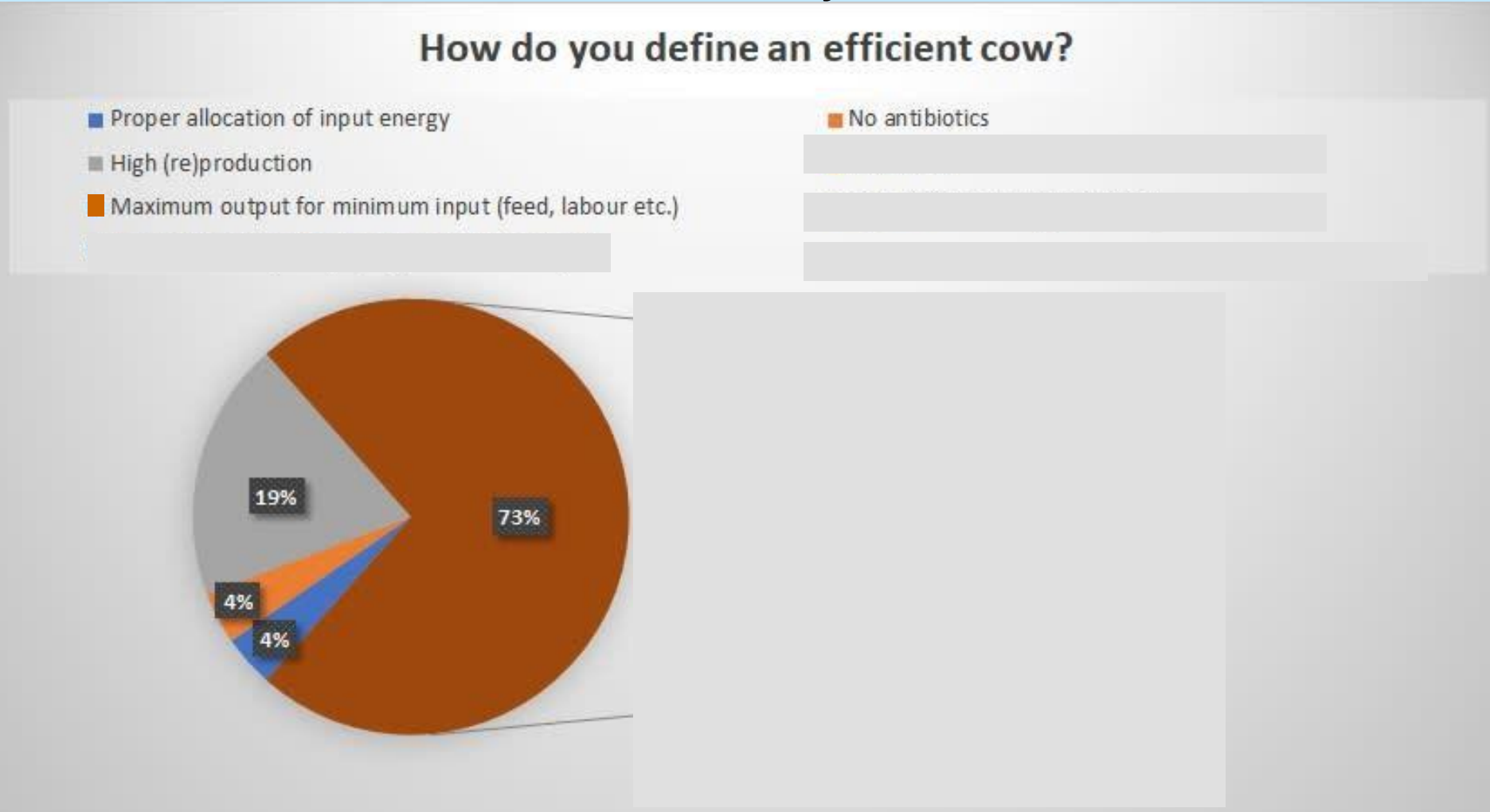
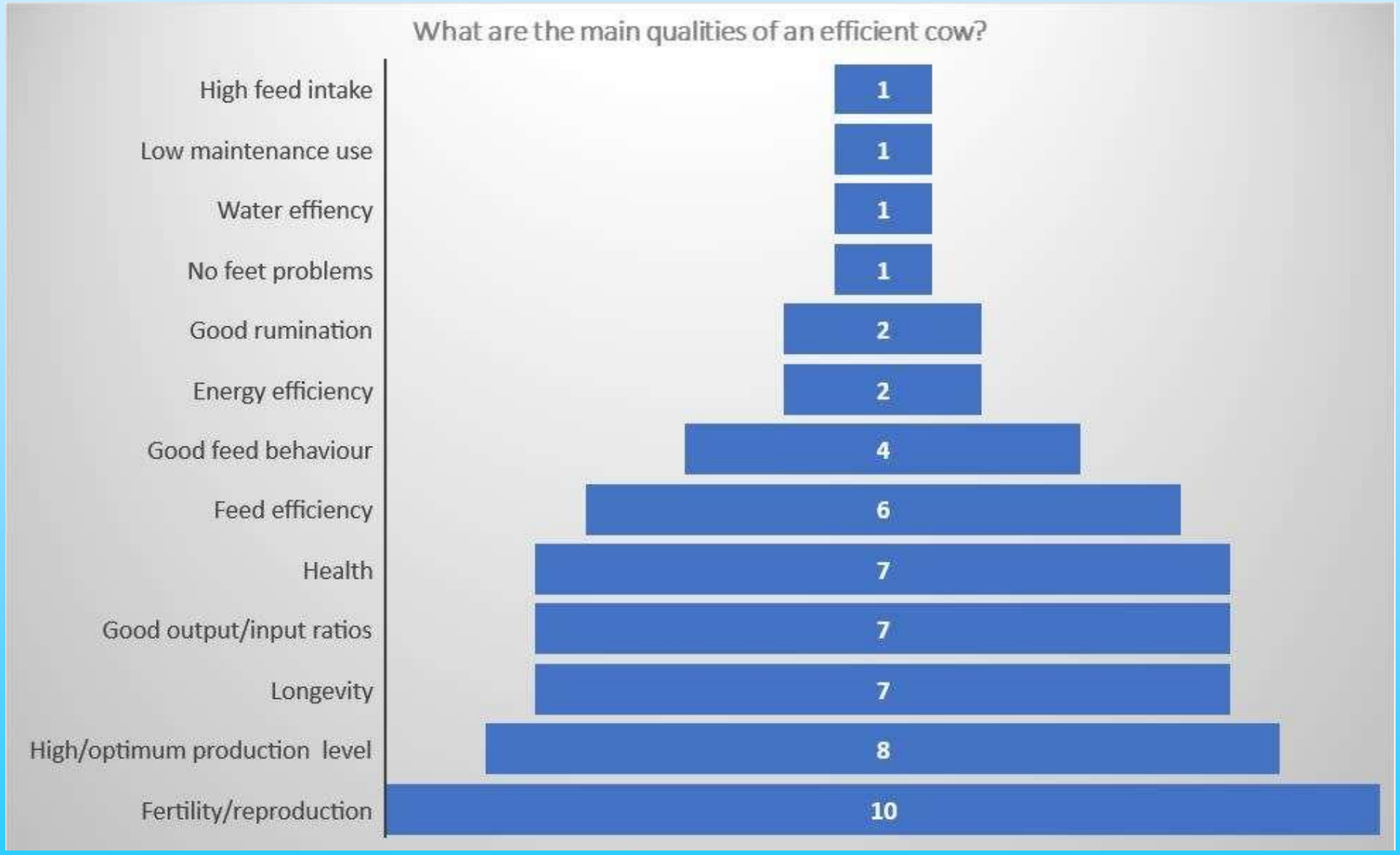
Efficiency: Real-world perceptions

