GIS and spatial modeling for evidence based control of cestod zoonoses

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Nature 1991, 351, 739-741

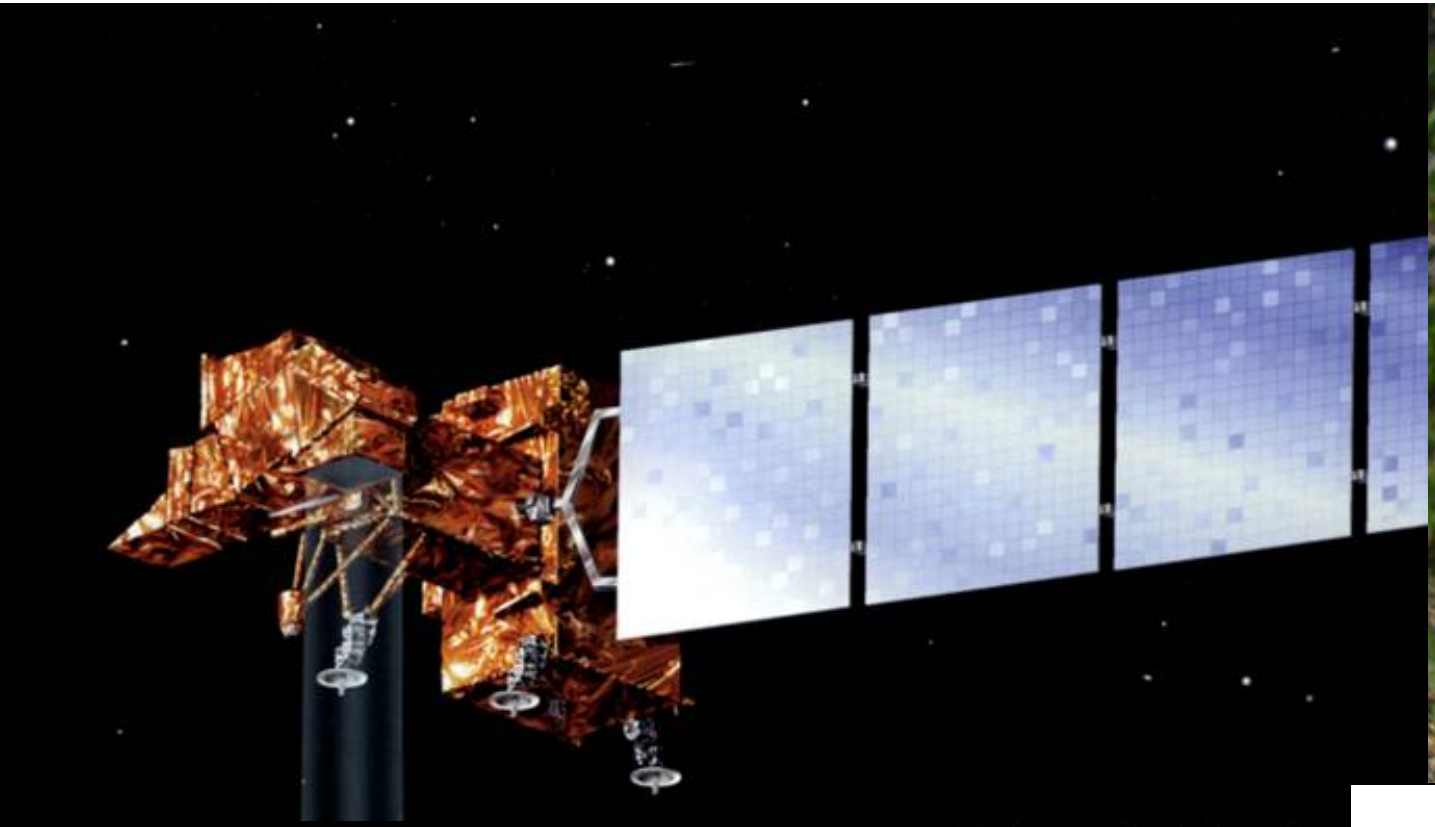
Mortality rates and population density of tsetse flies correlated with satellite imagery

D.J. Rogers and S.E. Randolph

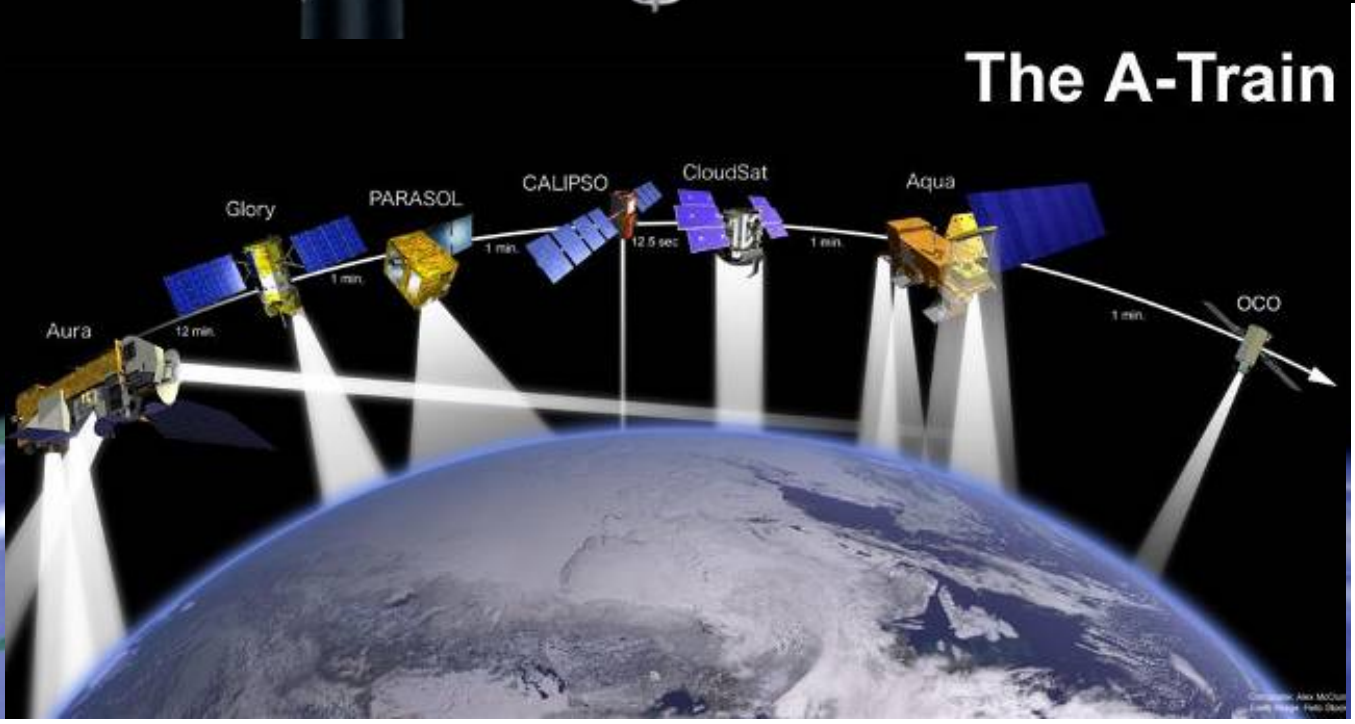
Malaria (Hay *et al.*, 1998, Malone *et al.*, 2006, Rogers et al. 2002)
Shagas disease (Cecere *et al.*, 2004)
American visceral leishmaniasis (Bavia *et al.*, 2005)
Old world cutaneous leishmaniasis (Cross *et al.*, 1996)
Bilharziasis and Fasciolosis (Kristensen *et al.*, 2001, Yang *et al.*, 2005)
Onchocerciasis (Gebre-Michael *et al.*, 2005)
Old World screwworm myiasis (Siddig *et al.*, 2005)
Bancroftian filariasis (Hassan, 2004)

+ virus vector-borne diseases (blue tongue, Hanta, La Crosse, West Nile, Sin Nombre, Rift Valley fever and tick-borne viruses, etc.) and some bacteria (e.g. cholera and leprosy)

+ Echinococcosis (Danson *et al.*, 2004, 2006, Pleydell *et al.*, 2004, 2008)




