Redes Complejas Aplicadas al Estudio de Enfermedades Parasitarias

Modeling the Complex Niches of (Complex) Diseases

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Who are we?

Del área de Enfermedades Emergentes

Programa de Complejidad y Salud Pública del C3, UNAM

-
- 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
- 5.- M. en C. Leopoldo Valiente Banuet
- 6.- L.C.C. Ricardo Arredondo Espinosa
- 7.- Dra. María Concepción García Aguirre
- 8.- Dr. Adolfo Unanue
- 9.- Biól. Daniel Pérez Castillo
-
- Grupo del Laboratorio de sistemas de información geográfica del Instituto de Biología de la UNAM.
- 10.- Dr. Víctor Sánchez-Cordero
- 11.- Dr. Ángel Rodríguez Moreno
- 12.- Dr. José Juan Flores Martínez
- 13.- Dr. Gabriel Granados Gutiérrez
- 14.- Dra. Camila González Rosas (Universidad de los Andes, Columbia)
- 15.- C. Dr. Carlos Napoleón Ibarra Cerdeña
- 16.- Est. Biól. Ruth Areli Gómez Rodríguez
- 17.- Est. Biól. María Azucena Trinidad Flores

Who are we?

- Grupo del laboratorio de inmunoparasitología del Departamento de Medicina Experimental de la Facultad de Medicina en la UNAM.
- 18.- Dra. Ingeborg Becker
- 19.- Dra. Miriam Berzunza Cruz
- 20.- QFB. Dulce Jocelyn Bailón Martínez
- 21.- M. en C. Adriana Godínez Álvarez
- 22.- M. en C. Cristina Cañedo Guzmán
- 23.- Biól. Lorena N. Alamilla Fonseca
- 24.- Biól. Diana Pérez Montiel
- 25.- Biól. Angélica del Rosario Pech May
- El Centro Regional de Investigación del Instituto Nacional de Salud Pública (Tapachula, Chis.)
- 26.- Dra. Janine M. Ramsey Willoquet
- 27.- Dr. Carlos Félix Marina Fernández
- 28.- Dra. Teresa Ordoñez
- 29.- Keynes De la Cruz Félix
- Grupo de Tabasco: División Académica de Ciencias Biológicas. Universidad Juárez Autónoma de Tabasco
- 30.- Dr. Mircea Gabriel Hidalgo Mihart
- 31.- 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
- 32.- Dr. Eduardo A. Rebollar Téllez
- 33.- Estudiante Jorge Jesús Rodrìguez Rosas
- Grupo de Jalisco: Centro Universitario de la Costa Sur. Universidad de Guadalajara.
- 34.- Dr. Luis Ignacio Iñiguez Dávalos
- 35.- Biól. Pilar Ibarra
- 36.- Biól. María Magdalena Ramírez Martínez
- **Participantes en el área de Diabetes**
- 37.- Dr. Javier Rosado Muñoz. Secretaría de Salud Pública
- 38.- Dr. Adonis Germinal Cocho Gil. Instituto de Física. Universidad de la Ciudad de México
- 39.- Dr. Carlos Gershenson García. IIMAS
- 40.- M. en C. Hugo Flores Huerta. IIMAS
- 41.- Dra. Marcia Hiriart Urdanivia. Instituto de Fisiología Celular
- 42.- Dr. Carlos Villarreal Luján. Instituto de Física
- **Participantes en el área de Influenza**
- 43.- Dra. Natalia Bárbara Mantilla Berniers. Facultad de Ciencias
- 44. Sergio Hernández, Facullad de Ciencias

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.
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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.
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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

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12.- 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).

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20.- 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).

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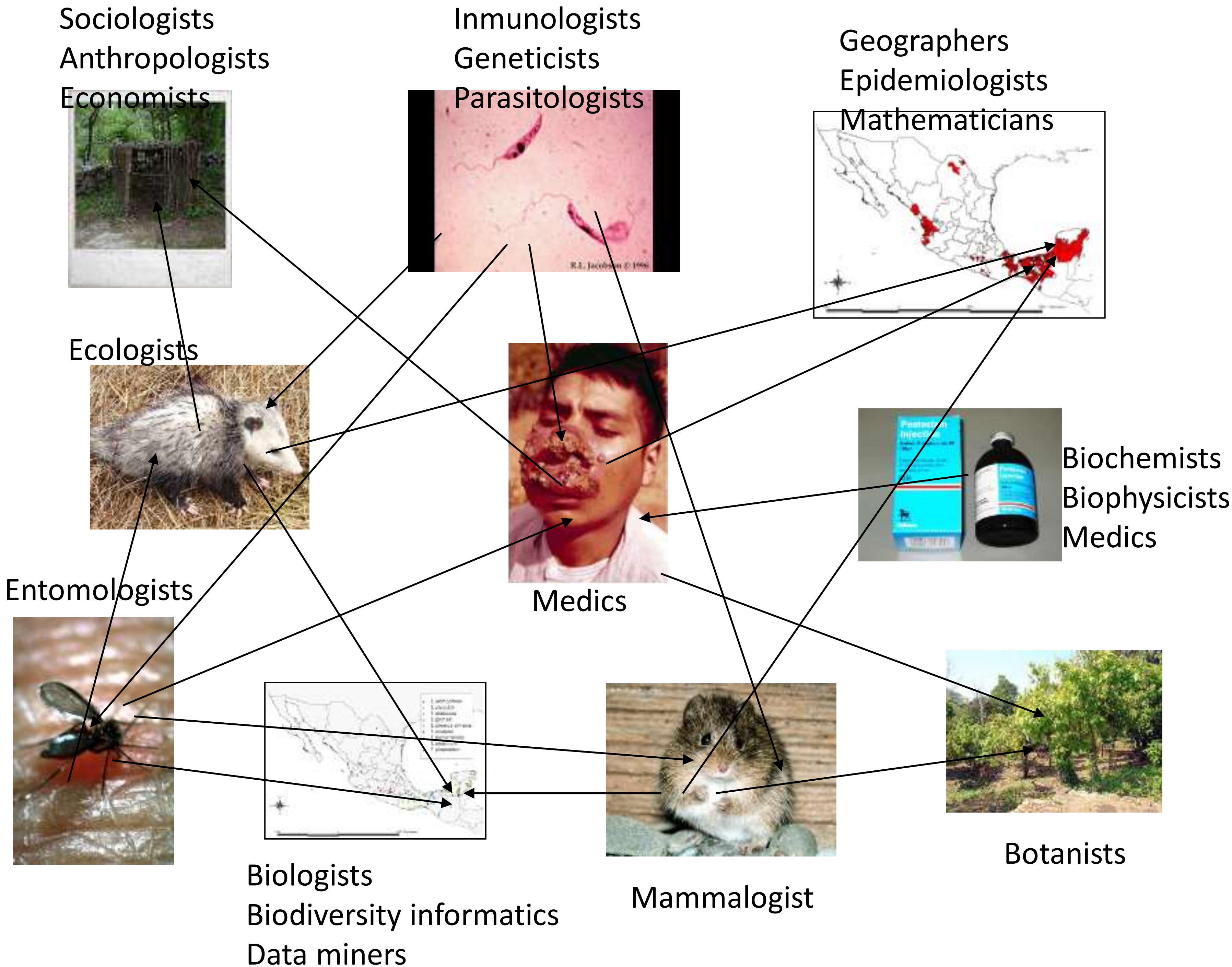
The Complexity of Disease and the Need for Transdisciplinarity

From micro to macro and back again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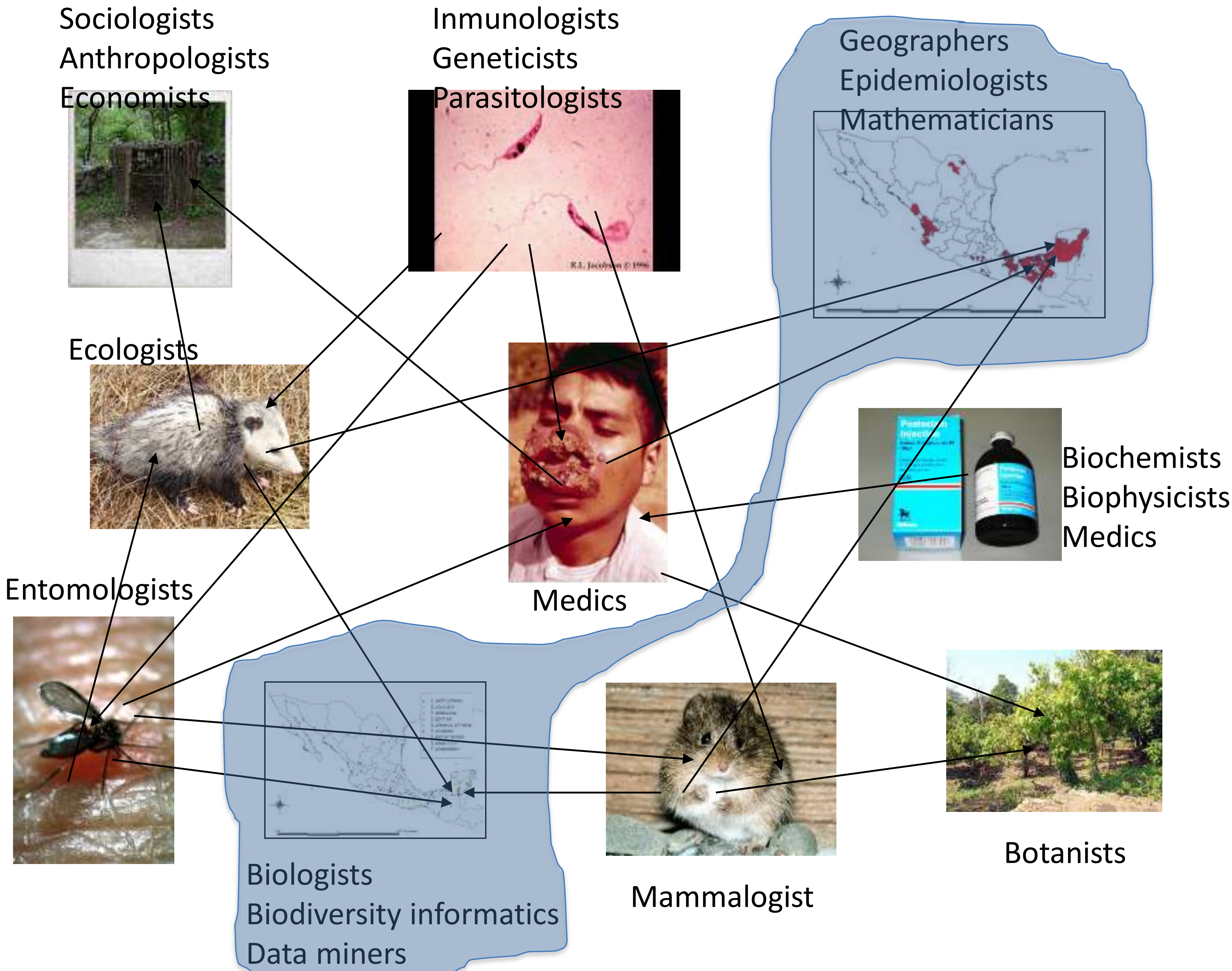
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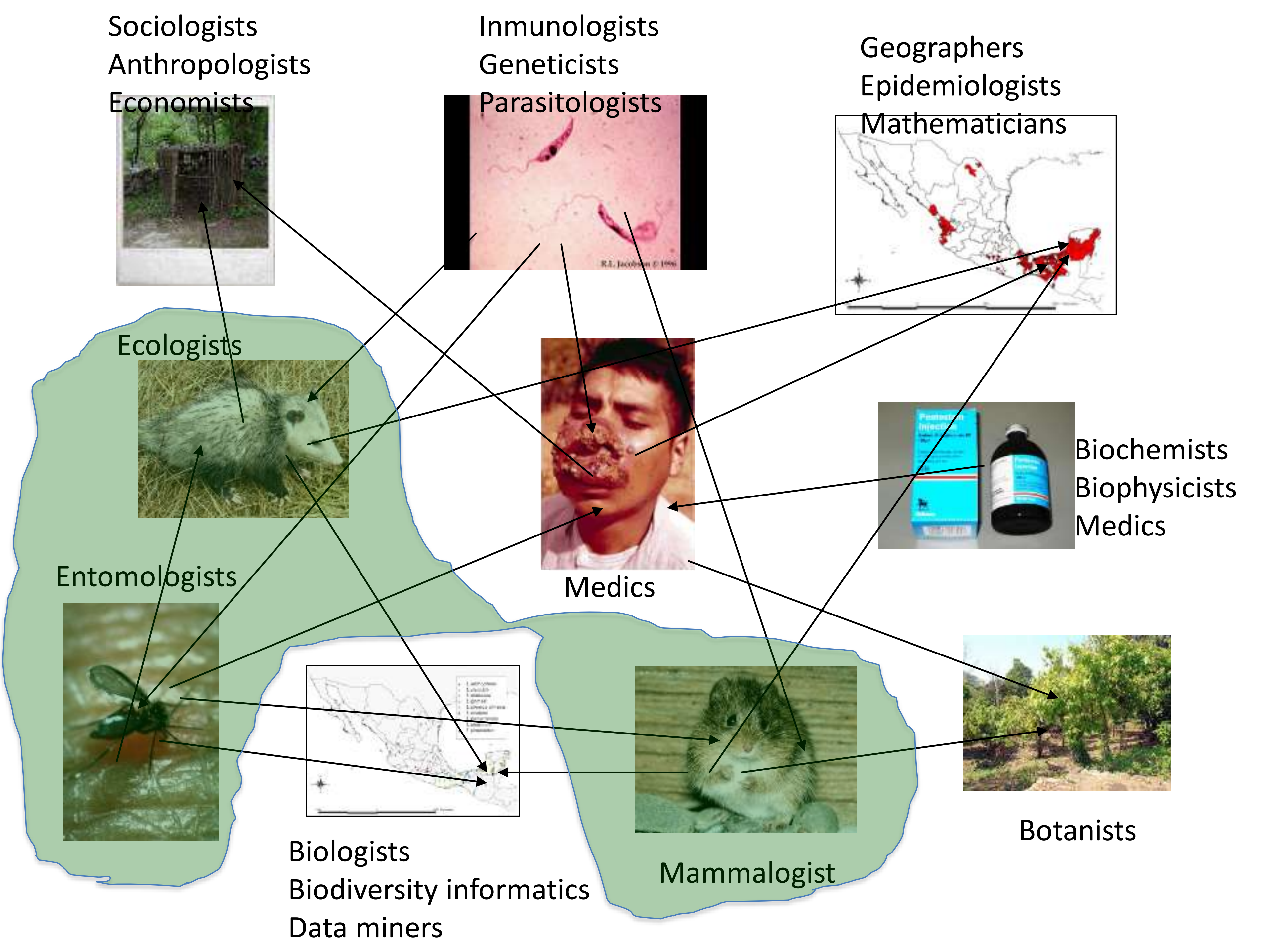

