



Dynamic model of the Swiss cattle population

Sara Schär^a, Jakob Zinsstag^b, Patrick Presi^a, Jan Hattendorf^b, Nakul Chitnis^b, Martin Reist^a

^a*Veterinary Public Health Institute/ University of Berne, Berne, Switzerland*

^b*Swiss Tropical and Public Health Institute/ University of Basel, Basel, Switzerland*

Content



- Background
- The Model
- Sensitivity analysis
- Outlook

Background



- Demographic composition and dynamic of animal and human populations are important determinants for the transmission dynamics of infectious disease.
- A dynamic population model can serve as building block for future disease transmission models and help policy makers in developing strategies regarding animal health, animal welfare and livestock management.
- Since 1999 Switzerland has an animal movement database (AMD) recording cattle movements, births, deaths and slaughter.



Background

The Swiss cattle population:

- Ca 41'000 farms with cattle
- Ca 1'600'000 cattle
- Ca 2/3 for milk production

-> the milk and beef populations differ in age structure

-> some surveillance programs cover milk farms through bulk milk testing which leads to different sampling strategies according to production type



Model - specifications

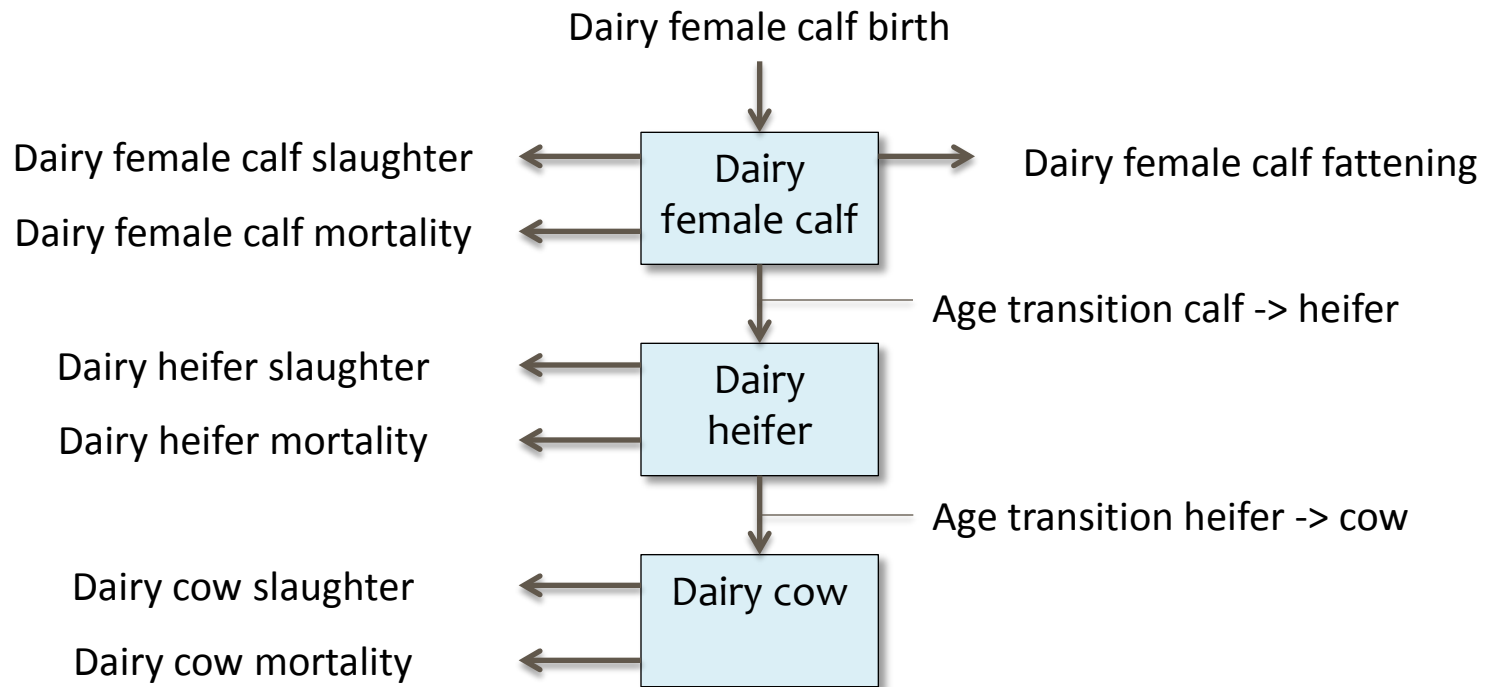
- Model build in Vensim*
- Two production types:
 - Dairy (initial D)
 - Beef (initial B)
- Three age categories:
 - Female (FC)/male calves (MC) (0-1 year)
 - Heifers (H)/young bulls (YB) (1-2 years)
 - Cows (C) /bulls (B) (older than 2 years)
- Offtake:
 - slaughter
 - mortality
 - fattening (dairy calfs)
- Input:
 - birth
 - age transition
 - fattening (beef calfs)