GARMIN


The A-Train
Aura
Glory
PARASOL
CALIPSO
CloudSat
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OCO
12 min.
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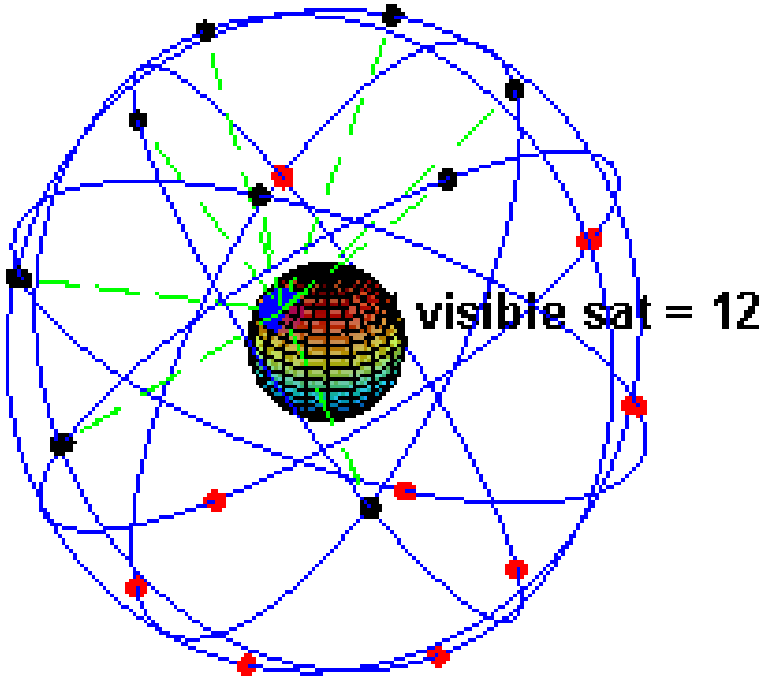
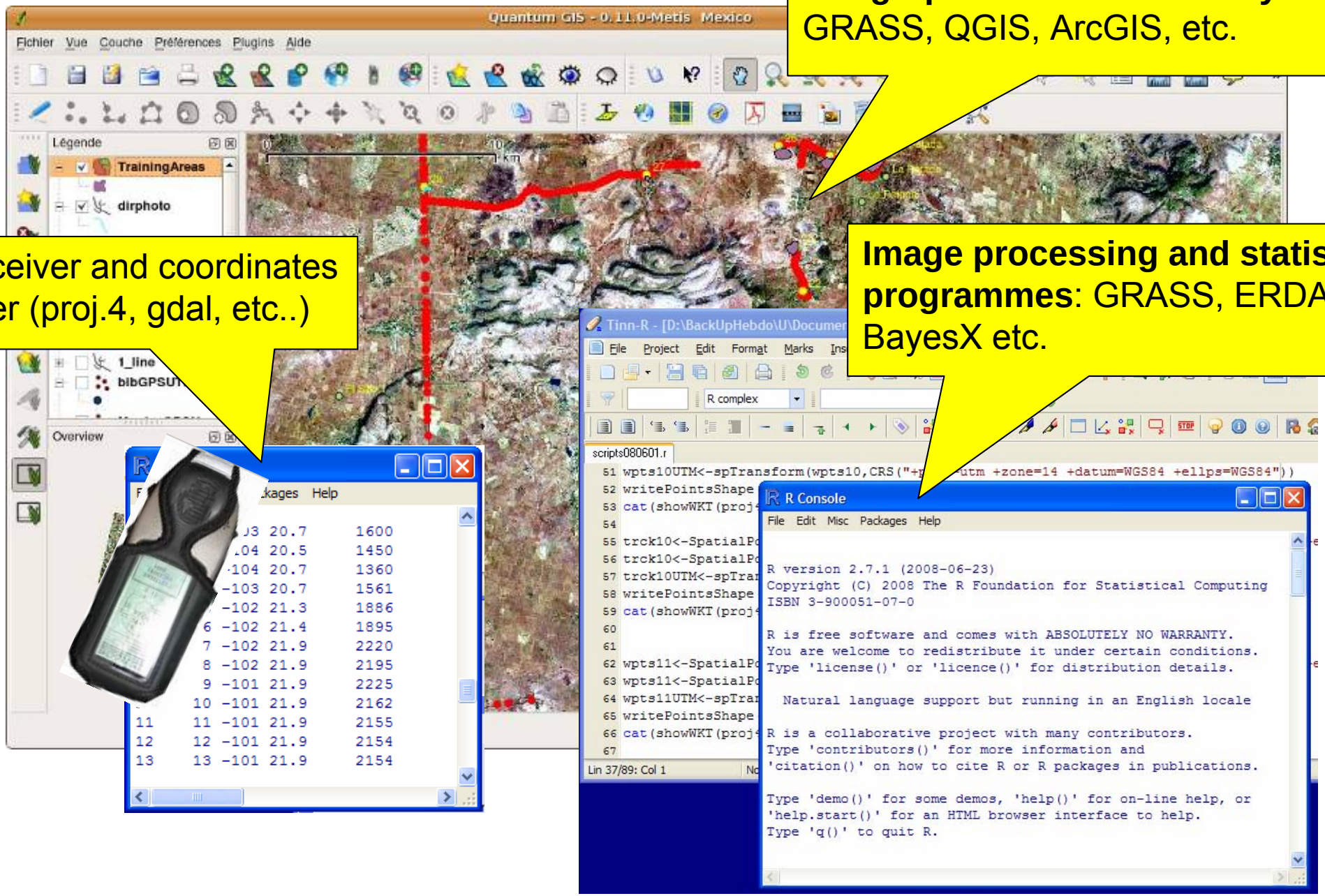
1 min.
12.5 sec
1 min.
1 min.


visible sat = 12

Geographical Information System: GRASS, QGIS, ArcGIS, etc.

GPS receiver and coordinates converter (proj.4, gdal, etc..)

Image processing and statistical programmes: GRASS, ERDAS; R, BayesX etc.



Articles including an approach spatially explicit and quantified for studying human cestod pathogens

E. multilocularis **> 12**

Gilot et al. 1988, Canadian Journal of Zoology
Pesson & Carbenier 1989, Bulletin d'Ecologie

Berke & al 2001, Preventive Veterinary Medicine
Berke & al. 2002, Berliner Und Munchener Tierarztliche Wochenschrift
Danson & al. 2003, Parasitology
Giraudoux et & al. 2003, Parasitology
Miterpakova et & al. 2003, Helminthologia
Graham et & al. 2004, Acta Tropica
Pleydell et & al. 2004, Acta Tropica
Danson et & al. 2006, Parasitology International
Pleydell et & al. 2008, PLoS NTD
Knapp et & al. 2009, PLoS NTD
Etc.

E. granulosus 1

Rinaldi & al. 2006, Geospatial Health

Taenia saginata 1

Alepuz & al, 2006, Veterinary Parasitology

Taenia solium 3

Lescano & al. 2007 Am J Trop Med Hyg
Morales & al. 2008. PLoS NTD
Ngowi & al. 2010. PLoS NTD

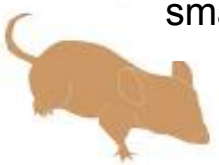
Taenia asiatica 0

Echinococcus multilocularis

Accidentally, humans ingest Em eggs. Suffering from the disease, they cannot transmit it