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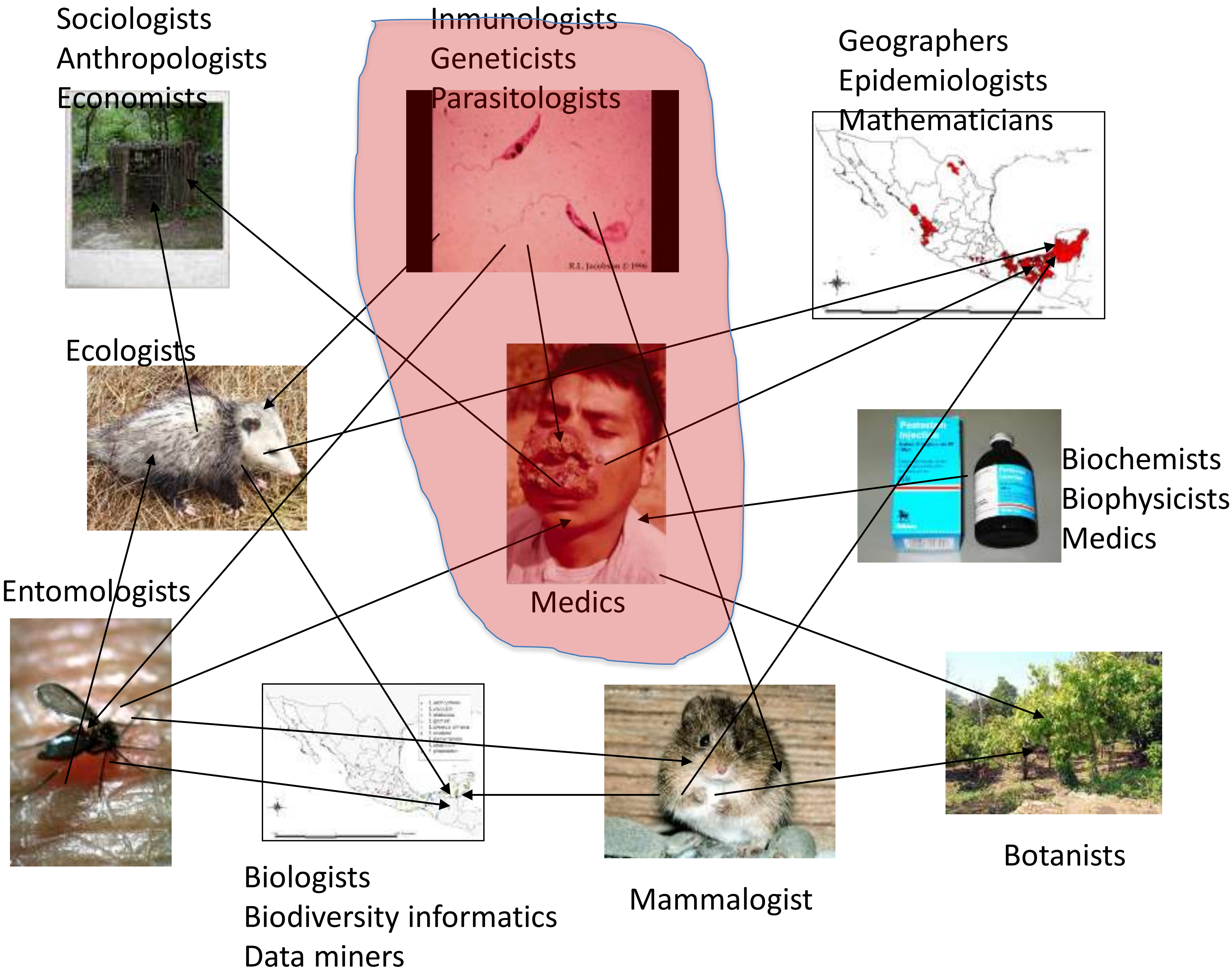
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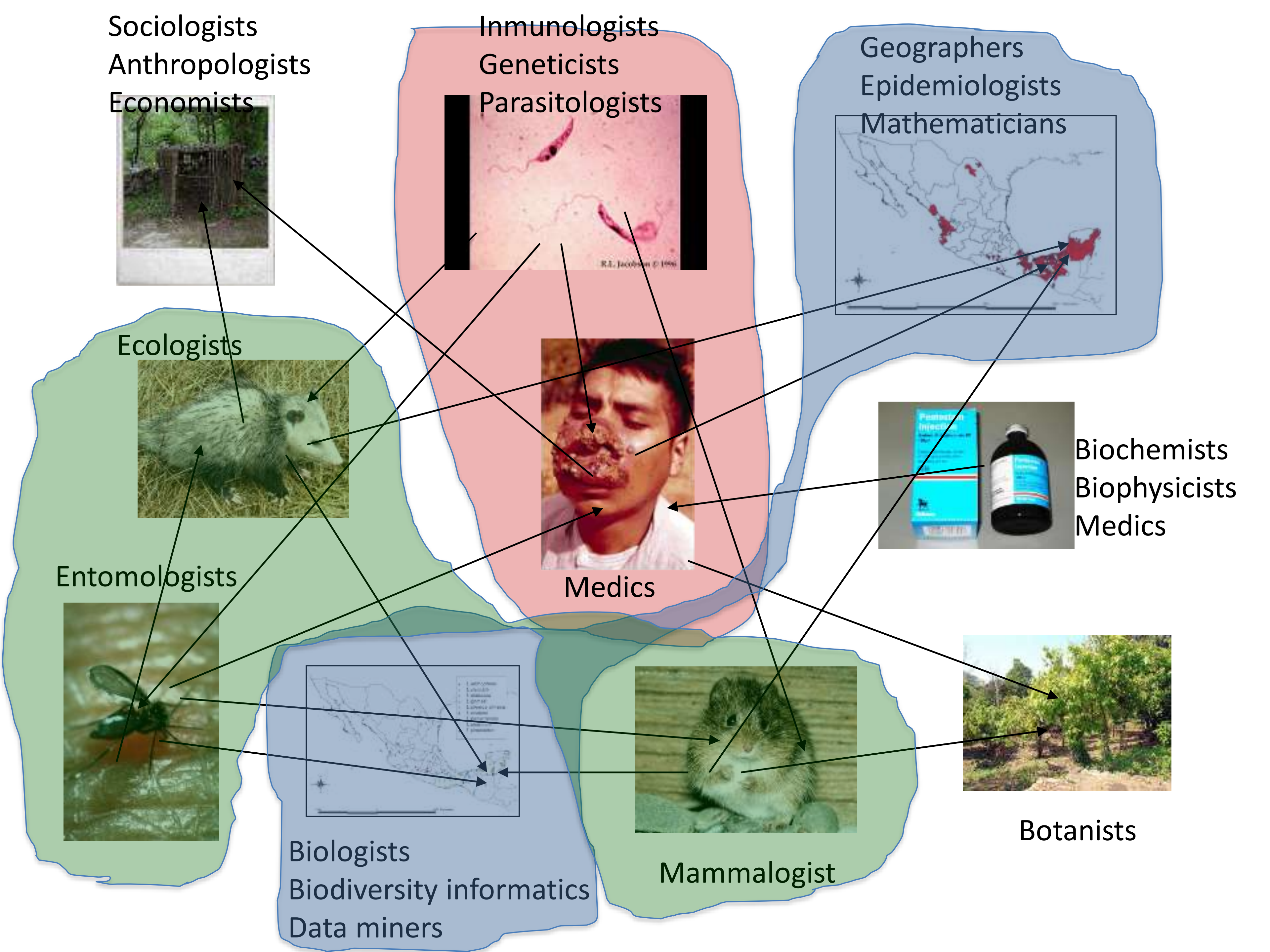

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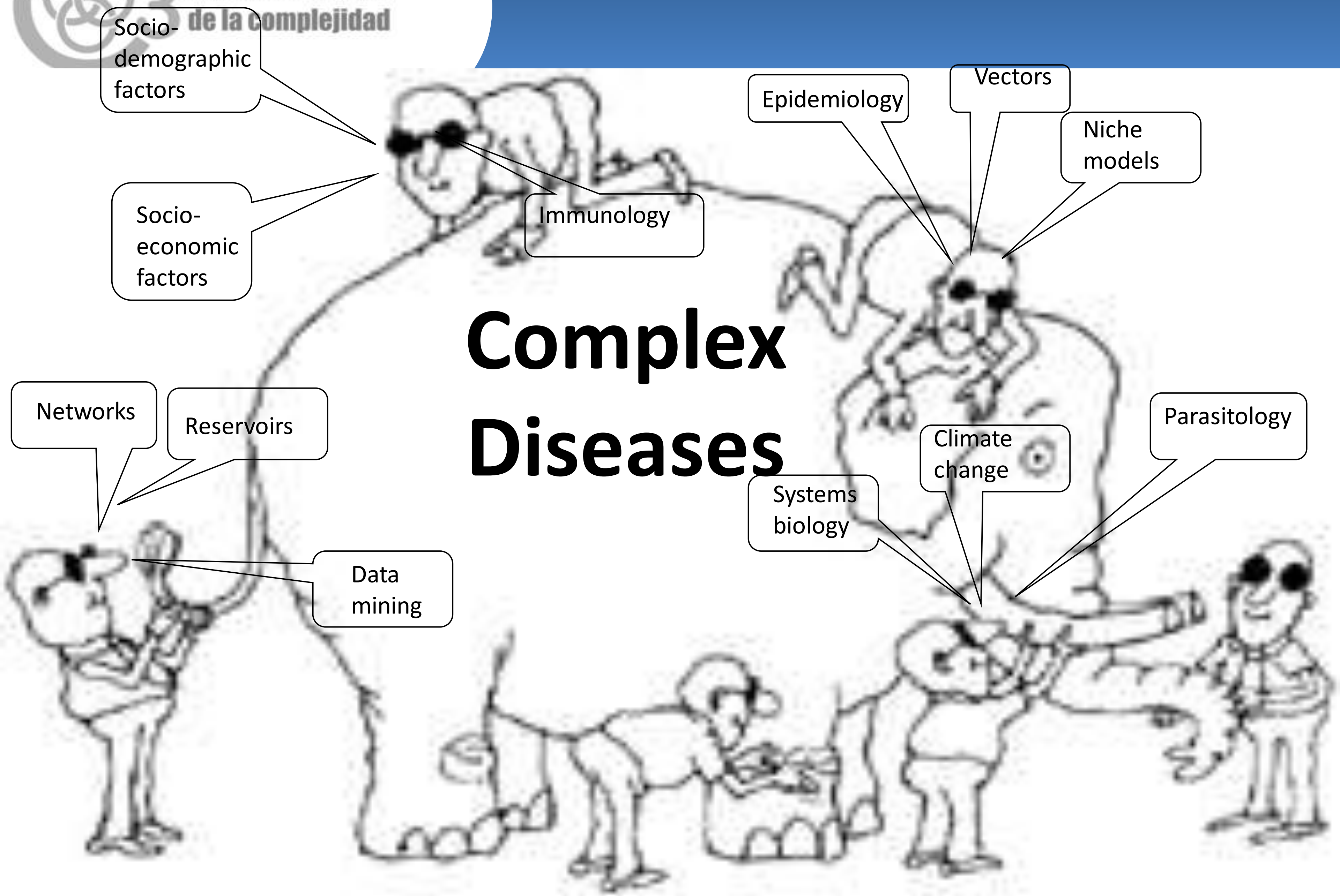
Complex Diseases



