EPISTIS

EPIdemiological Space-Time Information System

Remote Sensing tools to study the EPIdemiology and Space/TIme dynamicS of diseases

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Context

- Research Programme for Earth Observation: "STEREO II"
  - Belgian Science Policy Office
  - 2007-2011
- 2 major components:
  - **Foot & Mouth Disease**: South Africa
  - **Bluetongue:** Europe (Italy & Belgium)
- 2 main scientific objectives
  - explore how a wide range of **RS tools and GIS** can be integrated & contribute to the **understanding of the space-time dynamics of diseases**
  - explore how **integrated spatial analysis** outputs can contribute to **improved information & decision support** for disease management

If we knew what it was we were doing, it would not be called research, would it? (Einstein)

FMD Aims

- Spatio-Temporal risk model
  - Wildlife-Livestock-Human interface heterogeneity
  - Cattle distribution
  - Buffalo distribution
  - Disease control (eg fence & vaccination)
  - Focus on contact rather than transmission
    - Not disregarding transmission though
- Space-Time Information System (STIS)
  - "Real-time" risk information based on simplified risk model using RS & standard surveillance data

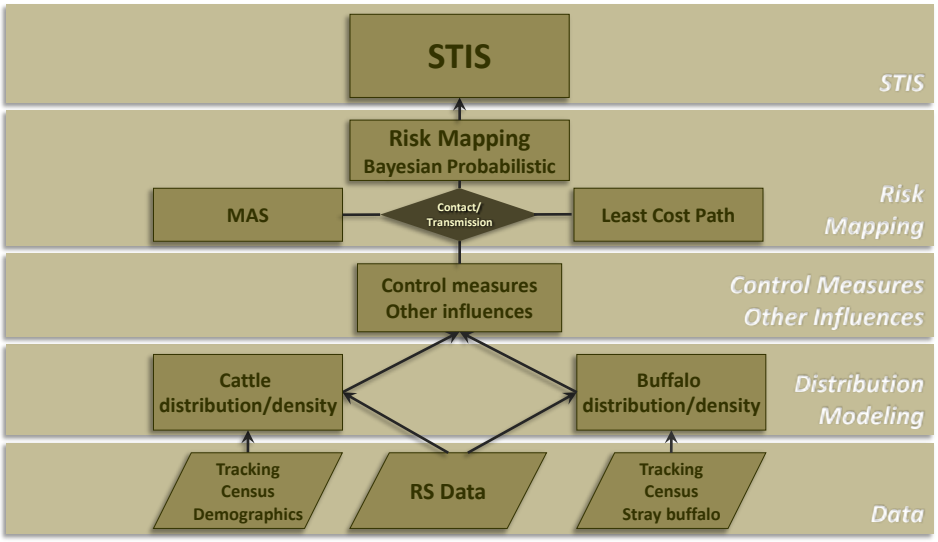
A perfection of means, and confusion of aims, seems to be our main problem (Einstein)

Partners (FMD)

- **University of Pretoria**, Faculty of Veterinary Science
  - *Department Veterinary Tropical Diseases & Centre for Veterinary Wildlife Studies*
  - SA Field Coordination & data/model integration
- **Institute of Tropical Medicine**, Antwerpen, Belgium
  - *Department Animal Health and Epidemiology*
  - Buffalo distribution modeling & other model parameters
- **Avia-GIS**, Zoersel (Belgium)
  - *Spatial epidemiology consultancy firm*
  - STIS development & cattle distribution modeling
- **Université Libre de Bruxelles,** Brussels, Belgium
  - *SIGTEL/ULB : Système d'Information Géographique et Télédétection, Institut de Gestion de l'Environnement et d'Aménagement du Territoire, Faculté des Sciences*
  - Very High Resolution Satellite Imagery & Least Cost Path model
- **Université catholique de Louvain,** Louvain la Neuve, Belgium
  - *Département de Géographie*
  - Multi-agent simulation (Scenario testing)
- **University of Oxford**, Oxford, UK
  - *Department of Zoology (Spatial Ecology & Epidemiology Group) [Informal collaboration]*
  - Bayesian Probabilistic Modeling