*The Ventana Simulation Environment, Vensim® Professional for Windows Version 5.8a, Copyright© 1988-2008 Ventana Systems Inc.

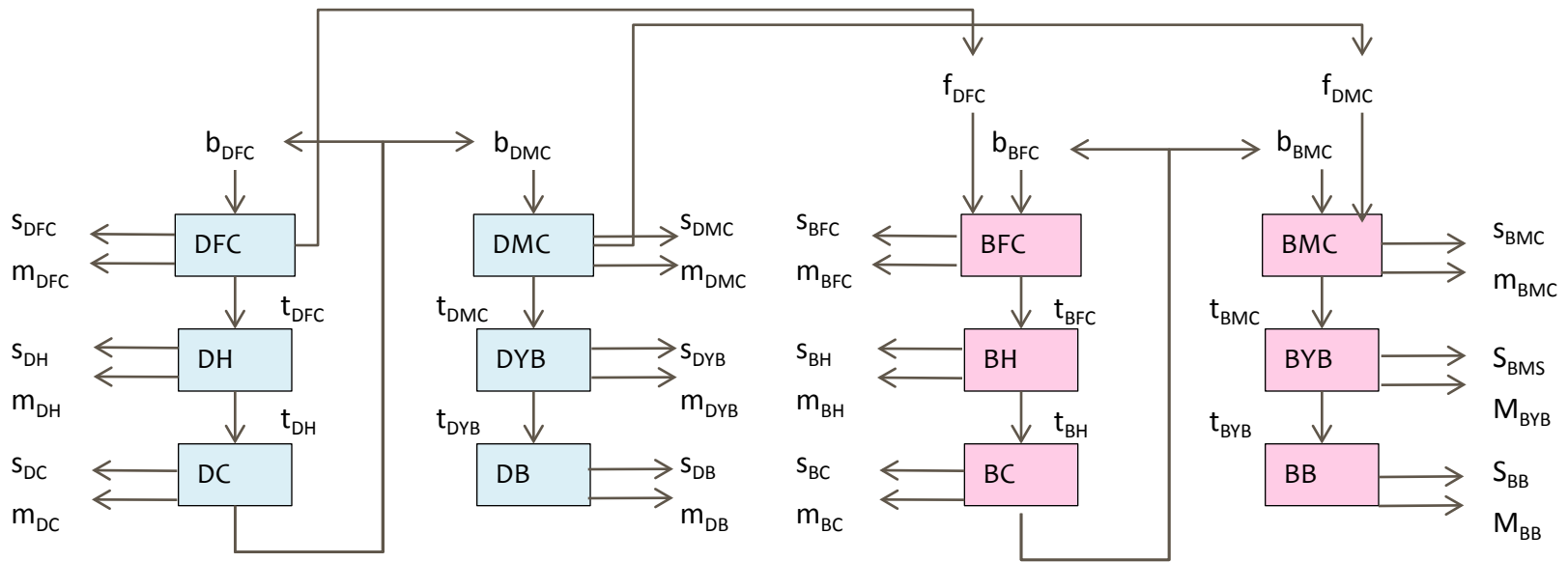


Model schema - detail

$$\frac{dDC}{dt} = bDCow - mDC - sDC - trDC$$



