Redes Complejas Ecológicas

Integrando las interacciones en los modelos de nicho (Minería de datos)

M. en C. Constantino González Salazar

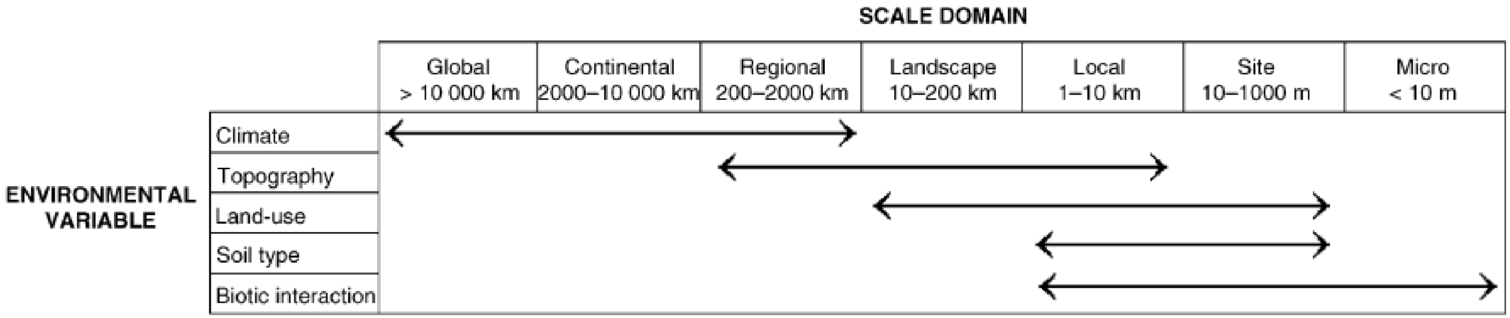

Fig. 5 Schematic example of how different factors may affect the distribution of species across varying spatial scales. Characteristic 'scale domains' are proposed within which certain variables can be identified as having a dominant control over species distributions. Approximate spatial extents have been assigned to categories of scale based in part on Willis & Whittaker (2002). It is assumed that large spatial extents are associated with coarse data resolutions, and small extents with fine data resolutions.

Macroecological signals of species interactions in the Danish avifauna

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ECOLOGY LETTERS

Ecology Letters, (2012) doi: 10.1111/ele.12043

LETTER

Species interactions constrain geographic range expansion over evolutionary time

Ecography 35: 001–010, 20
doi: 10.1111/j.1600-0587.2011.0710

Subject Editor: Miguel Araujo. Accepted 7 November 20

How do species interactions affect species distribution models?

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One of the most promising recent advances in biogeography has been the increased interest and understanding of species distribution models – estimates of the probability that a species is present given environmental data. Unfortunately, such analyses ignore many aspects of ecology, and so are difficult to interpret. In particular, we know that species interactions have a profound influence on distributions, but it is not usually possible to incorporate this knowledge into species distribution models. What is needed is a rigorous understanding of how unmeasured biotic interactions affect the inferences generated by species distribution models. To fill this gap, we develop a general mathematical approach that uses probability theory to determine how unmeasured biotic interactions affect inferences from species distribution models. Using this approach, we reanalyze one of the most important classes of mechanistic models of competition: models of consumer resource dynamics. We determine how measurements of one aspect of the environment – a single environmental variable – can be used to estimate the probability that an environment is suitable with species distribution models. We show that species distribution models, which ignore numerous facets of consumer resource dynamics such as the presence of a competitor or the dynamics of depletable resources, can furnish useful predictions for the probability that an environment is suitable in some circumstances. These results provide a rigorous link between complex mechanistic models of species interactions and species distribution models. In so doing they demonstrate that unmeasured biotic interactions can have strong and counterintuitive consequences on species distribution models.

BIOLOGICAL REVIEWS

Cambridge Philosophical Society

Biol. Rev. (2012), pp. 000–000.
doi: 10.1111/j.1469-185X.2012.00235.x

The role of biotic interactions in shaping distributions and realised assemblages of species: implications for species distribution modelling

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Journal of Biogeography (*J. Biogeogr.*) (2011)

SPECIAL ISSUE

Towards novel approaches to modelling biotic interactions in multispecies assemblages at large spatial extents

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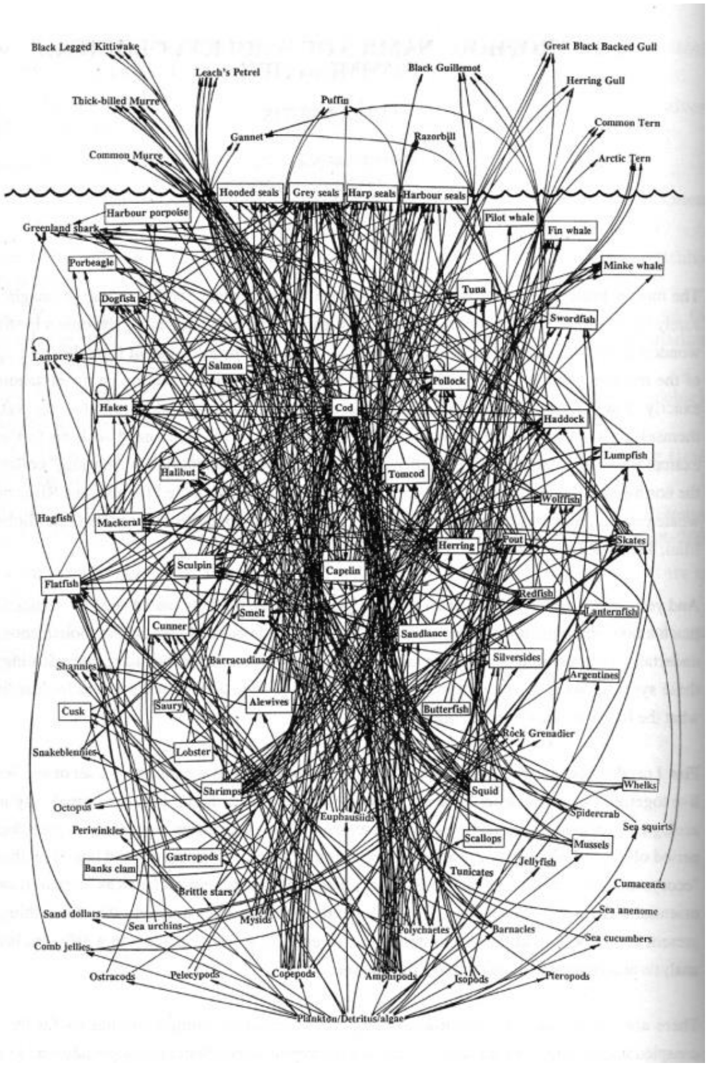
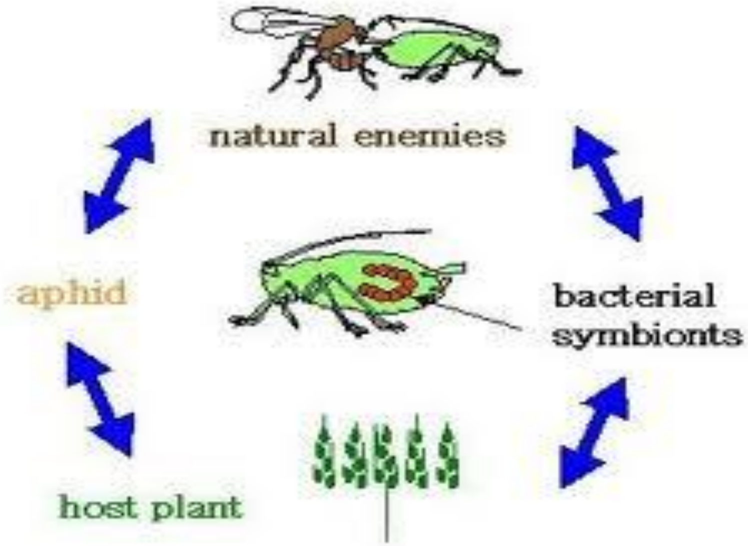
ABSTRACT

Aim Biotic interactions – within guilds or across trophic levels – have widely been ignored in species distribution models (SDMs). This synthesis outlines the development of 'species interaction distribution models' (SIDMs), which aim to incorporate multispecies interactions at large spatial extents using interaction matrices.

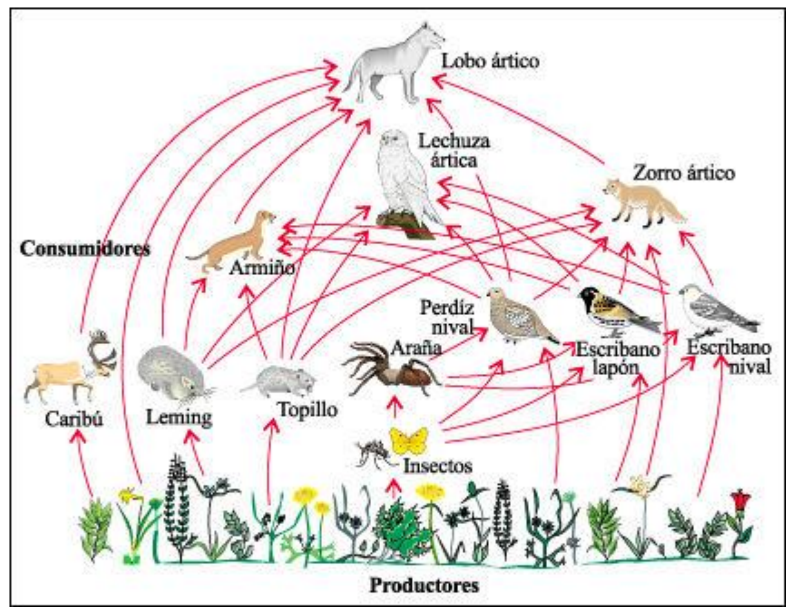
Location Local to global.



