Predicción de reservorios y vectores y sus interacciones usando redes complejas

Chris Stephens
C3 – Centro de Ciencias de la Complejidad y
Instituto de Ciencias Nucleares, UNAM
Simposio Ecología de enfermedades en vida silvestre
IV Congreso Mexicano de Ecologia, UJAT, Villahermosa Marzo 2013

Who are we?

Grupo de sistemas complejos de minería de datos

1.- Dr. Christopher R. Stephens
2.- Biól. Joaquín Giménez Héau
3.- M. en C. Raúl Sierra Alcocer
4.- M. en C. Constantino González Salazar

Grupo del Laboratorio de sistemas de información geográfica del Instituto de Biología de la UNAM.

5.- Dr. Víctor Sánchez-Cordero
6.- Dr. Ángel Rodríguez Moreno
7.- Dr. José Juan Flores Martínez
8.- Dr. Gabriel Granados Gutiérrez
9.- Dra. Camila González Rosas (Universidad de los Andes, Columbia)
10.- Dr. Carlos Napoleón Ibarra Cerdeña (INSP, Tapachula)
11.- Est. Biól. Ruth Areli Gómez Rodríguez
12.- Est. Biól. María Azucena Trinidad Flores

centro de ciencias de la complejidad

Who are we?

Grupo del laboratorio de inmunoparasitología del Departamento de Medicina Experimental de la Facultad de Medicina en la UNAM.

13.- Dra. Ingeborg Becker

14.- Dra. Miriam Berzunza Cruz

15.- QFB. Dulce Jocelyn Bailón Martínez

16.- M. en C. Cristina Cañedo Guzmán

El Centro Regional de Investigación del Instituto Nacional de Salud Pública (Tapachula, Chis.)

17.- Dra. Janine M. Ramsey Willoquet

18.- Dr. Carlos Félix Marina Fernández

19.- Dra. Teresa Ordoñez

20.- Keynes De la Cruz Félix

centro de ciencias de la complejidad

Who are we?

Grupo de Tabasco: División Académica de Ciencias Biológicas. Universidad Juárez Autónoma de Tabasco

21.- Dr. Mircea Gabriel Hidalgo Mihart
22.- Dra. Cristina Domingo Balcells

Grupo de Monterrey: Laboratorio de Entomología médica, Depto. de Zoología de Invertebrados. Facultad de Ciencias Biológicas, Universidad Autónoma de Nuevo León

23.- Dr. Eduardo A. Rebollar Téllez
24.- Estudiante Jorge Jesús Rodrìguez Rosas

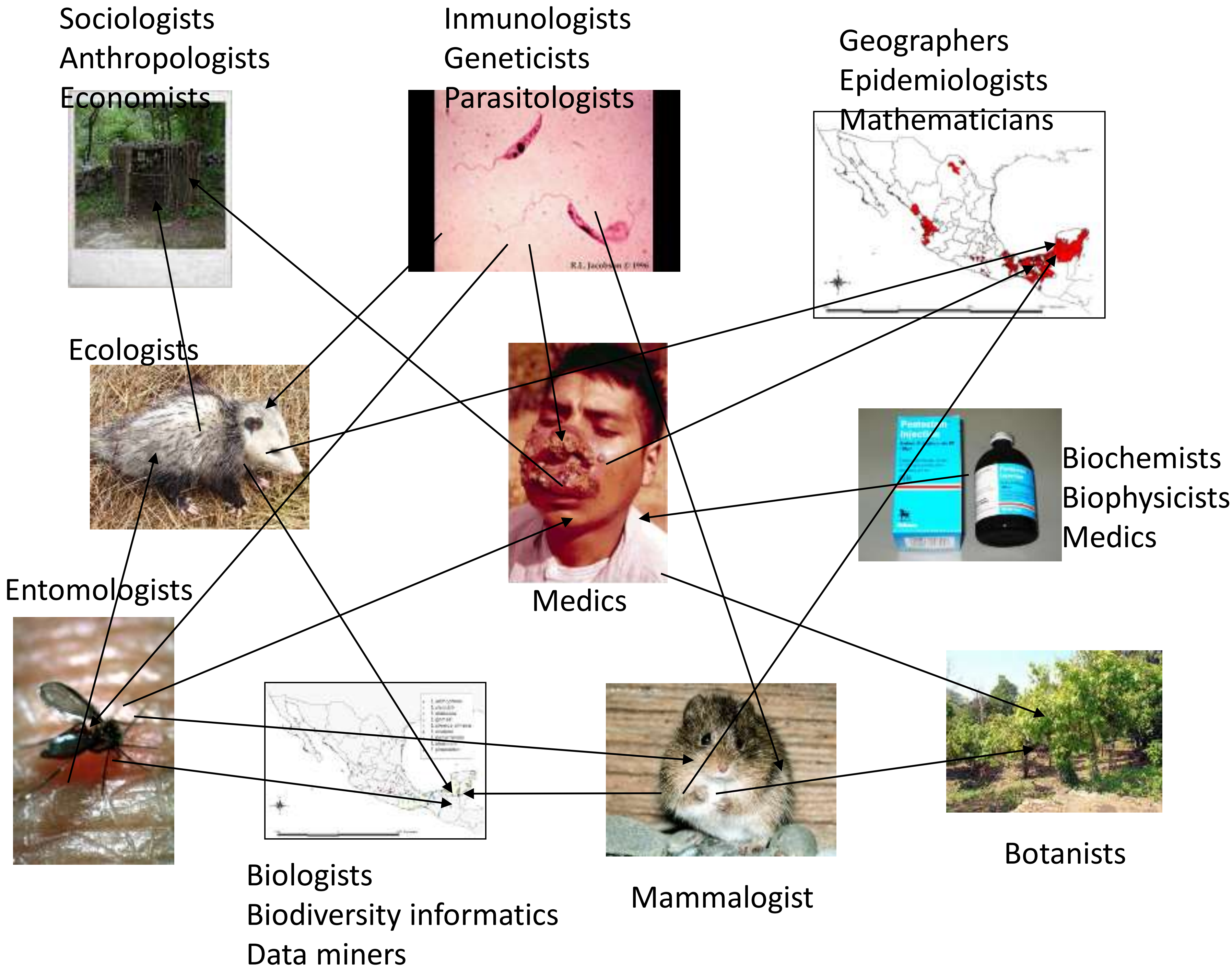
Grupo de Jalisco: Centro Universitario de la Costa Sur. Universidad de Guadalajara.

-
25.- Dr. Luis Ignacio Iñiguez Dávalos
26.- Biól. Pilar Ibarra
27.- Biól. María Magdalena Ramírez Martínez

centro de ciencias de la complejidad

The Complexity of Disease and the Need for Transdisciplinarity

From the micro to the macro and back again


Sociologists
Anthropologists
Economists
Inmunologists
Geneticists
Parasitologists
Geographers
Epidemiologists
Mathematicians
Ecologists
Medics
Biochemists
Biophysicists
Medics
Entomologists
Biologists
Biodiversity informatics
Data miners
Mammalogist
Botanists

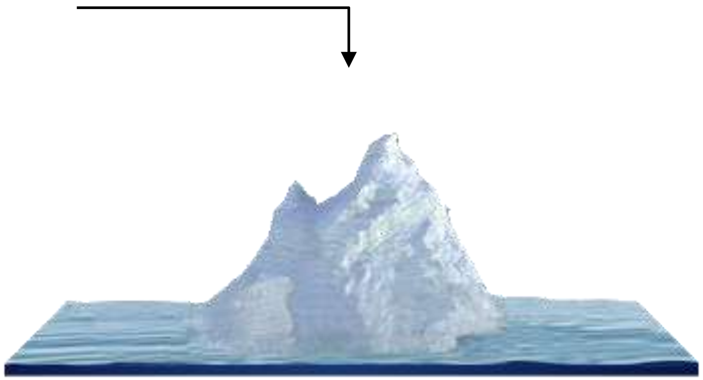
What are our goals?
The Santa Clause list

- Where will diseases emerge or re-emerge – why, when, what can we do about it and how do we know it's working?

- We want to predict, for instance
  - Disease reservoirs and vectors, their interactions and their relative importance
  - Spatio-temporal behaviour of disease and associated risk factors
  - Dispersal characteristics
  - Socio-demographic/economic risk factors
  - Genetic susceptibility (at all levels)

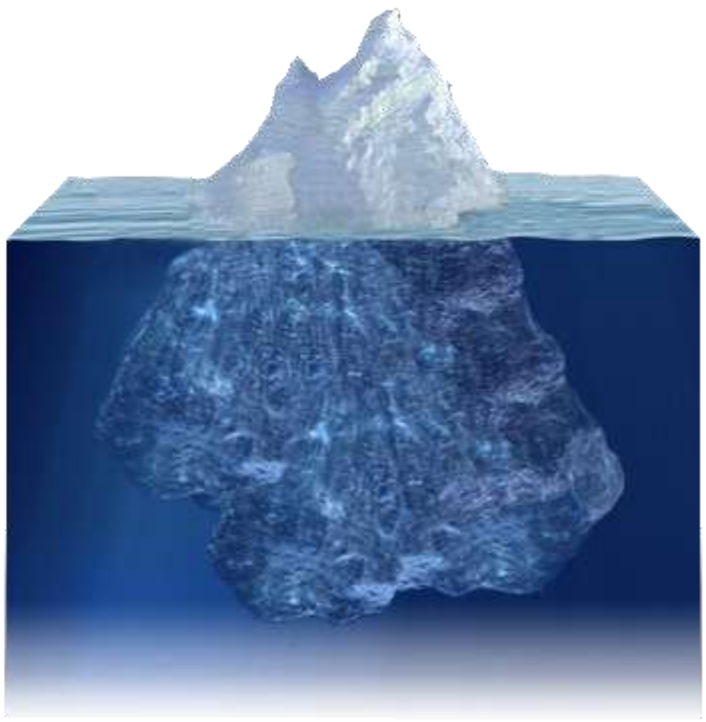
- We want an integrated systems analysis that takes into account the complex nature of disease and we want to understand

Known reservoirs
Known vectors
Known cases
Known risk factors



Known reservoirs
Known vectors
Known cases
Known risk factors

Unknown reservoirs
Unknown vectors
Unknown cases
Unknown risk factors



How do we model what's "under the water"?