He who joyfully marches in rank and file has already earned my contempt. He has been given a large brain by mistake, since for him the spinal cord would suffice (Einstein)

Overview



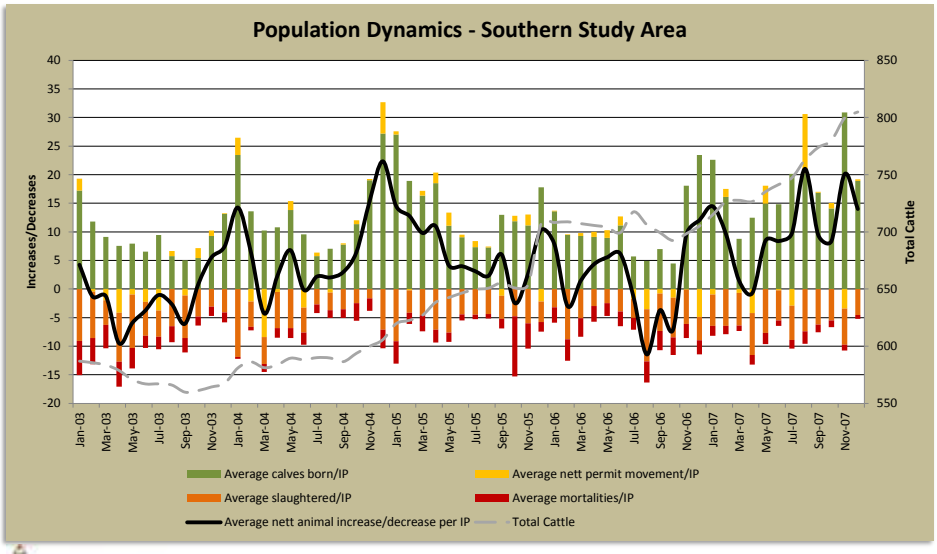
To raise new questions, new possibilities, to regard old problems from a new angle, requires creative imagination and marks real advance in science (Einstein)

Study Areas

	North	Central	South
Area (excluding reserves) (ha)	40 449	142 991	34 844
Households	2 321	30 762	40 023
Population density (people/ha)	0.23	0.94	5.31
Households keeping cattle	13.01%	6.73%	3.22%
Cattle	4 461	27 120	12 073
Cattle:Owner	19.6	13.1	7.8
Cattle density (cattle/ha)	0.11	0.19	0.35

It is a miracle that curiosity survives formal education (Einstein)

Cattle register dynamics



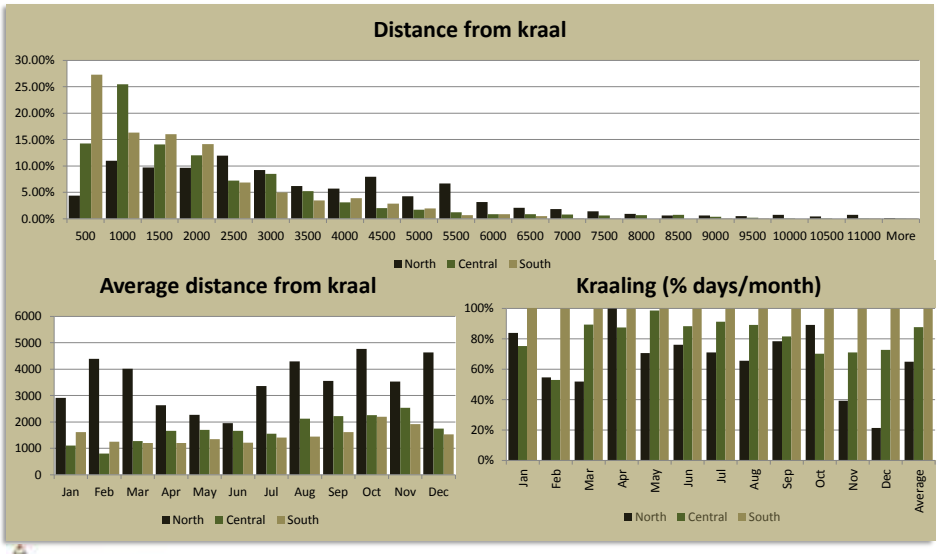
Any man who reads too much and uses his own brain too little falls into lazy habits of thinking (Einstein)