Model schema



Model - Fitting



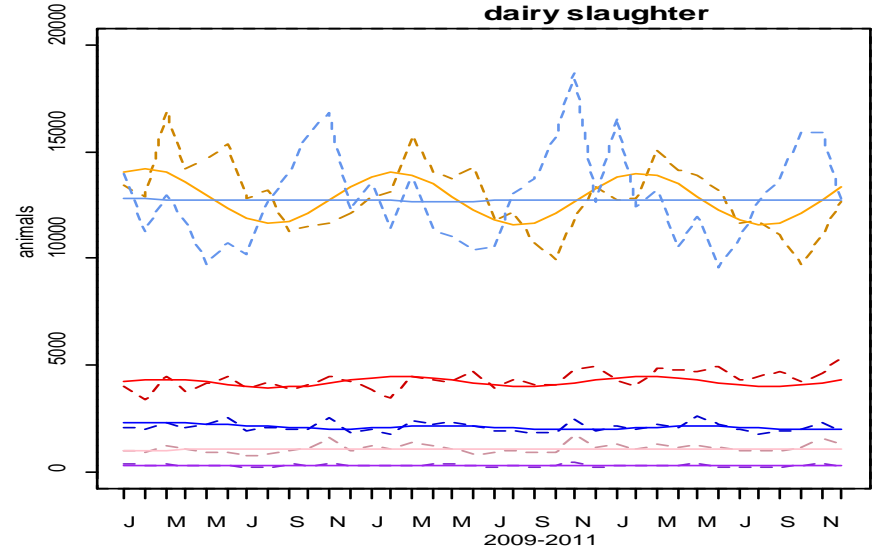
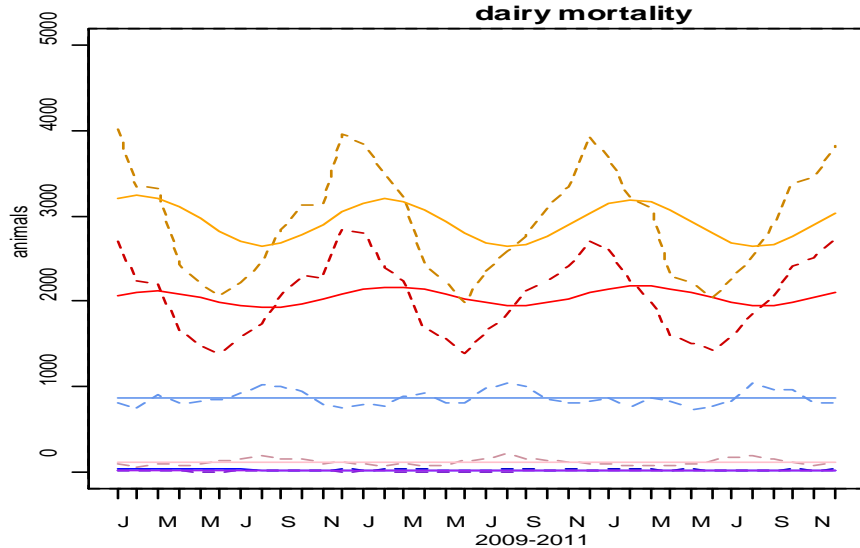
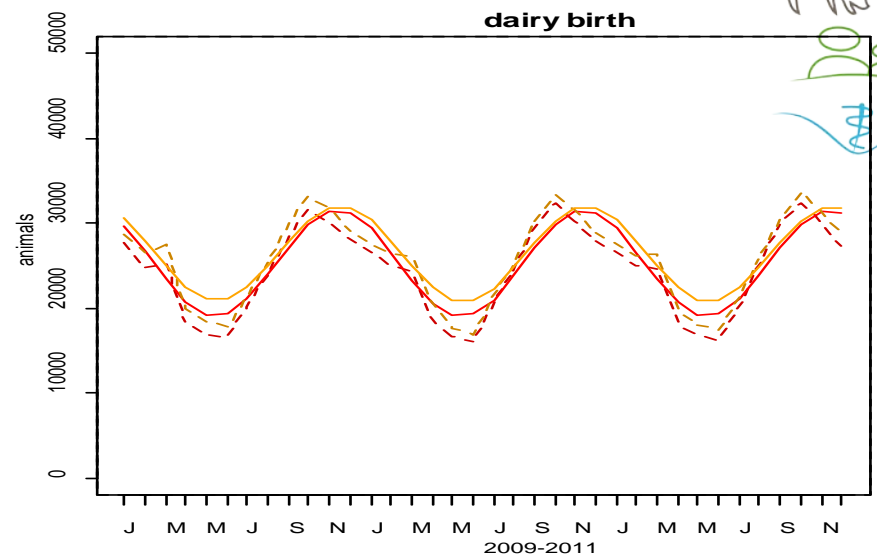
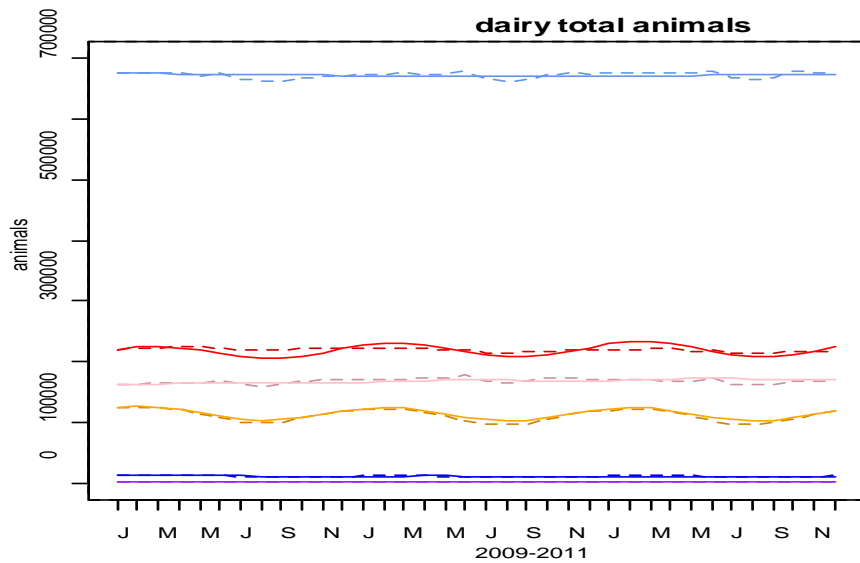
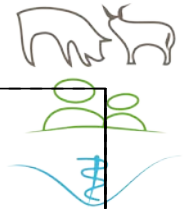
- Fitting rates
- **Sinus functions** for birthrates
 $a + \text{amp} * \sin(bt+c)$
- Optimizations using the data from the AMD for birth, slaughter, mortality and living animals per month