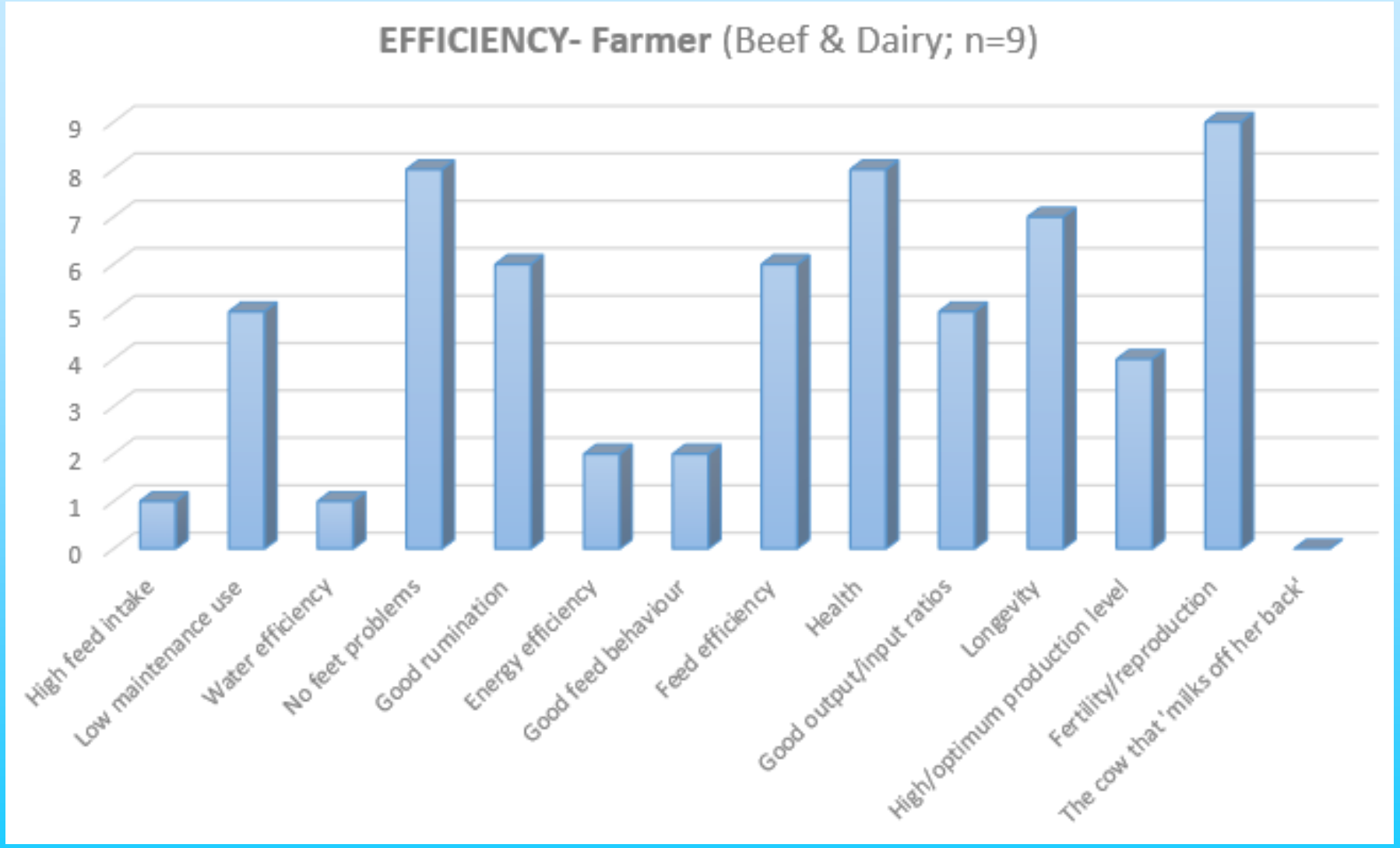
GenTORE stakeholder survey




What are the main qualities of an efficient cow?
High feed intake
1
Low maintenance use
1
Water effiency
1
No feet problems
1
Good rumination
2
Energy efficiency
2
Good feed behaviour
4
Feed efficiency
6
Health
7
Good output/input ratios
7
Longevity
7
High/optimum production level
8
Fertility/reproduction
10