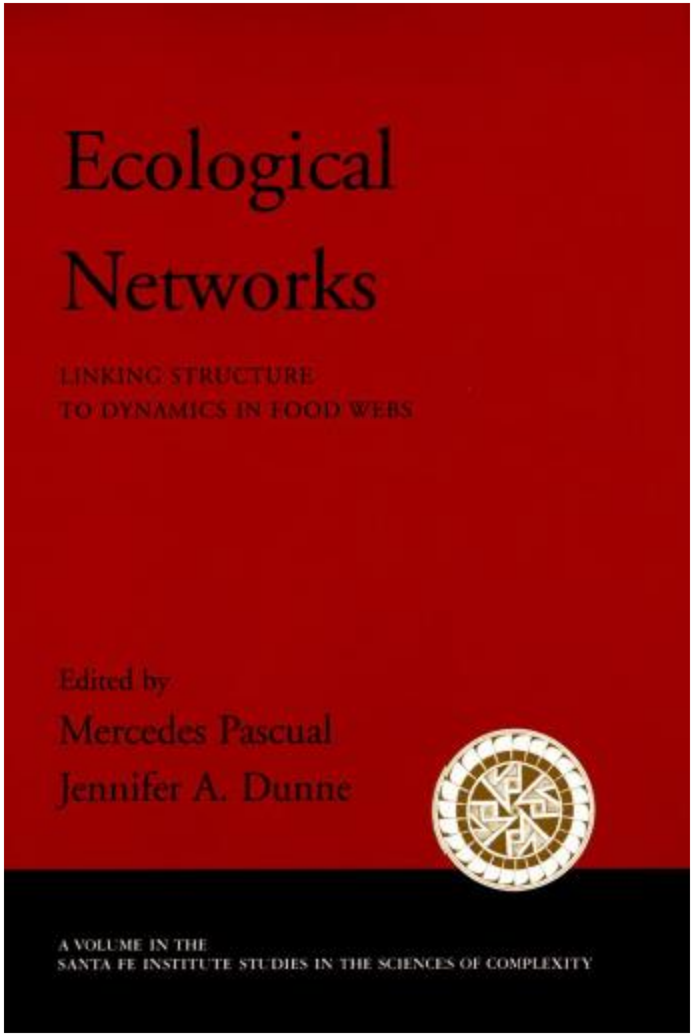
Black Legged Kittiwake
Great Black Backed Gull
Leach's Petrel
Black Guillemot
Herring Gull
Thick-billed Murre
Puffin
Common Tern
Gannet
Razorbill
Common Murre
Arctic Tern
Hooded seals
Grey seals
Harp seals
Harbour seals
Harbour porpoise
Greenland shark
Pilot whale
Fin whale
Porbeagle
Minke whale
Dogfish
Tuna
Swordfish
Lamprey
Salmon
Pollock
Hakes
Cod
Haddock
Lumpfish
Halibut
Tomcod
Wolffish
Hagfish
Mackerel
Herring
Pout
Skates
Sculpin
Capelin
Flatfish
Redfish
Smelt
Lanternfish
Cunner
Sandlance
Barracudina
Silversides
Shannies
Argentines
Cusk
Saury
Alewives
Butterfish
Rock Grenadier
Snakeblennies
Lobster
Whelks
Shrimps
Squid
Octopus
Spidercrab
Euphausiids
Sea squirts
Periwinkles
Scallops
Mussels
Gastropods
Jellyfish
Banks clam
Tunicates
Cumaceans
Brittle stars
Sea anemone
Sand dollars
Mysids
Sea urchins
Polychaetes
Barnacles
Sea cucumbers
Comb jellies
Ostracods
Pelecypods
Copepods
Amphipods
Isopods
Pteropods
Plankton/Detritus/algae



natural enemies
aphid
bacterial symbionts
host plant



Lobo ártico
Lechuza ártica
Zorro ártico
Consumidores
Armiño
Perdíz nival
Araña
Escribano lapón
Escribano nival
Caribú
Leming
Topillo
Insectos
Productores



insight review articles

Exploring complex networks

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The study of networks pervades all of science, from neurobiology to statistical physics. The most basic issues are structural: how does one characterize the wiring diagram of a food web or the Internet or the metabolic network of the bacterium *Escherichia coli*? Are there any unifying principles underlying their topology? From the perspective of nonlinear dynamics, we would also like to understand how an enormous network of interacting dynamical systems — be they neurons, power stations or lasers — will behave collectively, given their individual dynamics and coupling architecture. Researchers are only now beginning to unravel the structure and dynamics of complex networks.

Networks are on our minds nowadays. Sometimes we fear their power — and with good reason. On 10 August 1996, a fault in two power lines in Oregon led, through a cascading series of failures, to blackouts in 11 US states and two Canadian provinces, leaving about 7 million customers without power for up to 16 hours[1]. The Love Bug worm, the worst computer attack to date, spread over the Internet on 4 May 2000 and inflicted billions of dollars of damage worldwide.

In our lighter moments we play parlour games about connectivity. 'Six degrees of Marlon Brando' broke out as a nationwide fad in Germany, as readers of *Die Zeit* tried to connect a falafel vendor in Berlin with his favourite actor through the shortest possible chain of acquaintances[2]. And during the height of the Lewinsky scandal, the *New York Times* printed a diagram[3] of the famous people within 'six degrees of Monica'.

Meanwhile scientists have been thinking about networks too. Empirical studies have shed light on the topology of food webs[4,5], electrical power grids, cellular and metabolic networks[6–7], the World-Wide Web[10], the Internet backbone[11], the neural network of the nematode worm *Caenorhabditis elegans*[12], telephone call graphs[13], coauthorship and citation networks of scientists[14–16], and the quintessential 'old-boy' network, the overlapping boards of directors of the largest companies in the United States[17] (Fig. 1). These databases are now easily accessible, courtesy of the Internet. Moreover, the availability of powerful computers has made it feasible to probe their structure; until recently, computations involving million-node networks would have been impossible without specialized facilities.

Why is network anatomy so important to characterize? Because structure always affects function. For instance, the topology of social networks affects the spread of information and disease, and the topology of the power grid affects the robustness and stability of power transmission.

From this perspective, the current interest in networks is part of a broader movement towards research on complex systems. In the words of E. O. Wilson[18], "The greatest challenge today, not just in cell biology and ecology but in all of science, is the accurate and complete description of complex systems. Scientists have broken down many kinds of systems. They think they know most of the elements and forces. The next task is to reassemble them, at least in mathematical models that capture the key properties of the entire ensembles."

But networks are inherently difficult to understand, as the following list of possible complications illustrates.

1. Structural complexity: the wiring diagram could be an intricate tangle (Fig. 1).
2. Network evolution: the wiring diagram could change over time. On the World-Wide Web, pages and links are created and lost every minute.
3. Connection diversity: the links between nodes could have different weights, directions and signs. Synapses in

Box 1
Nonlinear dynamics: terminology and concepts[97]

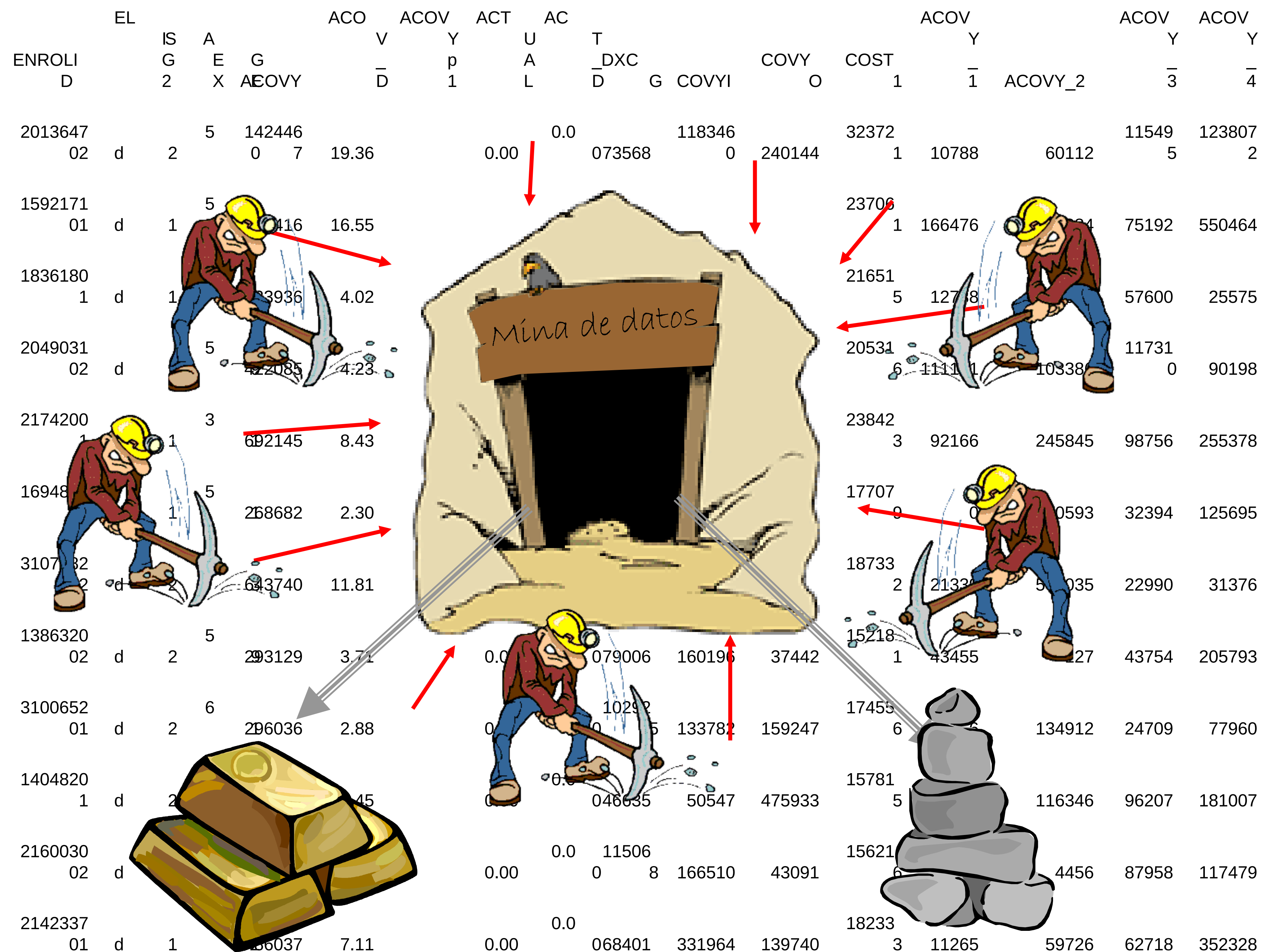
Dynamical systems can often be modelled by differential equations $d\mathbf{x}/dt = \mathbf{v}(\mathbf{x})$, where $\mathbf{x}(t) = (x_1(t), ..., x_n(t))$ is a vector of state variables, t is time, and $\mathbf{v}(\mathbf{x}) = (v_1(\mathbf{x}), ..., v_n(\mathbf{x}))$ is a vector of functions that encode the dynamics. For example, in a chemical reaction, the state variables represent concentrations. The differential equations represent the kinetic rate laws, which usually involve nonlinear functions of the concentrations.