Cattle distribution/density

- Cattle Tracking
  - Handheld GPS
    - Southern study area
    - Frequency: 5min
    - 24 herdsmen, 3d/week, 1yr
  - GPS collar
    - Central & Northern study areas
    - Frequency: 15min
    - 14 cattle, 24h, 1yr
- IP Selection based on
  - Cattle density
  - Distance from reserves
  - Distance from rivers
  - LCC
- Kraaling

Logic will get you from A to B. Imagination will take you everywhere (Einstein)

Grazing distance



Knowledge of what is does not open the door directly to what should be (Einstein)

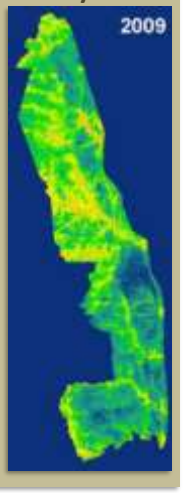
Cattle distribution/density

- Maximum Entropy modeling & multi-dimensional kriging
- Environmental variables
  - Water:
  - Vegetation classes
  - Climate
  - Elevation
  - MODIS time series (NDVI)
- Project output data
  - Land cover classification
  - Water
  - Riparian vegetation

If you are out to describe the truth, leave elegance to the tailor (Einstein)

Wildlife distribution/density

- Similar approach to cattle distribution/density
  - Annual census data (bulls/family herds)
  - Tracking data from previous/other studies



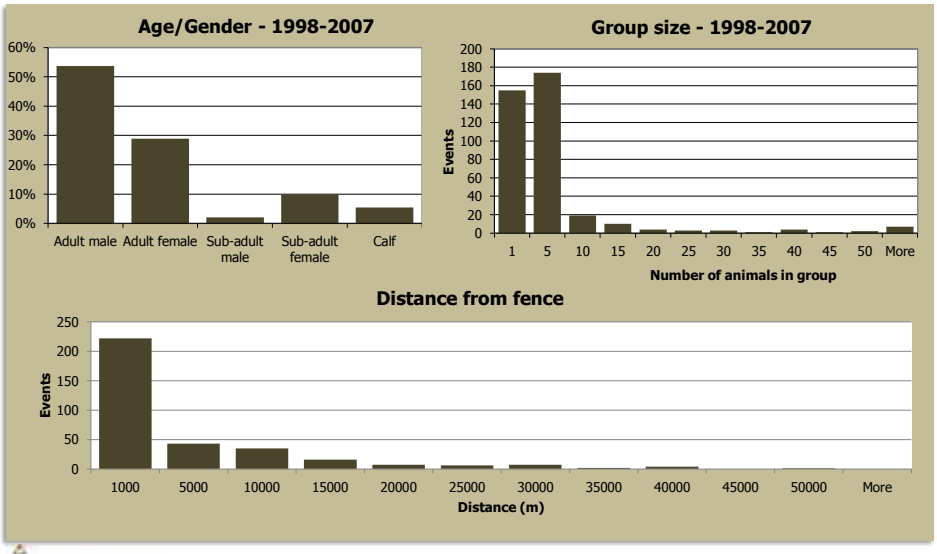
People love chopping wood. In this activity one immediately sees results (Einstein)