7

2 Metacestode larva develops in the liver of small mammals



1 Small mammals ingest parasite eggs with plants and earth (e.g. digging)

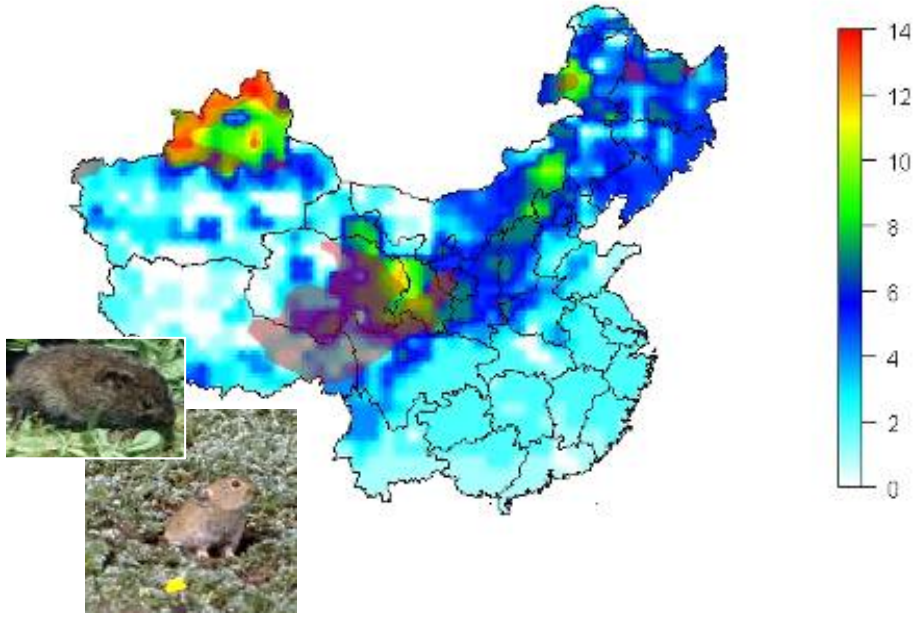
3 Foxes, dogs, cats eat small mammals

4 Protoscoleces develop into adult worms in the intestine

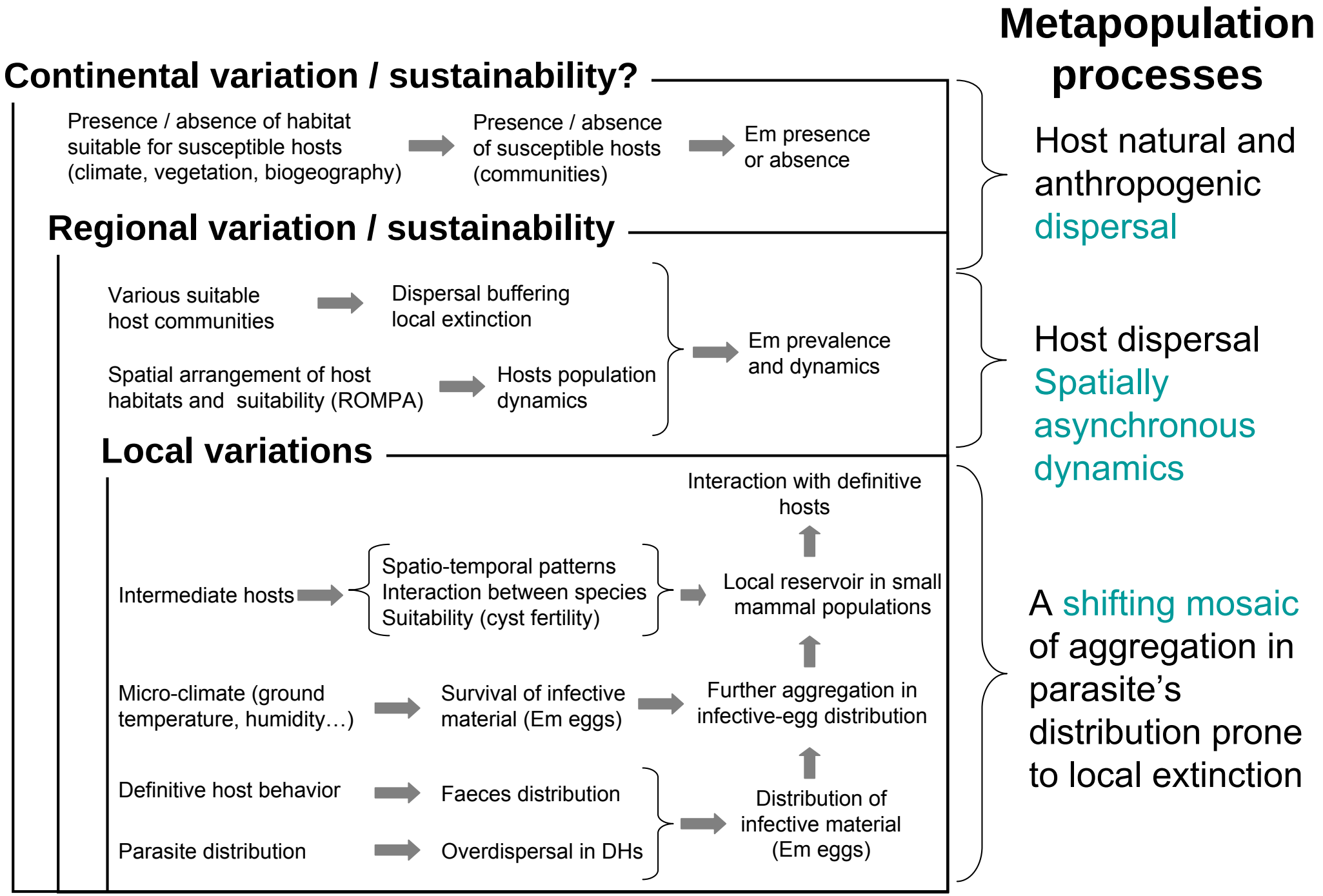
5 Parasite eggs are shed in the environment with faeces