Such nonlinear equations are typically impossible to solve analytically, but one can gain qualitative insight by imagining an abstract n-dimensional state space with axes $x_1, ..., x_n$. As the system evolves, $\mathbf{x}(t)$ flows through state space, guided by the 'velocity' field $d\mathbf{x}/dt = \mathbf{v}(\mathbf{x})$ like a speck carried along in a steady, viscous fluid.

Suppose $\mathbf{x}(t)$ eventually comes to rest at some point $\mathbf{x}^*$. Then the velocity must be zero there, so we call $\mathbf{x}^*$ a fixed point. It corresponds to an equilibrium state of the physical system being modelled. If all small disturbances away from $\mathbf{x}^*$ damp out, $\mathbf{x}^*$ is called a stable fixed point — it acts as an attractor for states in its vicinity.

Another long-term possibility is that $\mathbf{x}(t)$ flows towards a closed loop and eventually circulates around it forever. Such a loop is called a limit cycle. It represents a self-sustained oscillation of the physical system.

A third possibility is that $\mathbf{x}(t)$ might settle onto a strange attractor, a set of states on which it wanders forever, never stopping or repeating. Such erratic, aperiodic motion is considered chaotic if two nearby states flow away from each other exponentially fast. Long-term prediction is impossible in a real chaotic system because of this exponential amplification of small uncertainties or measurement errors.


Mína de datos

¿Qué es minería de datos?

"…la exploración y análisis de datos para descubrir patrones, correlaciones y otras *asociaciones*"

OPEN ACCESS Freely available online

PLoS one

Using Biotic Interaction Networks for Prediction in Biodiversity and Emerging Diseases

Christopher R. Stephens[1,2]*, Joaquín Giménez Heau[1,3], Camila González[1,3], Carlos N. Ibarra-Cerdeña[1,3], Victor Sánchez-Cordero[1,3], Constantino González-Salazar[1,3]

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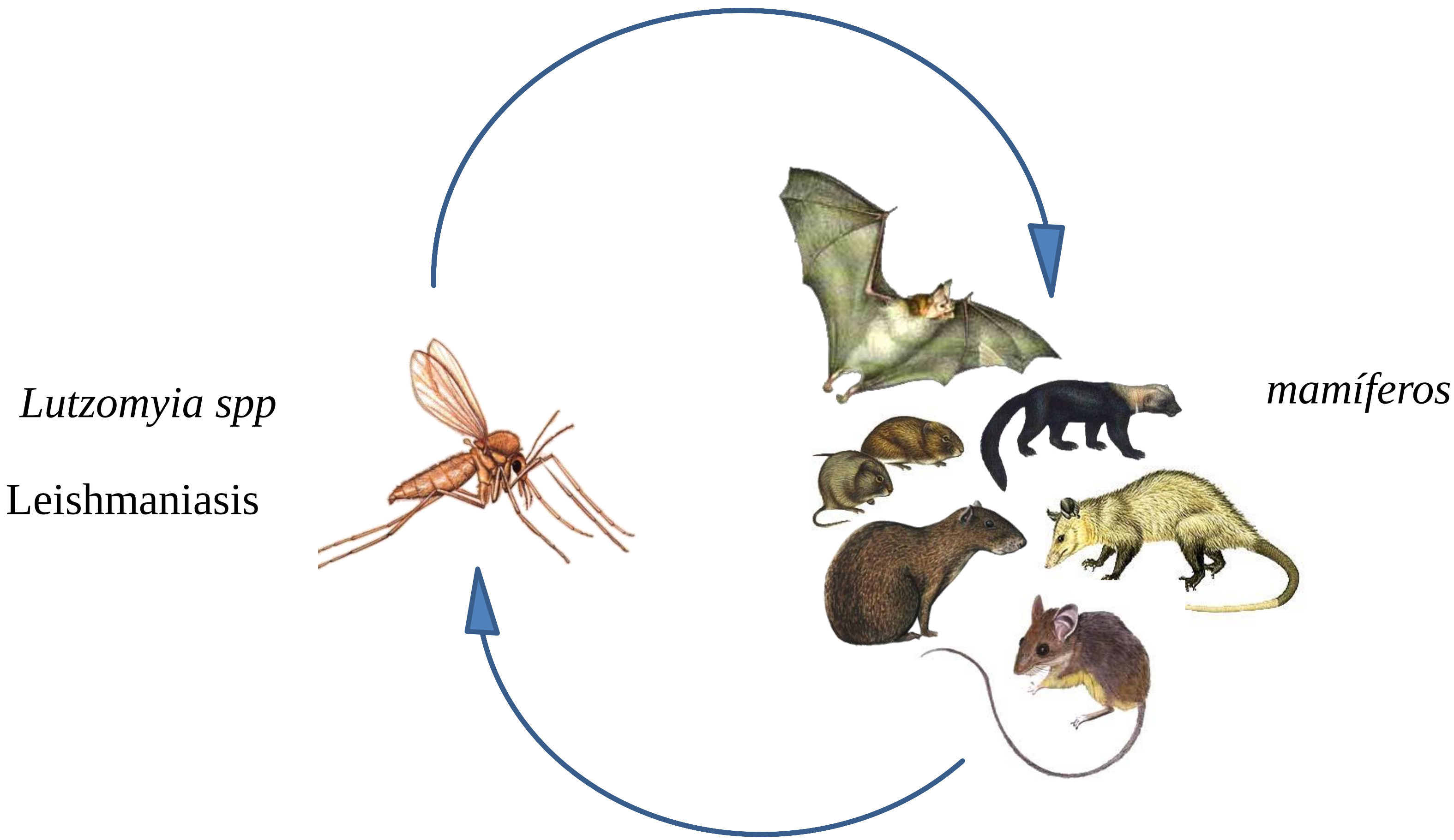
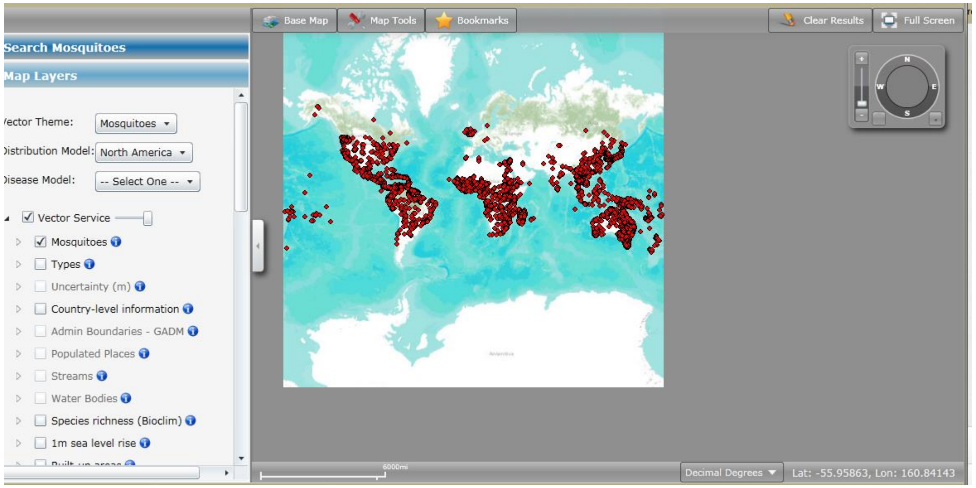