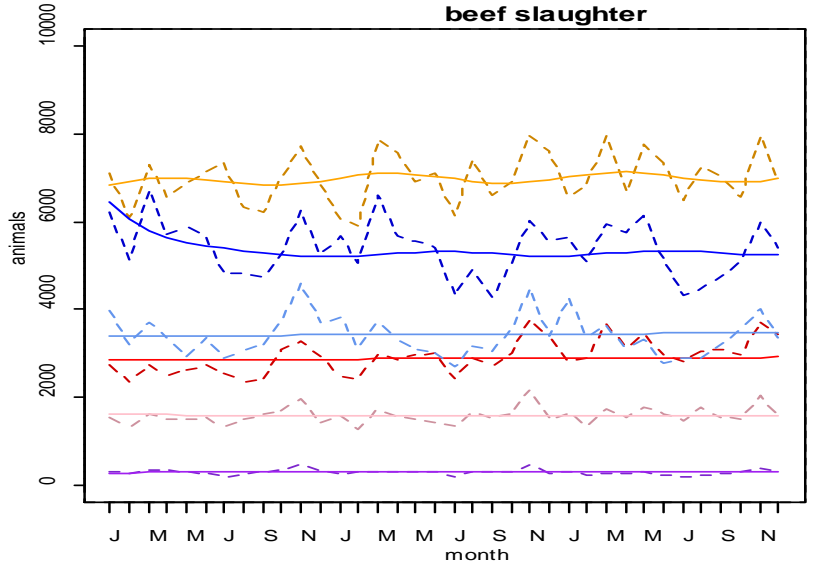
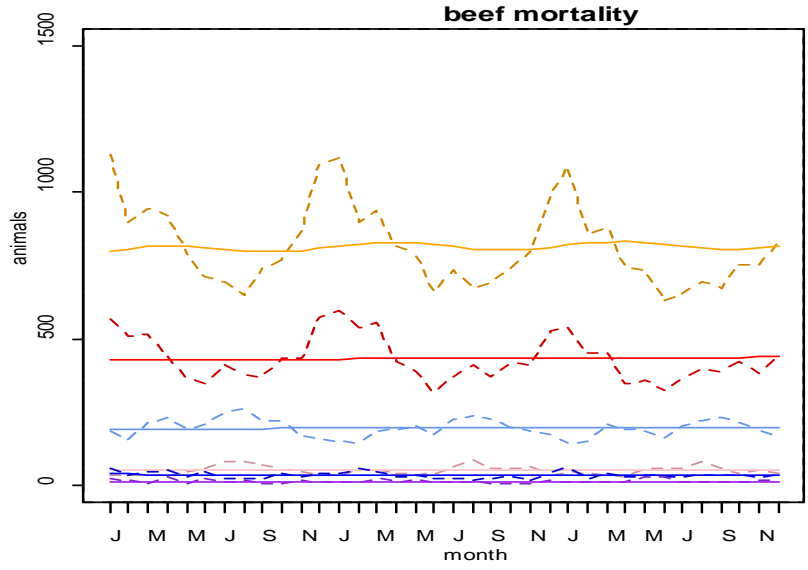