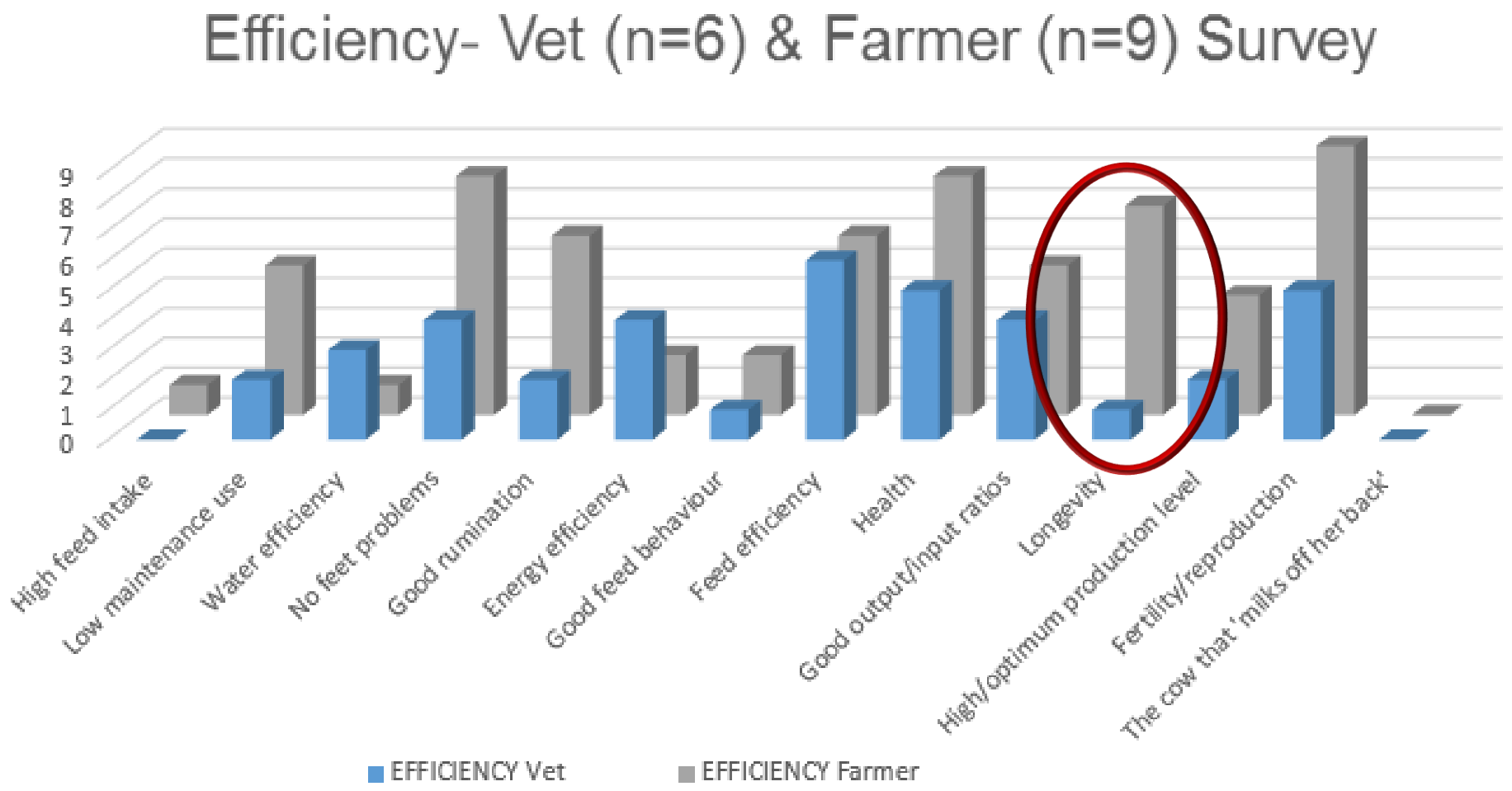
Efficiency: Real-world perceptions

RAFT UK Farmer Survey 2018



Efficiency: Real-world perceptions

RAFT Survey 2018-UK Vets vs Farmers



Real world perceptions of efficiency

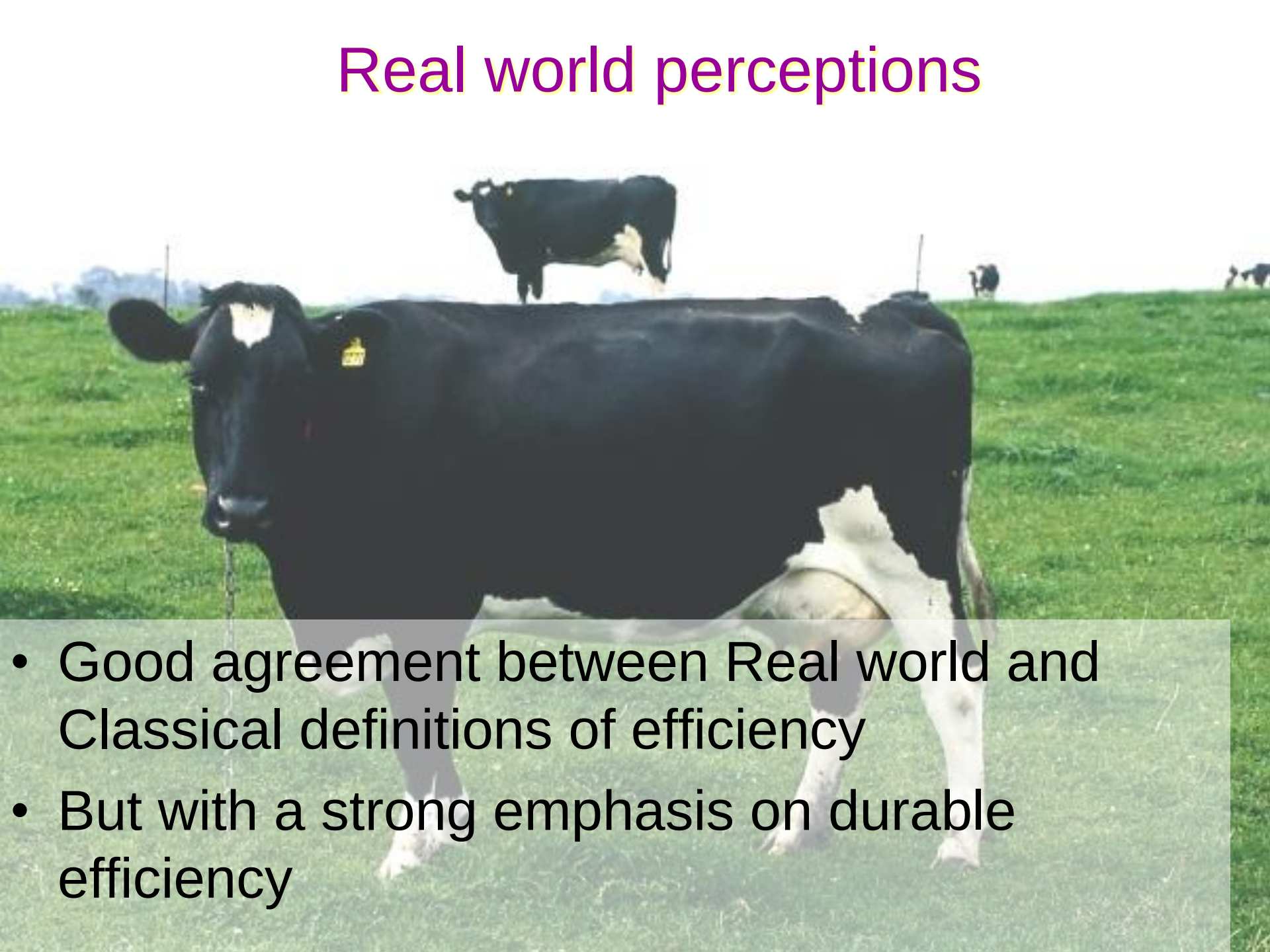
- High producing (milk yield)
- Good fertility
- Good health
- Good « feed efficiency »
  - Milk per kg of concentrate
  - Milk per kg of forage