Datos de colectas de mamíferos

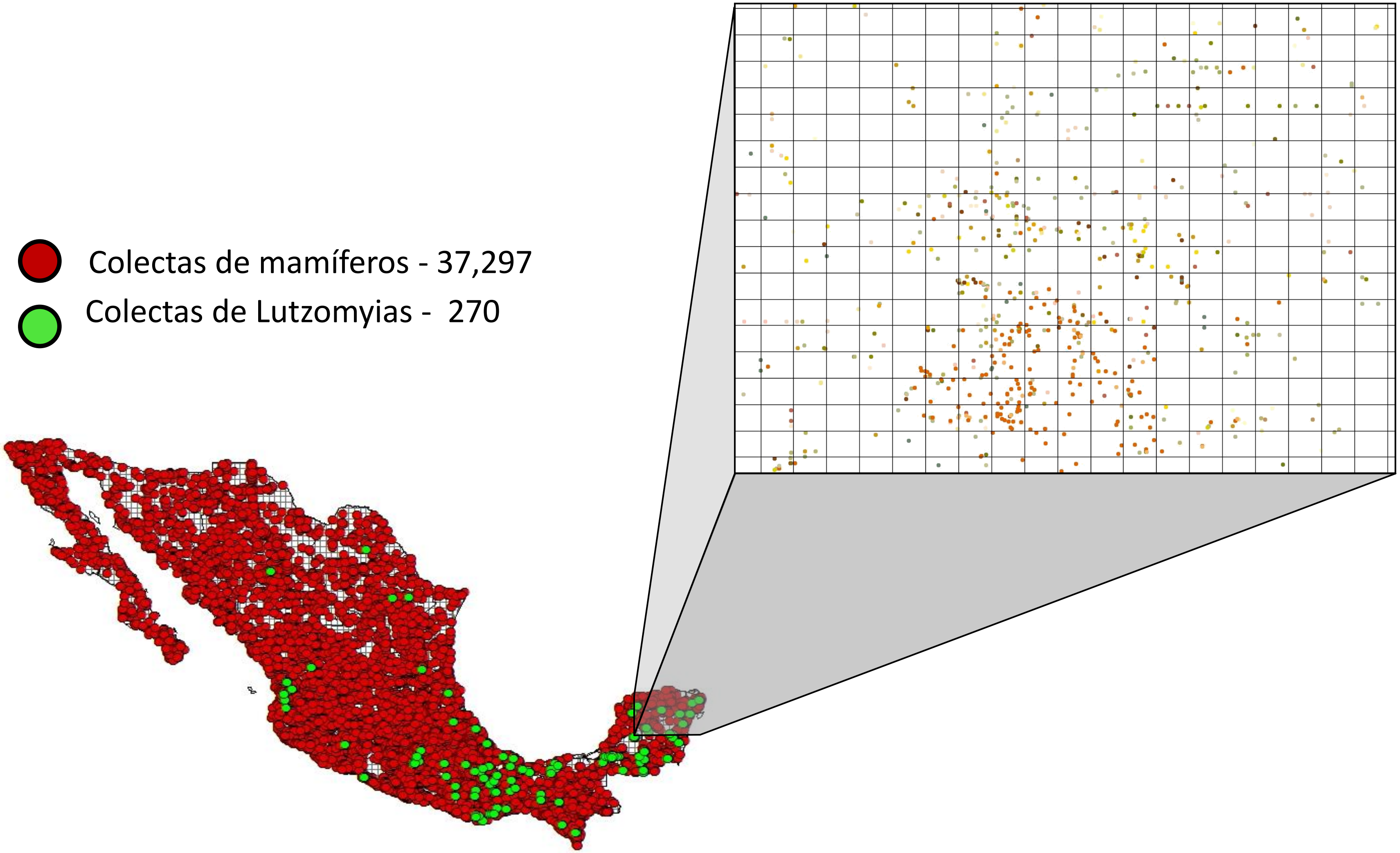
Datos de colectas de vectores



Co-ocurrencias como un proxy para inferir interacciones bióticas

Colectas de mamíferos - 37,297

Colectas de Lutzomyias - 270



Determinando los factores principales

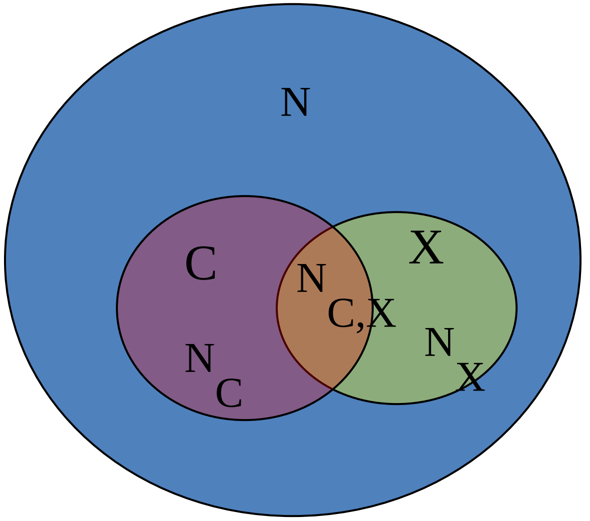
Classifier

Null hypothesis

$$\varepsilon = \frac{N_X(P(C|\mathbf{X}) - P(C))}{(N_X P(C)(1 - P(C)))^{1/2}}$$

"Signal"

"Noise"

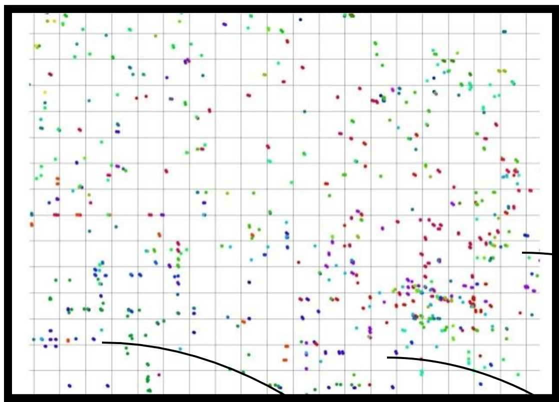


$P(\,C \mid X\,) = N_{C,X} / N_X$

$P(\,C\,) = N_C / N$

ej. X es un vector, C es el reservorio - $N_{C,X}$ es el número de cuadrantes donde coexisten, N_c es el número de cuadrantes donde hay reservorio y N_X es el número de cuadrantes donde hay vector.

$\varepsilon > 2$ implica una fuerte correlación positiva entre el vector y reservorio



Vector	Potential reservoir	Cells with Co-occurrences	Vector cells	Reservoir cells	Epsilon
L_cruciata	Rhogeessa aeneus	6	102	19	7.22
L_cruciata	Conepatus semistriatus	6	102	20	7.00
L_cruciata	Cryptotis magna	4	102	10	6.79
L_cruciata	Dermanura phaeotis	18	102	142	6.66
L_cruciata	Peromyscus melanocarpus	4	102	11	6.42
L_cruciata	Microtus umbrosus	2	102	3	6.40
L_cruciata	Carollia perspicillata	12	102	78	6.32
L_cruciata	Carollia sowelli	9	102	48	6.32
L_cruciata	Heteromys desmarestianus	9	102	49	6.23
L_cruciata	Eira barbara	7	102	32	6.18
L_cruciata	Sorex veraepacis	4	102	12	6.09
L_cruciata	Dasyprocta punctata	6	102	25	6.08
L_cruciata	Reithrodontomys gracilis	7	102	33	6.06
L_cruciata	Dasyprocta mexicana	4	102	13	5.80
L_cruciata	Heteromys gaumeri	10	102	65	5.77
L_cruciata	Thomomys umbrinus	1	102	203	-2.12
L_cruciata	Baiomys taylori	1	102	220	-2.24
L_cruciata	Peromyscus maniculatus	2	102	348	-2.69

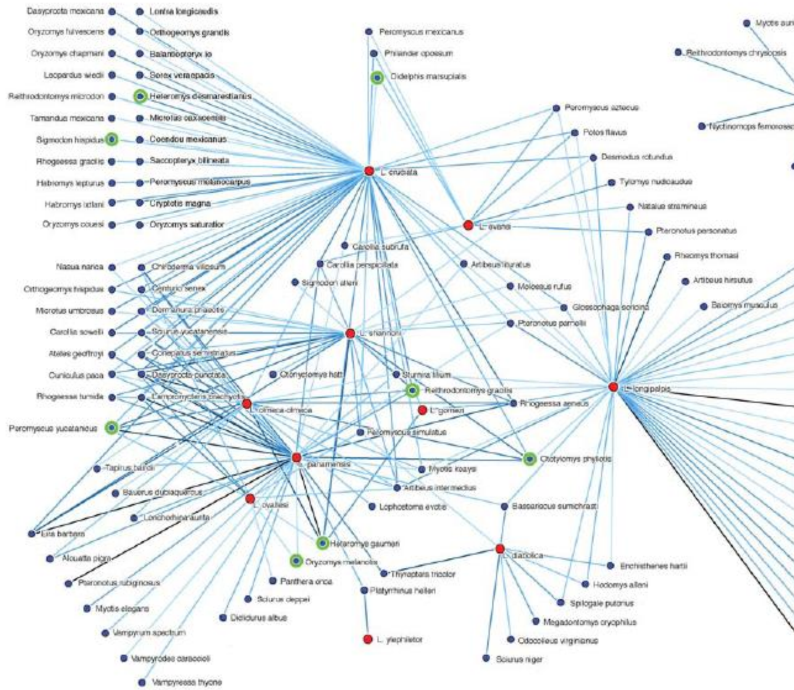
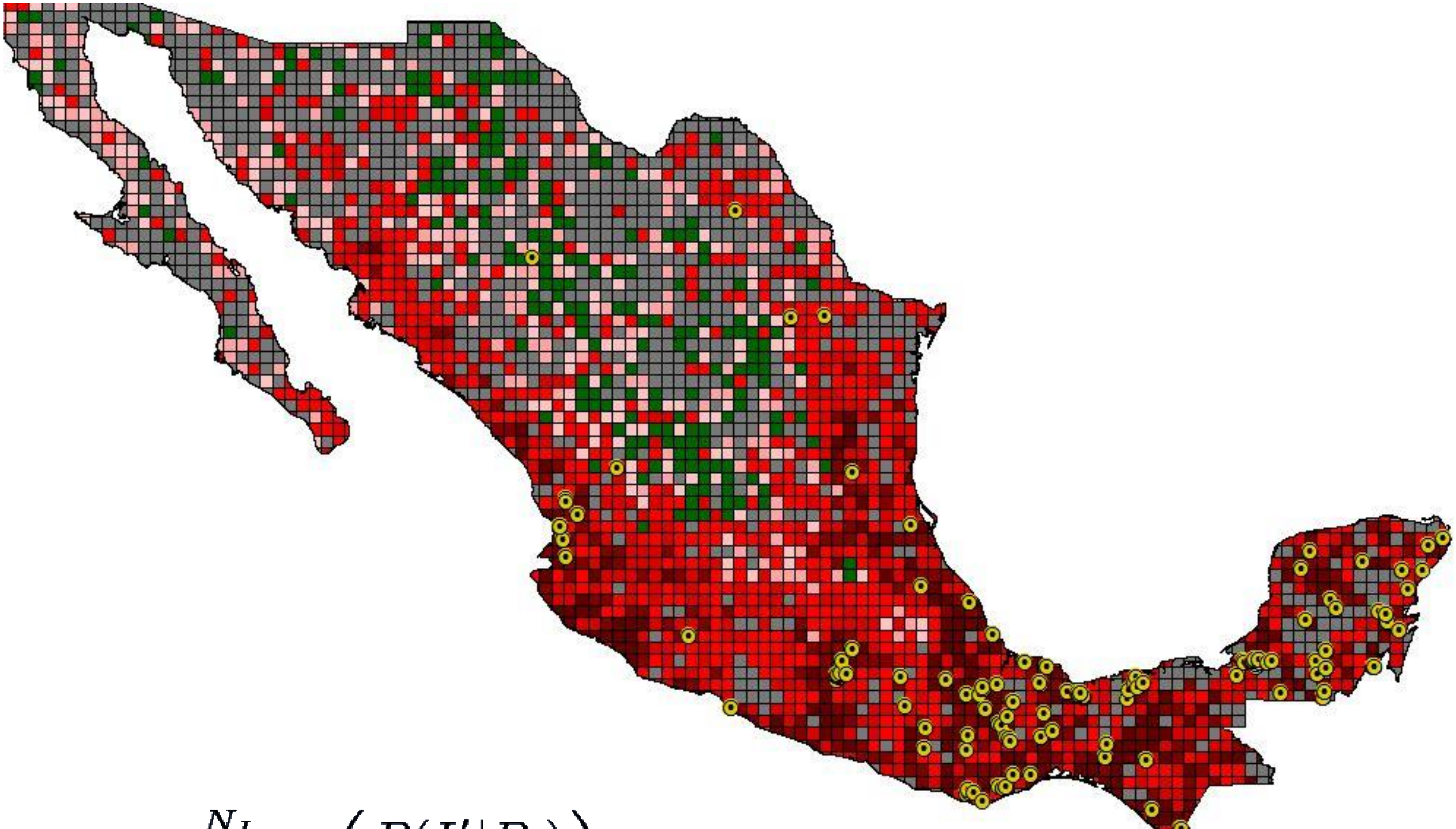