Really, what is it?

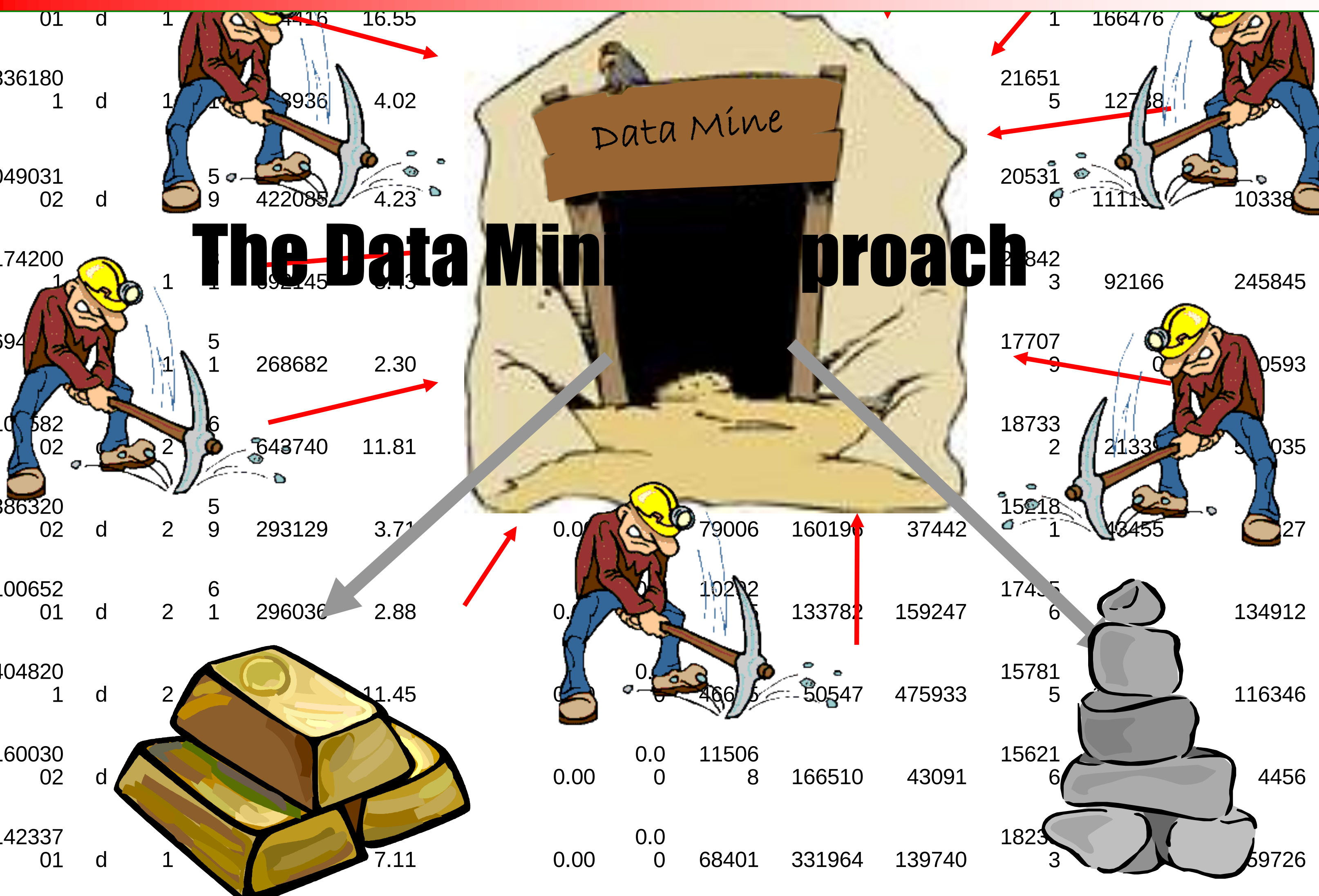
Just good old fashioned modeling, statistical inference, but with a few twists…

Many variables/dimensions and multi-scale

Electronic format, "Unintentional" data

All necessary for modeling complex phenomena

The Data Mini … proach



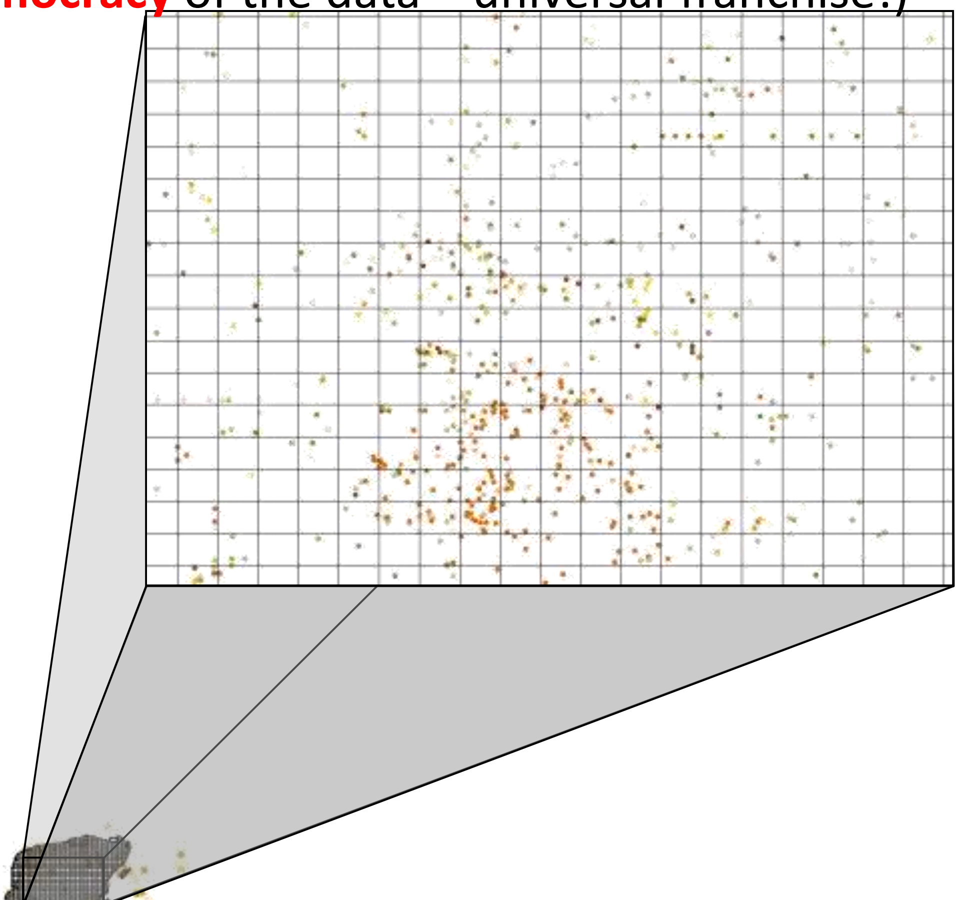
But what are we going to mine…!

centro de ciencias de la complejidad

Anything and everything!

(A **democracy** of the data – universal franchise!)

- Collection data
- Ecological niche data
- Ecological niche model data
- Socio-economic data
- Socio-demographic data
- Phenotypic data
- Vegetable and crop cover
- Geographical data
- Medical and public health data…