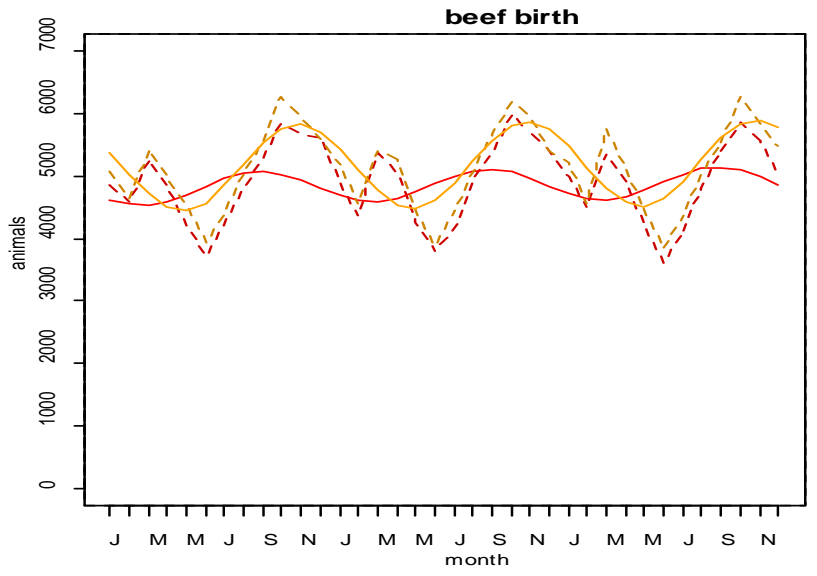
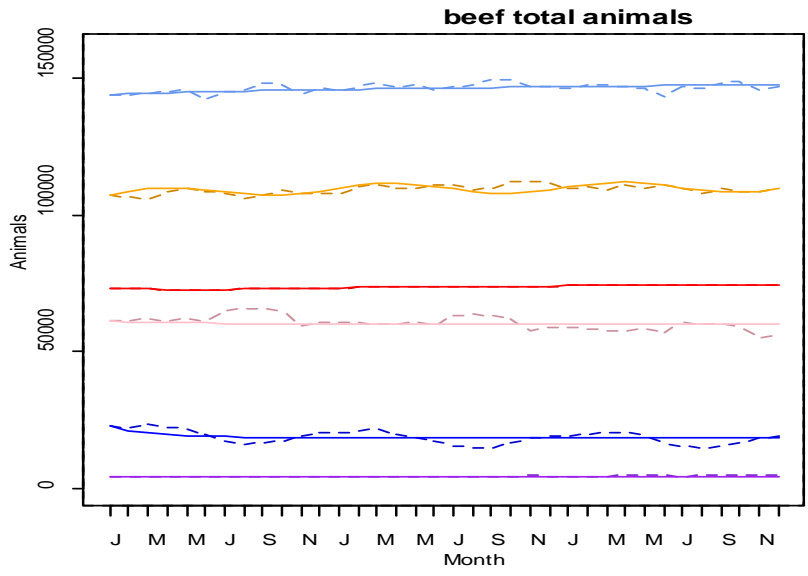
Model - Results