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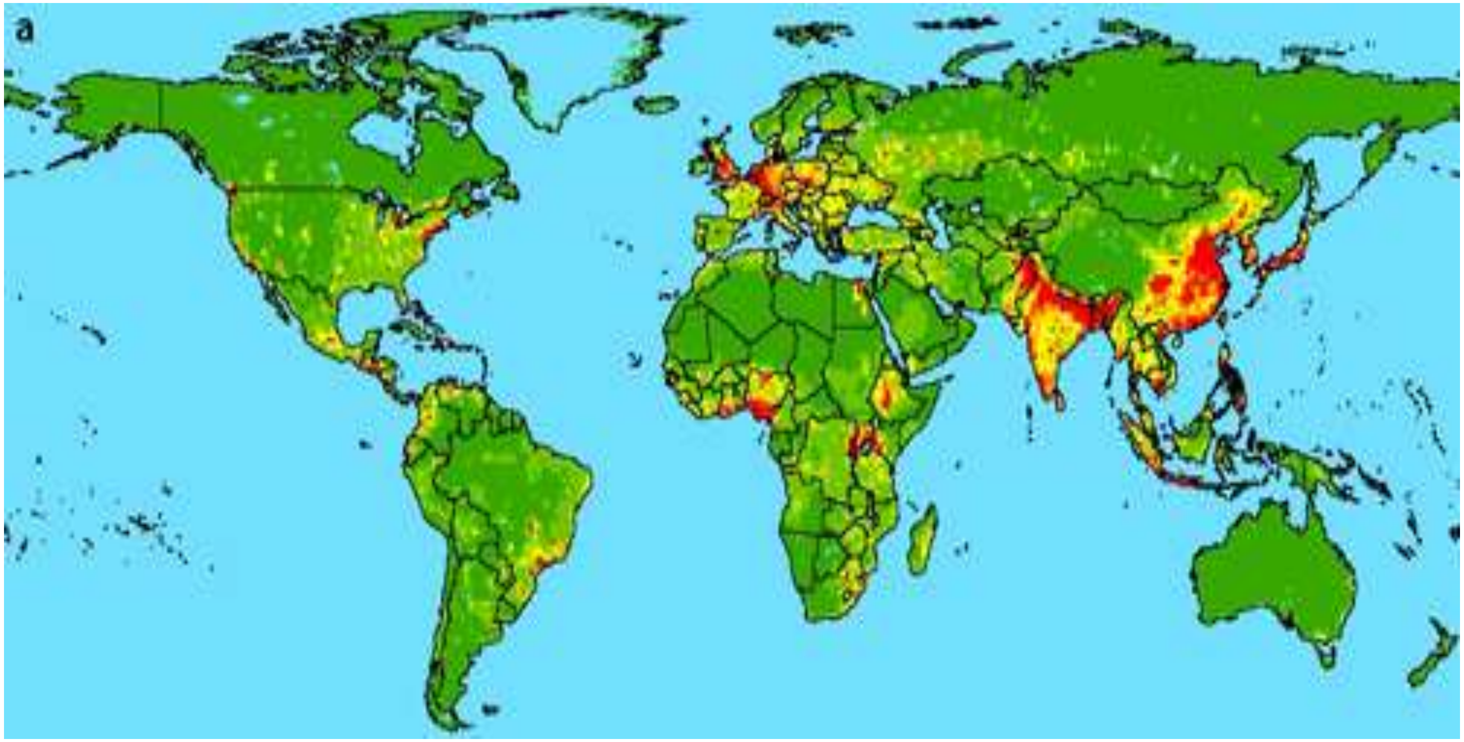


Nature ***451*, 990-993 (21 February 2008) | doi:10.1038/nature06536**

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?

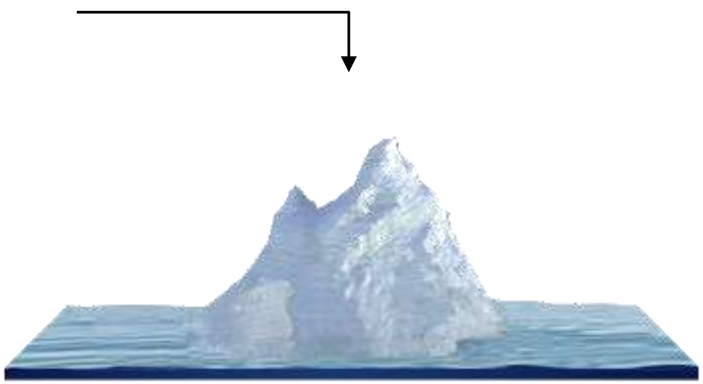
- We want to predict, for instance
  - Disease reservoirs and vectors, their interactions and their relative importance
  - Spatio-temporal behaviour of disease and associated risk factors
  - Dispersal characteristics
  - Socio-demographic/economic risk factors
  - Genetic susceptibility (at all levels)