The data are represented in space and time – spatial data mining

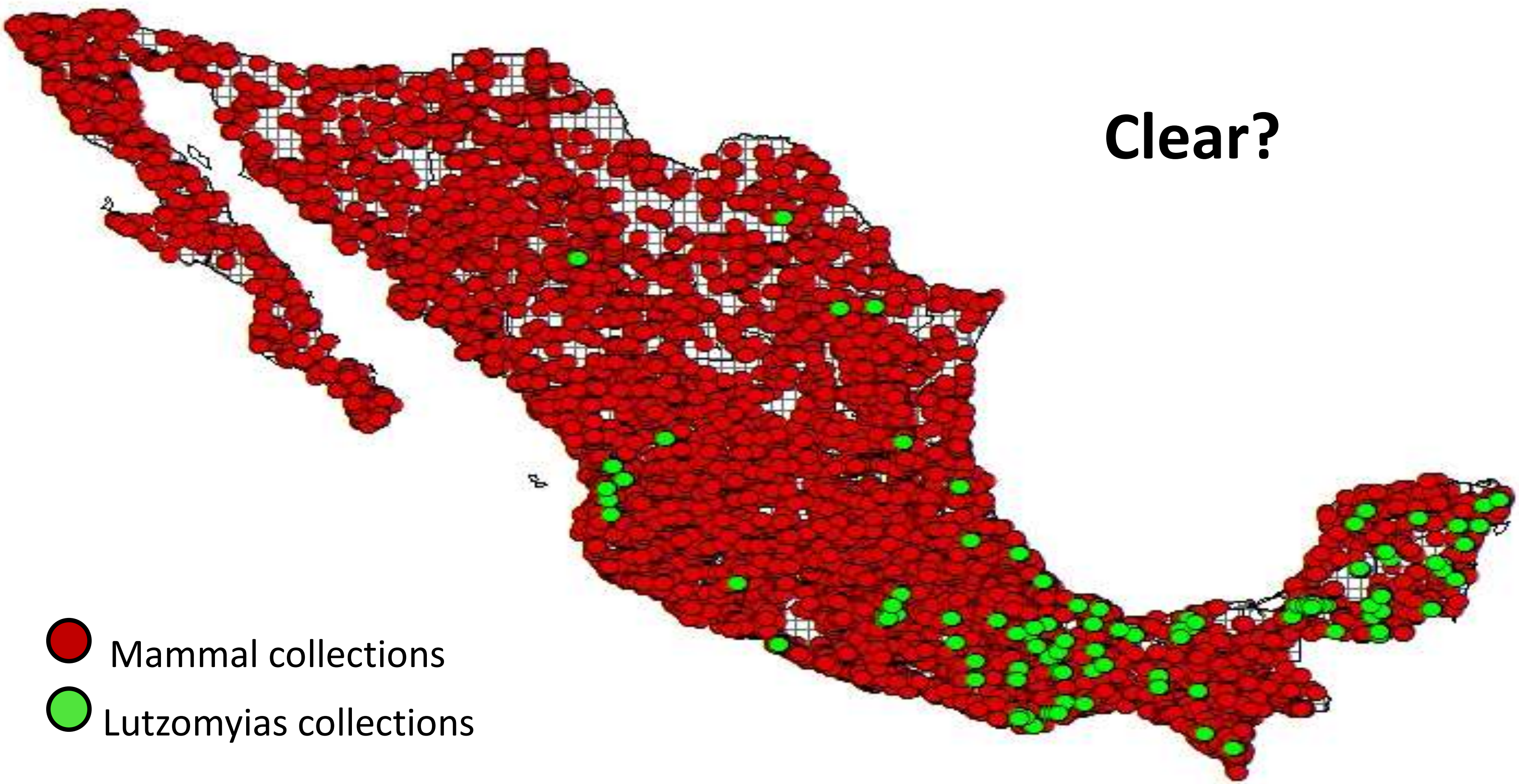
But all data are not created equal…

- Different sources
  - Different location, data base, access,…
- Different data type – categorical, metric
- Different spatial resolution
  - Explicit – e.g., pixel by pixel in environmental layers
  - Implicit – 30,000,000 data points versus 30
    - Quality versus quantity
    - Abiotic versus biotic

Need to avoid the tyranny of the majority and protect minority rights!
Also, we need to be able to compare apples with apples!

- But the real Niche Space of a disease is VERY big!
- Where do we start?
- With the biotic…
- With the “ecological” part, reservoirs and vectors and all that…

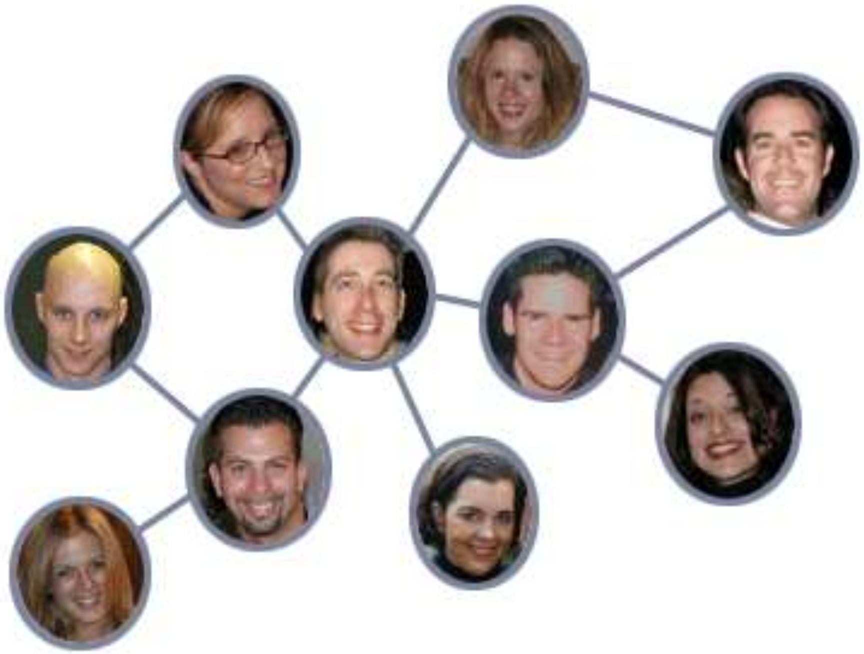
Clear?



You can judge a man

by his “friends”

or his “enemies”, or “parasites”,
or “prey” or “predators” or…



centro de ciencias de la complejidad

Typical Ecological Network

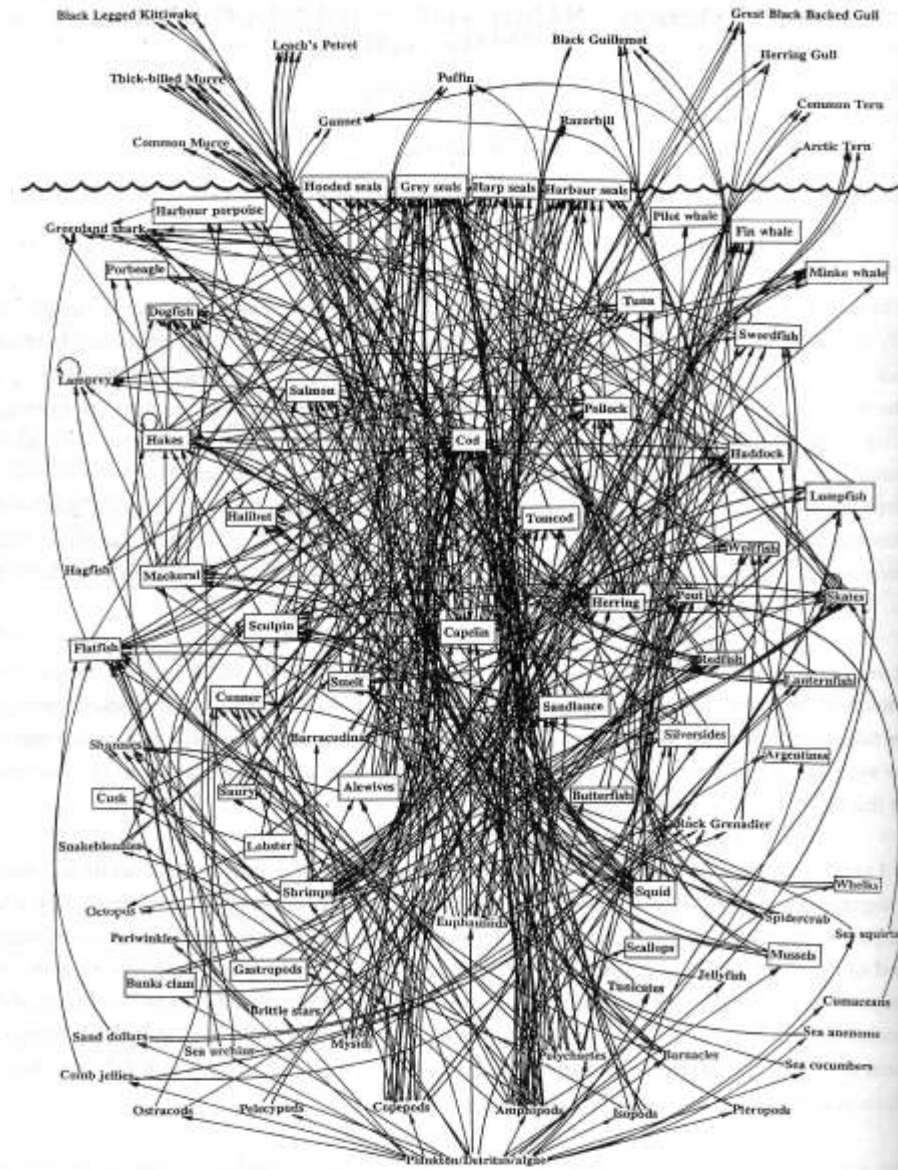
Food web associated with Cod for northwest Atlantic

Author(s):
Prof. David Lavigne

Institution:
Natural Sciences and Engineering Research Council

Visualization of ***known*** interactions at the species level

No spatio-temporal input



Using Networks to Infer Reservoir-Vector Interactions

- Take nodes to be…
  - Species, other taxonomic or phylogenetic groupings, groupings by phenotypic characteristics,
- Take links to be a statistical measure of spatial (temporal) co-occurrence
  - P(Y|X), epsilon(Y|X), P(A,B|C,D), epsilon(Z|X,Y)
  - What is a high/low degree of co-occurrence?
  - What spatial (temporal) resolution? (When do things co-occur?)