6 Plants, soil, animal hairs are contaminated

Species richness: IH species
Continental China



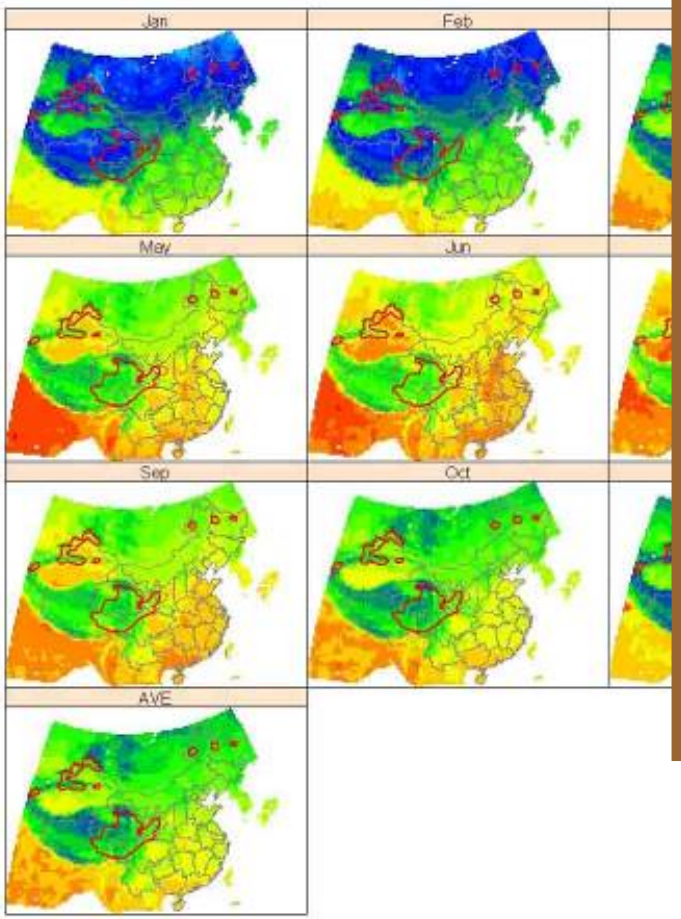
CHU Besançon

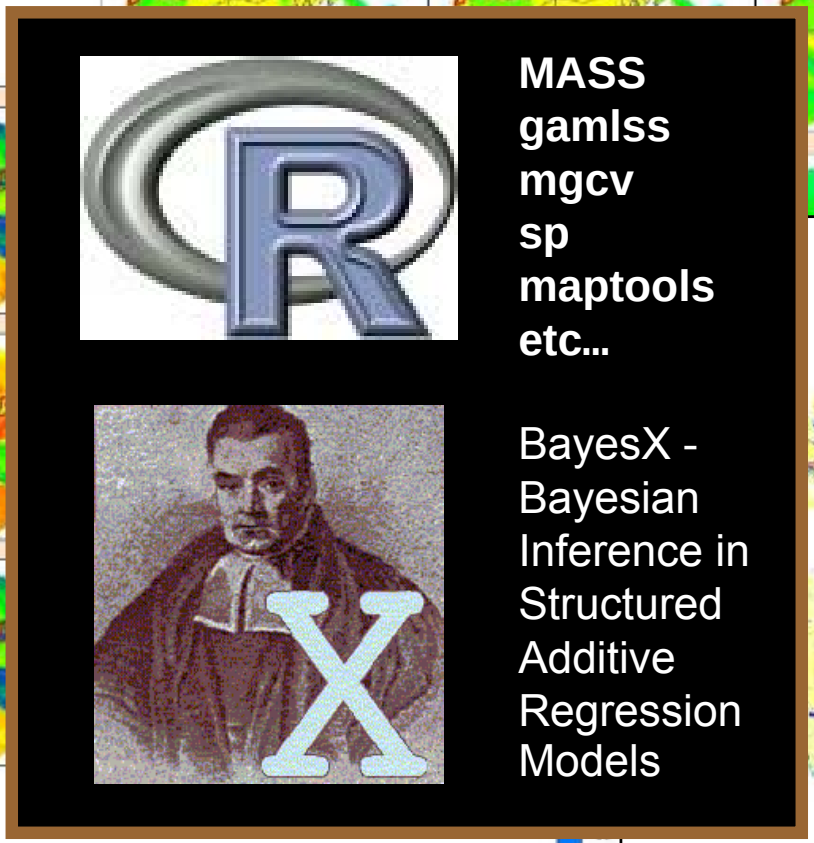


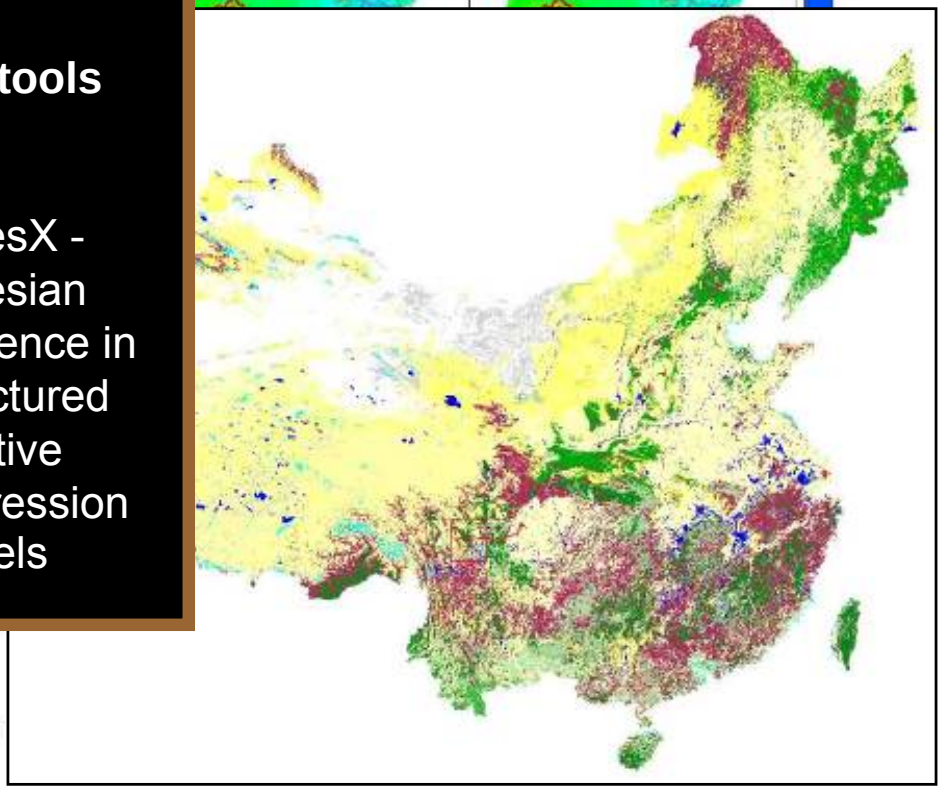
Giraudoux *et al.* 2006

AE cases ~ Environment variables (T°, rainfall, landscape classes, etc.) + Spatial structure + Residuals

Ecological factors or proxys for ecological factors







MASS
gamlss
mgcv
sp
maptools
etc...

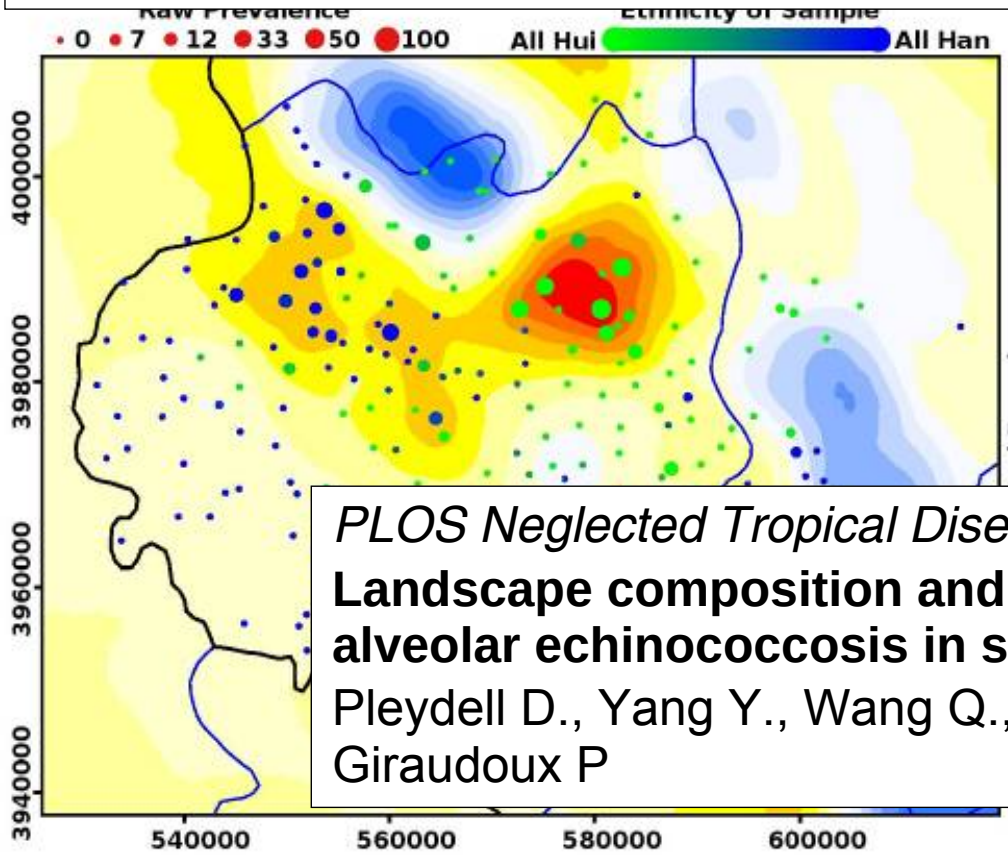
BayesX - Bayesian Inference in Structured Additive Regression Models

Regional scale: population dynamics processes and parasite transmission are responsive to spatial arrangement of habitats

Parasitology 2003, 127 : 121-131

Interactions between landscape changes and host communities can regulate *Echinococcus multilocularis* transmission

Giraudoux P., Craig P.S., Delattre P., Bartholomot B., Bao G., Barnish G., Harraga S., Quéré J.P., Raoul F., Wang Y.H., Shi D., Vuitton D.