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

and

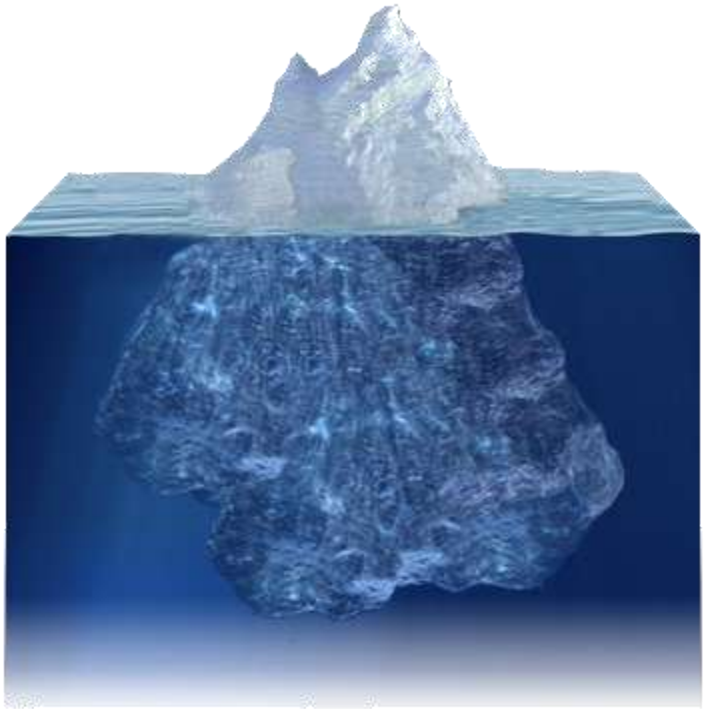
- We want to understand

Known reservoirs
Known vectors
Known cases
Known risk factors

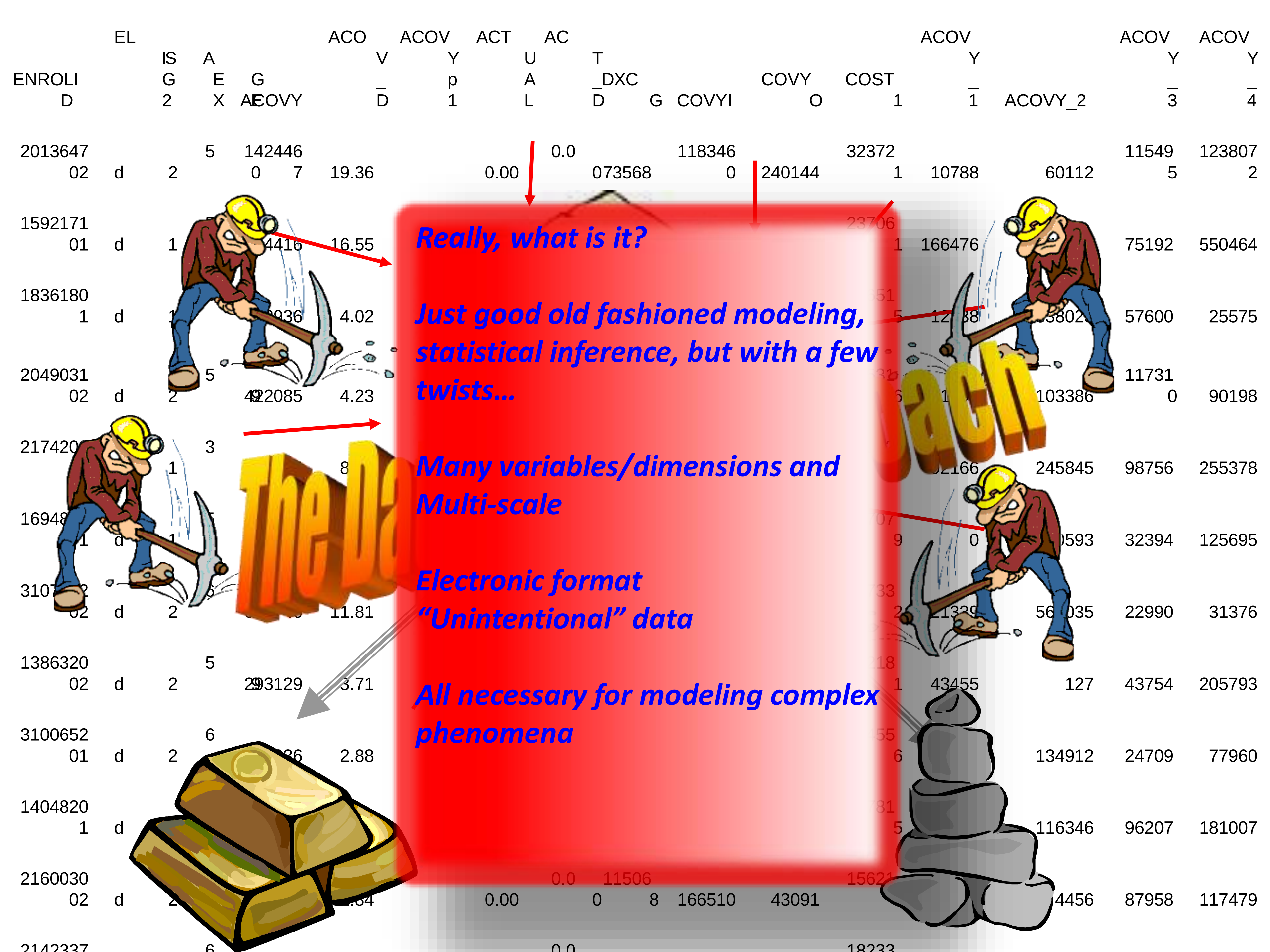


Unknown reservoirs
Unknown vectors
Unknown cases
Unknown risk factors

Known reservoirs
Known vectors
Known cases
Known risk factors



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



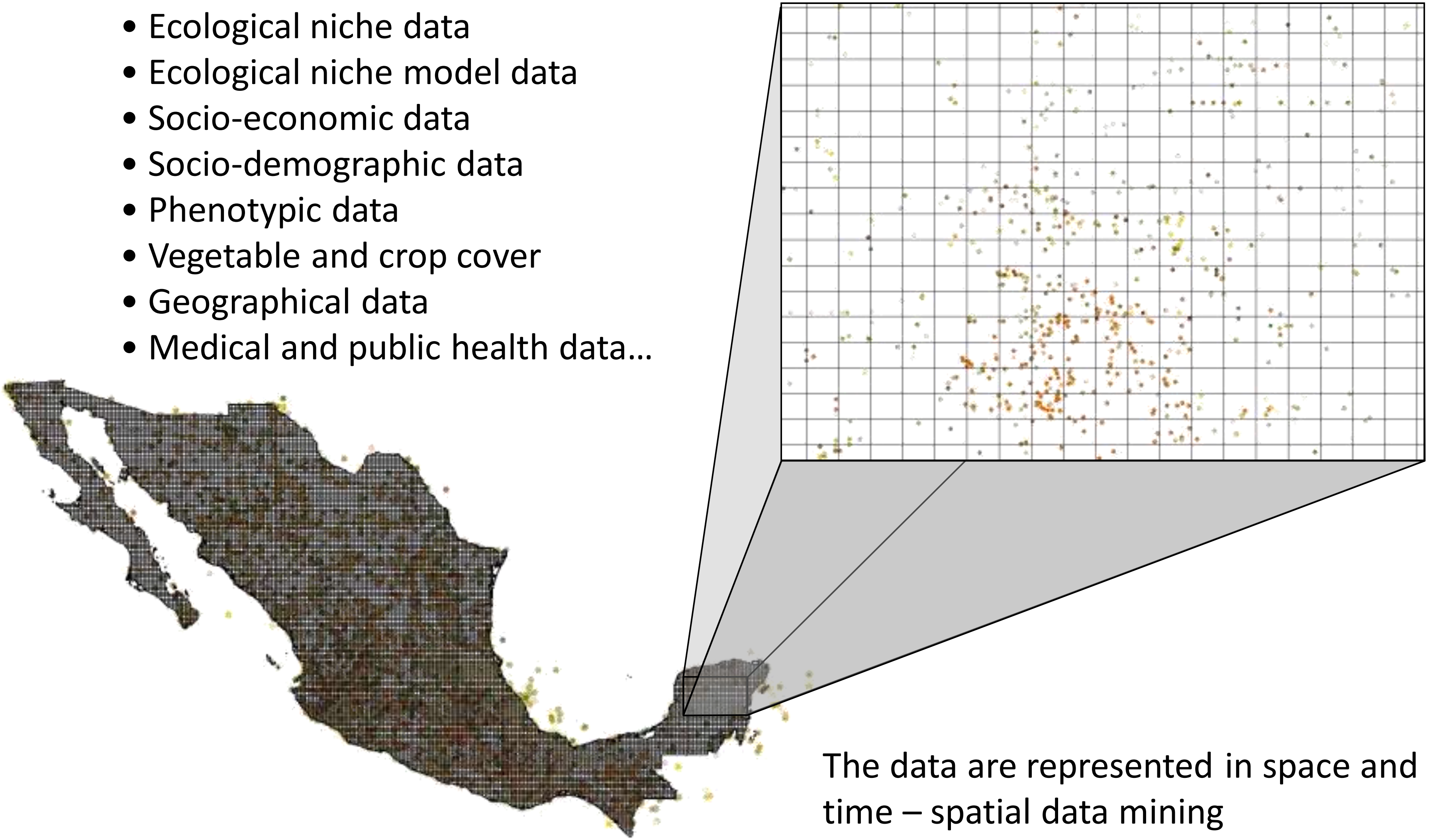
Really, what is it?
Just good old fashioned modeling, statistical inference, but with a few twists…
Many variables/dimensions and Multi-scale
Electronic format
"Unintentional" data
All necessary for modeling complex phenomena

But what are we going to mine…!

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

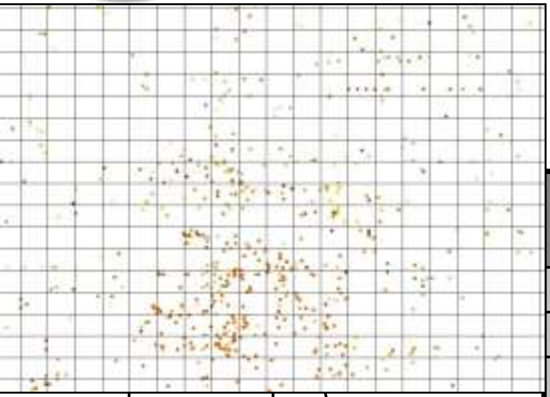
But all data are not created equal…

- Different sources
  - Different location, data base, access,…
- Different data types
  - categorical, metric, continuous, discrete,…
- Different spatial resolution
  - Explicit – e.g., pixel by pixel in environmental layers
  - Implicit – 30,000,000 data points versus 30
    - "Quality" (e.g. Phenotypic characteristic) 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!

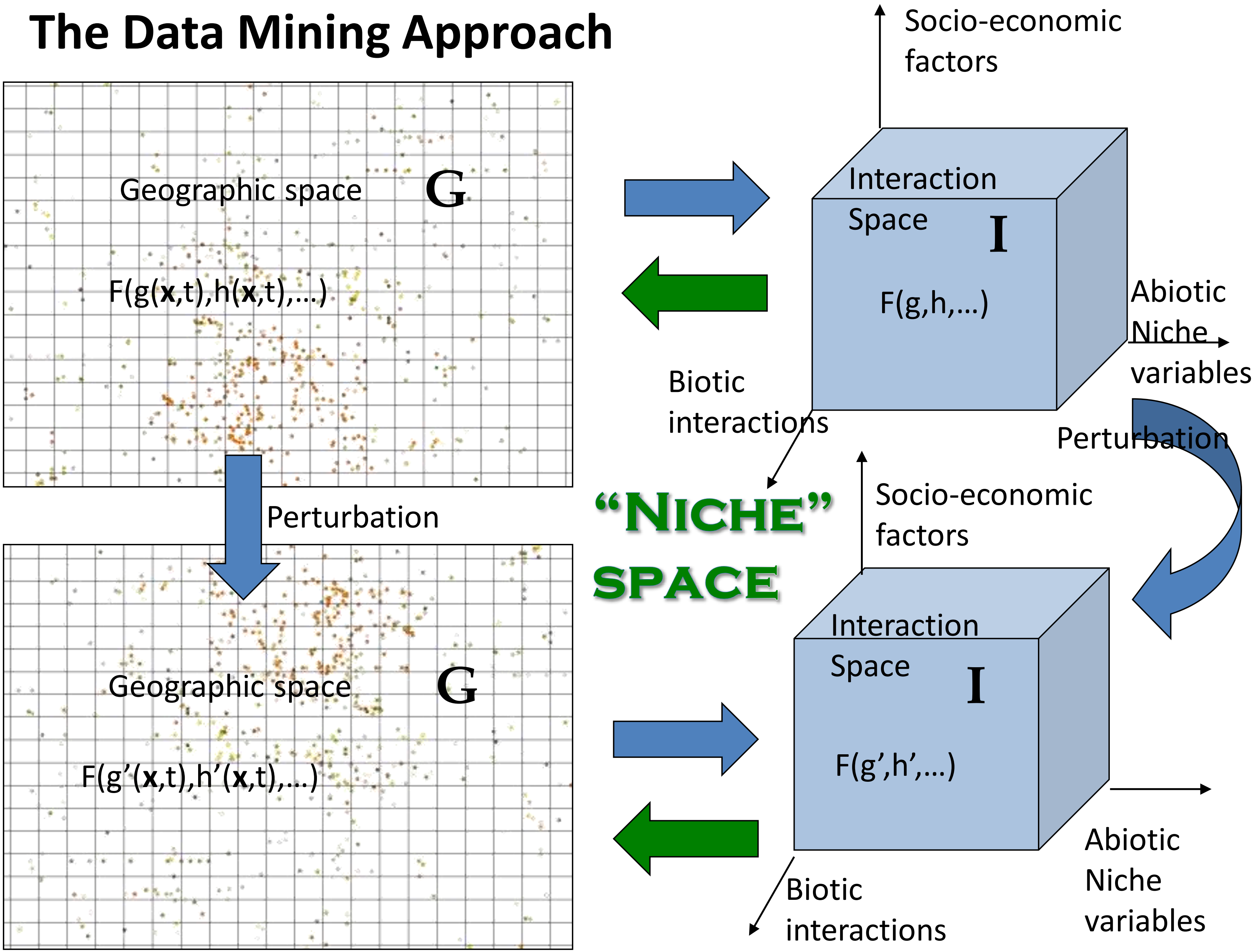
The Datamining Approach

Choose a spatial resolution: give everyone one vote there.
The "Senate" versus the "Congress" approach!



Cuadrante	Sigmodon hispidus	Dipetalogaser maxima	Casos Chagas	Precipitación anual	Temperatura promedio	GARP Triatoma maximus	GARP Diptaloster maxima	Perfil agricola
A1	1	3	1	23	18.6	1	1	4
A2	0	1	0	23	18.6	1	1	4
A3	0	2	0	23.7	18.7	1	1	1
A4	0	4	0	23.7	18.7	1	1	3
A5	0	2	1	23.7	18.7	1	1	3
A6	2	5	2	23.7	18.7	1	1	2
A7	0	1	0	23.3	18.4	1	1	5
A8	0	2	0	22.8	18.8	1	1	3
A9	1	3	1	22.8	18.8	1	1	1
A10	0	1	0	22.8	18.8	0	1	1
A11	0	0	0	22.8	18.8	0	1	1
A12	0	0	0	22.8	18.8	0	1	2
A13	0	0	0	22.8	18.8	0	0	4
A14	0	0	0	22.8	18.8	0	0	3
A15	0	2	0	22.8	18.8	0	1	4
A16	0	1	0	22.8	18.8	0	1	2
A17	0	0	0	22.8	18.8	0	1	1
A18	0	0	0	22.8	18.8	0	0	1

The Data Mining Approach



C – What we want to predict, e.g.,

– people with visceral Leishmania
- people with cutaneous Leishmania
- presence of Lutzomyias
- reservoirs of Leishmania
- deaths
- geographical area

(Importance of clinical data)

The *Niche*

$$P(C \mid \mathbf{X})$$

$$\mathbf{X} = \mathbf{X}_1 + \mathbf{X}_2 + \mathbf{X}_3 + \mathbf{X}_4 + \mathbf{X}_5 + \ldots$$

Socio-demographic data (Age, sex) → X_1

Socio-economic data (Maximum educational level, occupation) → X_2

Public health data (Type of hospital) → X_3

Species distribution data (Presence of wild reservoirs) → X_5

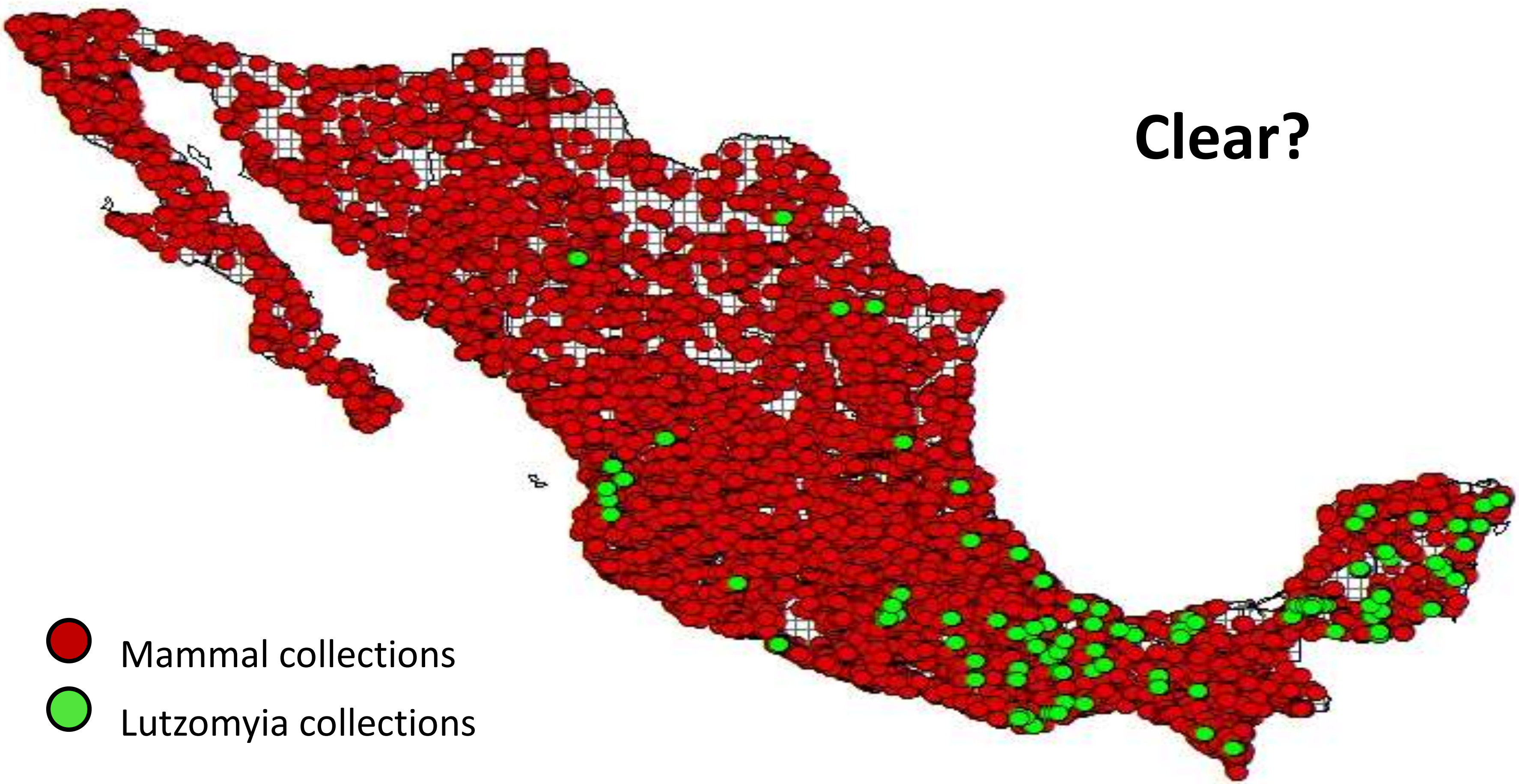
Medical data (Treatment)