No co-occurrences

		a			
			b		a
a					
	b			a	

→

Two co-occurrences

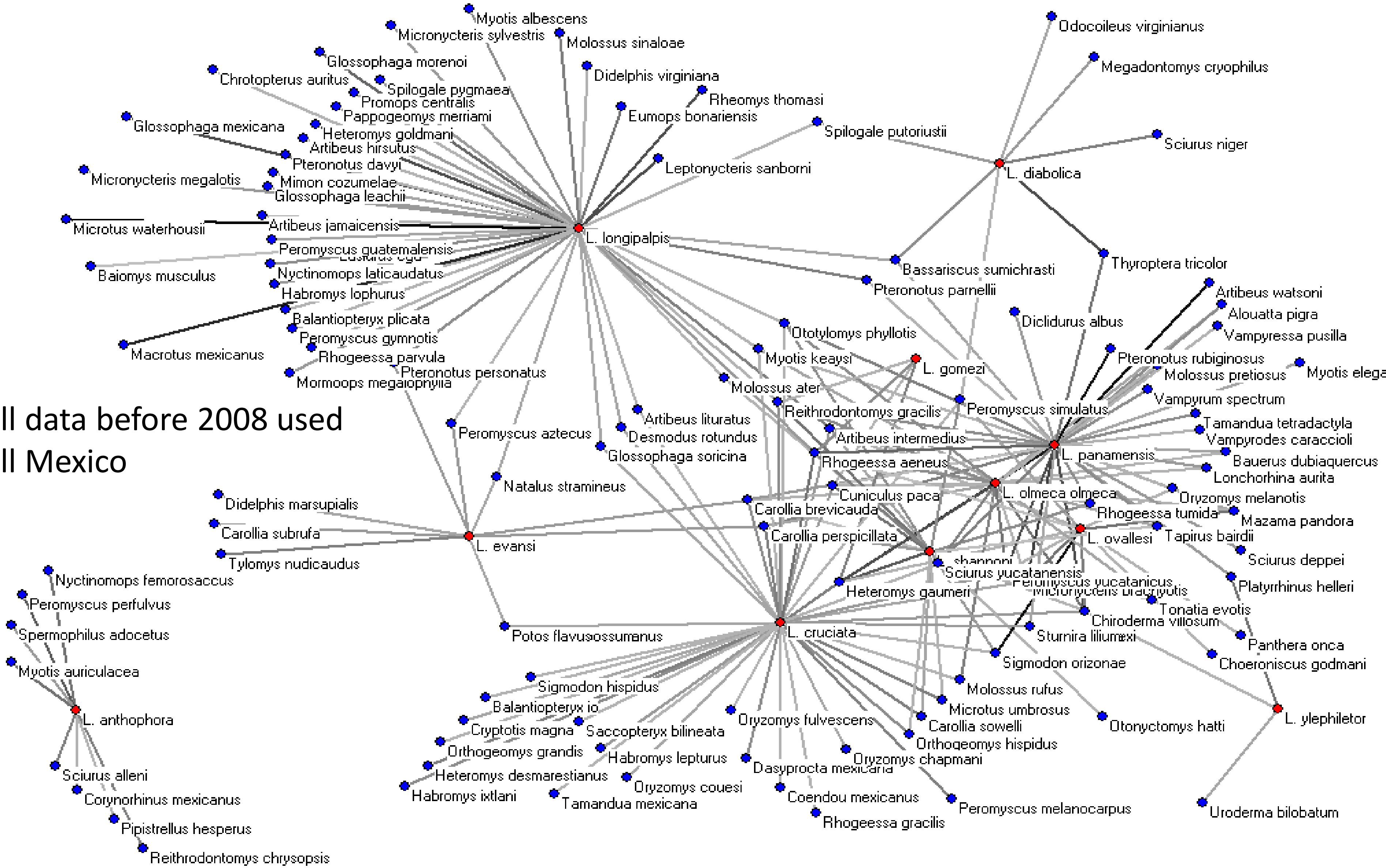
	a b	a
a		
a b		a

→

One co-occurrence

5 a 2b

Who's friends with Lutzomyias?



All data before 2008 used

All Mexico

centro de ciencias de la complejidad

Predicting Reservoirs

The 150 (out of 427) “best friends” of Lutzomyia as a genera.
The model works on known results.

	Mammals	Epsilon	Conf.
1	Eira barbara	10.1683	
2	Rhogeessa aeneus	9.3649	
3	Artibeus intermedius	9.1628	
4	Reithrodontomys gracilis	8.8921	Yes
5	Carollia sowelli	8.8303	
6	Heteromys gaumeri	8.8000	Yes
7	Peromyscus mexicanus	8.7859	
8	Heteromys desmarestianu	8.7164	Yes
9	Molossus rufus	8.6277	
10	Glossophaga soricina	8.5713	
11	Carollia perspicillata	8.5030	
12	Orthogeomys hispidus	8.3468	
13	Pteronotus parnellii	8.1632	
14	Desmodus rotundus	8.1519	
15	Dasyprocta mexicana	8.1128	
16	Sturnira lilium	8.0290	
17	Dermanura phaeotis	8.0055	
18	Dasyprocta punctata	7.9678	
19	Oryzomys couesi	7.7253	
20	Potos flavus	7.7246	
21	Conepatus semistriatus	7.6879	
22	Ototylomys phyllotis	7.5587	Yes
23	Ateles geoffroyi	7.4787	
24	Cryptotis magna	7.4207	
25	Cuniculus paca	7.3220	
26	Lampronycteris brachyotis	7.2852	
27	Sigmodon hispidus	7.2805	Yes
28	Peromyscus yucatanicus	7.2486	Yes
29	Oryzomys chapmani	7.1242	
30	Didelphis virginiana	7.1150	
31	Peromyscus melanocarpu	7.0260	
32	Microtus umbrosus	6.9630	
33	Thyroptera tricolor	6.9630	
34	Nasua narica	6.8953	
35	Megadontomys cryophilus	6.6830	
36	Oryzomys alfaroi	6.6816	
37	Sorex veraepacis	6.6797	
38	Carollia subrufa	6.6316	
39	Peromyscus aztecus	6.6173	
40	Didelphis marsupialis	6.4390	Yes
41	Sciurus yucatanensis	6.3865	
42	Philander opossum	6.2546	
43	Habromys ixtlani	6.1120	
44	Microtus waterhousii	6.1120	
45	Pteronotus rubiginosus	6.1120	
46	Reithrodontomys microdor	6.0967	
47	Coendou mexicanus	6.0268	
48	Centurio senex	6.0076	
49	Artibeus jamaicensis	5.9786	
50	Glossophaga morenoi	5.8847	
51	Molossus sinaloae	5.8518	
52	Artibeus lituratus	5.8422	
53	Mormoops megalophylla	5.8374	
54	Habromys lepturus	5.7848	
55	Myotis keaysi	5.6148	
56	Chiroderma villosum	5.5562	
57	Tamandua mexicana	5.4845	
58	Tylomys nudicaudus	5.4510	
59	Saccopteryx bilineata	5.2984	
60	Macrotus mexicanus	5.2472	
61	Sciurus aureogaster	5.2267	
62	Baiomys musculus	5.2092	
63	Rhogeessa tumida	5.1950	
64	Sciurus deppei	5.1414	
65	Dermanura watsoni	5.1338	
66	Otonyctomys hatti	5.1338	
67	Orthogeomys grandis	5.0556	
68	Alouatta palliata	5.0457	
69	Choeroniscus godmani	5.0457	
70	Peropteryx macrotis	5.0457	
71	Pteronotus personatus	5.0266	
72	Lontra longicaudis	4.9330	
73	Reithrodontomys mexicanu	4.9120	
74	Oryzomys rostratus	4.8681	
75	Mimon cozumelae	4.8327	
76	Pteronotus davyi	4.7943	
77	Herpailurus yagouaroundi	4.7100	
78	Glossophaga leachii	4.6849	
79	Rhogeessa gracilis	4.6317	
80	Sylvilagus brasiliensis	4.6317	
81	Hodomys alleni	4.5155	
82	Leopardus wiedii	4.4420	
83	Peromyscus simulatus	4.4195	
84	Sigmodon alleni	4.3707	
85	Bassariscus sumichrasti	4.3110	
86	Oryzomys fulvescens	4.3110	
87	Diphylla ecaudata	4.3013	
88	Oryzomys melanotis	4.2907	Yes
89	Micronycteris microtis	4.2338	
90	Mazama americana	4.2274	
91	Microtus oaxacensis	4.2061	
92	Rheomys thomasi	4.2061	
93	Oryzomys saturatior	4.2061	
94	Myotis elegans	4.2024	
95	Oligoryzomys fulvescens	4.1984	
96	Natalus stramineus	4.0626	
97	Balantiopteryx io	4.0522	
98	Nyctinomops laticaudatus	4.0522	
99	Tlacuatzin canescens	4.0119	
100	Odocoileus virginianus	3.9265	
101	Balantiopteryx plicata	3.8590	
102	Peromyscus leucopus	3.7994	
103	Sturnina ludovici	3.7888	
104	Enchisthenes hartii	3.6929	
105	Vampyrodes caraccioli	3.6929	
106	Eptesicus furinalis	3.6453	
107	Liomys pictus	3.6107	
108	Glossophaga commissaris	3.4861	
109	Lonchorhina aurita	3.4781	
110	Phyllostomus discolor	3.4781	
111	Peromyscus gymnotis	3.4516	
112	Anoura geoffroyi	3.4201	
113	Platyrrhinus helleri	3.3586	
114	Eumops bonariensis	3.3398	
115	Sciurus variegatoides	3.3398	
116	Uroderma bilobatum	3.3373	
117	Lasiurus intermedius	3.2197	
118	Lasiurus ega	3.1739	
119	Peromyscus megalops	3.1410	
120	Eumops glaucinus	3.0564	
121	Urocyon cinereoargenteus	2.9697	
122	Procyon lotor	2.9502	
123	Hylonycteris underwoodi	2.9343	
124	Rhynchonycteris naso	2.8580	
125	Eptesicus brasiliensis	2.8106	
126	Myotis albescens	2.8106	
127	Lophostoma evotis	2.8106	
128	Tapirus bairdii	2.8106	
129	Vampyrum spectrum	2.8106	
130	Marmosa mexicana	2.7731	Yes
131	Peromyscus furvus	2.7731	
132	Myotis velifera	2.5757	
133	Spilogale putorius	2.5411	
134	Microtus mexicanus	2.5268	
135	Dasypus novemcinctus	2.4725	
136	Myotis nigricans	2.4704	
137	Lophostoma brasiliense	2.4407	
138	Diclidurus albus	2.4407	
139	Sciurus niger	2.4407	
140	Leptonycteris curasoae	2.4268	
141	Nyctomys sumichrasti	2.4026	
142	Sigmodon mascotensis	2.3815	
143	Alouatta pigra	2.3374	
144	Peromyscus melanophrys	2.2204	
145	Dermanura tolteca	2.1920	
146	Trachops cirrhosus	2.1663	
147	Bauerus dubiaquercus	2.1612	
148	Spilogale pygmaea	2.1612	
149	Leptonycteris nivalis	2.1402	
150	Sylvilagus floridanus	2.1002	

