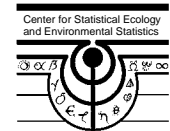




Geographic and Network Surveillance for Arbitrarily Shaped Hotspots

G.P. Patil, R. Acharya, W.L. Myers, P. Patankar, Y. Cai, and S.L. Rathbun
The Penn State University, University Park, PA 16802

R. Modarres
George Washington University, Washington, D.C.



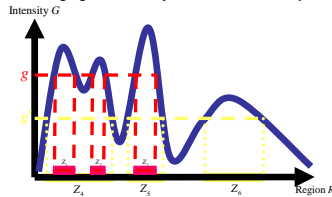
Overview

Surveillance Geoinformatics for Hotspot Detection, Prioritization, Early Warning and Sustainable Management

Upper Level Set Scan System

Definition: A *hotspot* is that portion of the study region with an elevated risk of an adverse outcome

Changing Connectivity of ULS as Level Drops



Features of ULS Scan Statistic:

- Identifies arbitrarily shaped hotspots
- Applicable to data on a network
- Confidence sets and hotspot ratings
- Computationally efficient
- Generalizes to space-time scan

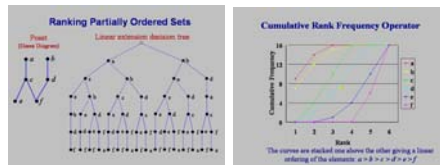
Poset Prioritization System

Objective: Prioritize or rank hotspots based on multiple indicator and stakeholder criteria without having to integrate indicators into an index, using Hasse diagrams and partially ordered sets.

Example: Prioritization of disease clusters with Multiple Indicators

cluster	* SRR	LL	Young Cases	Multiple Cancers	Atypical Demographics	Late Stage of Diagnosis	Rank
LF2	2.69	10.36	2	1	1	1	2
LM4	1.5	36	2	0	0	0	2
LM6	2.04	19.21	2	0	0	0	2
LF7	1.51	15.43	1	1	1	1	1
B2	1.21	31.3	2	1	0	0	2
B4	1.25	28.4	1	0	0	0	0
LM1	2.32	21.81	0	1	0	0	2
LM2	2.13	21.26	1	1	0	0	1
LM7	2.12	13.33	1	0	0	0	2

Admissible linear extensions are comprised of rankings compatible with the rankings of all indicators. Treating each linear extension as a voter, the cumulative rank function is obtained from the frequencies at which each object receives each rank.



Federal Agency Partnerships
CDC DOD EPA NASA NIH NOAA USFS USGS

National Applications and Case Studies

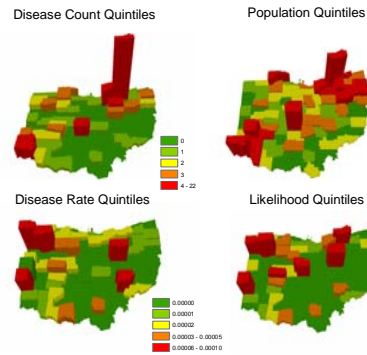
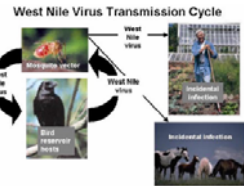
- Biosurveillance
- Carbon Management
- Costal Management
- Community Infrastructure
- Crop Surveillance
- Disaster Management
- Disease Surveillance
- Ecosystem Health
- Environmental Justice
- Sensor Networks
- Robotic Networks
- Environmental Management
- Environmental Policy
- Homeland Security
- Invasive Species
- Poverty Policy
- Public Health
- Public Health and Environment
- Syndromic Surveillance
- Social Networks
- Stream Networks

Geospatial Surveillance

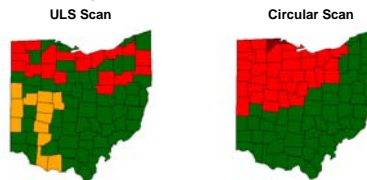
Upper Level Set Scan Statistic System

Example: West Nile Virus

First isolated in 1937, this mosquito born disease, indigenous to north Africa, the Middle East and west Asia was first introduced into the United States in 1999.