Abiotic factors (Maximum Annual Temperature)

Immunological data

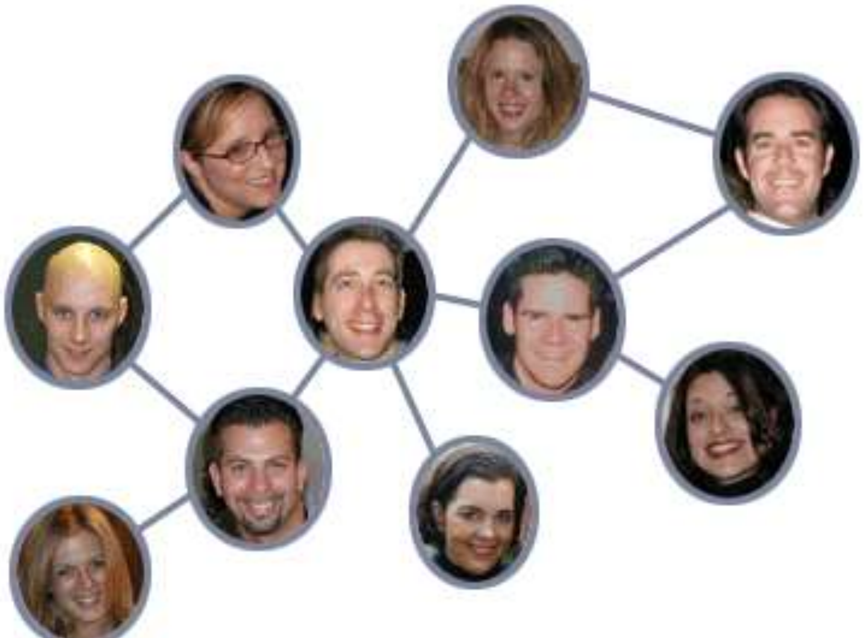
- But the real **Niche Space** of a disease is VERY big!
- Where do we start?
- With the biotic…
- With the "ecological" part, reservoirs and vectors and all that…
- We will use Leishmaniasis as a case study…

Clear?



You can judge a man by his “friends”

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



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Typical Ecological Network

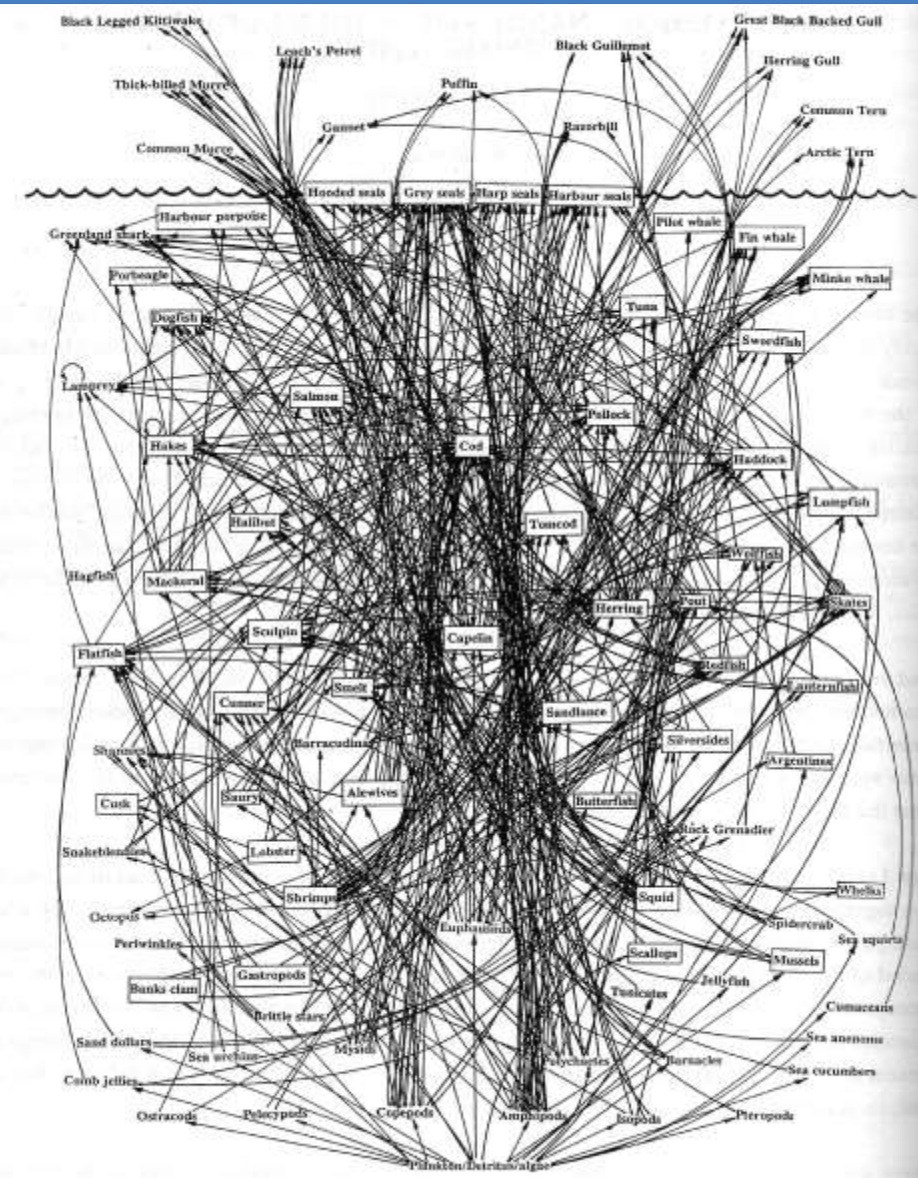
Food web associated with Cod for northwest Atlantic

Author(s):
Prof. David Lavigne

Institution:
Natural Sciences and Engineering Research Council

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

No spatio-temporal input



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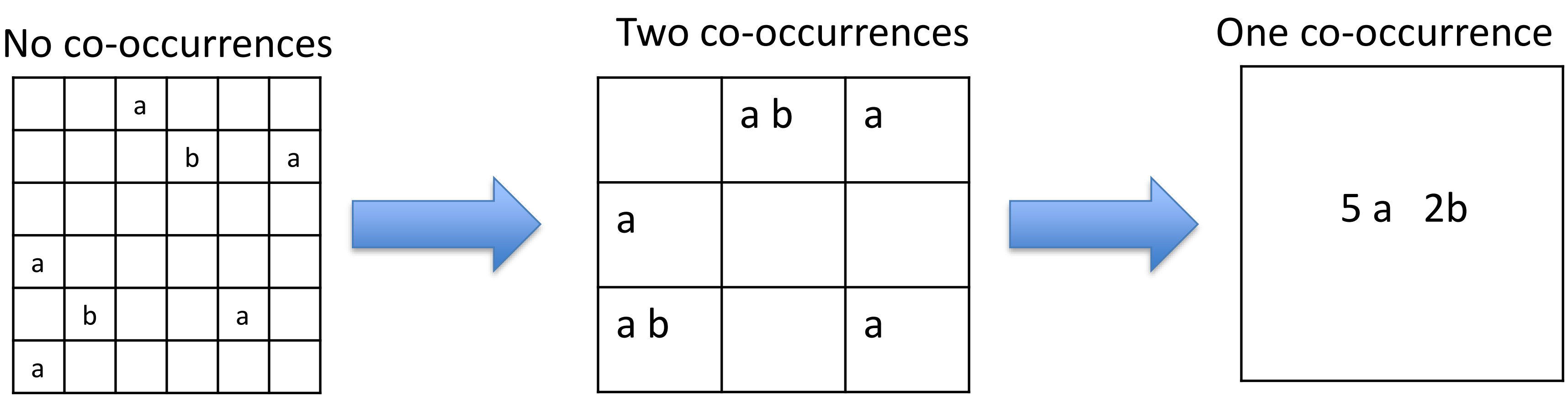
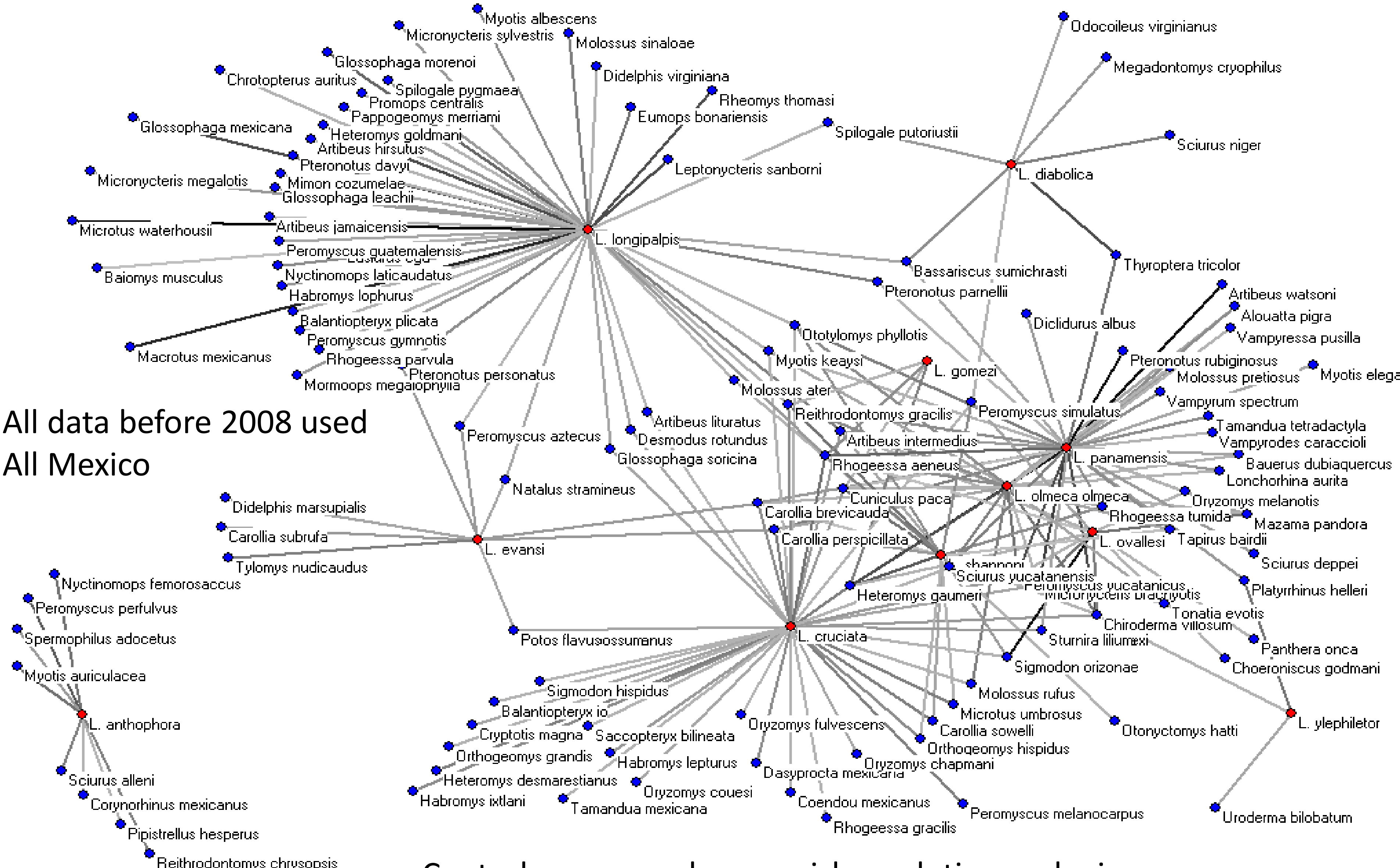
Using Networks to Infer Reservoir-Vector Interactions

- 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? (Choosing a null hypothesis)
  - What spatial (temporal) resolution? (When do things co-occur?)