Photo credit: Mike Kerby

Real world perceptions of efficiency

- High producing (milk yield)
  - Peaks quickly and ‘high’..and hard to dry off
- High value on « Stayability »
  - Easy back in calf, problem-free
- Tending to take a long view on efficiency
  - Efficiency for the farmer/farm
  - Not the cow

Real world perceptions



- Good agreement between Real world and Classical definitions of efficiency
- But with a strong emphasis on durable efficiency

Useful observation:

Farmer’s take pride in longevity….
But act on resilience vs production

Resilience and Efficiency

- Real world perceptions
- Classical definitions
- Common ground (underlying biology)

Commonality in traits for R & E

Resilience

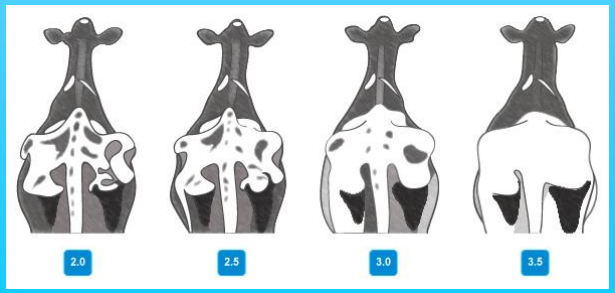
Underlying traits:

- Body condition & Energy balance
- Fertility & oestrus expression
- Immunity & health
- Balance & adaptability to change
- Social behaviours

Efficiency

Underlying traits:

- Milk yield & Energy balance
- Rumen microbiome & fermentation
- Forage vs concentrate intake
- Dry matter intake & social dominance
- Health



Efficiency: ”Dilution of maintenance”

Apparent trade-off between Efficiency and Resilience

Intake
(Resource acquisition)

Nutrient supply

Nutrient Partition

Efficiency

Production
(milk, lean)

Body reserves, maintenance

(Rate of loss of body fat, protein)

Health status

Ability to reproduce

Risk of disease

Reproductive problems

Well-being Resilience Longevity

Efficiency: ”Dilution of maintenance”

Possible harmony between Efficiency and Resilience

Intake
(Resource acquisition)

Nutrient supply

Nutrient Partition

Efficiency

Production
(milk, lean)

Body reserves, maintenance

(Rate of loss of body fat, protein)

Health status

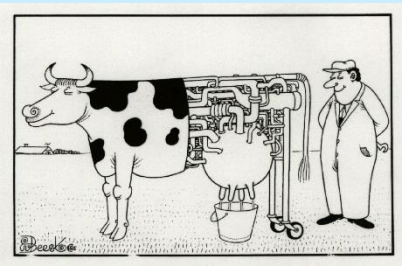
Ability to reproduce

Risk of disease

Reproductive problems

Well-being Resilience Longevity

Efficiency: ”Dilution of non-productive lifespan”



Efficiency: classical definition

- The ratio energy in the product:energy ingested to achieve that production…..
- ….. **measured over a *time period* that is relevant to ensure that any efficiency gains are sustainable**

Key Questions

- How long a period?
- What balance between R & E?
- What to measure?

Short- vs Long-term Efficiency

Intake
(Resource acquisition)

Nutrient supply

Nutrient Partition

Production
(milk, lean)

Body reserves, maintenance

Adaptive capacity

Health status

Ability to reproduce

Risk of disease

Reproductive problems

Efficiency

Well-being Resilience Longevity

Linking biology of R & E: **Working up** from gene expression and physiological mechanisms

Resilience

- Oestrus expression & IGF1
- AMH & follicular dynamics
- Embryo viability & Interferon tau, P4
- Nutrition, Epigenetics & effective methylation mechanisms
- Liver function & Immunity

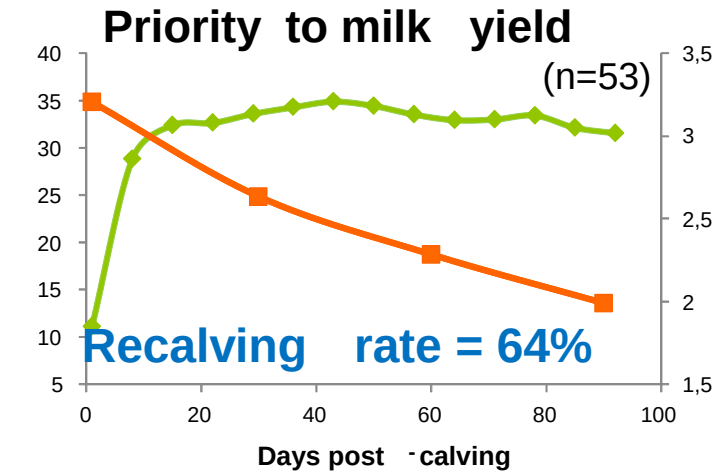
Efficiency

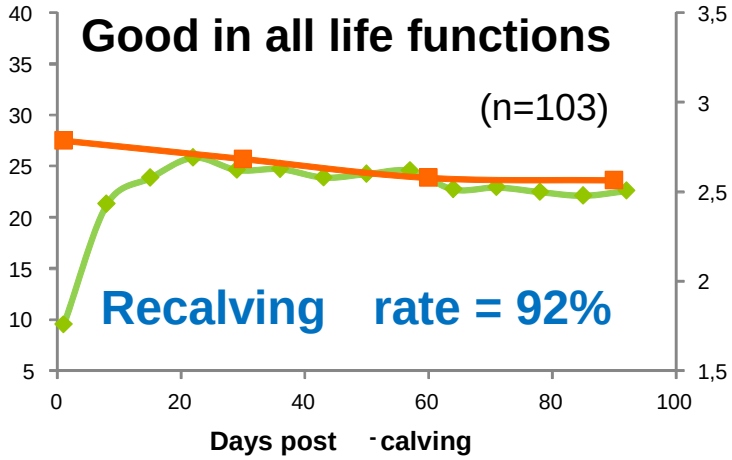
- Energy balance
- NEFA & BHB
- Liver function and VLDL
- IGF, Leptin and Ghrelin
- Microbiome
- Bite size
- Appetite-Hepatic oxidation & vagal function

Linking biology of R & E: **Working down** from lifetime measures

- Lifetime efficiency as the accumulated result of R & E
  - Or proxies thereof
- Product of appropriate balance between:
  - Trajectories of performances (milk vs reserves, etc)
  - Adaptive capacity
- Very difficult and expensive to measure
  - Only in research farms, and even then

Partition between life functions in early lactation affects re-calving





Milk Yield (kg/d)