- Estimated rates to describe the monthly change in the population

	amplitude	phase	average	slaughter rate	mortality rate	transition rate	fattening rate
DFC	0.0093	1.8865	0.0376	0.0192	0.0094	0.0680	0.0175
DH				0.0062	0.0007	0.0802	
DC				0.0190	0.0013		
DMC	0.0083	1.8337	0.0393	0.1121	0.0256	0.0206	0.0726
DYB				0.1702	0.0017	0.0235	
DB				0.1113	0.0022		
BMC	0.0047	2.1965	0.0353	0.0637	0.0074	0.0511	
DYB				0.2828	0.0017	0.0167	
BB				0.0637	0.0026		
BFC	0.0017	3.2632	0.0331	0.0390	0.0059	0.0723	
BH				0.0262	0.0008	0.0619	
BC				0.0234	0.0013		



- Model
- Dairy female calf
- Dairy male calf
- - - AMD
- Dairy heifer
- Dairy young bull
- Dairy cow
- Dairy bull



- Model
- Beef female calf
- Beef male calf
- AMD
- Beef heifer
- Beef young bull
- Beef cow
- Beef bull

Sensitivity Analysis - methods



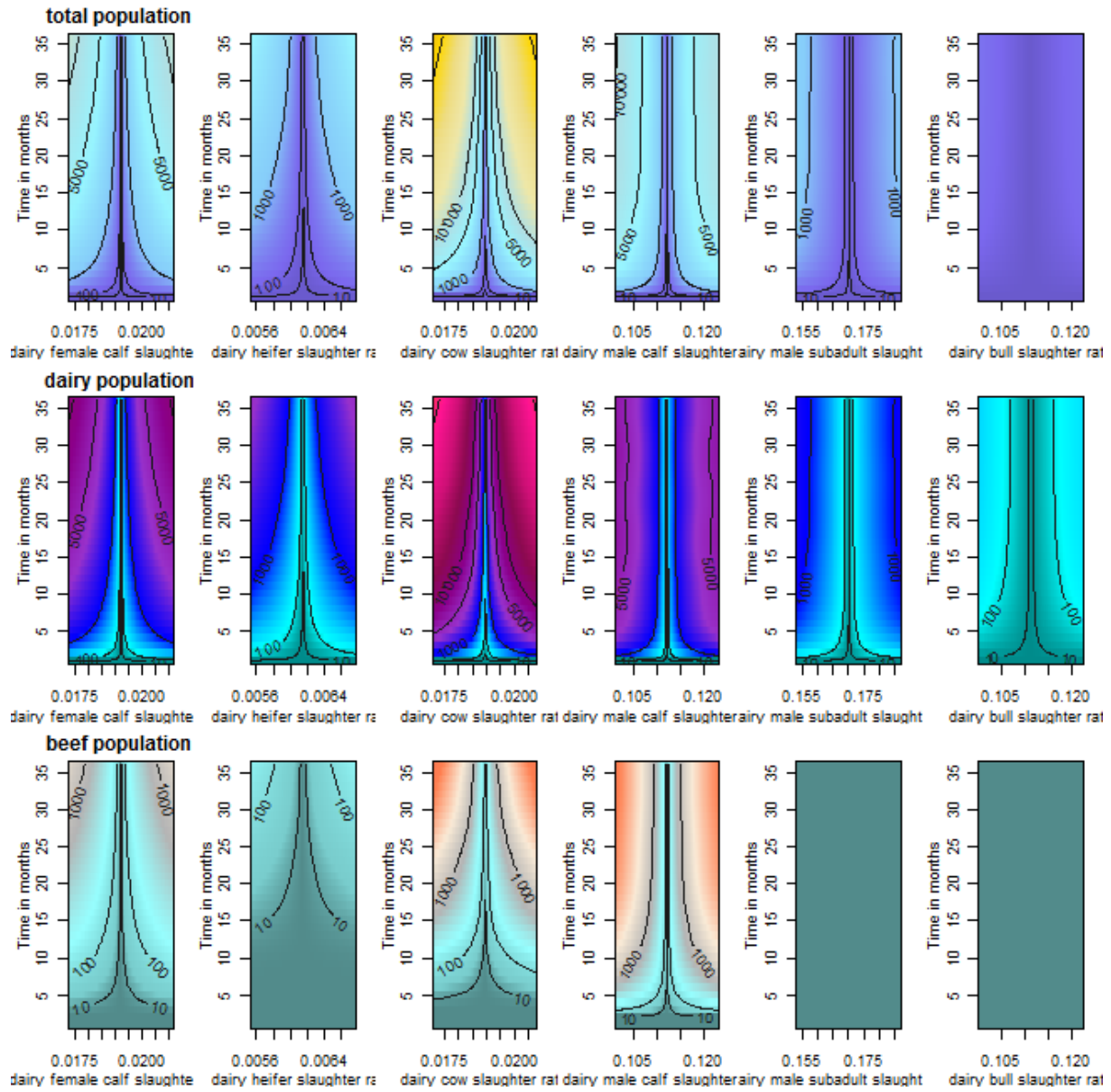
- The Model was rebuilt in R*
- Each parameter was varied separately using a range from -10% to +10% of the fitted value from the VENSIM model (baseline)
- For each value, the resulting absolute **change in total numbers of animals compared to the baseline** was represented graphically for the total, dairy and beef population