But how to test it...? The Emerging Disease production line

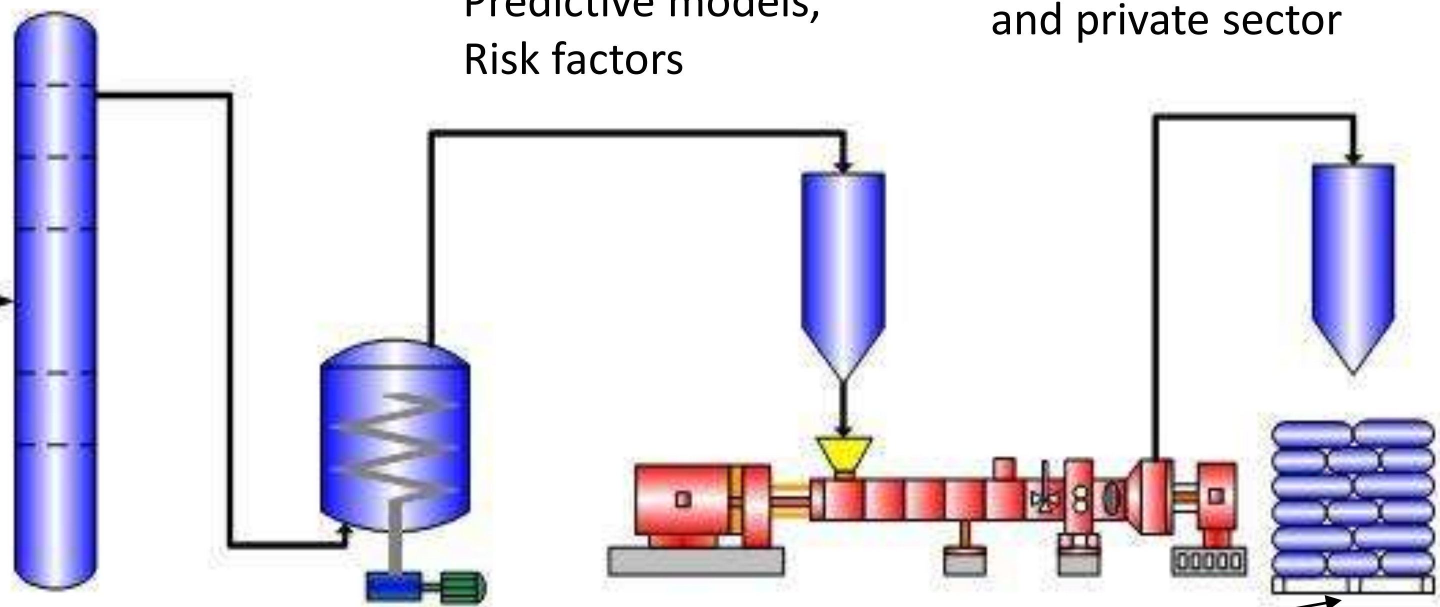
Links to IMSS and INSP

Requires large, well-organized interdisciplinary team

Data Mining:
Predictive models,
Risk factors

Close relationship with public health authorities and private sector

Field work : samples



Five groups distributed throughout Mexico
DF, Chiap., NL, Jal., Tab.

Laboratory analysis

Solutions:
- Decision support systems
- Treatments
- Intelligent software

Over 1200 mammals collected from over 70 species

Two laboratories

PCR tests on samples for different diseases

centro de ciencias
de la complejidad

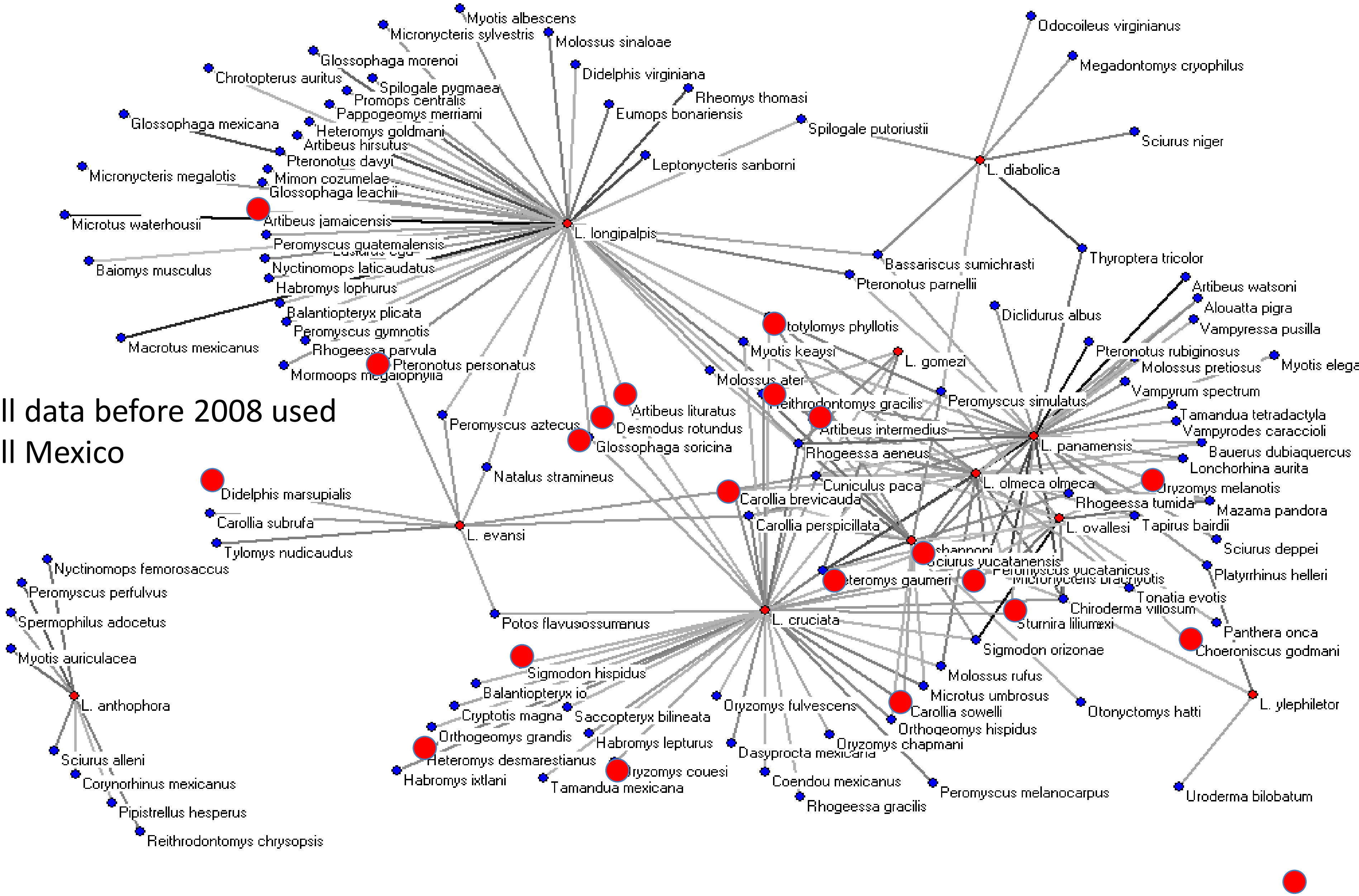
Predicting Reservoirs

	Mammals	Epsilon	Conf.
1	Eira barbara	10.1683	
2	Rhogeessa aeneus	9.3649	
3	Artibeus intermedius	9.1628	
4	Reithrodontomys gracilis	8.8921	Yes
5	Carollia sowelli	8.8303	
6	Heteromys gaumeri	8.8000	Yes
7	Peromyscus mexicanus	8.7859	
8	Heteromys desmarestianu	8.7164	Yes
9	Molossus rufus	8.6277	
10	Glossophaga soricina	8.5713	
11	Carollia perspicillata	8.5030	
12	Orthogeomys hispidus	8.3468	
13	Pteronotus parnellii	8.1632	
14	Desmodus rotundus	8.1519	
15	Dasyprocta mexicana	8.1128	
16	Sturnira lilium	8.0290	
17	Dermanura phaeotis	8.0055	
18	Dasyprocta punctata	7.9678	
19	Oryzomys couesi	7.7253	
20	Potos flavus	7.7246	
21	Conepatus semistriatus	7.6879	
22	Ototylomys phyllotis	7.5587	Yes
23	Ateles geoffroyi	7.4787	
24	Cryptotis magna	7.4207	
25	Cuniculus paca	7.3220	
26	Lampronycteris brachyotis	7.2852	
27	Sigmodon hispidus	7.2805	Yes
28	Peromyscus yucatanicus	7.2486	Yes
29	Oryzomys chapmani	7.1242	
30	Didelphis virginiana	7.1150	
31	Peromyscus melanocarpu	7.0260	
32	Microtus umbrosus	6.9630	
33	Thyroptera tricolor	6.9630	
34	Nasua narica	6.8953	
35	Megadontomys cryophilus	6.6830	
36	Oryzomys alfaroi	6.6816	
37	Sorex veraepacis	6.6797	
38	Carollia subrufa	6.6316	
39	Peromyscus aztecus	6.6173	
40	Didelphis marsupialis	6.4390	Yes
41	Sciurus yucatanensis	6.3865	
42	Philander opossum	6.2546	
43	Habromys ixtlani	6.1120	
44	Microtus waterhousii	6.1120	
45	Pteronotus rubiginosus	6.1120	
46	Reithrodontomys microdor	6.0967	
47	Coendou mexicanus	6.0268	
48	Centurio senex	6.0076	
49	Artibeus jamaicensis	5.9786	
50	Glossophaga morenoi	5.8847	

