

Livestock farming and uncertainties: exploring resilience

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FOOD
AGRICULTURE
ENVIRONMENT

INRA

OUTLINE

- 1** – Resilience : from verbal argument to mathematical definition
- 2** – Illustrate some aspects of resilience with a simple dynamic herd model
- 3** – Future research needs to improve our understanding of resilience

From verbal argument to mathematical definition

What is 'resilience' ?

Holling 1973 – “resilience is the capacity of a system to
Walker 2004 **absorb disturbance** and reorganize [...] so as
to still retain the **same function**, structure,
identity and feedback”

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Kitano 2004 – “robustness is a property that allows a system
Napel et al. 2011 to maintain **its functions** against **internal and
external perturbations**”

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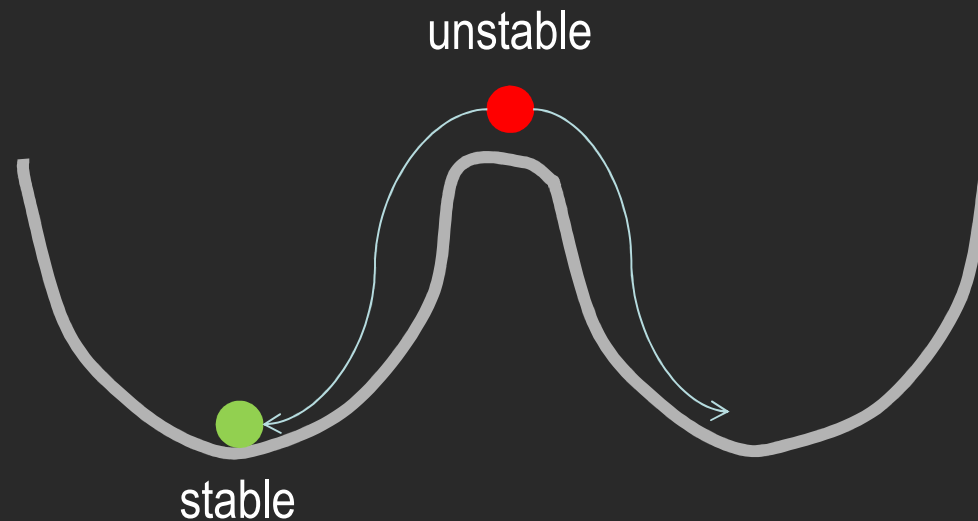
and many more....

From verbal argument to mathematical definition

What is 'resilience' ?

Resilience is about
change and identity

Limits to change!