Who's friends with Lutzomyias?



All data before 2008 used
All Mexico

Control programs, human risk, evolutionary logic

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Predicting Reservoirs

The 150 (out of 427) “best friends” of Lutzomyia as a genera. The model predicts 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	
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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	
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But how to test it...?
The Emerging Disease production line

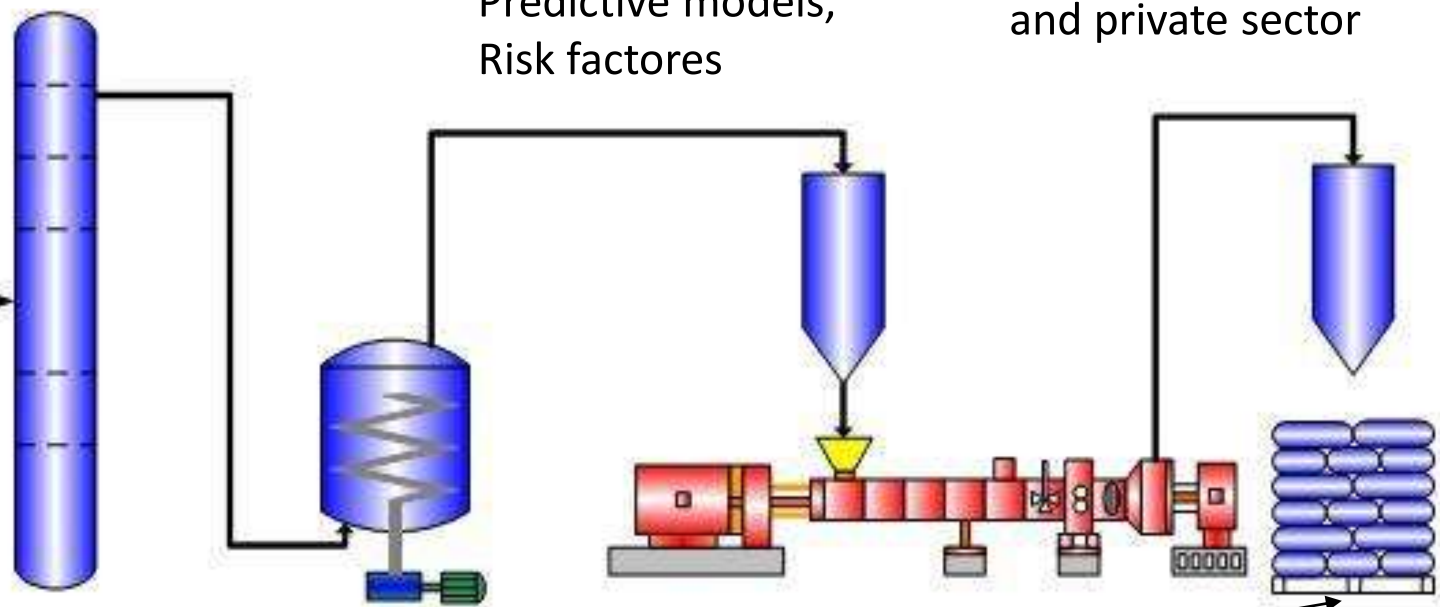
Links to IMSS and INSP

Requires large, well-organized interdisciplinary team

Data Mining:
Predictive models,
Risk factores

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

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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	
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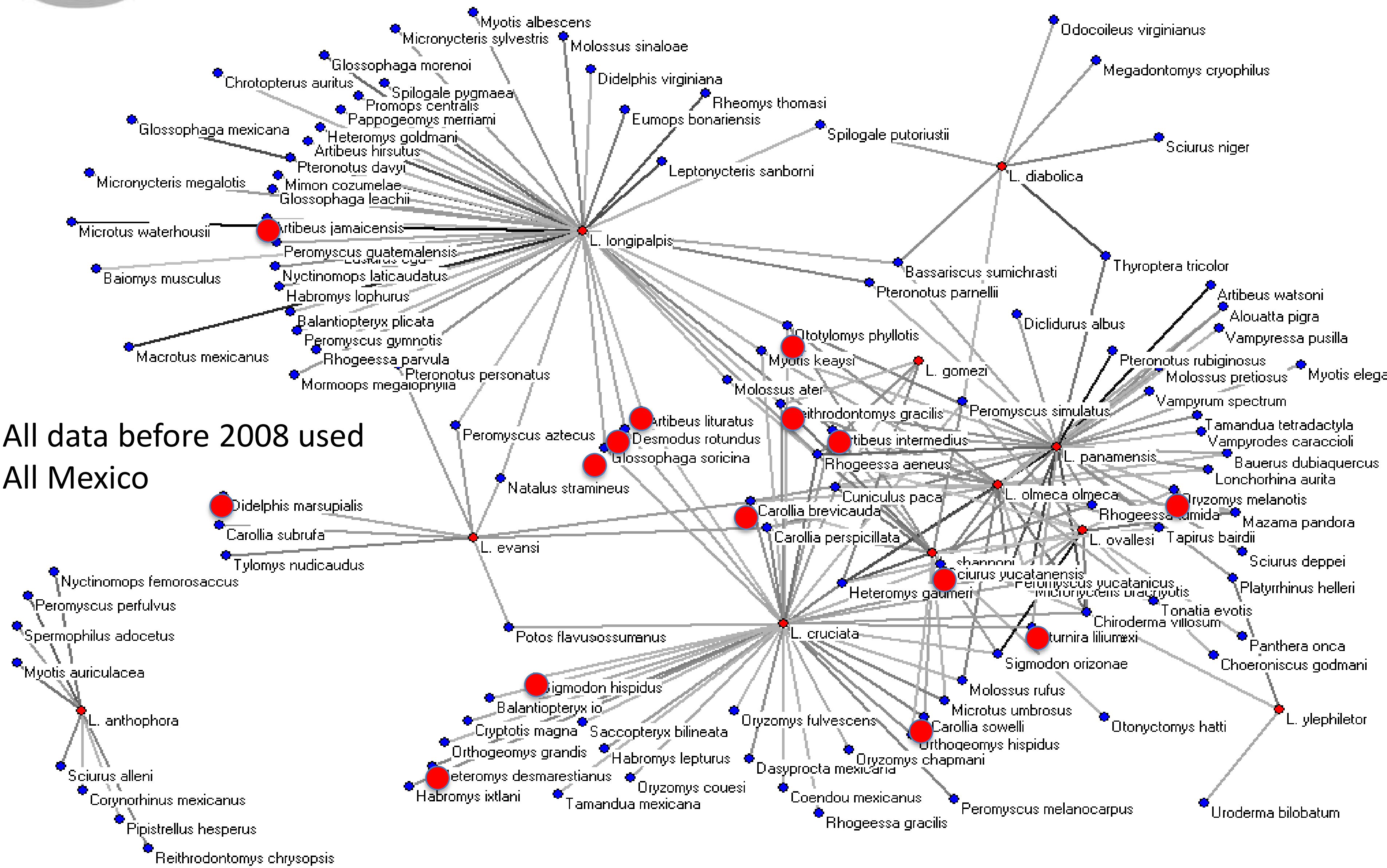

All data before 2008 used

All Mexico

What does this tell us about vector control?

Modelling Works!

- Predicted and confirmed 16 new species of mammal as carriers of Leishmania in Mexico
- 10 of them are bats, identified for the first time in Mexico
- Squirrels identified as carriers

- 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

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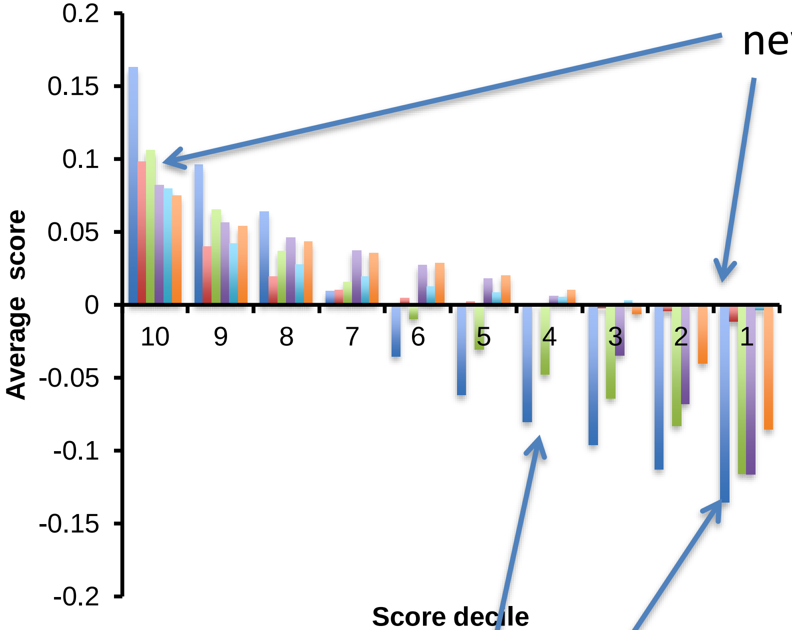
Modelling the Niche Space of Leishmaniasis (well, Lutzomyias really)

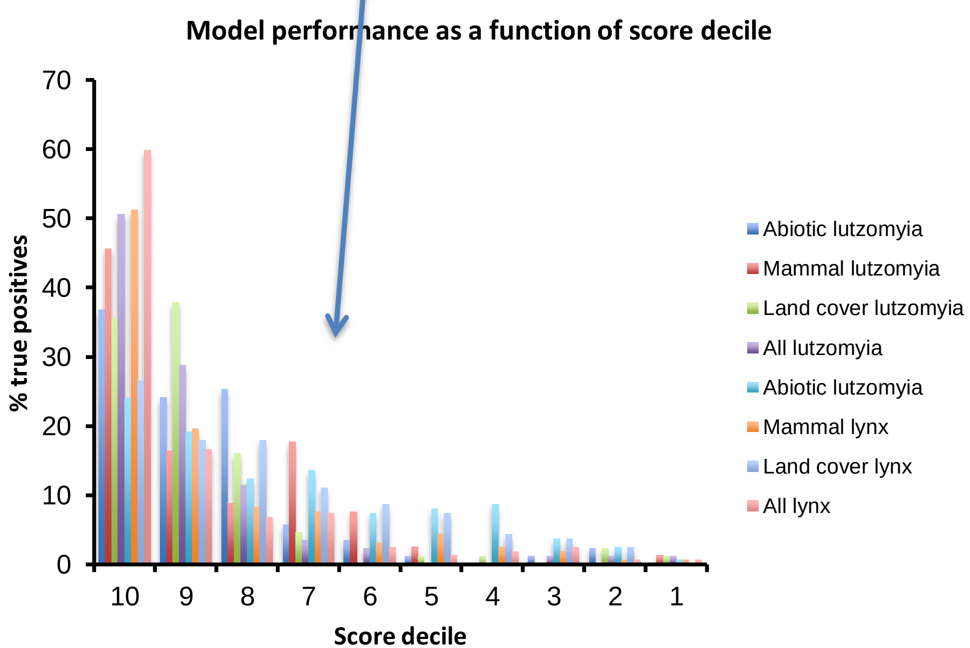
TOP DECILE Optimal niche conditions for *Lutzomyia*				BOTTOM DECILE Suboptimal niche conditions for *Lutzomyia*			
C VARIABLES	RANGE	Epsilon	Score contribution	ABIOTIC VARIABLES	RANGE	Epsilon	Score contribution
	88-219	*8.960*	*5.013*	BIO12	42-507	*-5.604*	*-2.279*
	23.3-26.4	*8.938*	*1.006*	BIO16	18-218	*-5.001*	*-2.328*
	22.2-25.3	*8.873*	*2.322*	BIO18	1-249	*-3.839*	*-3.799*
	26-63	*8.782*	*4.916*	BIO6	3.1-3.4	*-3.761*	*-2.931*
	25.35-33.09	*7.543*	*2.152*	BIO7	26.3-28.4	*-3.544*	*-8.853*
	13.4-16.6	*7.524*	*3.293*	BIO2	16.5-18.4	*-3.535*	*-2.997*
	392-774	*7.107*	*12.913*	BIO11	2.9-12.5	*-3.271*	*-4.482*
	28.5-30.6	*7.012*	*3.803*	BIO4	3310-7184	*-2.971*	*-9.551*
	1019-2019	*6.925*	*12.175*	BIO19	192-383	*-2.940*	*-0.448*
	192-383	*6.618*	*4.157*	BIO10	28.9-32.3	*-2.669*	*-0.916*
	1906-3302	*6.314*	*8.701*	BIO1	10.3-19.9	*-2.189*	*-1.033*
	9.8-10.8	*6.130*	*4.458*	BIO3	3.7-5.5	*-2.130*	*-3.576*
	623-746	*5.748*	*1.260*	BIO8	28.4-31.7	*-1.964*	*-0.731*
RESERVOIRS				**RESERVOIRS**			
lontomys gracilis		*8.892*	*2.640*	*Sigmodon hispidus*		*6.946*	*1.244*
nys gaumeri		*8.800*	*2.234*				
nys desmarestianus		*8.716*	*2.381*				
nys phyllotis		*7.559*	*2.028*				
scus yucatanicus		*7.249*	*2.116*				
on hispidus		*6.946*	*1.244*				
s marsupialis		*5.774*	*1.662*				
ys melanotis		*3.494*	*1.387*				
a mexicana		*2.773*	*1.541*				
LAND COVER				**LAND COVER**			
rest		*6.642*	*1.408*	Subtropical scrub		*-1.675*	*-1.527*
evergreen forest		*6.603*	*4.476*	Subtropical scrub with secondary vegetation		*-1.849*	*-1.658*
rest with secondary vegetation		*6.028*	*1.459*	Xeric scrub with secondary vegetation		*-2.092*	*-3.640*
evergreen forest with secondary vegetation		*6.007*	*4.344*	Xeric scrub		*-2.924*	*-4.044*
ure areas		*5.966*	*1.736*	Mesquite		*-3.337*	*-1.714*
settlement		*4.947*	*0.577*	Grassland		*-3.734*	*-1.874*
us tropical forest with secondary vegetation		*4.081*	*1.013*	Mangroves		*-4.063*	*-2.000*