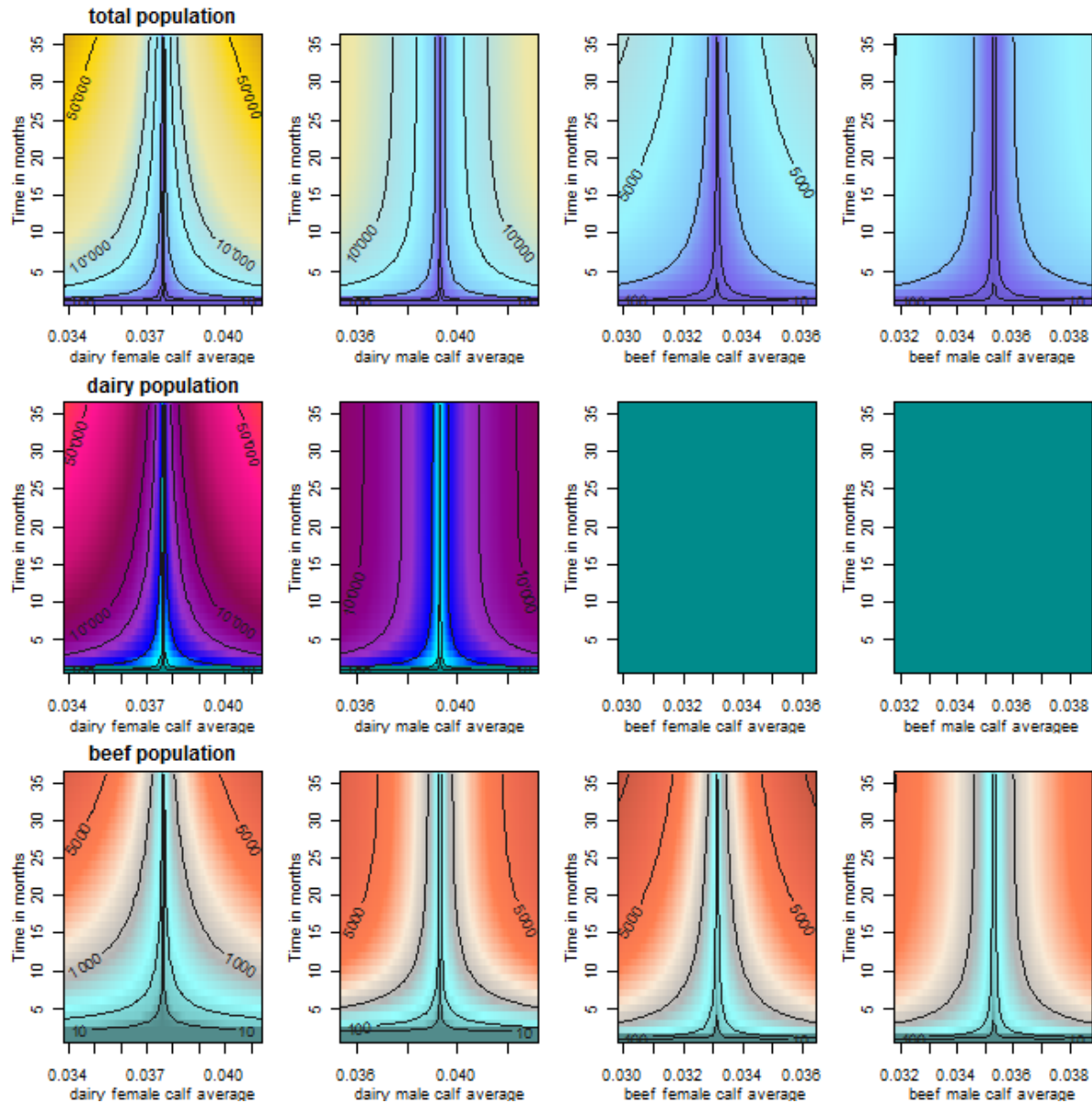
*R Development Core Team (2011). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL <http://www.R-project.org/>.

Sensitivity Analysis - results



- The model reacts most sensitive to the average dairy calf birth rate and the dairy cow slaughter rate (dairy, beef and total population)





Outlook



- Backbone for the development of age and sex structured models of infectious disease transmission.
- Use for the simulation of disease surveillance in abattoirs as compared to field sampling.
- Comparative use with livestock demographic models in other countries → Mongolian, Ethiopia, Kyrgyzstan (in development)

Thank you for your attention!