Figure 1. Interaction network between potential and confirmed vectors and reservoirs for *Leishmania* in Me
confirmed as reservoirs for *Leishmania mexicana*, responsible for the cutaneous form of the disease are marked with a dou
Didelphis marsupialis is the known sylvatic reservoir for the visceral form.
doi:10.1371/journal.pone.0005725.g001

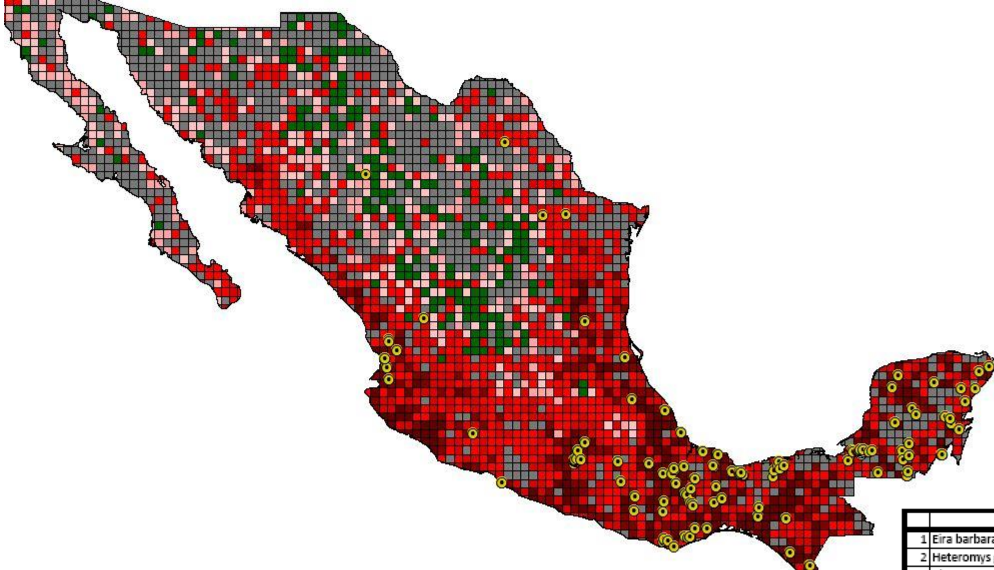
	Mammals	Epsilon	Conf.
1	Eira barbara	8.0256	
2	Heteromys gaumeri	7.3806	YES
3	Rhogeessa aeneus	7.2139	
4	Dasyprocta punctata	7.1071	
5	Peromyscus mexicanus	6.8456	
6	Reithrodontomys gracilis	6.8283	
7	Heteromys desmarestianus	6.7385	
8	Orthogeomys hispidus	6.6434	
9	Carollia sowelli	6.6423	
10	Dermanura phaeotis	6.5812	
11	Dasyprocta mexicana	6.4628	
12	Carollia perspicillata	6.4421	
13	Molossus ater	6.2416	
14	Artibeus intermedius	6.2252	
15	Conepatus semistriatus	6.0551	
16	Micronycteris brachyotis	5.8553	
17	Glossophaga soricina	5.7809	
18	Carollia brevicauda	5.7534	
19	Ateles geoffroyi	5.7310	
20	Glossophaga morenoi	5.7310	
21	Microtus umbrosus	5.6363	
22	Thyroptera tricolor	5.6363	
23	Potos flavus	5.6220	
24	Peromyscus melanocarpus	5.5843	
25	Peromyscus yucatanicus	5.4991	YES
26	Pteronotus parnellii	5.4433	
27	Oryzomys couesi	5.3761	
28	Sturnira lilium	5.2763	
29	Desmodus rotundus	5.2550	
30	Sigmodon hispidus	5.1338	YES
31	Habromys ixtlani	4.9816	
32	Microtus waterhousii	4.9816	
33	Pteronotus rubiginosus	4.9816	
34	Artibeus watsoni	4.9816	
35	Balantiopteryx balantiopteryx	4.9816	
36	Ototylomys phyllotis	4.9569	YES
37	Nasua narica	4.9294	
38	Megadontomys cryophilus	4.9289	
39	Cuniculus paca	4.8416	
40	Chiroderma villosum	4.7304	
41	Oryzomys chapmani	4.6930	
42	Didelphis marsupialis	4.6508	YES
43	Philander opossum	4.6294	
44	Habromys lepturus	4.5801	
45	Coendou mexicanus	4.5175	
46	Molossus sinaloae	4.4670	
47	Orthogeomys grandis	4.4437	
48	Oryzomys alfaroi	4.4041	
49	Didelphis virginiana	4.3131	
50	Peromyscus aztecus	4.2975	
51	Myotis keaysi	4.2596	
52	Macrotus mexicanus	4.1863	
53	Sciurus yucatanensis	4.1373	
54	Alouatta palliata	4.0343	
55	Reithrodontomys microdon	4.0343	
56	Cryptotis magna	4.0218	
57	Otonyctomys hatti	4.0218	
58	Tylomys nudicaudus	3.9872	
59	Rhogeessa tumida	3.9779	
60	Artibeus lituratus	3.9776	
61	Mormoops megalophylla	3.9317	
62	Choeroniscus godmani	3.8806	
63	Peropteryx macrotis	3.8806	
64	Artibeus jamaicensis	3.7936	
65	Centurio senex	3.7933	
66	Sorex veraepacis	3.7926	
67	Oryzomys rostratus	3.7926	
68	Tamandua mexicana	3.6461	
69	Saccopteryx bilineata	3.6413	
70	Pteronotus personatus	3.6300	
71	Sylvilagus brasiliensis	3.5882	
72	Pteronotus davyi	3.4724	
73	Baiomys musculus	3.4138	
74	Peromyscus simulatus	3.4040	
75	Rhogeessa gracilis	3.4040	
76	Bassariscus sumichrasti	3.3864	
77	Leptonycteris sanborni	3.3864	
78	Glossophaga mexicana	3.3864	
79	Oryzomys fulvescens	3.3864	
80	Rheomys thomasi	3.3806	
81	Heteromys goldmani	3.3806	
82	Molossus rufus	3.3806	
83	Sigmodon orizonae	3.3806	
84	Mimon cozumelae	3.3596	
85	Glossophaga leachii	3.3235	
86	Herpailurus yagouaroundi	3.2893	
87	Sciurus aureogaster	3.2661	
88	Lontra longicaudis	3.2487	
89	Mazama americana	3.2367	
90	Balantiopteryx io	3.2367	
91	Hodomys alleni	3.2231	
92	Myotis elegans	3.1422	
93	Diphylla ecaudata	3.0973	
94	Micronycteris megalotis	3.0973	
95	Nyctinomops laticaudatus	3.0838	
96	Sciurus deppei	3.0690	
97	Sigmodon alleni	3.0368	
98	Uroderma bilobatum	3.0368	
99	Oryzomys melanotis	3.0265	YES
100	Odocoileus virginianus	2.8956	
101	Enchisthenes hartii	2.8527	
102	Chrotopterus auritus	2.8527	
103	Vampyrodes caraccioli	2.8527	
104	Natalus stramineus	2.7998	
105	Oligoryzomys fulvescens	2.7104	
106	Microtus oaxacensis	2.6443	
107	Sciurus variegatoides	2.6443	
108	Eumops bonariensis	2.6443	
109	Artibeus cinereus	2.6443	
110	Artibeus glaucus	2.6443	
111	Oryzomys saturatior	2.6443	
112	Peromyscus gymnotis	2.6428	
113	Lasiurus ega	2.6137	
114	Sturnira ludovici	2.6137	
115	Phyllostomus discolor	2.5787	
116	Eptesicus furinalis	2.5540	
117	Lonchorhina aurita	2.4727	
118	Platyrrhinus helleri	2.4727	
119	Tlacuatzin canescens	2.4657	
120	Agouti paca	2.4593	
121	Leopardus wiedii	2.4590	
122	Carollia subrufa	2.3346	
123	Balantiopteryx plicata	2.3309	
124	Peromyscus megalops	2.1901	
125	Myotis albescens	2.1897	
126	Eptesicus brasiliensis	2.1897	
127	Tonatia evotis	2.1897	
128	Sphiggurus mexicanus	2.1897	
129	Vampyrum spectrum	2.1897	
130	Tapirus bairdii	2.1897	
131	Tamandua tetradactyla	2.1897	
132	Glossophaga commissarisi	2.1694	
133	Eumops glaucinus	2.1509	
134	Mimon bennettii	2.1509	
135	Artibeus phaeotis	2.0657	
136	Peromyscus leucopus	2.0534	
137	Reithrodontomys mexicanus	2.0510	
138	Lasiurus intermedius	2.0502	
139	Sigmodon mascotensis	1.9987	
140	Rhynchonycteris naso	1.9489	
141	Marmosa mexicana	1.9489	
142	Hylonycteris underwoodi	1.8977	
143	Peromyscus furvus	1.8759	
144	Pappogeomys merriami	1.8687	
145	Tonatia brasiliense	1.8687	
146	Spilogale pygmaea	1.8687	
147	Molossus pretiosus	1.8687	
148	Diclidurus albus	1.8687	
149	Liomys pictus	1.8210	
150	Spilogale putorius	1.6746	