Body condition score

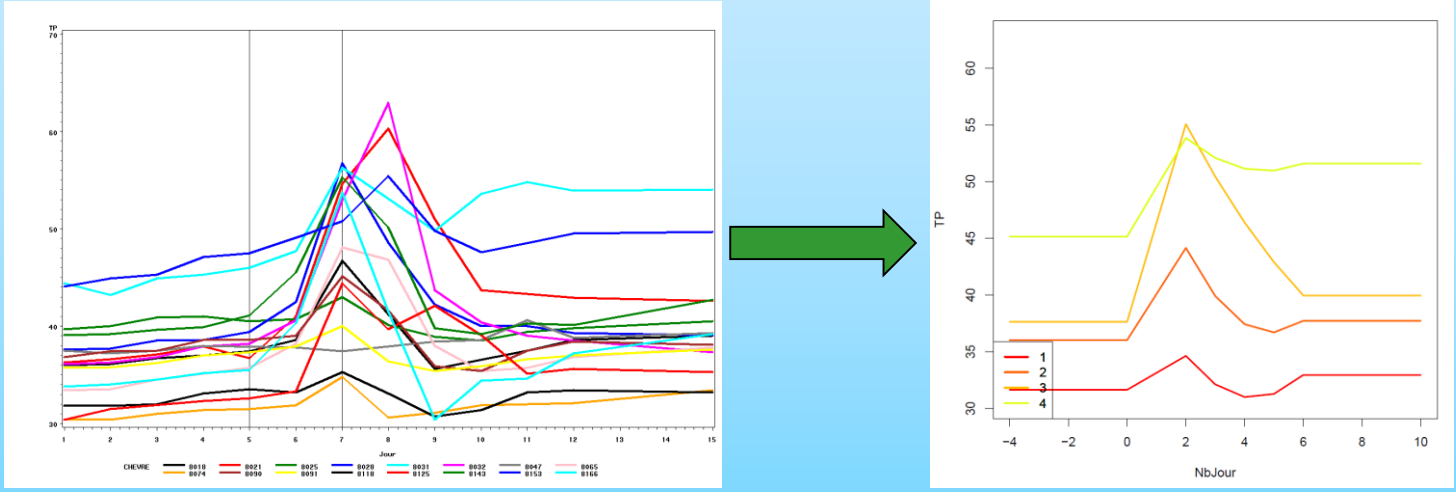
Ollion et al , 2016,

Linking biology of R & E: **Working down** from lifetime measures

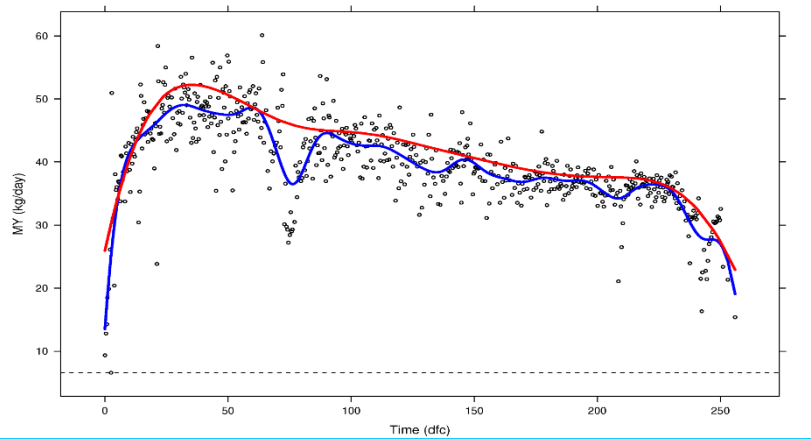
- Lifetime efficiency as the accumulated result of R & E
  - Or proxies thereof
- Product of appropriate balance between:
  - Trajectories of performances (milk vs reserves, etc)
  - Adaptive capacity
- Increasingly deducable from time-series measures on commercial farms
  - Precision livestock technologies