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



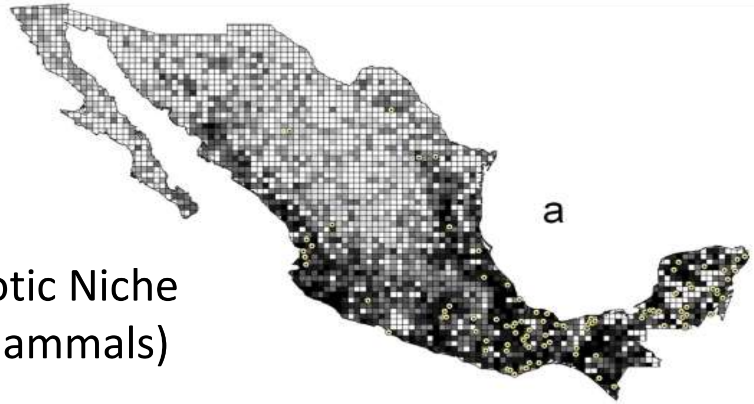
Lutzomyias love mammals, never met one they didn't like

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



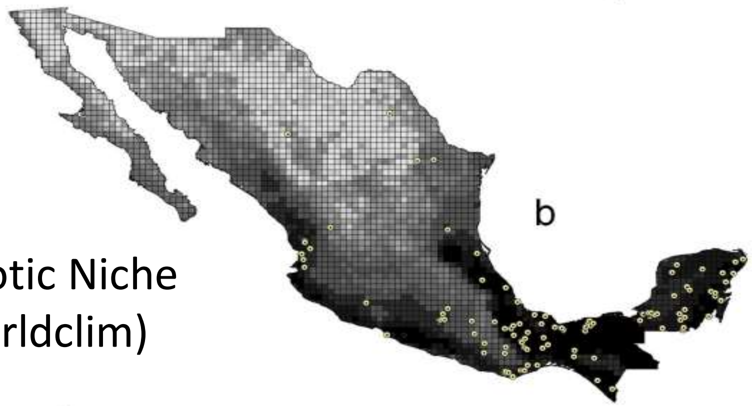
Climatic factors are more important for determining where Lutzomyias aren't rather than where they are

Lutzomyia Risk Maps according to Different Niche models



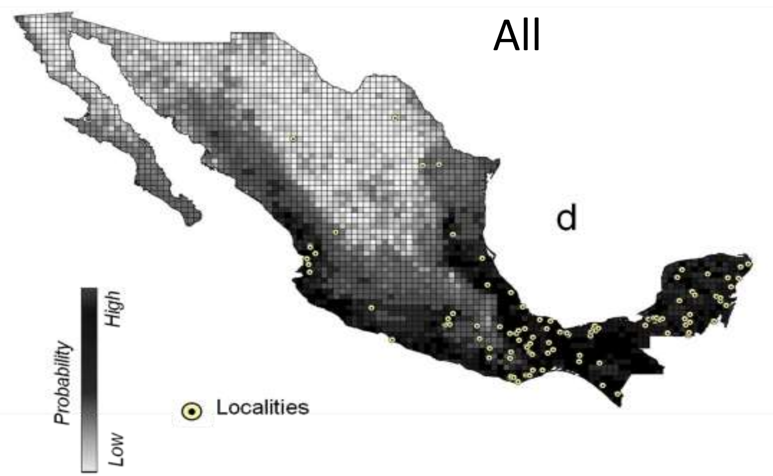
Biotic Niche (Mammals)

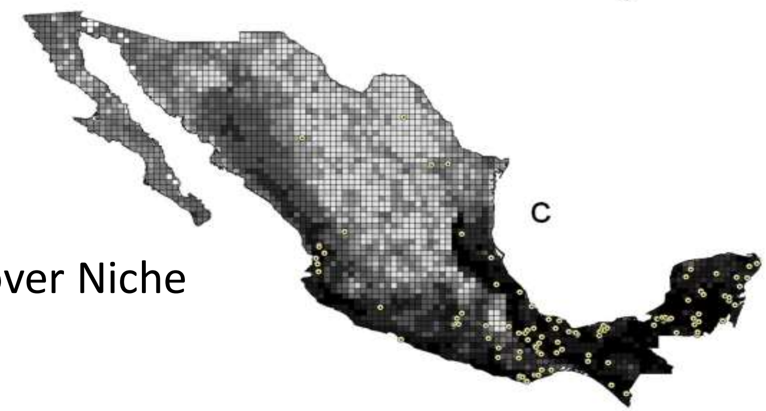
Relatively higher probability to find Lutzomyias in the north of Mexico from the biotic model than the abiotic one. Are Lutzomyias more common in the north of Mexico than previous data or models would suggest?



Abiotic Niche (Worldclim)

All



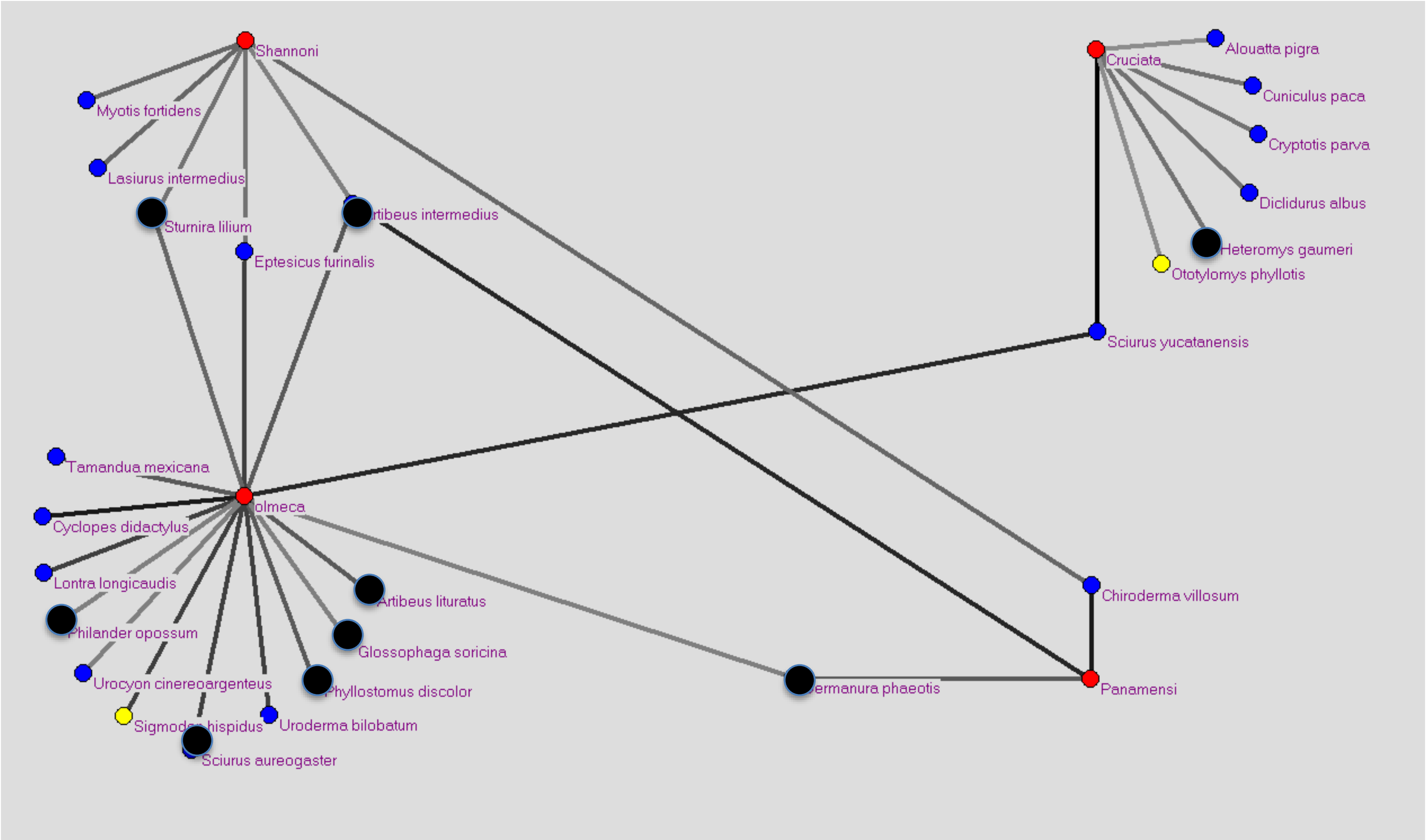


Landcover Niche

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

Lutzomyia Risk Maps according to Mammals and Landcover

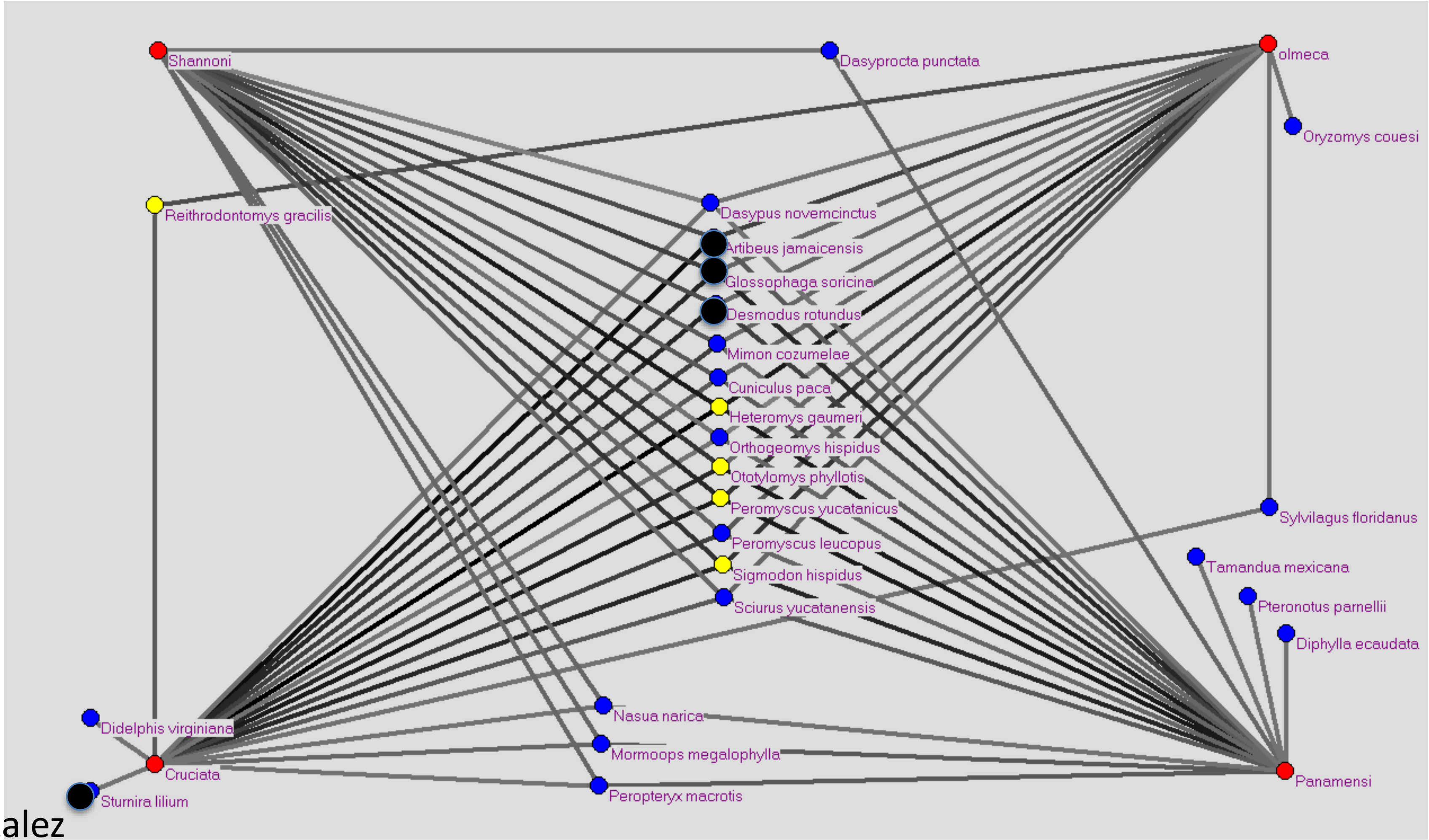
Drilling down to a more local level…
The biotic network for Tabasco