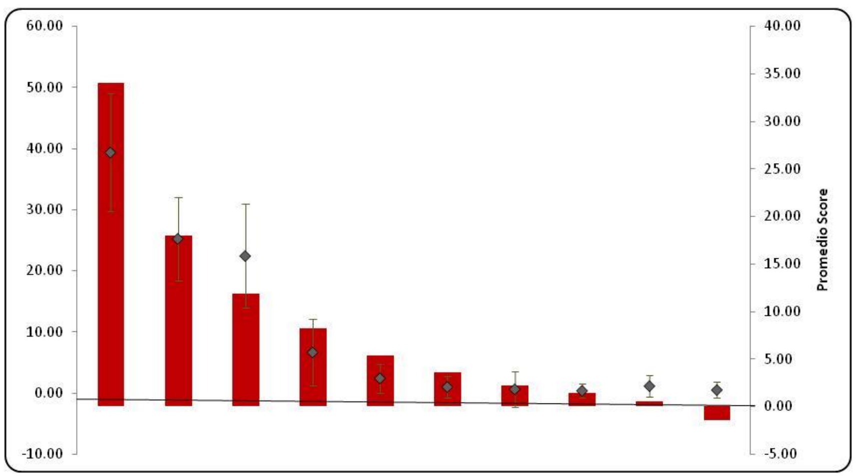
Construcción del modelo predictivo

Utilizando un función de score derivada de naive Bayes calculamos la contribución de una variable ***I*** a la presencia de una especie ***B***



$$S(B_i|\mathbf{I}') = \sum_{j=1}^{N_I} \ln \left(\frac{P(I'_j|B_i)}{P(I'_j|\bar{B}_i)} \right)$$