Assessing resilience

- Responses to planned challenges



- Responses to non-controlled perturbations

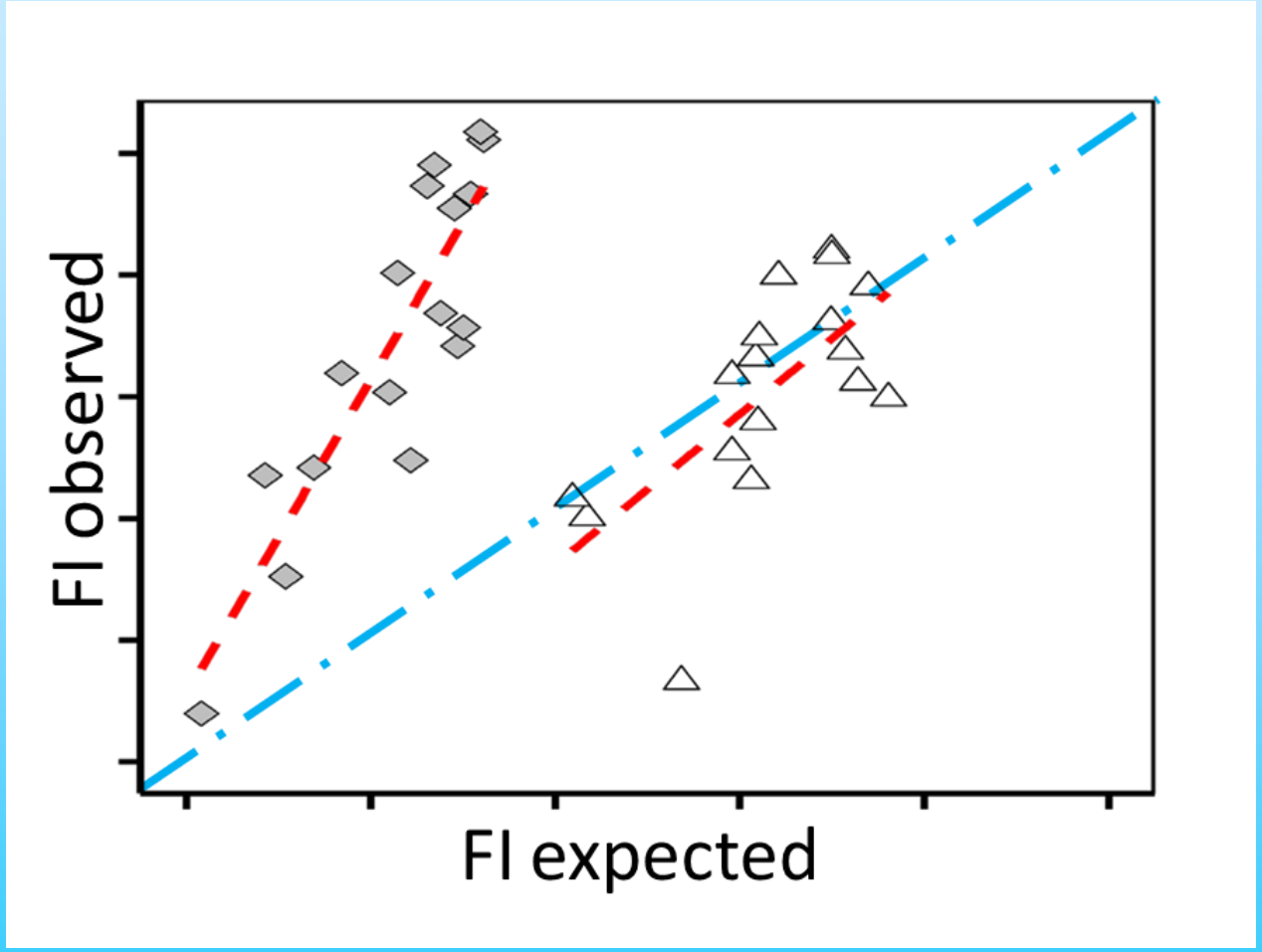


Watch this space

Two key issues

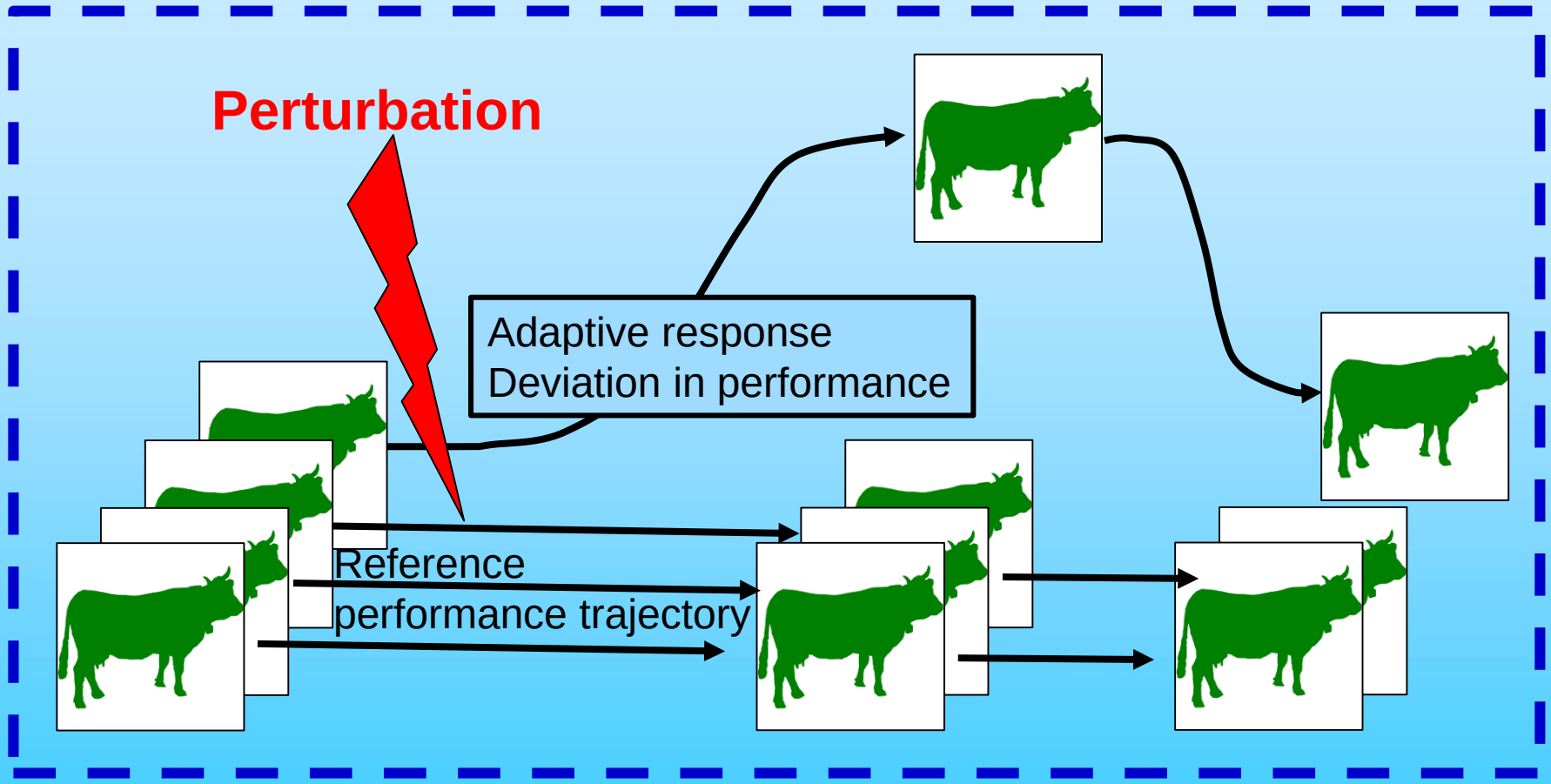
- Finding shorter-term measures or proxies, e.g:
  - look for correlations between efficiency measured in one short period and lifetime efficiency (see Fischer et al 2018)
  - Probability of repro success as a resilience proxy
- Dealing with differences due to local production environments