Photogrammetric Engineering and Remote Sensing, 2003 70 (3) : 359-366

Landscape dynamics and risk modelling of Alveolar Echinococcosis

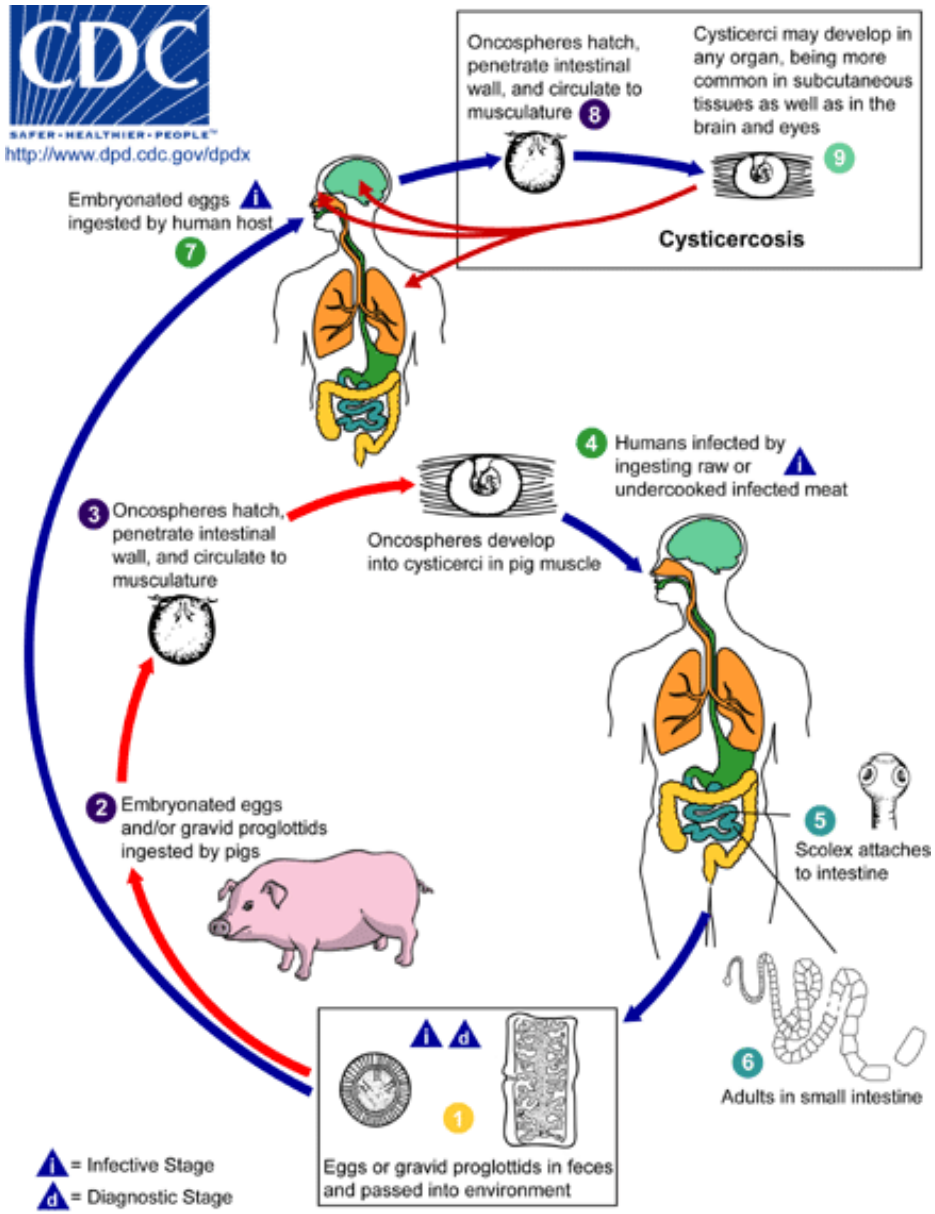
Danson, F.M., Craig, P.S., Man, W., Shi, D. & Giraudoux, P.

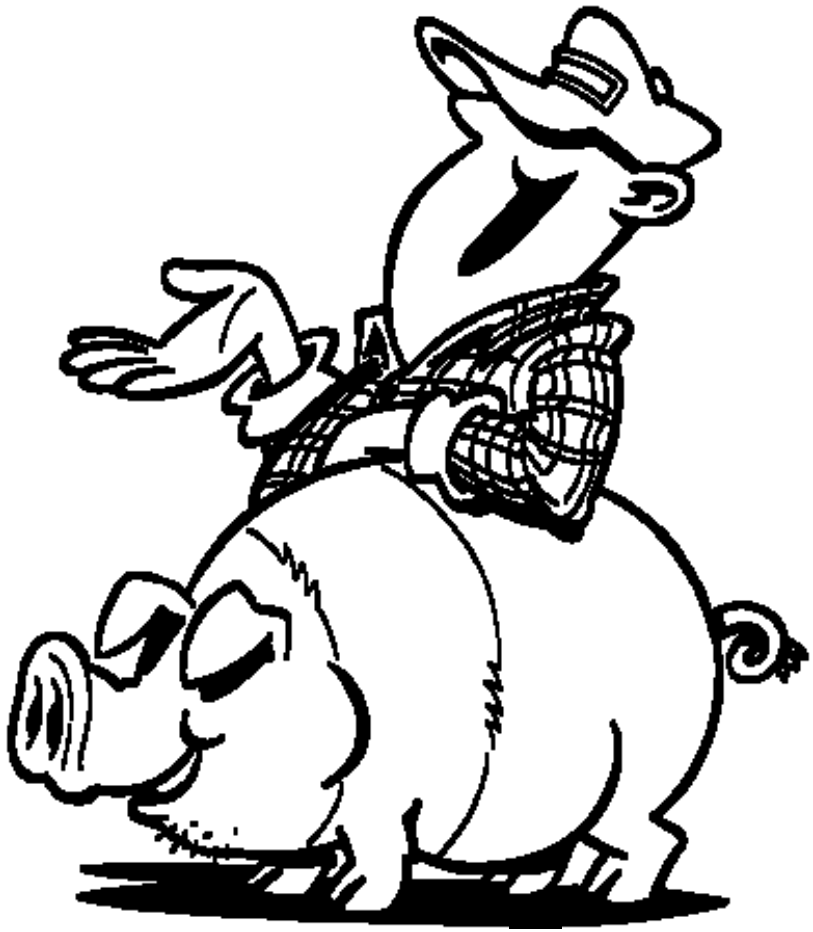
PLOS Neglected Tropical Diseases 2008, 2(9) : e287

Landscape composition and spatial prediction of a zoonosis: the case of alveolar echinococcosis in southern Ningxia, China

Pleydell D., Yang Y., Wang Q., Raoul F., Danson, M., Craig P., Vuitton D., Giraudoux P

Taenia solium





RESEARCH ARTICLE OPEN ACCESS

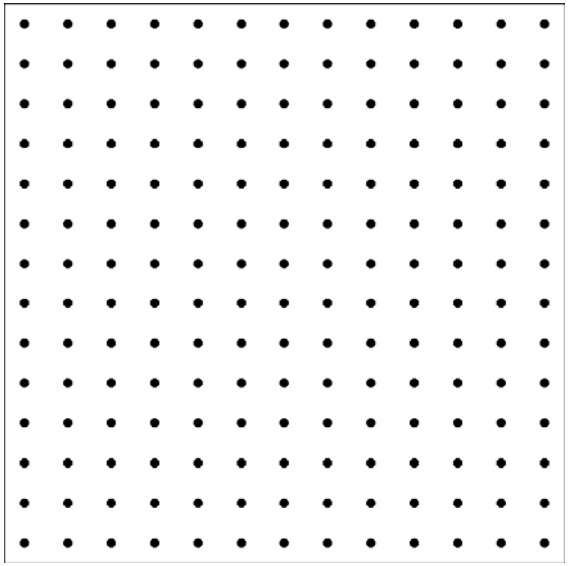
Spatial Clustering of Porcine Cysticercosis in Mbulu District, Northern Tanzania

Helena A. Ngowi[1*], Ayub A. Kassuku[2], Hélène Carabin[3], James E. D. Mlangwa[1], Malongo R. S. Mlozi[4], Boniface P. Mbilinyi[5], Arve L. Willingham III[6]

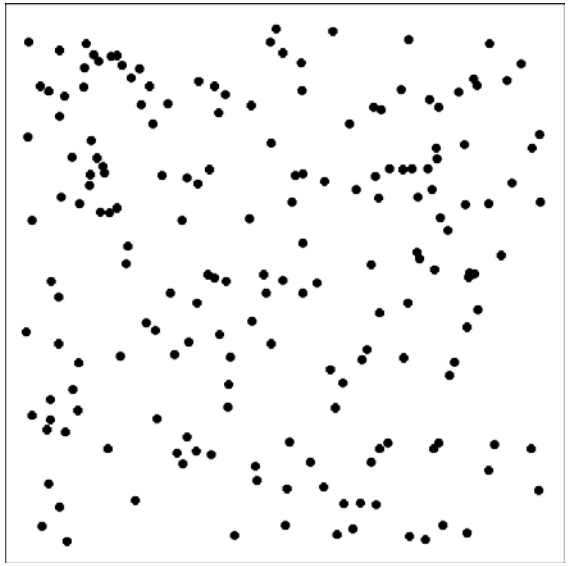
2010 PLoS NEGLECTED TROPICAL DISEASES

Spatial patterns of *T. solium* infections (...) could be used to guide efficient and effective utilization of limited financial and personnel resources through targeting intervention areas. Analysis of spatial point patterns of porcine cysticercosis (...) would be very valuable in this aspect.