	Mammals	Epsilon	Conf.
51	Molossus sinaloae	5.8518	
52	Artibeus lituratus	5.8422	
53	Mormoops megalophylla	5.8374	
54	Habromys lepturus	5.7848	
55	Myotis keaysi	5.6148	
56	Chiroderma villosum	5.5562	
57	Tamandua mexicana	5.4845	
58	Tylomys nudicaudus	5.4510	
59	Saccopteryx bilineata	5.2984	
60	Macrotus mexicanus	5.2472	
61	Sciurus aureogaster	5.2267	
62	Baiomys musculus	5.2092	
63	Rhogeessa tumida	5.1950	
64	Sciurus deppei	5.1414	
65	Dermanura watsoni	5.1338	
66	Otonyctomys hatti	5.1338	
67	Orthogeomys grandis	5.0556	
68	Alouatta palliata	5.0457	
69	Choeroniscus godmani	5.0457	
70	Peropteryx macrotis	5.0457	
71	Pteronotus personatus	5.0266	
72	Lontra longicaudis	4.9330	
73	Reithrodontomys mexicanu	4.9120	
74	Oryzomys rostratus	4.8681	
75	Mimon cozumelae	4.8327	
76	Pteronotus davyi	4.7943	
77	Herpailurus yagouaroundi	4.7100	
78	Glossophaga leachii	4.6849	
79	Rhogeessa gracilis	4.6317	
80	Sylvilagus brasiliensis	4.6317	
81	Hodomys alleni	4.5155	
82	Leopardus wiedii	4.4420	
83	Peromyscus simulatus	4.4195	
84	Sigmodon alleni	4.3707	
85	Bassariscus sumichrasti	4.3110	
86	Oryzomys fulvescens	4.3110	
87	Diphylla ecaudata	4.3013	
88	Oryzomys melanotis	4.2907	Yes
89	Micronycteris microtis	4.2338	
90	Mazama americana	4.2274	
91	Microtus oaxacensis	4.2061	
92	Rheomys thomasi	4.2061	
93	Oryzomys saturatior	4.2061	
94	Myotis elegans	4.2024	
95	Oligoryzomys fulvescens	4.1984	
96	Natalus stramineus	4.0626	
97	Balantiopteryx io	4.0522	
98	Nyctinomops laticaudatus	4.0522	
99	Tlacuatzin canescens	4.0119	
100	Odocoileus virginianus	3.9265	

	Mammals	Epsilon	Conf.
101	Balantiopteryx plicata	3.8590	
102	Peromyscus leucopus	3.7994	
103	Sturnina ludovici	3.7888	
104	Enchisthenes hartii	3.6929	
105	Vampyrodes caraccioli	3.6929	
106	Eptesicus furinalis	3.6453	
107	Liomys pictus	3.6107	
108	Glossophaga commissaris	3.4861	
109	Lonchorhina aurita	3.4781	
110	Phyllostomus discolor	3.4781	
111	Peromyscus gymnotis	3.4516	
112	Anoura geoffroyi	3.4201	
113	Platyrrhinus helleri	3.3586	
114	Eumops bonariensis	3.3398	
115	Sciurus variegatoides	3.3398	
116	Uroderma bilobatum	3.3373	
117	Lasiurus intermedius	3.2197	
118	Lasiurus ega	3.1739	
119	Peromyscus megalops	3.1410	
120	Eumops glaucinus	3.0564	
121	Urocyon cinereoargenteus	2.9697	
122	Procyon lotor	2.9502	
123	Hylonycteris underwoodi	2.9343	
124	Rhynchonycteris naso	2.8580	
125	Eptesicus brasiliensis	2.8106	
126	Myotis albescens	2.8106	
127	Lophostoma evotis	2.8106	
128	Tapirus bairdii	2.8106	
129	Vampyrum spectrum	2.8106	
130	Marmosa mexicana	2.7731	Yes
131	Peromyscus furvus	2.7731	
132	Myotis velifera	2.5757	
133	Spilogale putorius	2.5411	
134	Microtus mexicanus	2.5268	
135	Dasypus novemcinctus	2.4725	
136	Myotis nigricans	2.4704	
137	Lophostoma brasiliense	2.4407	
138	Diclidurus albus	2.4407	
139	Sciurus niger	2.4407	
140	Leptonycteris curasoae	2.4268	
141	Nyctomys sumichrasti	2.4026	
142	Sigmodon mascotensis	2.3815	
143	Alouatta pigra	2.3374	
144	Peromyscus melanophrys	2.2204	
145	Dermanura tolteca	2.1920	
146	Trachops cirrhosus	2.1663	
147	Bauerus dubiaquercus	2.1612	
148	Spilogale pygmaea	2.1612	
149	Leptonycteris nivalis	2.1402	
150	Sylvilagus floridanus	2.1002	

centro de ciencias de la complejidad



All data before 2008 used

All Mexico

Modelling Works!

- Predicted and confirmed 20 new species of mammal as carriers of Leishmania in Mexico
- 12 of them are bats, identified for the first time in Mexico
- Squirrels identified as carriers
- Changes the picture for control of Leishmania totally; Leishmania and Lutzomyias are eclectic in their host source. Linnean classification is NOT ecologically relevant
- So we can see that the biotic (mammals/food)part of the Niche Space for Leishmaniasis is important. What about other factors?
  - Abiotic – Worldclim
  - Vegetation/landcover

centro de ciencias
de la complejidad

Modelling the Niche Space of Leishmaniasis (well, Lutzomyias really)

TOP DECILE
Optimal niche conditions for *Lutzomyia*

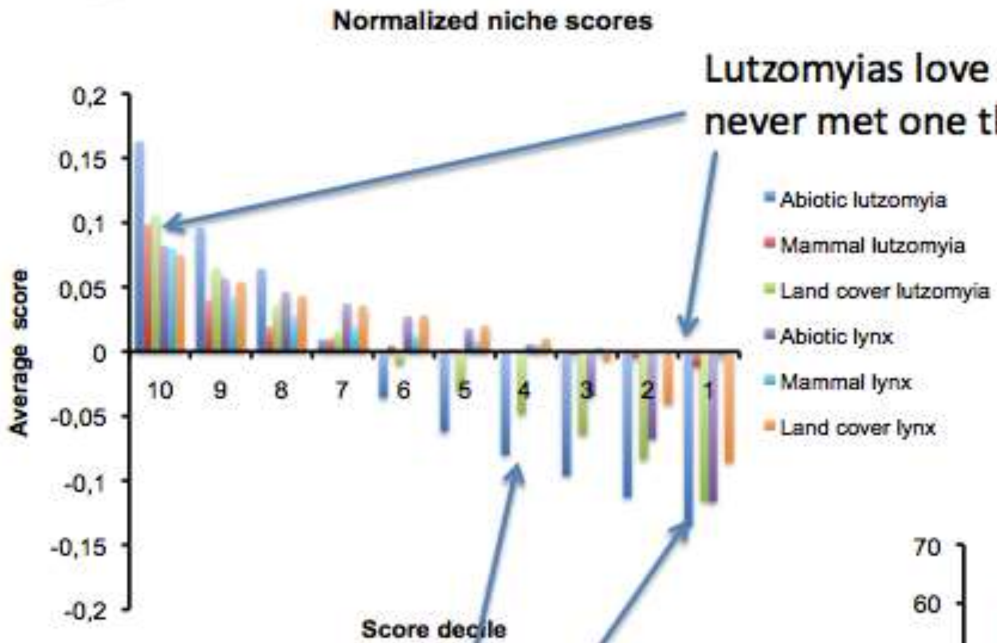
ABIOTIC VARIABLES	RANGE	Epsilon	Score contribution
BIO17	88-219	8.960	5.013
BIO1	23.3-26.4	8.938	1.006
BIO11	22.2-25.3	8.873	2.322
BIO14	26-63	8.782	4.916
BIO4	25.35-33.09	7.543	2.152
BIO6	13.4-16.6	7.524	3.293
BIO13	392-774	7.107	12.913
BIO7	28.5-30.6	7.012	3.803
BIO16	1019-2019	6.925	12.175
BIO19	192-383	6.618	4.157
BIO12	1906-3302	6.314	8.701
BIO2	9.8-10.8	6.130	4.458
BIO18	623-746	5.748	1.260
RESERVOIRS			
Reithrodontomys gracilis		8.892	2.640
Heteromys gaumeri		8.800	2.234
Heteromys desmarestianus		8.716	2.381
Ototylomys phyllotis		7.559	2.028
Peromyscus yucatanicus		7.249	2.116
Sigmodon hispidus		6.946	1.244
Didelphis marsupialis		5.774	1.662
Oryzomys melanotis		3.494	1.387
Marmosa mexicana		2.773	1.541
LAND COVER			
Cloud forest		6.642	1.408
Tropical evergreen forest		6.603	4.476
Cloud forest with secondary vegetation		6.028	1.459
Tropical evergreen forest with secondary vegetation		6.007	4.344
Agriculture areas		5.966	1.736
Human settlement		4.947	0.577
Deciduous tropical forest with secondary vegetation		4.081	1.013

BOTTOM DECILE
Suboptimal niche conditions for *Lutzomyia*

ABIOTIC VARIABLES	RANGE	Epsilon	Score contribut
BIO12	42-507	-5.604	-2.279
BIO16	18-218	-5.001	-2.328
BIO18	1-249	-3.839	-3.799
BIO6	3.1-3.4	-3.761	-2.931
BIO7	26.3-28.4	-3.544	-8.853
BIO2	16.5-18.4	-3.535	-2.997
BIO11	2.9-12.5	-3.271	-4.482
BIO4	3310-7184	-2.971	-9.551
BIO19	192-383	-2.940	-0.448
BIO10	28.9-32.3	-2.669	-0.916
BIO1	10.3-19.9	-2.189	-1.033
BIO3	3.7-5.5	-2.130	-3.576
BIO8	28.4-31.7	-1.964	-0.731
RESERVOIRS			
Sigmodon hispidus		6.946	1.244
LAND COVER			
Subtropical scrub		-1.675	-1.527
Subtropical scrub with secondary vegetation		-1.849	-1.658
Xeric scrub with secondary vegetation		-2.092	-3.640
Xeric scrub		-2.924	-4.044
Mesquite		-3.337	-1.714
Grassland		-3.734	-1.874
Mangroves		-4.063	-2.000

Modelling the Niche Space of Leishmaniasis (well, Lutzomyias really)