Repeatability of efficiency measures



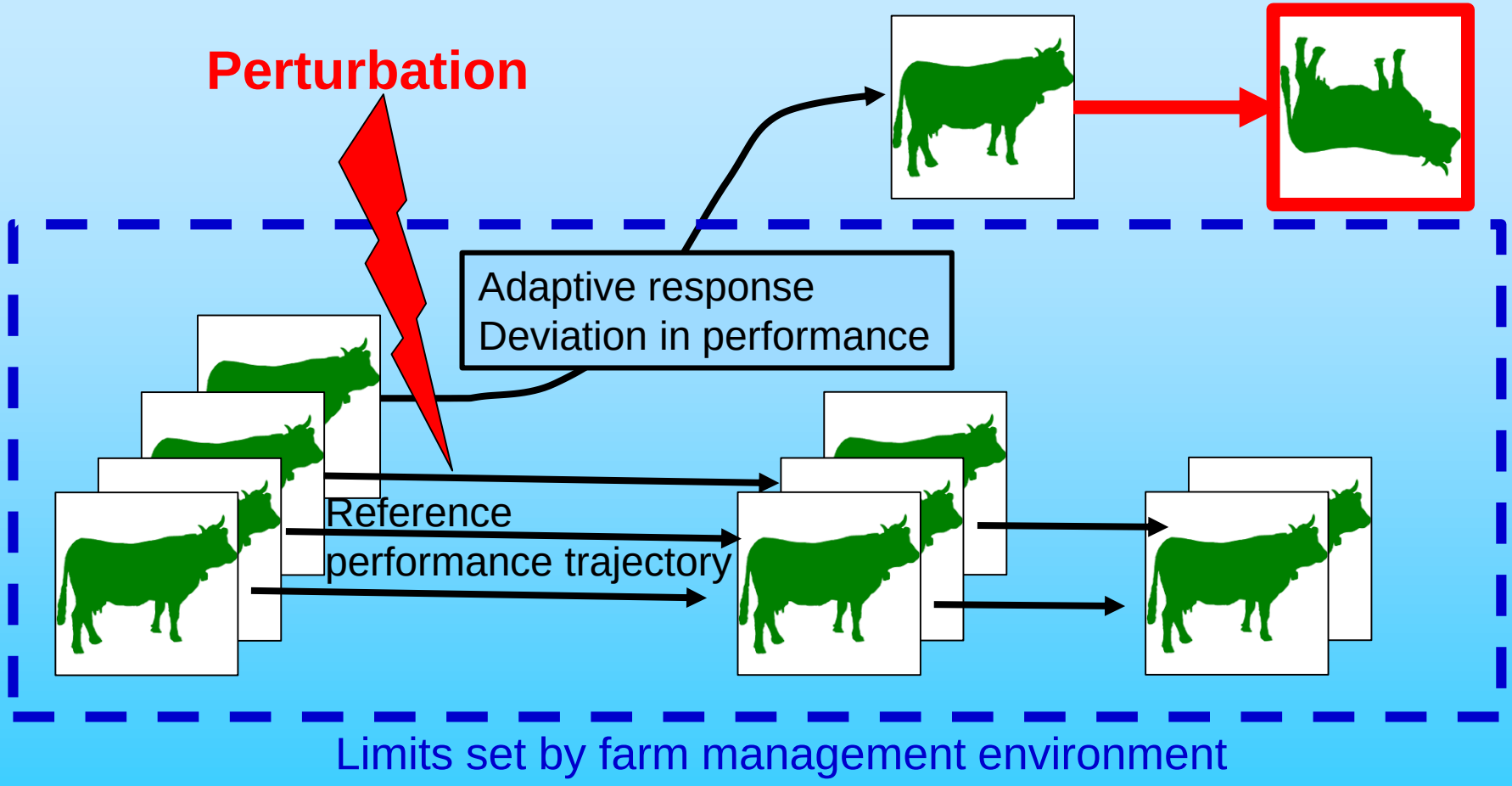
- 17 2-week periods in lactation
- Data of Fischer et al., (2018)

Farm management context affects animal outcomes



Adapted from Ollion (2015)

Farm management context affects animal outcomes

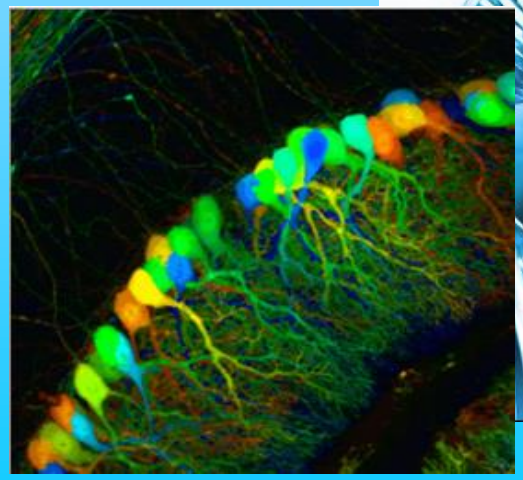


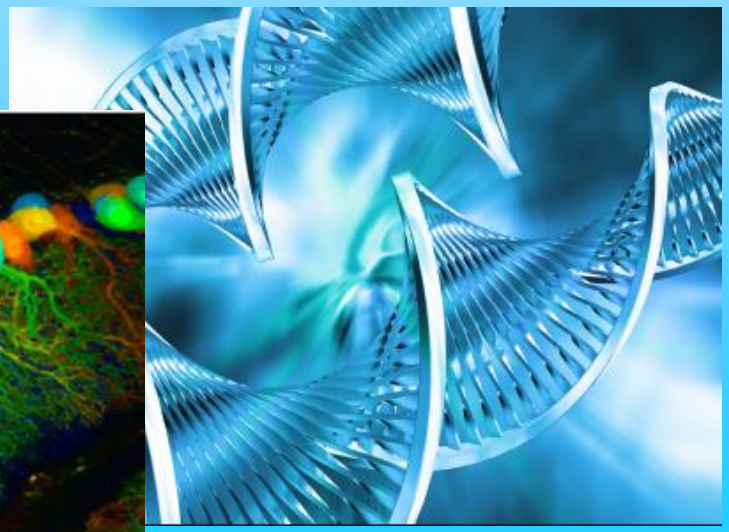
Dealing with local production environments