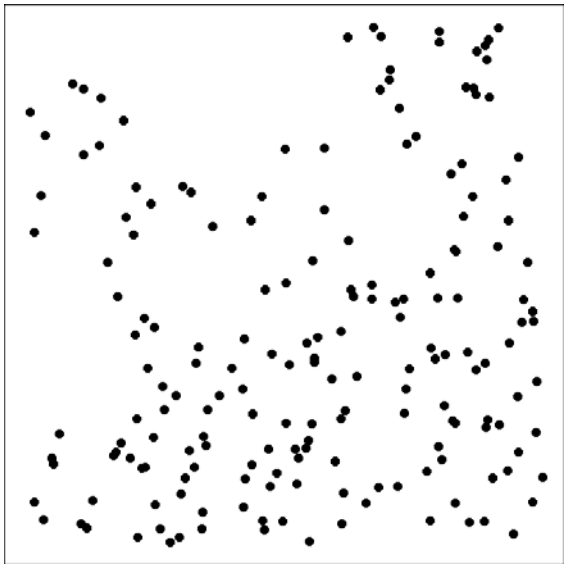
Regular



Random



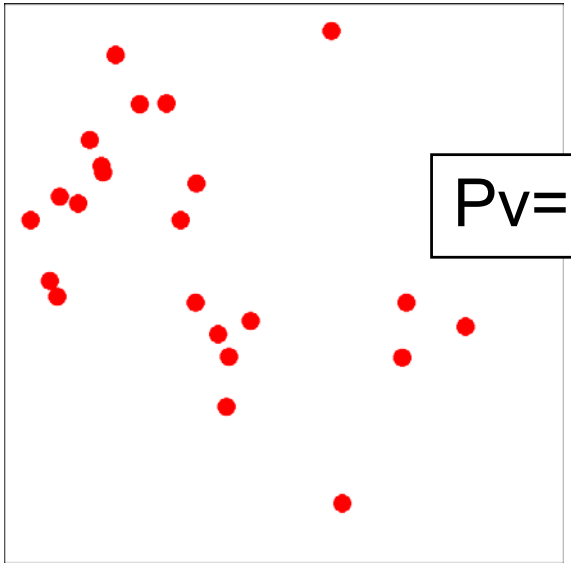
Aggregated
(overdispersed)



SaTScan™

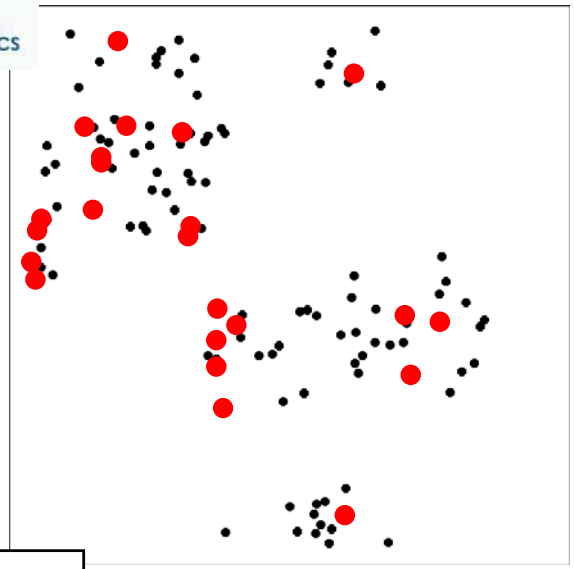
Software for the spatial, temporal, and space-time scan statistics

"clustered" cases

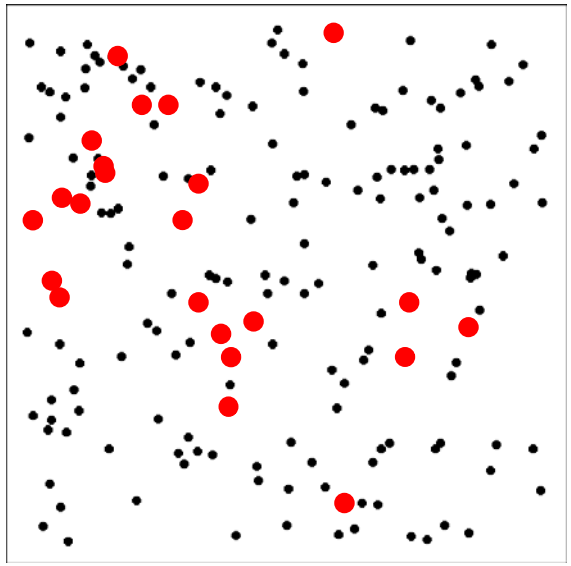


Pv= 10%

clustered population



complete randomness



Stationnary (homogeneous) transmission

```
Total population.............: 117
Total number of cases........:  23
```

MOST LIKELY CLUSTER

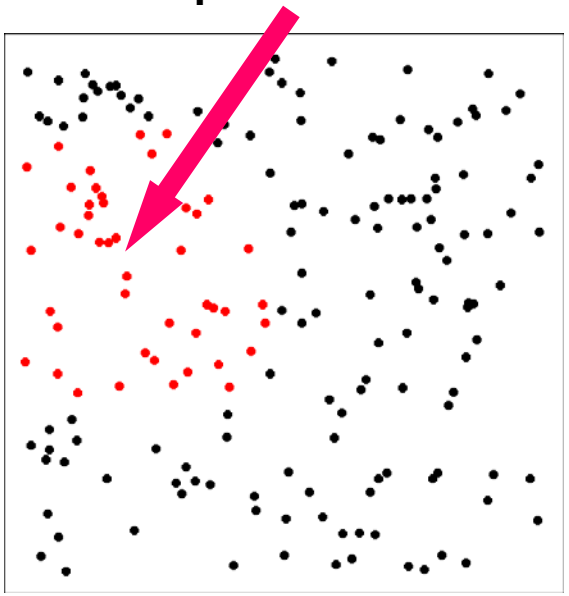
...

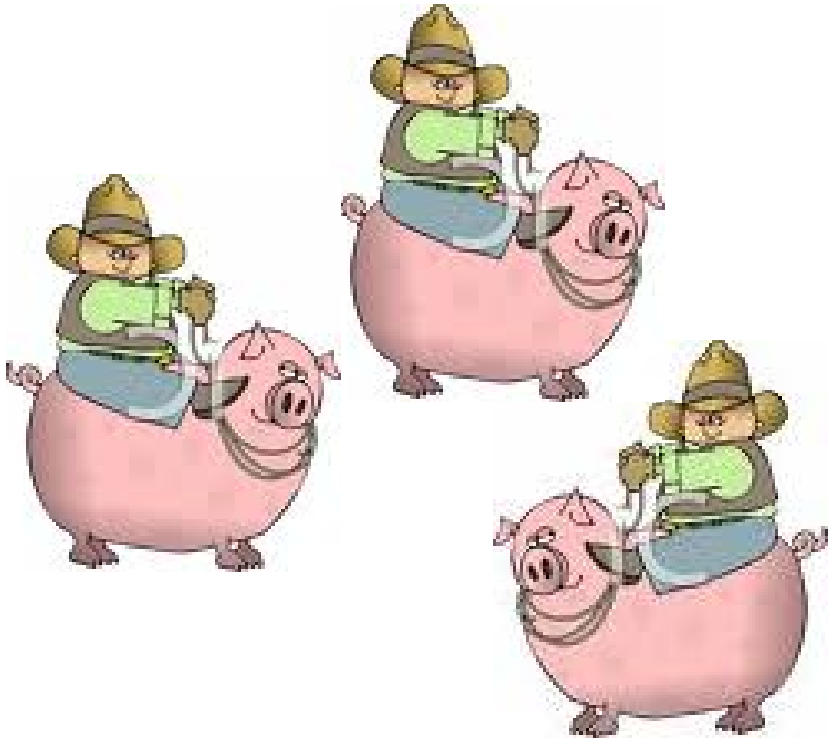
P-value.....: 0.232

Transmission more intensive locally

1 cluster, relative risk = 6.8

p = 0.002





Massive control on widely roaming people/pigs

Stationnary (homogeneous) transmission

```
Total population.............: 117
Total number of cases........:  23
```