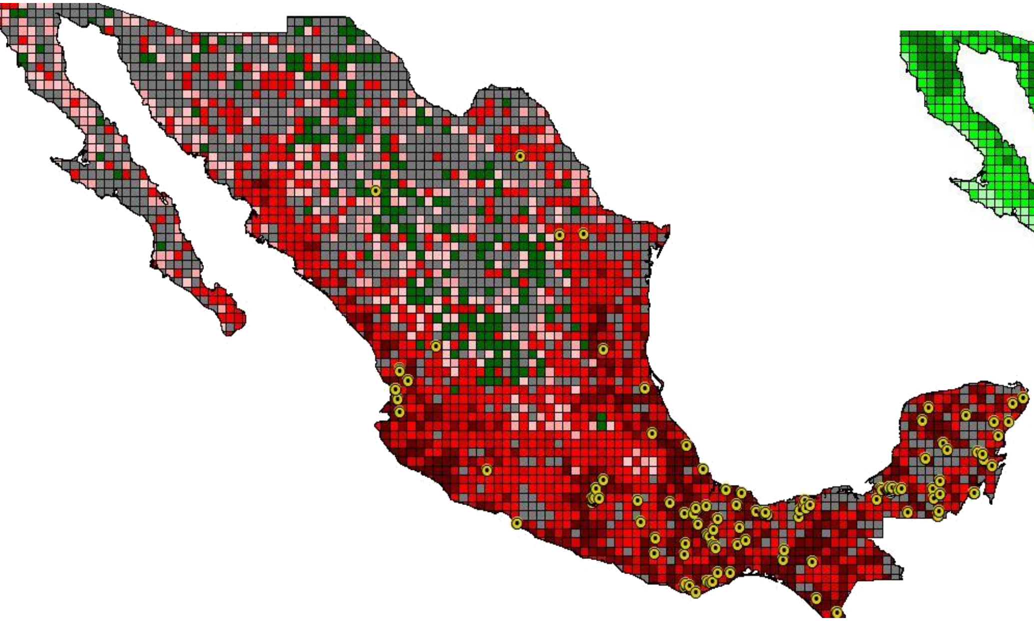


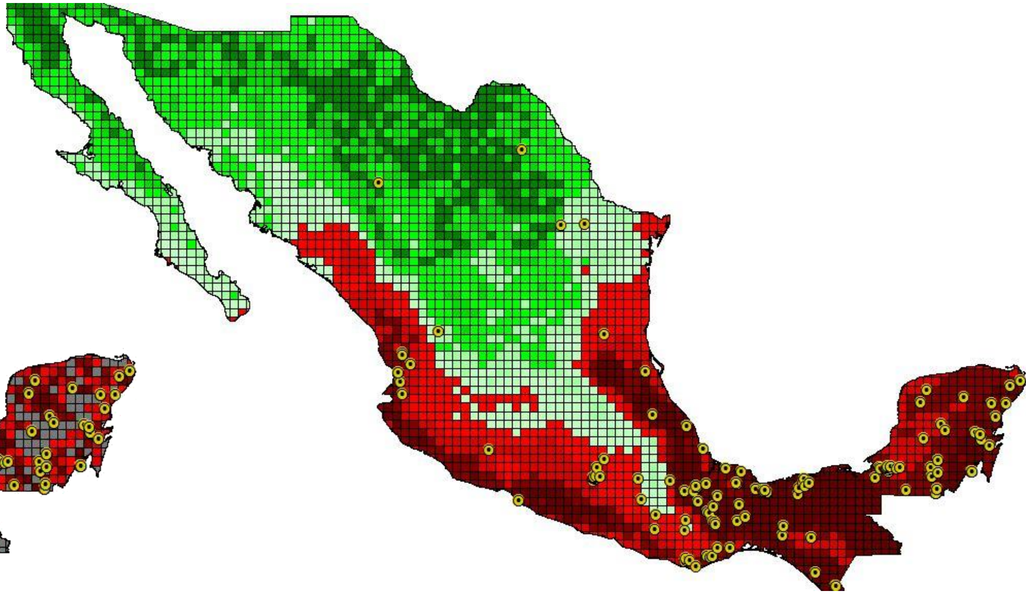


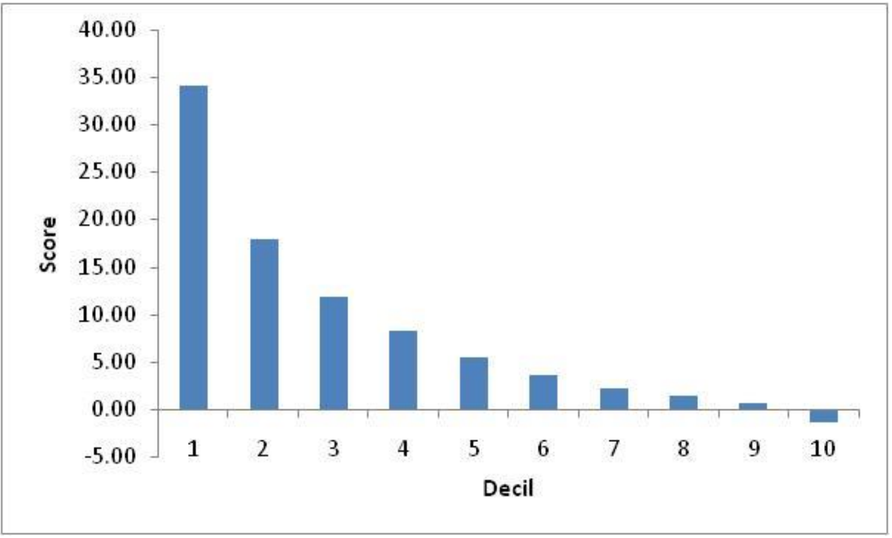
	Mammals	Epsilon	Conf.
1	Eira barbara	8.0256	
2	Heteromys gaumeri	7.3806	YES
3	Rhogeessa aeneus	7.2139	
4	Dasyprocta punctata	7.1071	
5	Peromyscus mexicanus	6.8456	
6	Reithrodontomys gracilis	6.8283	
7	Heteromys desmarestianus	6.7385	
8	Orthogeomys hispidus	6.6434	
9	Carollia sowelli	6.6423	
10	Dermanura phaeotis	6.5812	
11	Dasyprocta mexicana	6.4628	
12	Carollia perspicillata	6.4421	
13	Molossus ater	6.2416	
14	Artibeus intermedius	6.2252	
15	Conepatus semistriatus	6.0551	
16	Micronycteris brachyotis	5.8553	
17	Glossophaga soricina	5.7809	
18	Carollia brevicauda	5.7534	
19	Ateles geoffroyi	5.7310	
20	Glossophaga morenoi	5.7310	
21	Microtus umbrosus	5.6363	
22	Thyroptera tricolor	5.6363	
23	Potos flavus	5.6220	
24	Peromyscus melanocarpus	5.5843	
25	Peromyscus yucatanicus	5.4991	YES
26	Pteronotus parnellii	5.4433	
27	Oryzomys couesi	5.3761	
28	Sturnira lilium	5.2763	
29	Desmodus rotundus	5.2550	
30	Sigmodon hispidus	5.1338	YES
31	Habromys ixtlani	4.9816	
32	Microtus waterhousii	4.9816	
33	Pteronotus rubiginosus	4.9816	
34	Artibeus watsoni	4.9816	
35	Balantiopteryx balantiopteryx	4.9816	
36	Ototylomys phyllotis	4.9569	YES
37	Nasua narica	4.9294	
38	Megadontomys cryophilus	4.9289	
39	Cuniculus paca	4.8416	
40	Chiroderma villosum	4.7304	
41	Oryzomys chapmani	4.6930	
42	Didelphis marsupialis	4.6508	YES
43	Philander opossum	4.6294	
44	Habromys lepturus	4.5801	
45	Coendou mexicanus	4.5175	
46	Molossus sinaloae	4.4670	
47	Orthogeomys grandis	4.4437	
48	Oryzomys alfaroi	4.4041	
49	Didelphis virginiana	4.3131	
50	Peromyscus aztecus	4.2975	
51	Myotis keaysi	4.2596	
52	Macrotus mexicanus	4.1863	
53	Sciurus yucatanensis	4.1373	
54	Alouatta palliata	4.0343	
55	Reithrodontomys microdon	4.0343	
56	Cryptotis magna	4.0218	
57	Otonyctomys hatti	4.0218	
58	Tylomys nudicaudus	3.9872	
59	Rhogeessa tumida	3.9779	
60	Artibeus lituratus	3.9776	
61	Mormoops megalophylla	3.9317	
62	Choeroniscus godmani	3.8806	
63	Peropteryx macrotis	3.8806	
64	Artibeus jamaicensis	3.7936	
65	Centurio senex	3.7933	
66	Sorex veraepacis	3.7926	
67	Oryzomys rostratus	3.7926	
68	Tamandua mexicana	3.6461	
69	Saccopteryx bilineata	3.6413	
70	Pteronotus personatus	3.6300	
71	Sylvilagus brasiliensis	3.5882	
72	Pteronotus davyi	3.4724	
73	Baiomys musculus	3.4138	
74	Peromyscus simulatus	3.4040	
75	Rhogeessa gracilis	3.4040	
76	Bassariscus sumichrasti	3.3864	
77	Leptonycteris sanborni	3.3864	
78	Glossophaga mexicana	3.3864	
79	Oryzomys fulvescens	3.3864	
80	Rheomys thomasi	3.3806	
81	Heteromys goldmani	3.3806	
82	Molossus rufus	3.3806	
83	Sigmodon orizonae	3.3806	
84	Mimon cozumelae	3.3596	
85	Glossophaga leachii	3.3235	
86	Herpailurus yagouaroundi	3.2893	
87	Sciurus aureogaster	3.2661	
88	Lontra longicaudis	3.2487	
89	Mazama americana	3.2367	
90	Balantiopteryx io	3.2367	
91	Hodomys alleni	3.2231	
92	Myotis elegans	3.1422	
93	Diphylla ecaudata	3.0973	
94	Micronycteris megalotis	3.0973	
95	Nyctinomops laticaudatus	3.0838	
96	Sciurus deppei	3.0690	
97	Sigmodon alleni	3.0368	
98	Uroderma bilobatum	3.0368	
99	Oryzomys melanotis	3.0265	ES
100	Odocoileus virginianus	2.8956	
101	Enchisthenes hartii	2.8527	
102	Chrotopterus auritus	2.8527	
103	Vampyrodes caraccioli	2.8527	
104	Natalus stramineus	2.7998	
105	Oligoryzomys fulvescens	2.7104	
106	Microtus oaxacensis	2.6443	
107	Sciurus variegatoides	2.6443	
108	Eumops bonariensis	2.6443	
109	Artibeus cinereus	2.6443	
110	Artibeus glaucus	2.6443	
111	Oryzomys saturatior	2.6443	
112	Peromyscus gymnotis	2.6428	
113	Lasiurus ega	2.6137	
114	Sturnira ludovici	2.6137	
115	Phyllostomus discolor	2.5787	
116	Eptesicus furinalis	2.5540	
117	Lonchorhina aurita	2.4727	
118	Platyrrhinus helleri	2.4727	
119	Tlacuatzin canescens	2.4657	
120	Agouti paca	2.4593	
121	Leopardus wiedii	2.4590	
122	Carollia subrufa	2.3346	
123	Balantiopteryx plicata	2.3309	
124	Peromyscus megalops	2.1901	
125	Myotis albescens	2.1897	
126	Eptesicus brasiliensis	2.1897	
127	Tonatia evotis	2.1897	
128	Sphiggurus mexicanus	2.1897	
129	Vampyrum spectrum	2.1897	
130	Tapirus bairdii	2.1897	
131	Tamandua tetradactyla	2.1897	
132	Glossophaga commissarisi	2.1694	
133	Eumops glaucinus	2.1509	
134	Mimon bennettii	2.1509	
135	Artibeus phaeotis	2.0657	
136	Peromyscus leucopus	2.0534	
137	Reithrodontomys mexicanus	2.0510	
138	Lasiurus intermedius	2.0502	
139	Sigmodon mascotensis	1.9987	
140	Rhynchonycteris naso	1.9489	
141	Marmosa mexicana	1.9489	
142	Hylonycteris underwoodi	1.8977	
143	Peromyscus furvus	1.8759	
144	Pappogeomys merriami	1.8687	
145	Tonatia brasiliense	1.8687	
146	Spilogale pygmaea	1.8687	
147	Molossus pretiosus	1.8687	
148	Diclidurus albus	1.8687	
149	Liomys pictus	1.8210	
150	Spilogale putorius	1.6746	