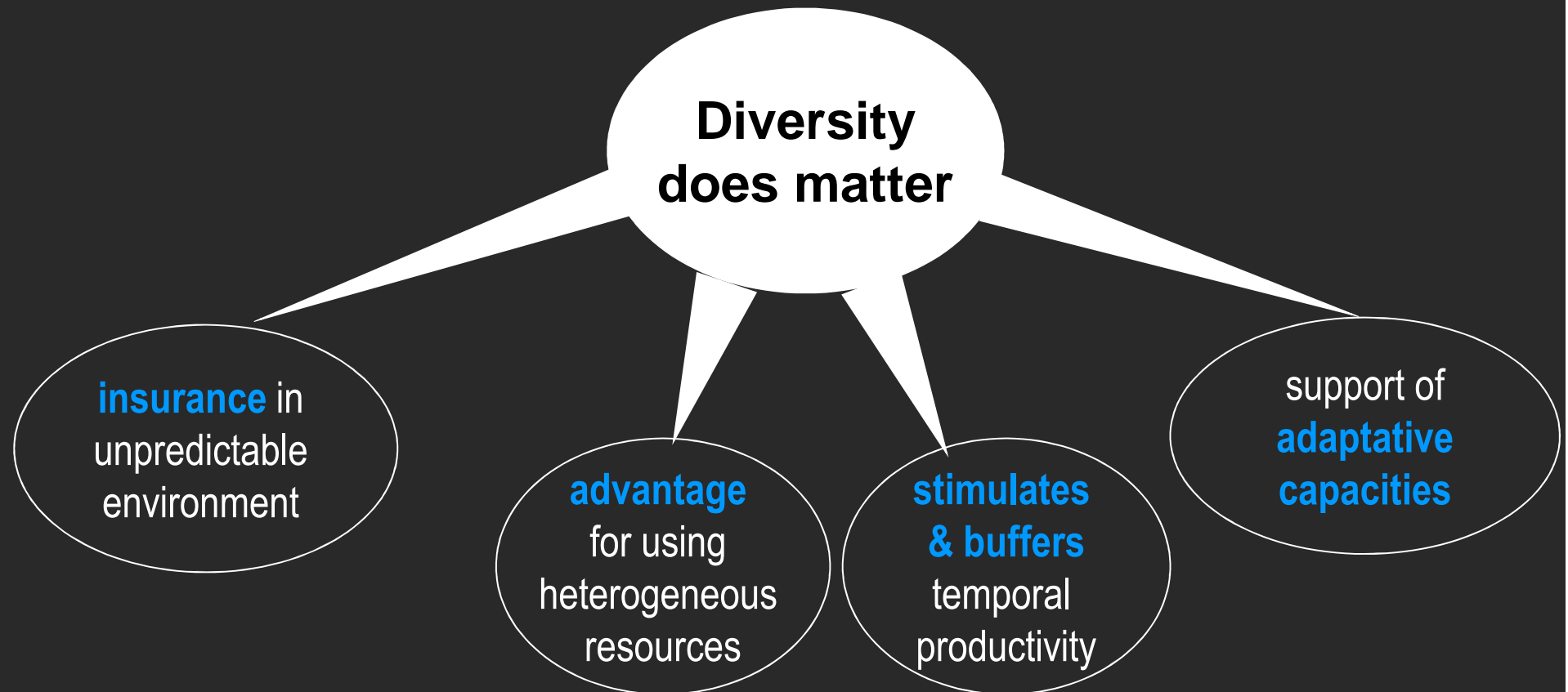


From verbal argument to mathematical definition

Darnhofer et al. 2010

Tichit et al. 2011

What promotes
resilience ?



From verbal argument to mathematical definition

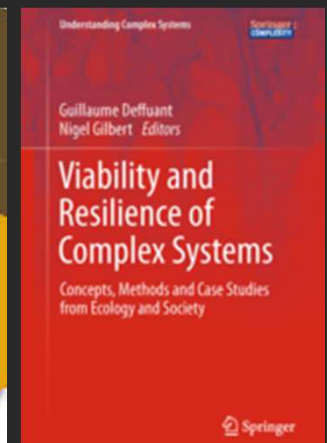
Measuring resilience?

Width and depth of the attraction basin are measures of resilience



after Napel et al. 2011

a measure of a **desired property** of the system = set of states which are not necessarily attractors → **Viability theory**

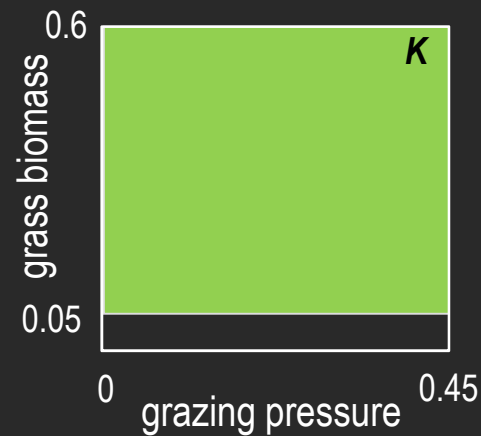


From verbal argument to mathematical definition

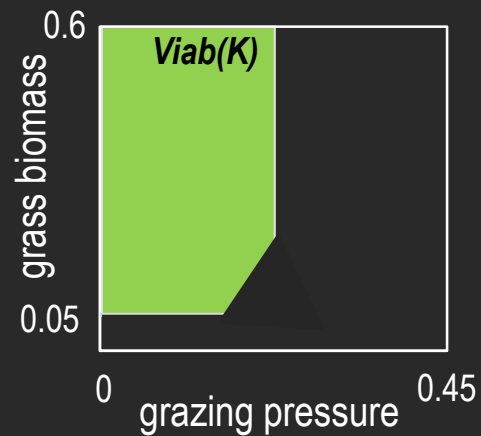
Viability theory = framework for measuring resilience

