# *Social-Ecological Systems Simulation Centre (SESS)*

# *Basic Concepts*

## Our Mission

Understanding the complexity of dynamic adaptive systems and their inherent feedbacks to support the development and application of social-ecological systems simulation for management of social-ecological systems in the real world.

# What is a social-ecological system and why are they interesting?

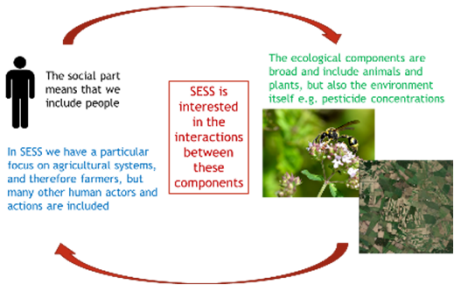
The social part means that we include people

In SESS we have a particular focus on agricultural systems, and therefore farmers, but many other human actors and actions are included

SESS is interested in the interactions between these components

The ecological components are broad and include animals and plants, but also the environment itself e.g. pesticide concentrations

# What is a social-ecological system and why are they interesting?




This is interesting because these systems are complex, meaning the system cannot be described by a single rule but shows complex emergent characteristics….

….. they are also often very important to us, e.g. food production systems.

Honey bees are a great example of complex systems, as well as being clearly an SES (including beekeepers and farmers).

It is notoriously difficult to predict the impact of e.g. pesticides on honey bees since the colony and exposure to the pesticide, and even the response of the bees are all very context dependent – simple rules are difficult to find.

# Some factors driving the honey bee health

Resource provision (their food) – it may be gardens like this or large fields of flowering crops, but people are responsible for providing most of the resources honey bees forage from.

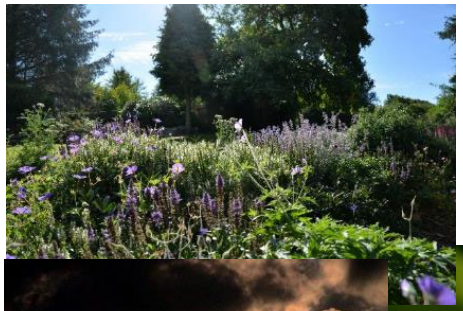
# Some factors driving the honey bee health

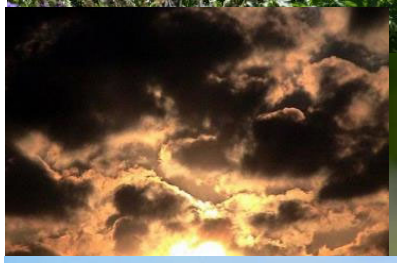
Weather – drives the plant growth but also whether they bees can forage, how much energy they need to keep warm or cool, alters egg laying rates and even affects when farmers might spray pesticides which the bees might be exposed to later.

# Some factors driving the honey bee health

Pesticides and other chemicals can affect bees if they are exposed to them. They can return them to the colony, store them (inadvertently) in honey, pollen, and comb wax and be exposed when these resources are used/re-used. They can kill foragers directly and can affect the egg laying rate, homing ability and brood survival.

# Some factors driving the honey bee health





Biological agents, such as *Varroa* here, or viruses and other diseases are common in bees and have deleterious effects. There are also bee predators for the bees to contend with

# Some factors driving the honey bee health

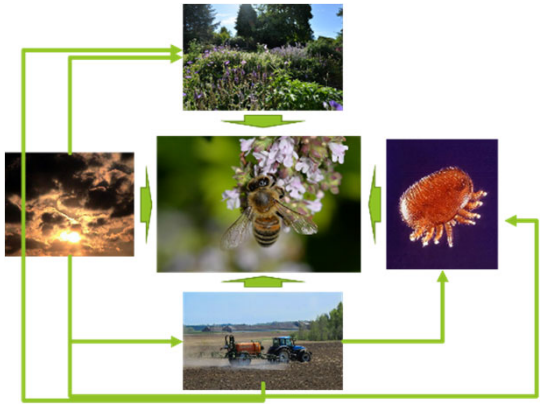
All these factors affect bees

# Some factors driving the honey bee health

All these factors affect bees

But also each other!

# Simple to complex systems



The bee system is much more complicated than this diagram represents – many factors determine whether the farmer grows a flowering crop, or applies a pesticide, and these factors interact in a complex way, e.g. market prices would determine the acreage of oilseed rape crops (many flowers)

For biological agents it is also complex, the effects of these stressors is determined by interactions between them and e.g. pesticides, altering the immuno-competence of the bees at an individual level.

This means that often  +  > the sum of the individual effects of the two.

When all these interactions are taken into account the result is often hard to predict = **complex system**

# Some aspects of complex systems

- They are complex (and often complicated) so emergent dynamics are often unpredictable at all but the most general levels
- They can change. Relationships between parts of the systems may alter with time – they are often even self-reflexive i.e. entities can evaluate system states and alter their own behaviour to affect performance
- They are infinite – complex systems have no natural limit, in the end everything can in some way affect everything else
- Details matter – outcomes depend on small changes in inputs

To handle this SESS uses a non-traditional approach to modelling

# SESS approach

Traditionally ecological modelling uses general approaches and is very fond of Occam's razor, or KISS (keep it simple stupid) e.g. $\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$ ….. in social science and more recently in ecology agent-based models have also been used, but again with the same underlying ideals. These models are often very useful, but are rarely predictive.

The SESS approach is to attempt to simulate using detailed models in an attempt to get as close as possible to an engineering digital twin

# SESS Uses ALMaSS

- SESS uses ALMaSS (Animal Landscape and Man Simulation System) as the main modelling tool
- ALMaSS (see www.ALMaSS.dk ) provides an environment for modelling detailed interactions between agents (e.g. animals, people) and between agents and their environment
- In development for 20 years ALMaSS hosts a growing range of species and people models and highly detailed landscape and farming simulations
- ALMaSS models are under development in 11 EU countries with current national coverage in Denmark, Poland and The Netherlands

# Thanks for your attention

Contact us at ::::::::::::::.dk

ALMaSS