C. Gonzalez

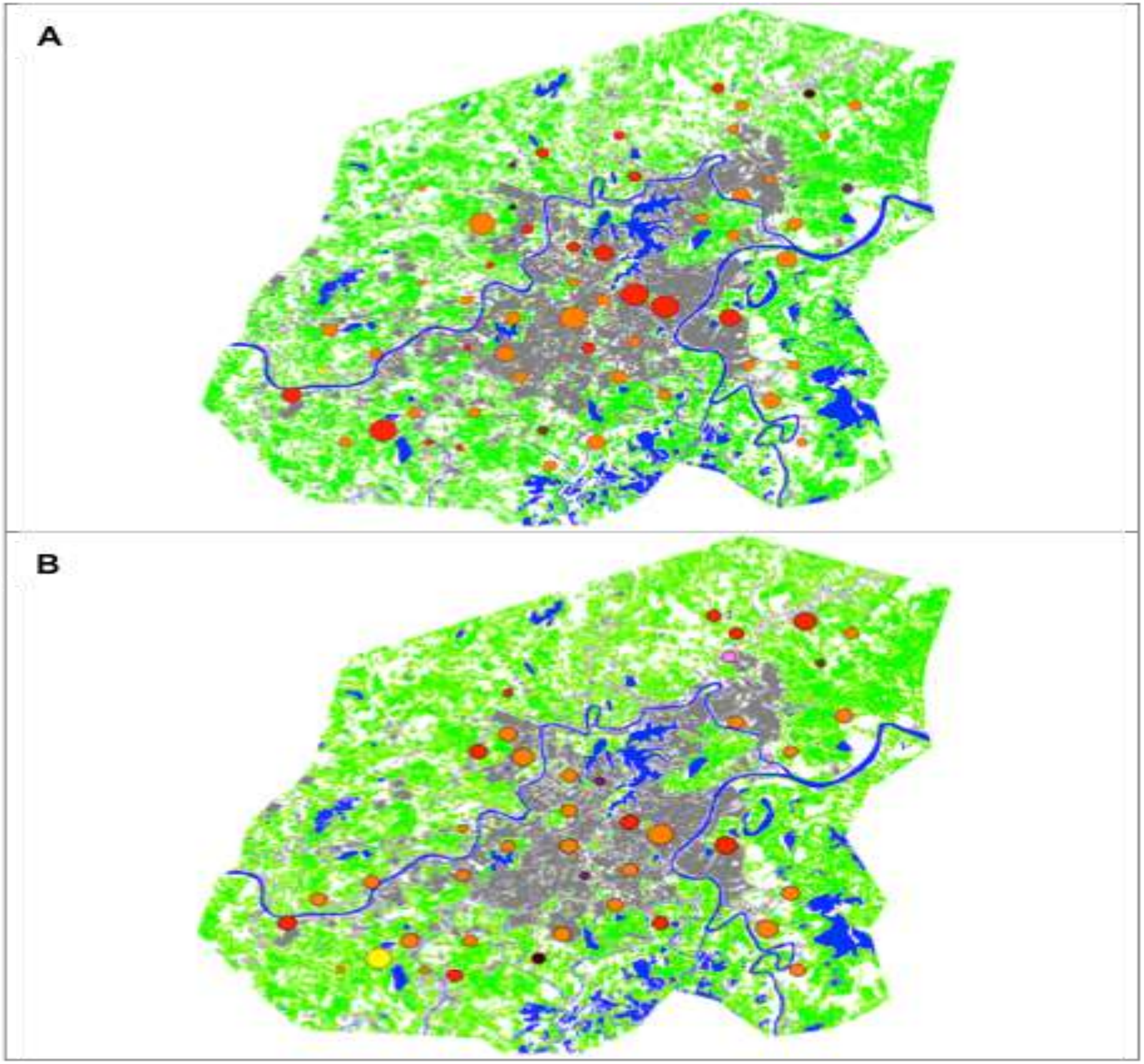
Drilling down to a more local level… The biotic network for Yucatan

Two places can be very much niche but might differ greatly in their species distributions. This hints at the fact that species might not be a relevant label for biotic niche dimensions. This is important for potential interventions.



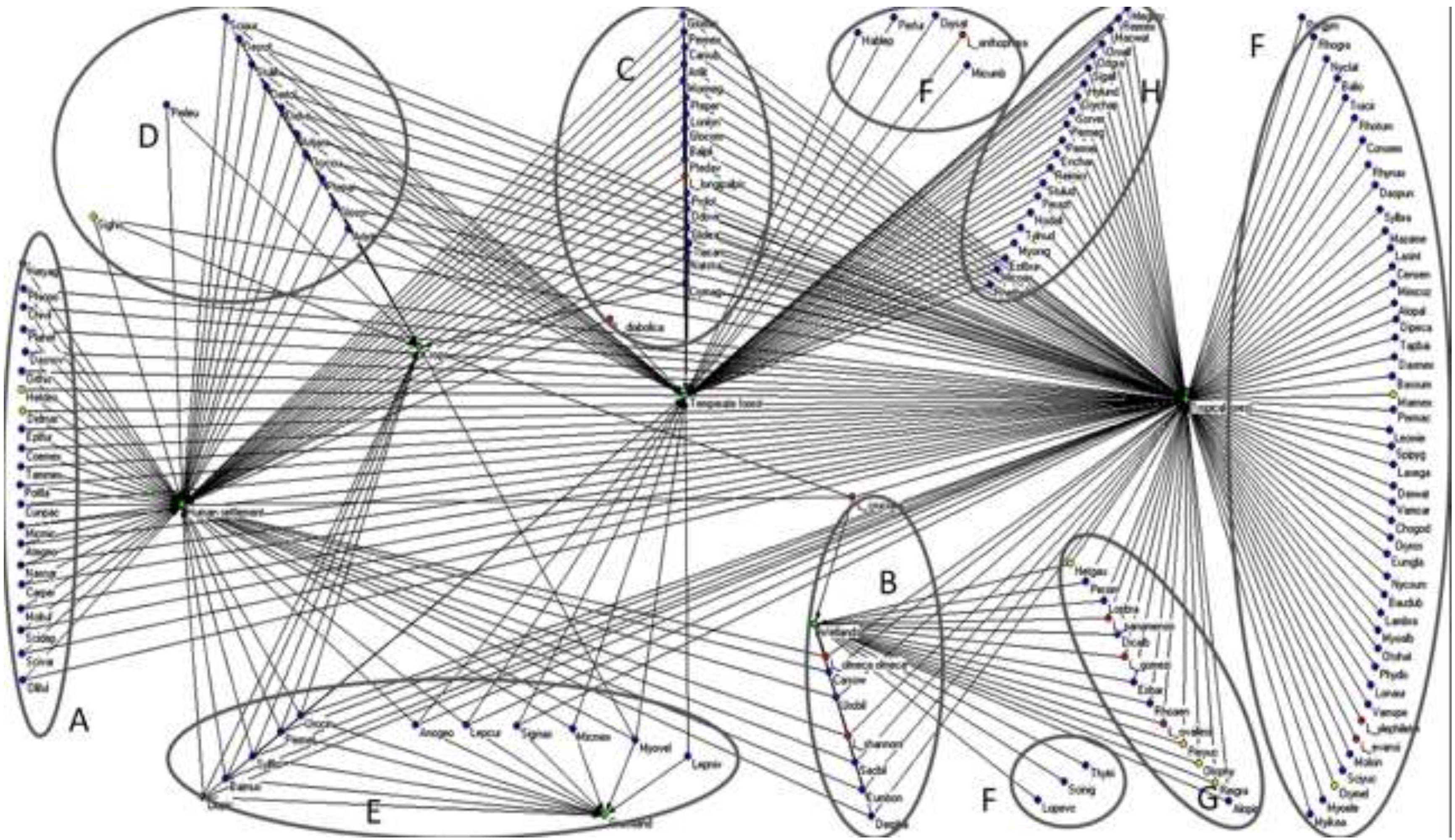
C. Gonzalez

Drilling down evern further…
Risk map for Villahermosa

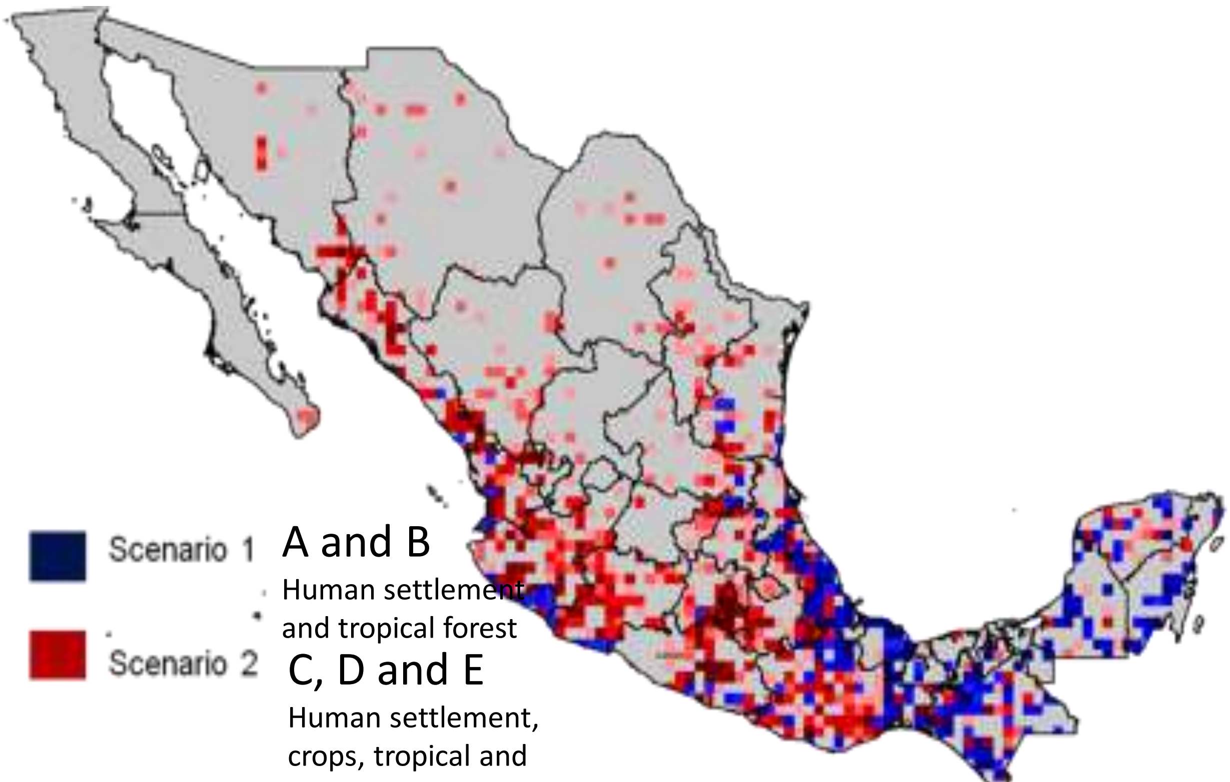


M. Hidalgo
C. Ibarra

Making the Network more complex: Potential patterns of dispersal



Generating dispersal scenarios



A and B

Human settlement and tropical forest

C, D and E

Human settlement, crops, tropical and temperate forest

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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
  - Phenomenological versus “fundamental” models