Martin, Deffuant & Calabrese 2011

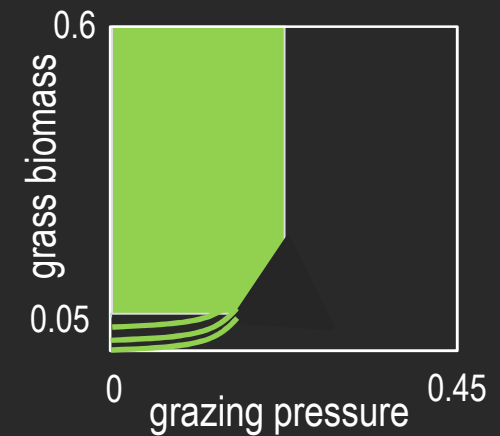
K = the desired set



$\text{Viab}(K)$ = the viability kernel

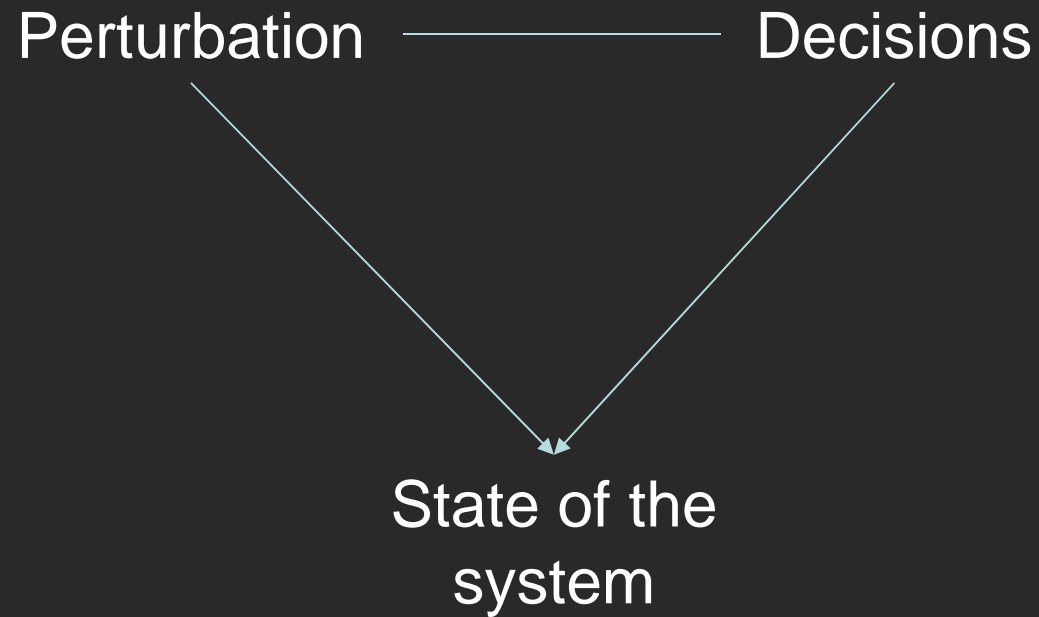


The resilience basin



From verbal argument to mathematical definition

Managing resilience ?