Disease control

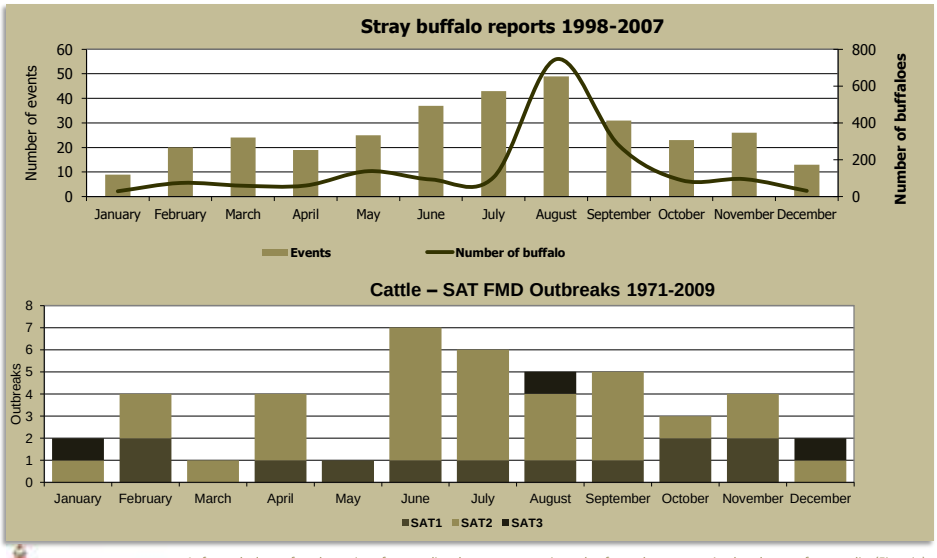
- Fence
  - Main factors influencing permeability
    - Type
    - River crossings
    - Human pressure
    - Elephant pressure
  - Stray buffaloes
- Vaccination

The whole of science is nothing more than a refinement of everyday thinking (Einstein)

Stray buffaloes



Stray buffaloes & FMD



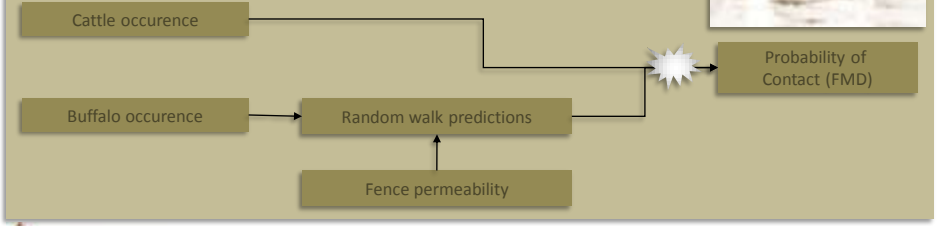
Vaccination

- Limited data availability
  - Start with global values for entire area/sub-areas
  - Need to define spatial and temporal characteristics of vaccination better

Everything should be as simple as it is, but not simpler (Einstein)

Risk Model

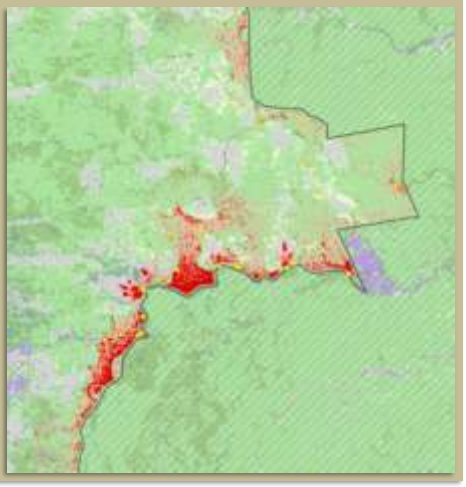
- Bayesian probabilistic framework (R)
  - Temporal resolution: 1 week
  - Spatial resolution: 250m
  - Distribution: Multidimensional Kriging
  - Contact: same cell, same time step
  - Outputs: Monthly, Seasonal & Annual



Essentially, all models are wrong, but some are useful (Box & Draper 1987)