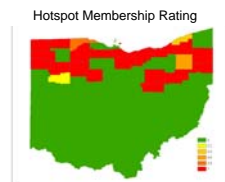


Comparison of ULS Scan with Circular Scan



Method	ULS Scan		Circular Scan
	Hotspot 1 (red)	Hotspot 2 (orange)	Hotspot 1 (red)
log likelihood	17.799	9.312	15.748
p-value	0.001	0.015	0.004
relative risk	3.189	3.391	1.625

Confidence set for ULS Hotspot

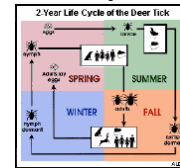


Spatial-Temporal Surveillance

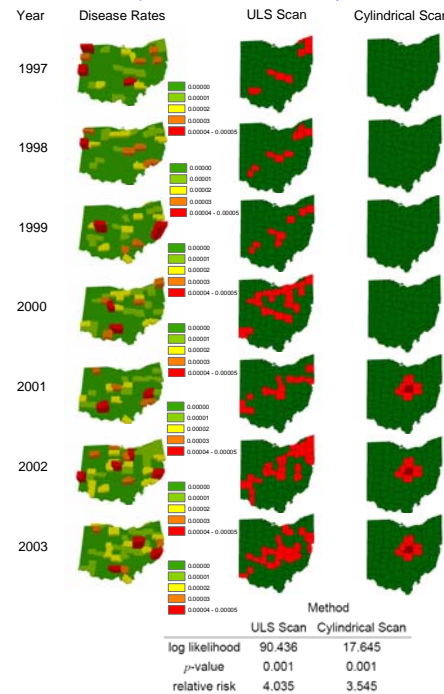
Typology of Space-Time Hotspots

Example: Lyme Disease

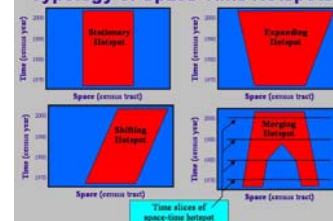
Infections from the bacterium *Borelia burgdorferi* vectored by ticks from the genus *Ixodes*.



Comparison of ULS Scan with Cylindrical Scan



Typology of Space-Time Hotspots



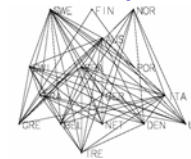
Hotspot Prioritization

Ranking Without Having to Integrate Multiple Indicators

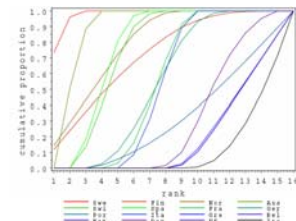
Example: Human-environment indicator values for 16 European countries.

Country	Rank	Land	Air	Water
Sweden	1	69.01	35.24	100
Finland	6	76.46	19.05	98
Norway	3	27.38	63.98	100
Austria	2	40.57	29.85	100
Switzerland	5	30.17	28.10	100
Spain	3	32.63	7.74	100
France	7	28.34	6.50	100
Germany	8	32.56	2.10	100
Portugal	10	34.62	14.29	82
Italy	9	23.35	6.89	100
Greece	14	21.59	3.20	98
Belgium	11	21.84	0.00	100
Netherlands	11	19.43	1.07	100
Denmark	15	9.83	5.04	100
United Kingdom	11	12.64	1.13	100
Ireland	16	9.25	1.99	100

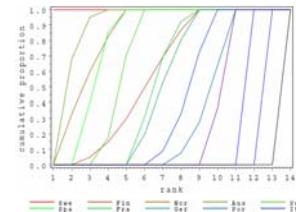
Hasse Diagram



There are a total of 3,764,448 admissible linear extensions. The cumulative rank function for Sweden exceeds that of all remaining countries. The crf's of all countries dominate that of Ireland. The remaining countries cannot be uniquely ordered based on their crf's. Belgium, Netherlands and United Kingdom have identical crf's.



The crf's also form a partially ordered set. There are only 182 admissible linear extensions for this poset, yielding the cumulative rank function:



One more iteration yields the rankings in the data table.