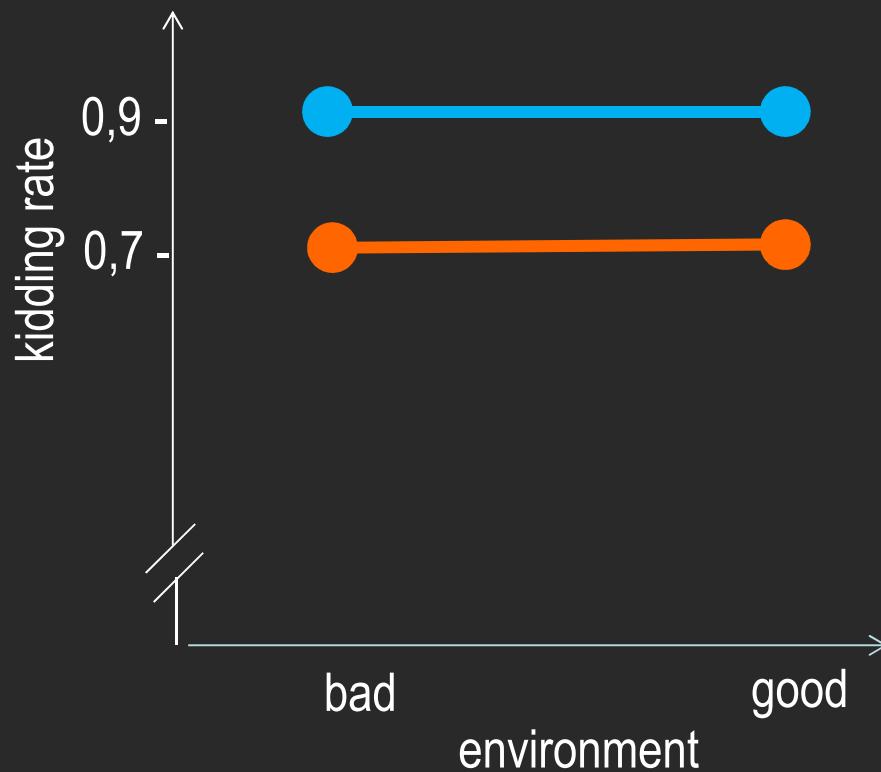
OUTLINE

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A simple dynamic herd model

Dairy goat herd = two types of individuals

specialists
generalists



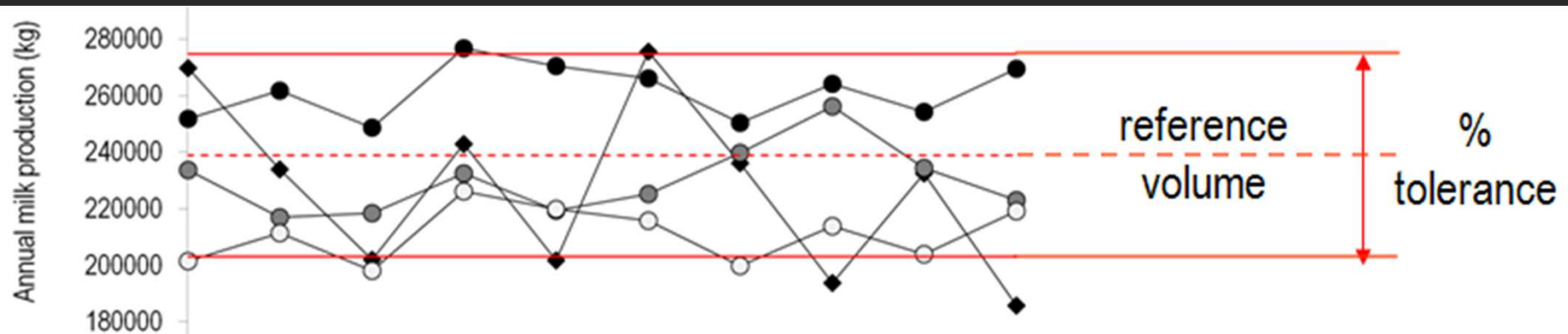
A simple dynamic herd model

- Matrix population model = stage structured
- Culling policy:
 - Total number of individual culled
 - Preference for culling = % of specialists/ total number of individual culled
- Discrete time dynamics over 20 years with Scilab
- Explore different scenarios of environmental perturbation (extreme events of thermal stress)

A simple dynamic herd model

Resilience = a **desired property**
= a yearly milk volume within a certain target

Within the target volume → 15% bonus on milk price



Scenario (1)

Variable climate and stable herd composition & size

Scenario (2)