MOST LIKELY CLUSTER

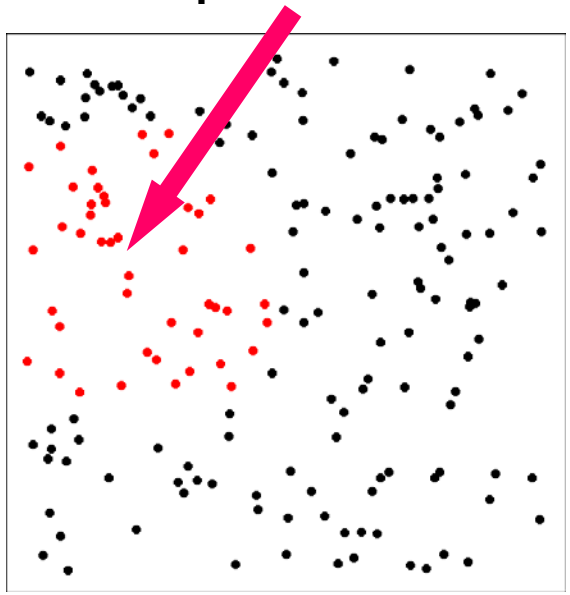
…

P-value.....: 0.232

Transmission more intensive locally

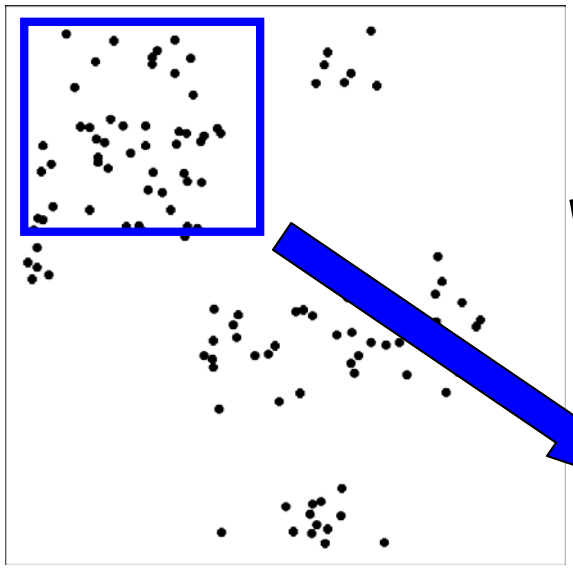
1 cluster, relative risk = 6.8

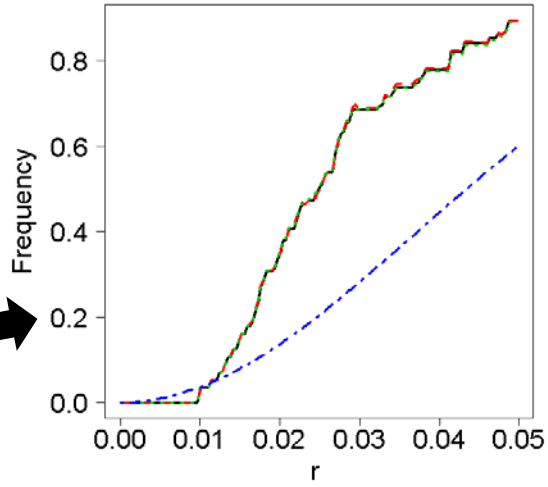
p = 0.002

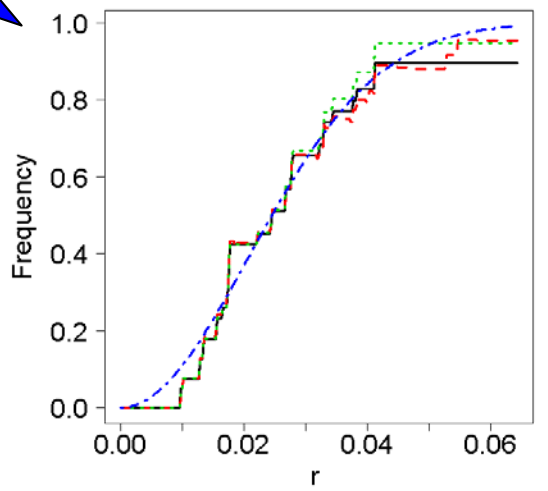


Spatially targeted control on more sedentary people/pigs

Distance to nearest neighbour (G function)