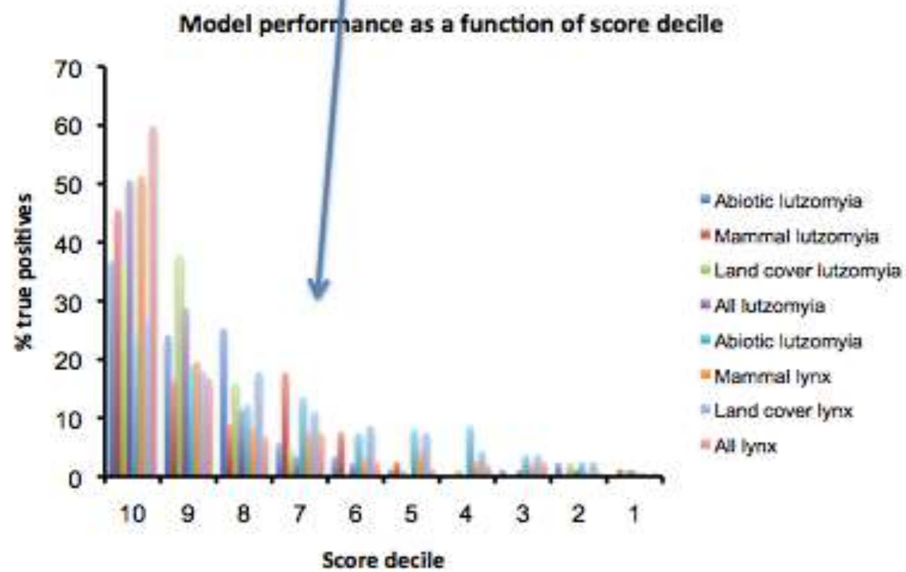
centro de ciencias de la complejidad



Lutzomyias love mammals, never met one they didn't like

Including in a fuller, richer Niche Space leads to more predictive models (less false positives/negatives)

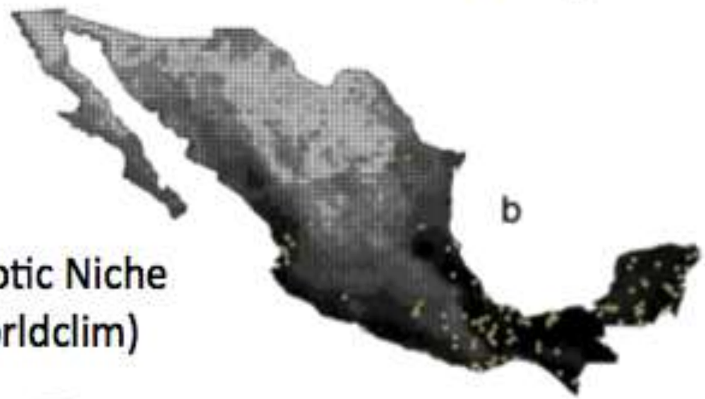
Climatic factors are more important for determining where Lutzomyias aren't rather than where they are



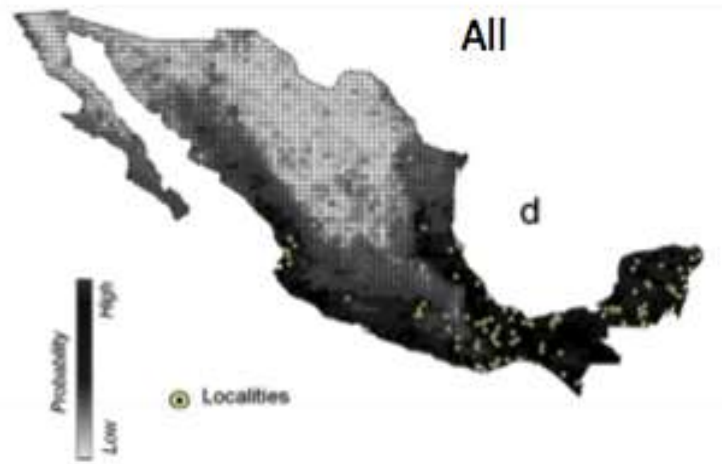
Lutzomyia Risk Maps from Different Niche models

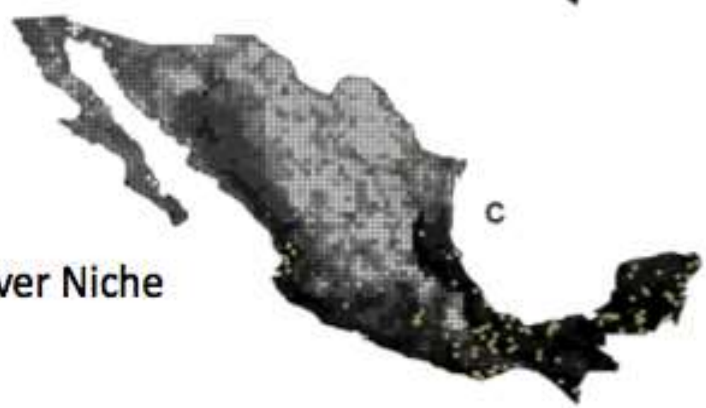
Biotic Niche
(Mammals)

Relatively higher probability to find Lutzomyias in the north of Mexico from the biotic model than the abiotic one. Are Lutzomyias more common in the north of Mexico than previous data or models would suggest?



Abiotic Niche
(Worldclim)





Landcover Niche

Results: 51 individuals from 5 sites in Nuevo Leon collected from 10 species of Lutzomyia. Also positive resultads from Tamaulipas.

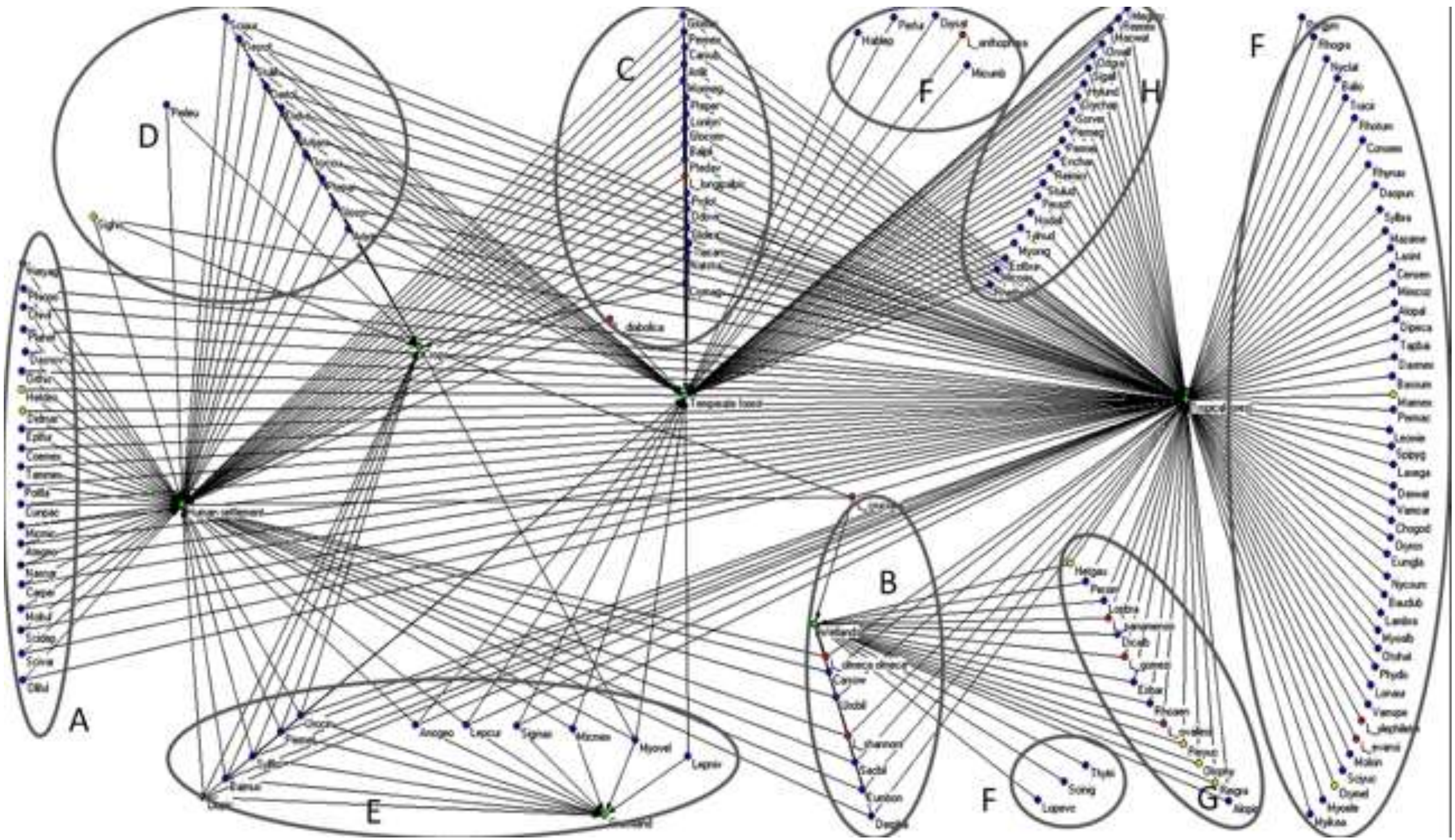
centro de ciencias de la complejidad

Lutzomyia Risk Maps from Mammals and Landcover

Biased Lutzomyia collections. Our modeling indicated that there were potential biases.