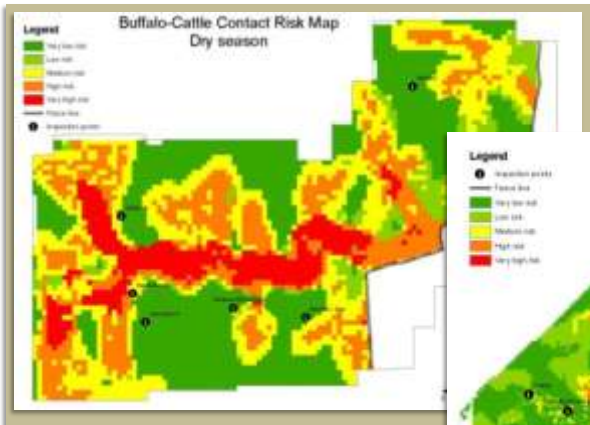
Multi-agent simulation

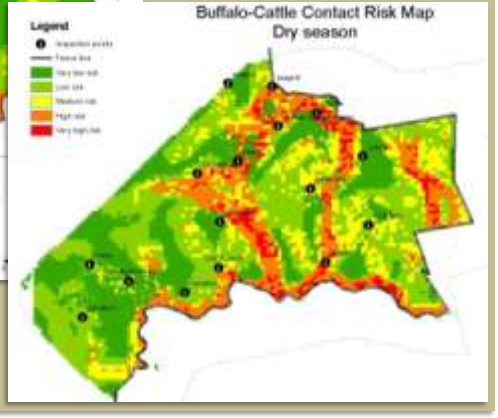
- Currently only employed in southern study area
  - Incorporates VHRRS data
  - Sensitivity analysis
  - Scenario testing



No amount of experimentation can ever prove me right; a single experiment can prove me wrong (Einstein)

GIS Model: Least Cost Path

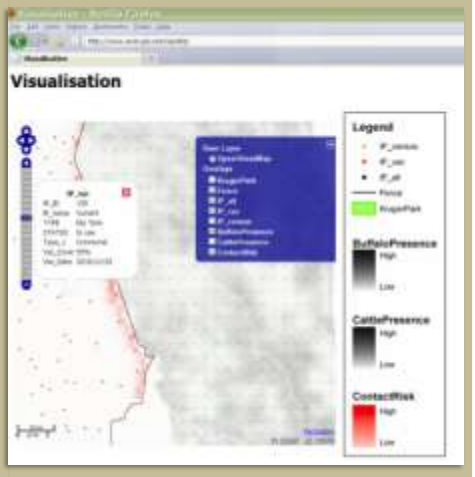




Insanity: doing the same thing over and over again and expecting different results (Einstein)

STIS

- Space-Time Information System
  - Updated with Bayesian Probabilistic Model outputs
  - Regular RS and field data updates
    - Risk based on most "current" data
    - Incorporates actual risk mitigation with each run
  - Intervention prioritization
    - Vaccination
    - Contribution of fence permeability to risk?
  - Additional??
    - Extrapolation to larger area (TFCA) &/or other areas?
    - "What if?" analyses
    - Aid in control zone refinement



Occurrences in this domain are beyond the reach of exact prediction because of the variety of factors in operation, not because of any lack of order in nature (Einstein)

Known limitations

- It's a model…
- Infectivity/Transmission/Susceptibility
- Temporal extrapolation?
- Undetected spread
  - Currently no spread model included in risk model
    - Not enough time/resources to complete during EPISTIS period
    - **But,** available data and current risk model lends itself toward inclusion of a spread/outbreak component
- Validation!
  - Contact/Outbreak data

Determining a model's accuracy, spatial limitations & practical application to disease control, rather than just predicting infection risk, is the real challenge in modelling *(Brooker et al. 2002)*

22 March 2011

Open Science Day

Presentations on all components of EPISTIS

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Science is a wonderful thing if one does not have to earn one's living at it (Einstein)