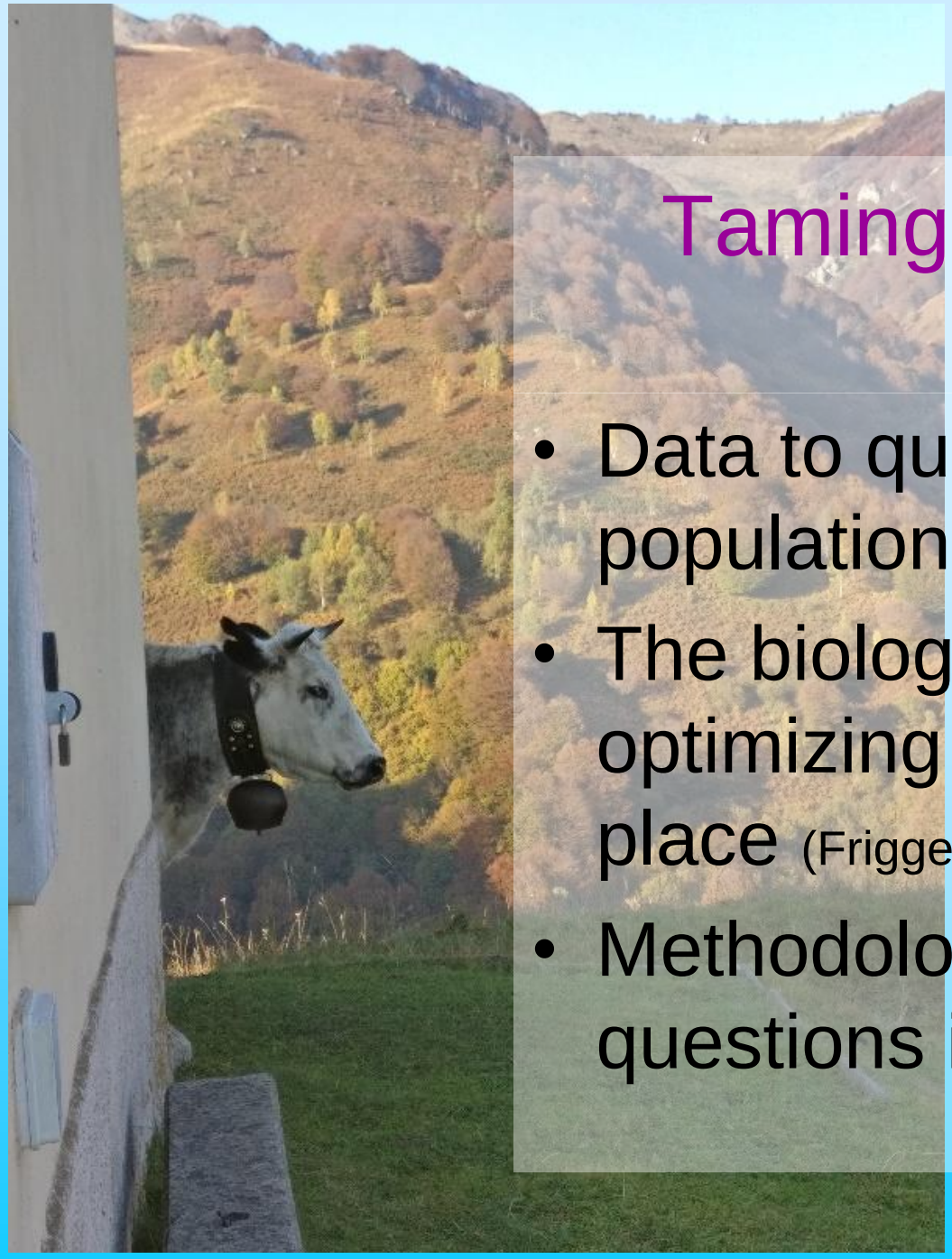
~ Exploit the solutions for the systematic environmental effects in the statistical model at population level

~ ‘best linear unbiased estimates’ (BLUE):

~ *Estimated that BLUE were associated with at least **two-thirds** of the improvement in Calving Interval and milk production over the past 10 yr (Dunne et al 2018)*







Taming the underlying biology

- Data to quantify R & E in large populations now available
- The biological framework for optimizing R & E is now in place (Friggens et al 2017)
- Methodology to tackle the key questions is rapidly developing

Synergies for harnessing Resilience & Efficiency

- Considerable number of the limitations disappear when applying genomics in the context of precision agriculture
- The combination opens up for:
  - Objective phenotypes from repeated measures
  - Precision mating
  - Tailoring to local production environments

Precision Genomic Management

- Genotyping of females allows precision mating
  - Reducing unwanted recessive genes
  - Increasing favourable gene combinations
- Augmentation of genomic information with information on the animals phenotypic trajectory
  - Prior performance
  - Prior health events, etc.
  - Bespoke decision making to the environment the animal is actually operating in..

Precision Genomic/Phenotypic Management

- Prediction of an animals probability of:
  - Reproductive success
  - Completing the coming production cycle

- Used to make better informed culling and breeding decisions
- Relativised to the local production environment
  - Herd as own control
  - Weighting of e.g. resilience vs efficiency

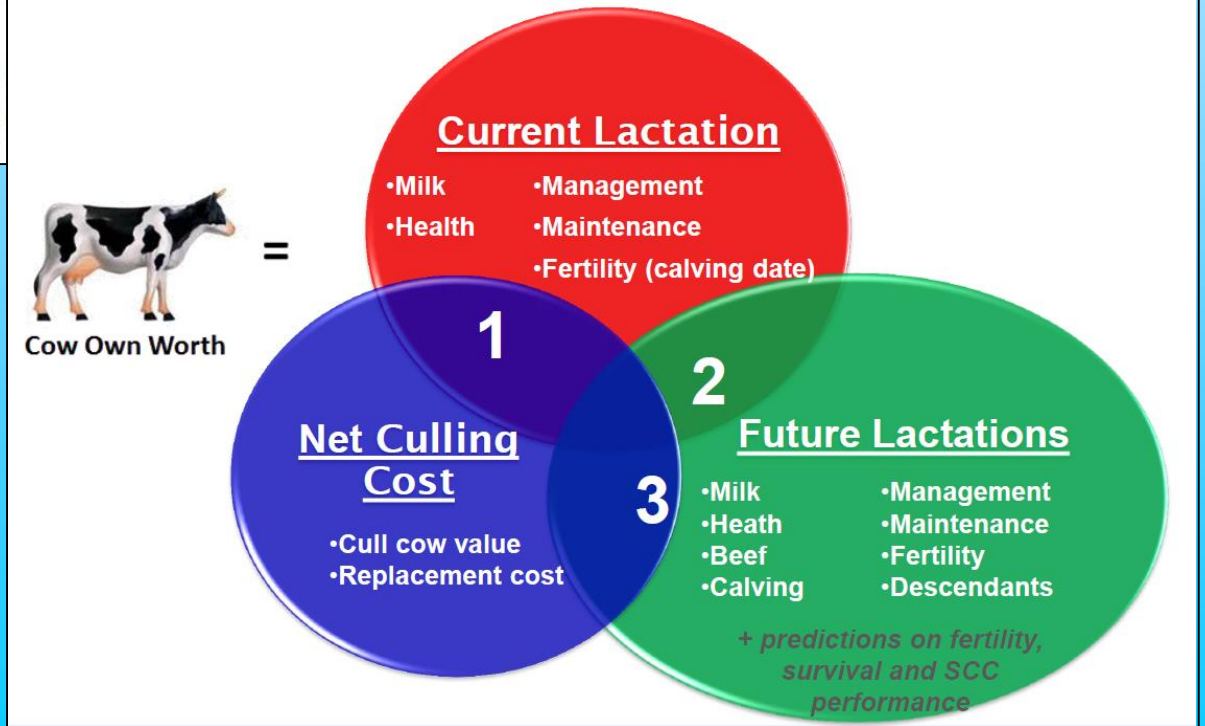
IRISH CATTLE BREEDING FEDERATION

Cow Own Worth (COW) Index



Margaret Kelleher PhD

Example



Concluding remarks

- Good agreement between real-world and classical scientific definitions of R & E

- The keys to optimising R & E lie in:
  - Considering long-term consequences
  - Exploiting precision livestock data
  - Giving farmers the tools to rank their animals on stability and stayability (SASI)

Thank you for your attention

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