Stable climate and variable herd composition

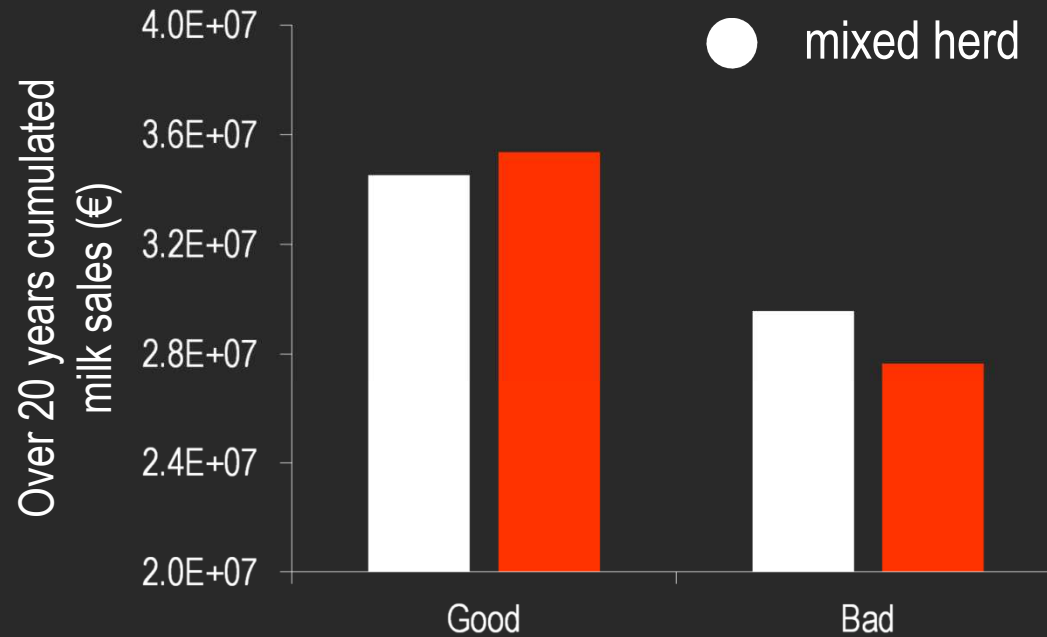
S (1) Variable climate and stable herd composition & size



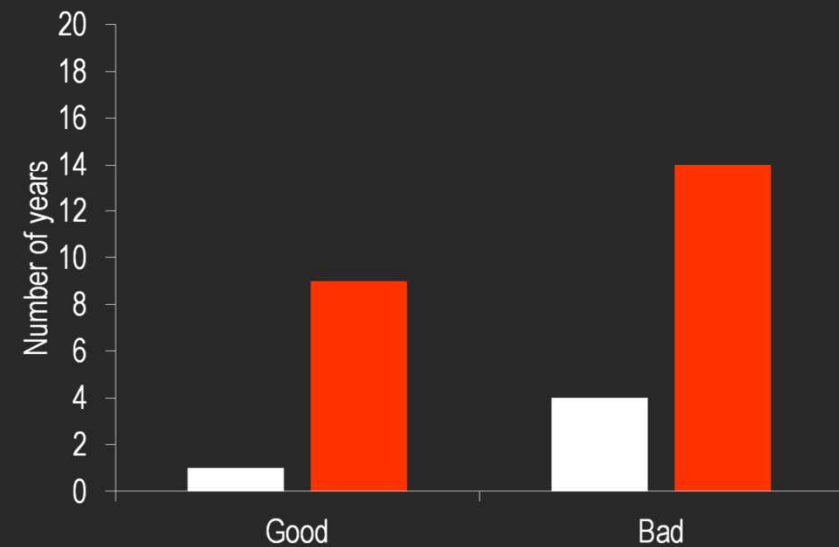
S (1) Variable climate and stable herd composition & size



S (1) Climate impact and stable herd composition & size



Nb of years when milk target volume is not satisfied



Scenario (1)