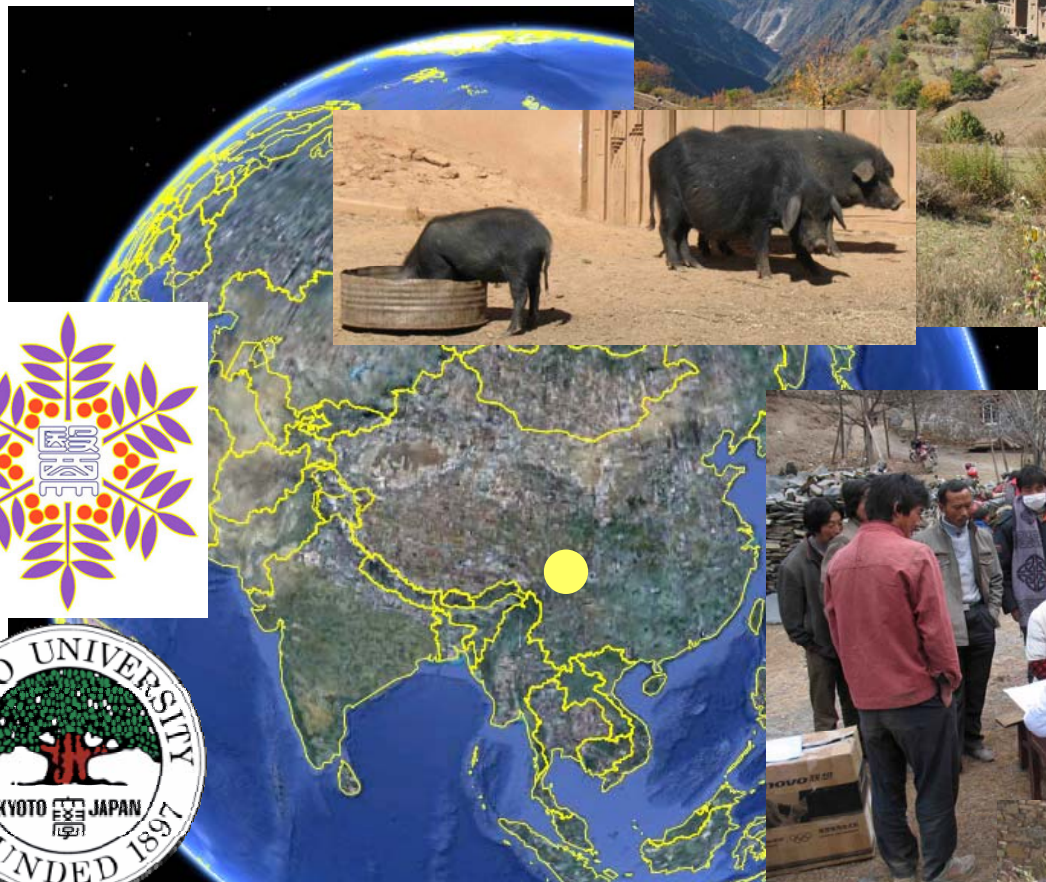


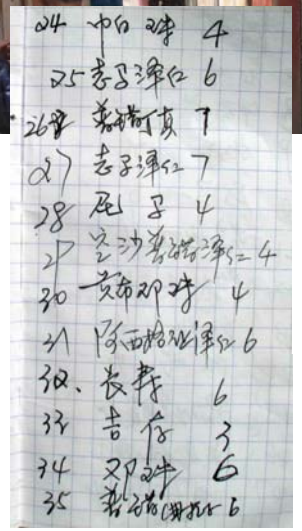


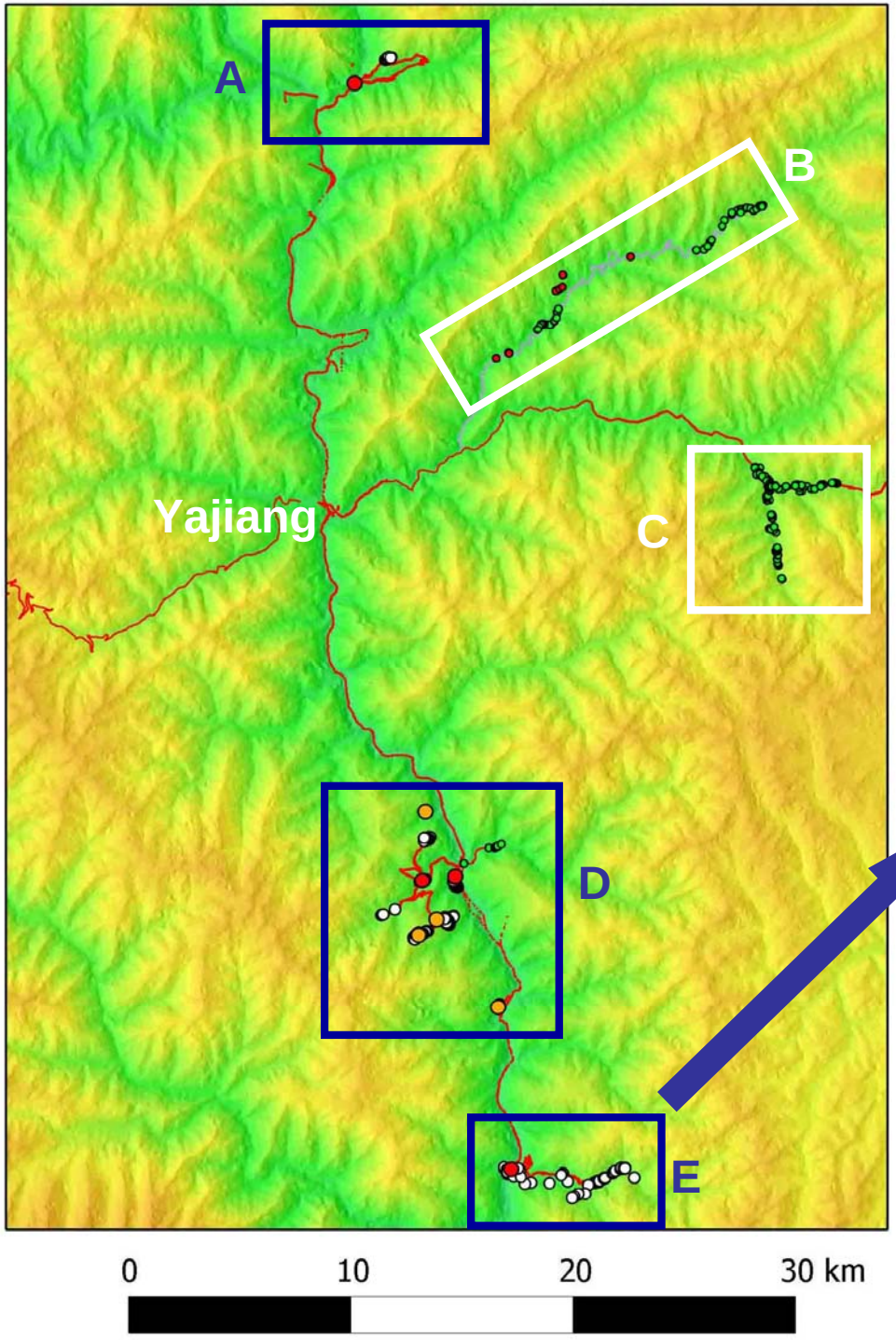
Patterns and processes are scale dependent

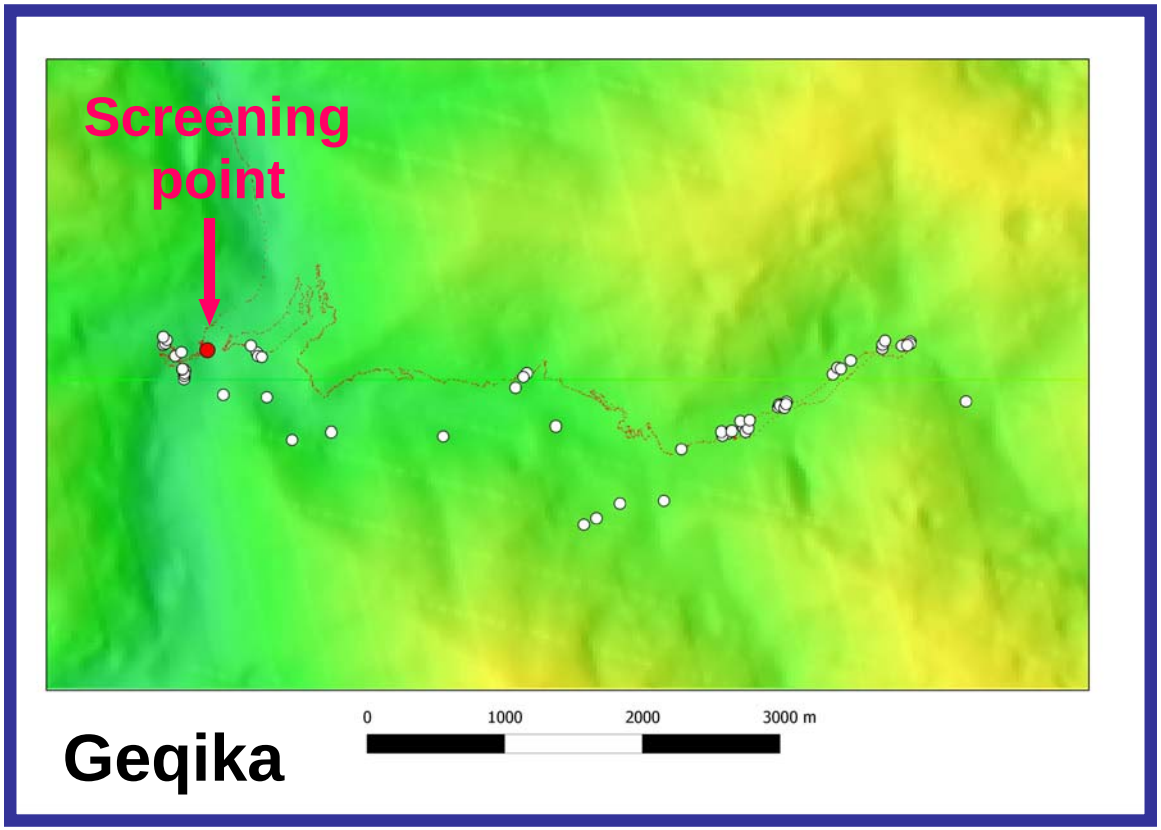
Results from samplings based on administrative boundaries are intrinsiqually scale dependent

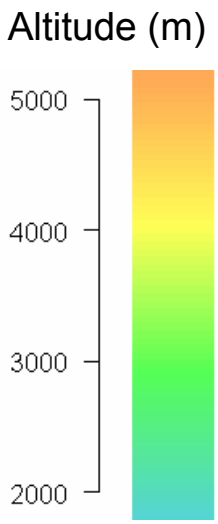
Yajiang cooperative programme 2009-2012











- **Scale #1: Houses clustered in villages or stretching along valleys**
- **Scale #2: Discrete villages scattered in the area**
- **Possible recruitment bias: the closer their house from the screening point the more likely may people be to come ?**

Conclusions

- Spatial methods (GIS, RS, modelling) have been successfully used to understand Em transmission and to help prevention and control interventions

- Such methods have been little considered for other human cestod pathogens, although spatial patterns can potentially provide info on transmission processes at various scales

- A large number of tools and methods are now available to handle spatial data. This may help to guide research and evidence based control of cestod zoonoses.

Thanks for your attention !