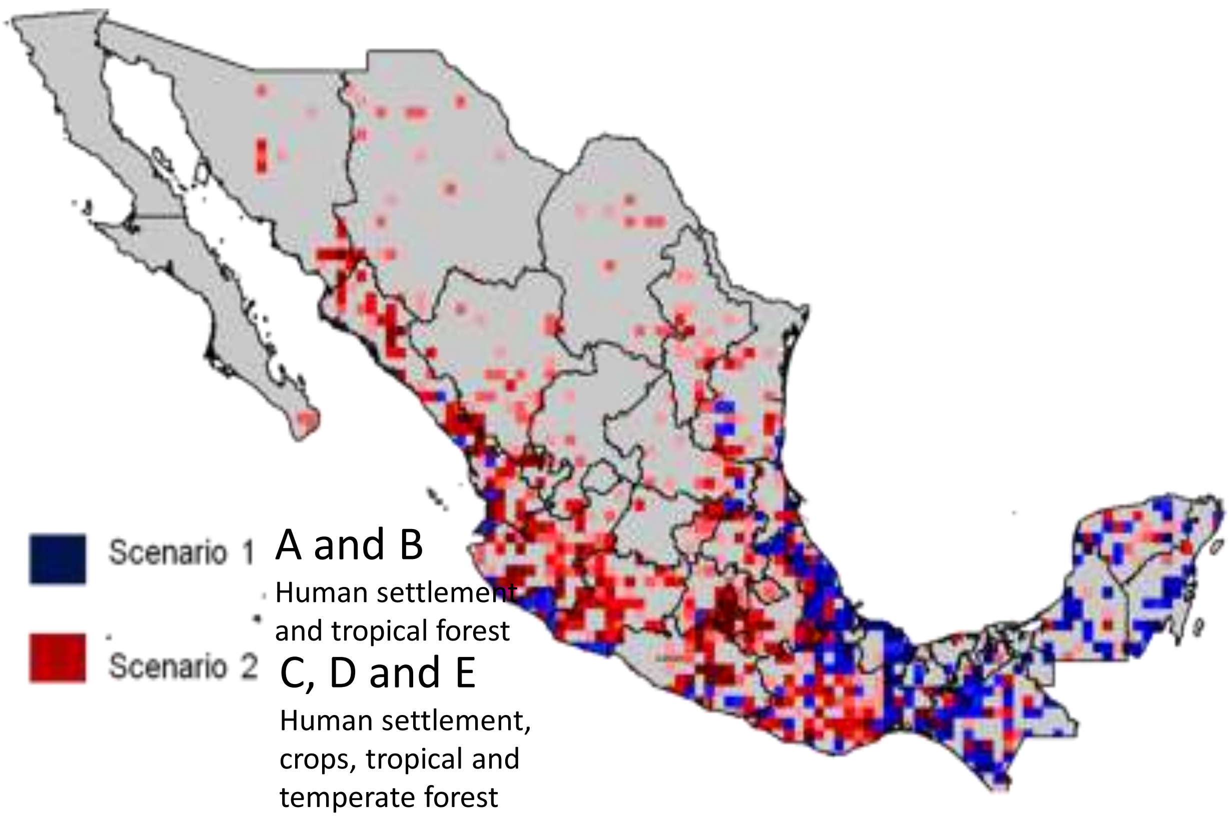
centro de ciencias
de la complejidad

Making the Network more complex: Potential patterns of dispersal



centro de ciencias de la complejidad

Generating dispersal scenarios



centro de ciencias de la complejidad

Conclusions

- Emerging zoonoses are complex SYSTEMS
  - They are also composed of complex SUB-SYSTEMS
  - Many variables are relevant and the micro and the macro are intimately related
  - Their study requires potentially large, interdisciplinary teams
- We CANNOT do "science" (separate, controlled experiments) to determine the effect of every variable (No PV=RT)
- The world is awash with data
  - Much of this data can be used to (indirectly) infer interactions/relationships/risk factors
  - E.g. Predicting the distribution of Lutzomyia, a model with about 500 variables, using point collection data
  - Inference networks are a great way of understanding and visualising potential biotic/abiotic/other interactions
- Modeling at a true systems level IS possible
  - Difference between prediction and understanding
  - Correlation versus causation

centro de ciencias de la complejidad

Publications

1.- Argueta A.L., Valle J, Marina C.F. 2010. Efectos ovicida y larvicida del spinosad en Aedes aegypti (Diptera: Culicidae). Revista Colombiana de Entomología (en revisión).

2.- Miriam Berzunza-Cruz, Guadalupe Bricaire, Norma Salaiza Suazo, Ruy Pérez-Montfort, Ingeborg Becker. 2009. PCR for identification of species causing American cutaneous leishmaniasis. Parasitol Res. 104(3):691-9.

3.- Delgado-Domínguez, J., González-Aguilar, H., Aguirre-García, M., Gutiérrez-Kobeh, L., Berzunza-Cruz, M., Ruiz-Remigio, A., Robles-Flores, M., Becker, I. 2010. Leishmania mexicana lipophosphoglycan (LPG) differentially regulates PKCa-induced oxidative burst in macrophages of BALB/c and C57BL/6 mice. Parasite Immunology, 32, 440-449.

4.- Escalona-Montaño, A. R., Pardavé-Alejandre, D., Cervantes-Sarabia, R., García-López, P., Gutiérrez-Quiroz, M, Gutiérrez-Kobeh, L., Becker-Fauser, I., Aguirre-García, M. 2010. Leishmania mexicana promastigotes secrete a protein tyrosine phosphatase. Parasitol Res. 107:309-315.

5.- Fernández-Presas, A.M, Tato, P, Becker, I, Solano, S, Kopitin, N, Berzunza, M, Willms K, Hernández J, Molinari J.L. Specific antibodies induce apoptosis in Trypanosoma cruzi epimastigotes. Parasitol Res. 2010 May;106:1327-37.

6.- González C., Wang O.,Strutz, S.E., González.Salazar, C., Sánchez-Cordero, V., Sarkar,S. (2010). Climate change and risk of Leishmaniasis in North America: Predictions from Ecological Niche Models of Vector and Reservoir Species, PLoS Negl Trop Dis. 4(1):e585.

7.- Hérnández, J. L, Rebollar-Téllez, E. A, Infante, F. Morón, A., Castillo, A. 2020. Indicadores de Infestación, Colonización e Infección de Triatoma dimidiata (Latreille) (Hemiptera: Reduviidae) en Campeche, México. Neotropical Entomology 39(6):1024-1031

8.- Ibañez-Bernal, S., May-Uc, E. & Rebollar-Téllez, E. A. 2010. Two new species of phlebotomine sand flies from Quintana Roo, Mexico (Diptera: Psychodidae, Phlebotominae). Zootaxa, 2448: 26-34.

9.- Ibarra-Cerdeña, C., V. Sánchez-Cordero, A. Townsed and J. Ramsey. 2009. Ecology of North American Triatominae. Acta Tropica. Vol. 110. Issues 2-3.

10.- López-Ordoñez, T.F. Panzera, E. Tun-ku, I. Fernández, J. Ramsey. 2009. Contribuciones de la genetica y la proteómica al estudio de la enfermedad del Chagas. Salud Pública, 51 supl 3: 5410-5443.

11.- Marina C.F, Bond J.G., Casas M., Muñoz J., Orozco A., Valle J. & Williams T. Spinosad as an effective larvicide for control of Aedes albopictus and Aedes aegypti, vectors of dengue in southern Mexico¿ Pest Management Science (en prensa).

Publications

12.- Marina C.F, Bond J.G., Casas M., Muñoz J., Orozco A., Valle J. & Williams T. Spinosad as an effective larvicide for controlof Aedes albopictus and Aedes aegypti, vectors of dengue in southern Mexico¿ Pest Management Science (en prensa).

13.- May-Uc, E., Hernández-Arana, H. & Rebollar-Téllez, E. A. Distribución de flebotomineos (Díptera: Psychodidae) en Quintana Roo, México. Acta Zoológica Mexicana (En Prensa) AZM09-87 14.- Meneses G, Berzunza M, Becker I, Bobes R, Rosas G, Sciutto E, and Fragoso G. 2009. Taenia crassiceps cysticercosis: Variations in its parasite growth permissiveness that encounter with local immune features in BALB/c substrains. Exp Parasitol. 123(4):362-8.

14.- Pech-May, A., Escobedo-Ortegón, F. J. , Berzunza-Cruz, M. & Rebollar-Téllez, E. A. 2010. Incrimination of four sandfly species previously unrecognised as vectors of Leishmania parasites in Mexico. Medical and Veterinary Entomology, 24, 150-161.

15.- Ramsey, J.M., Gutiérrez-Cabrera, A.E., Salgado, L., P. Townsed, Sánchez-Cordero, V., Ibarra-Cerdeña, C.N. Trypanosoma cruzi resrvoirs and Triatoma pallidipennis (Triatominae: Reduvaidae) hosts for sylvan, ecotone and domestic hábitats. Submited to Plos Neglected Tropical Diseases.

16.- Sánchez-García, L, , Berzunza-Cruz, M., Becker-Fauser I., Rebollar-Téllez E. A., 2010. Sand flies naturally infected by Leishmania (L.) mexicana in the peri-urban area of Chetumal city, Quintana Roo, México, Transactions of the Royal Society of Tropical Medicine and Hygiene, 104: 406-411.

17.- Stephens, C.R., Gimenez-Heau, J., González, C., Ibarra-Cedeña, C., Sánchez-Cordero, V., González-Salazar, C. 2009. Using biotic interaction networks for prediction in biodiversity and emerging disease. Plos One 4(5):e5725.

18.- Valdés-Reyes, L., Argueta, J., Morán, J., Salaiza, N, Hernández, J, Berzunza, M., Aguirre-García, M., Becker, I., Gutierrez-Kobeh, L. 2009. Leishmania mexicana: Inhibition of camptothecin-induced apoptosis of monocyte-derived dendritic cells. Exp Parasitol. 121(3):199-207. Divulgación 1.- Godínez- Álvarez A., Ibáñez-Bernal S., 2010. Catálogo de Psychodidae (Diptera) de la colección de artrópodos con importancia médica del INDRE. Secretaría de Salud, México, Acta Zoológica Mexicana (n.s.) 26(1).

19. Sanchez-Cordero, V., Gutiérrez-Granados, G., Flores, J. J. en prensa Roedores y riesgo agrícola: el modelado del nicho ecológico como herramienta de predicción.