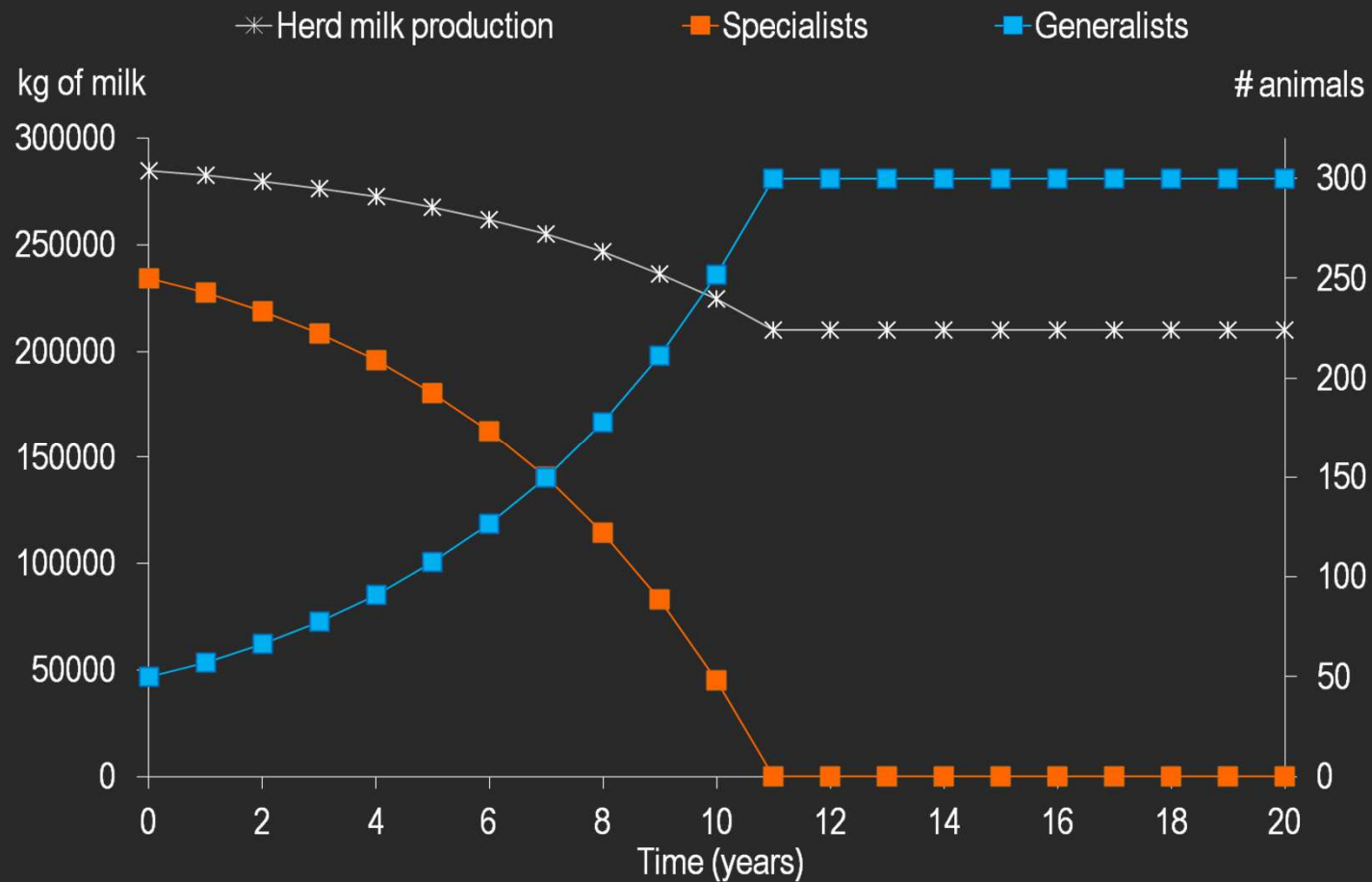
Variable climate and stable herd composition & size

Scenario (2)

Stable climate and variable herd composition

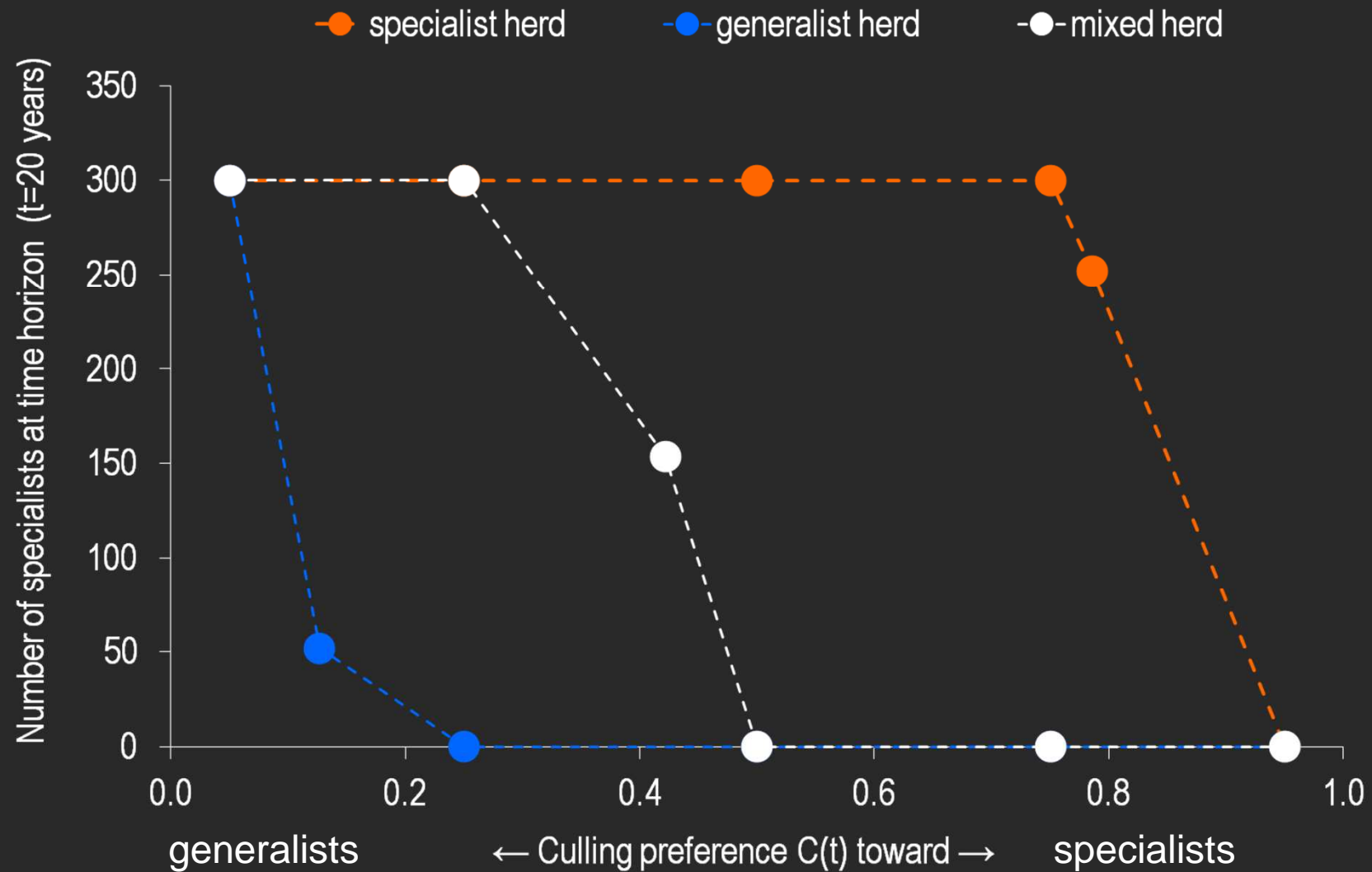
S (2) Stable climate and variable management

Constant herd size = 300 individuals
Initial herd dominated / specialists
Culling preference toward specialists

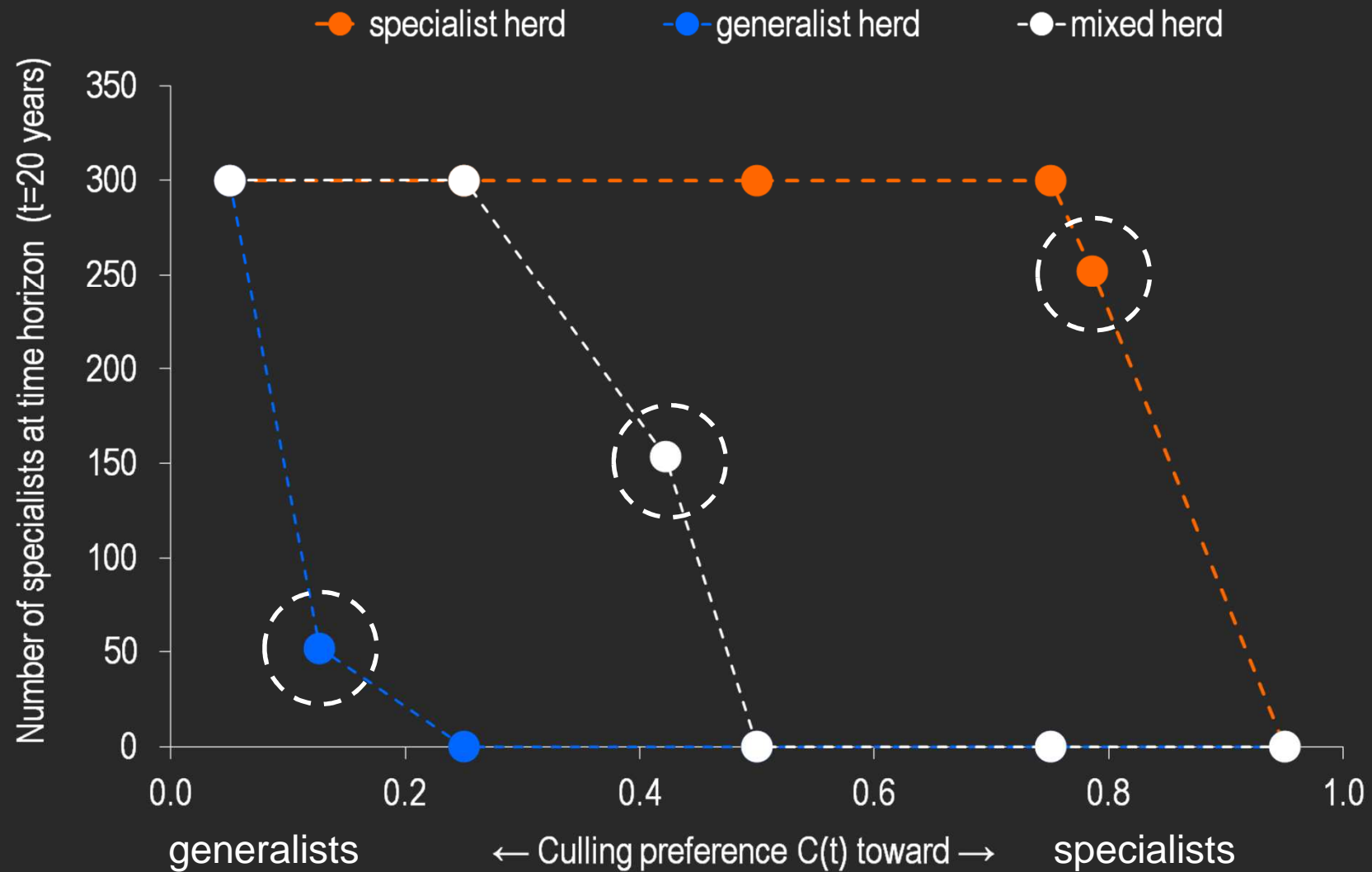


27%
in milk
production

R (2) - Culling preference = soft or strong driver



R (2) - Culling preference = soft or strong driver



Future research

- Generalist vs Specialist : continuum ?
- Variable environment **X** variable management (i.e. change of culling policy over time)
- Viability algorithm to predict culling decisions that ensure at any time step the target milk volume or minimize time outside target volume

Conclusion

- Better **understanding** of resilience in LFS needs to disentangle its biological and decisional components
- **Managing** resilience requires **early warning indicators**

Thank you

*« Failure is not falling down but refusing to get up »
old chinese quote*

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