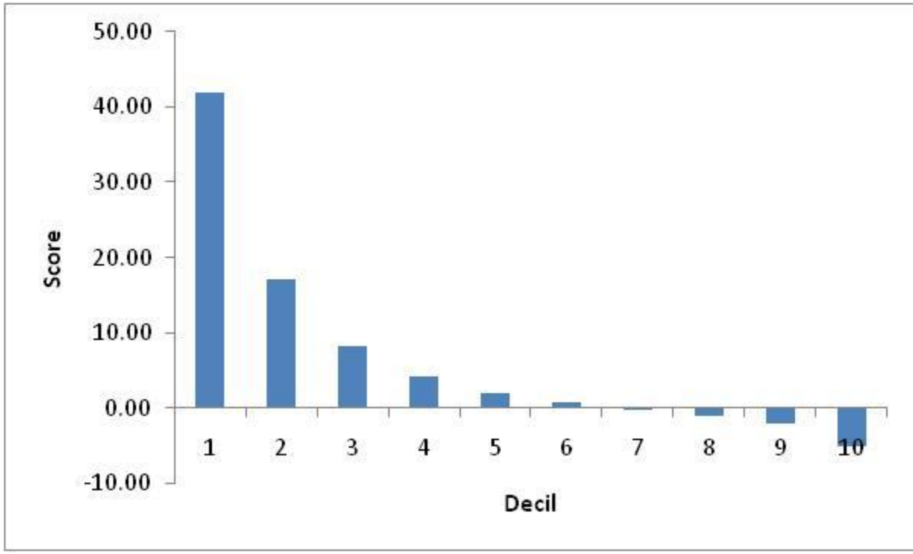
Mamíferos

Clima









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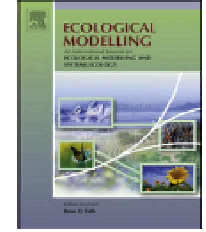
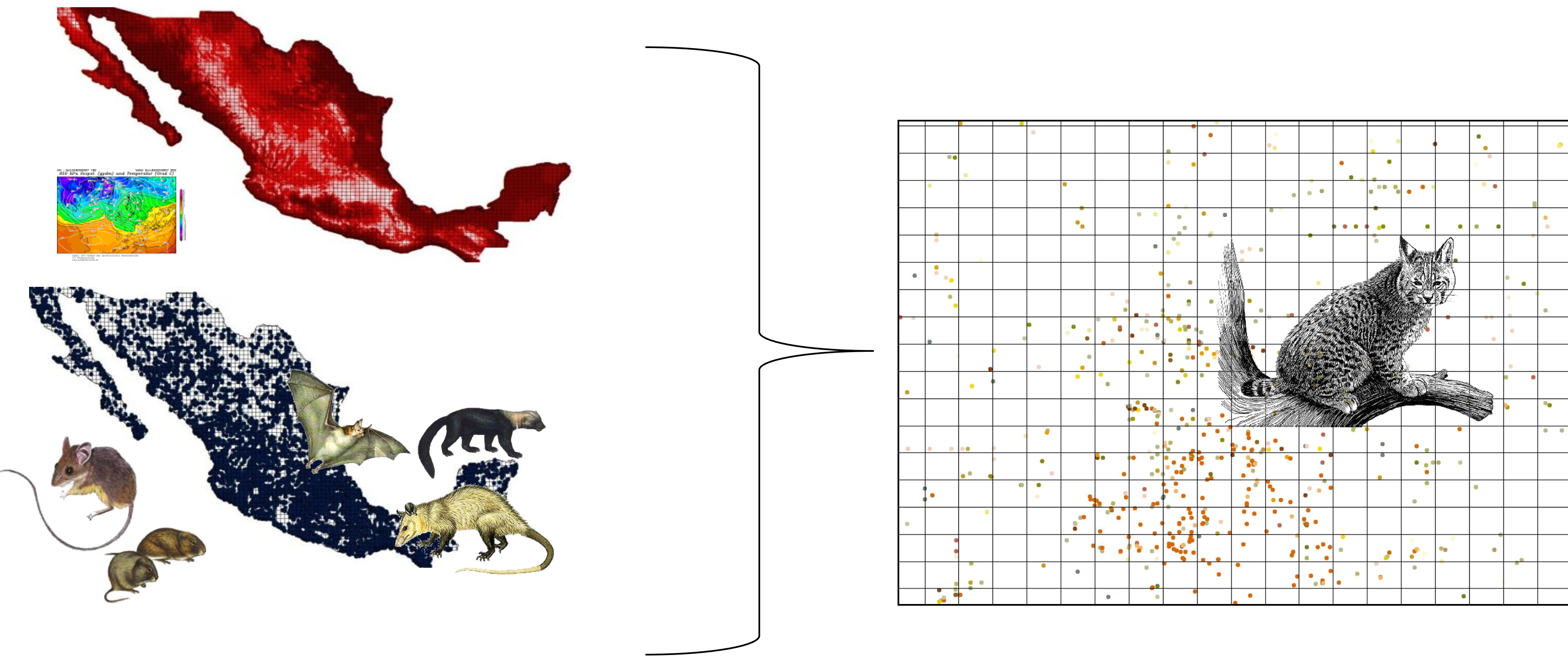
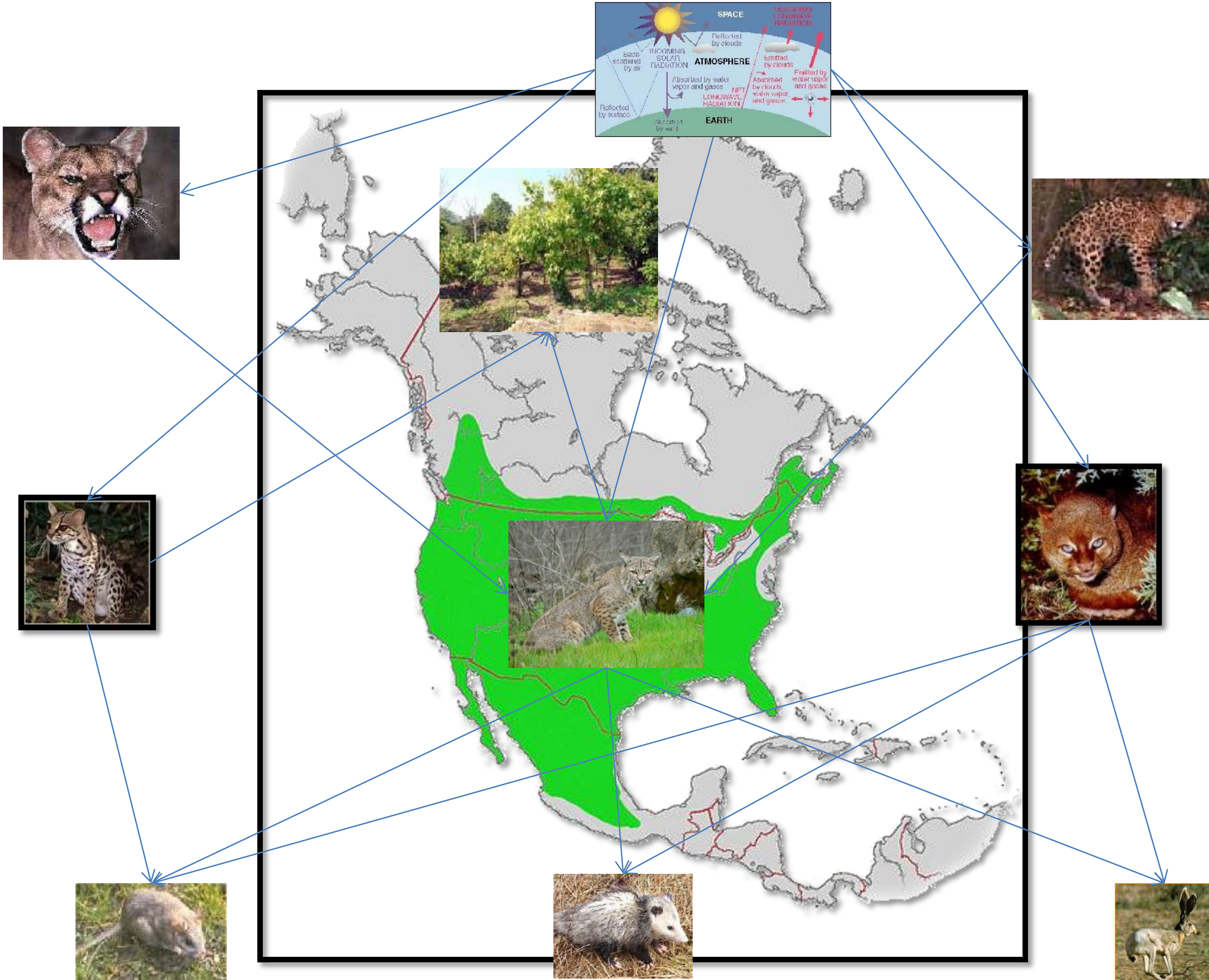
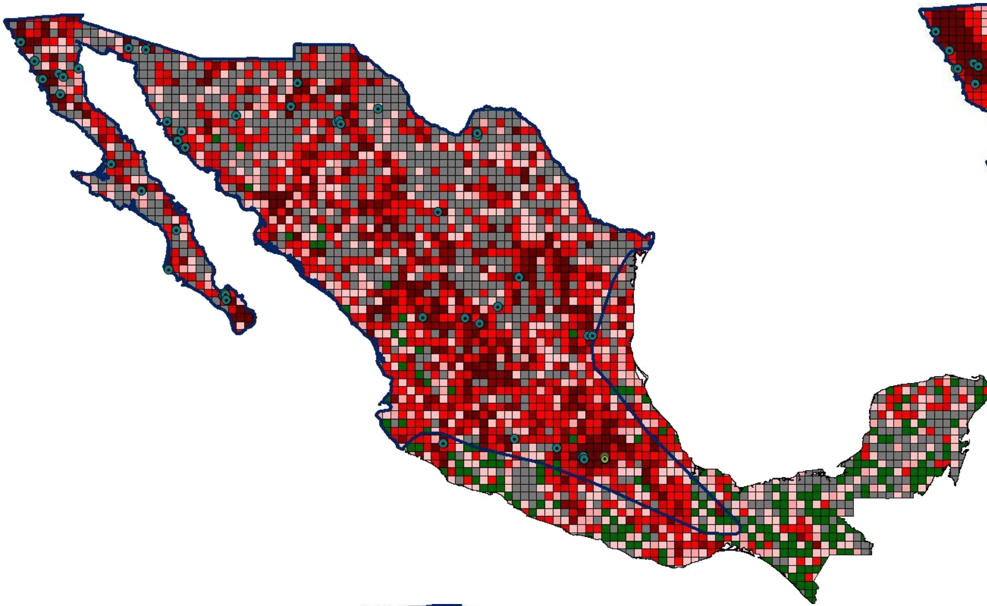


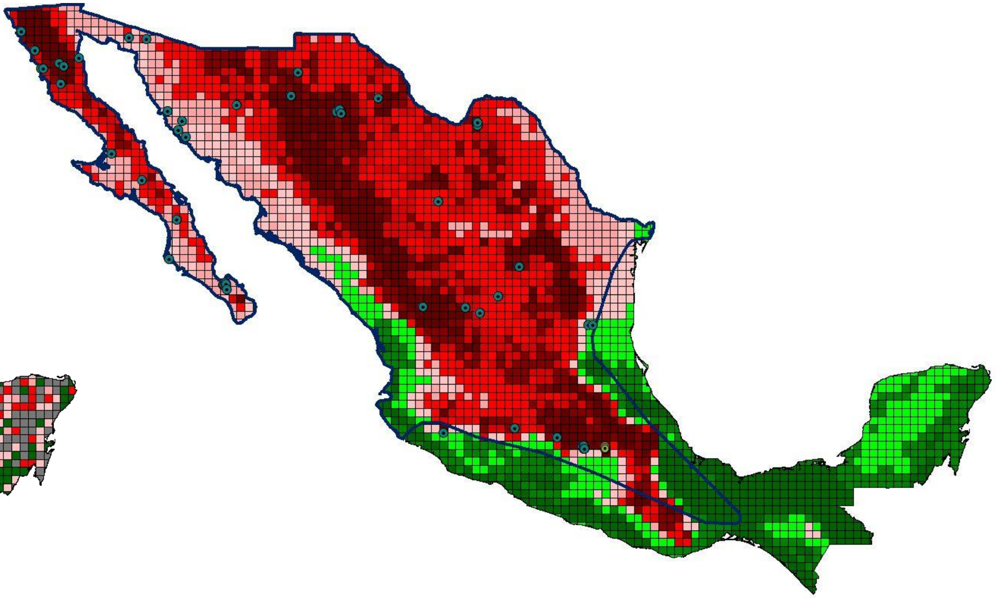
Comparing the relative contributions of biotic and abiotic factors as mediators of species' distributions

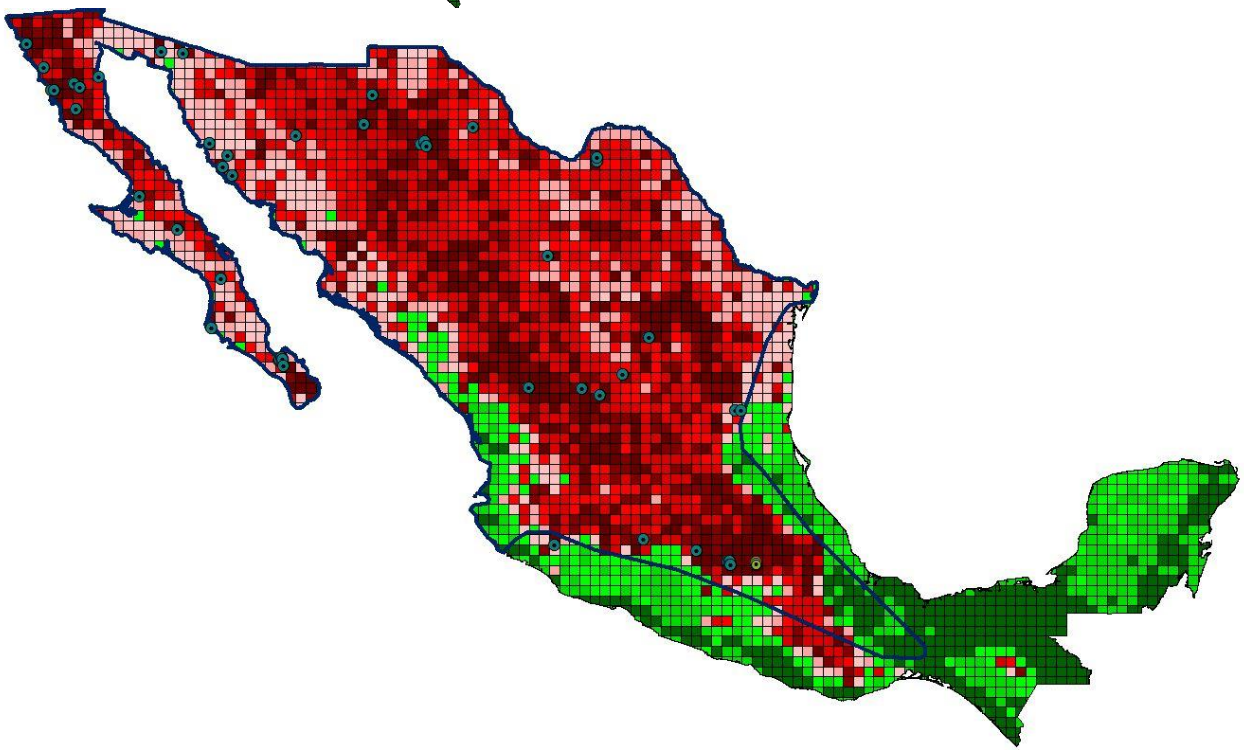
Constantino González-Salazar[a,c,*], Christopher R. Stephens[b,c,1], Pablo A. Marquet[d,e,f,2]



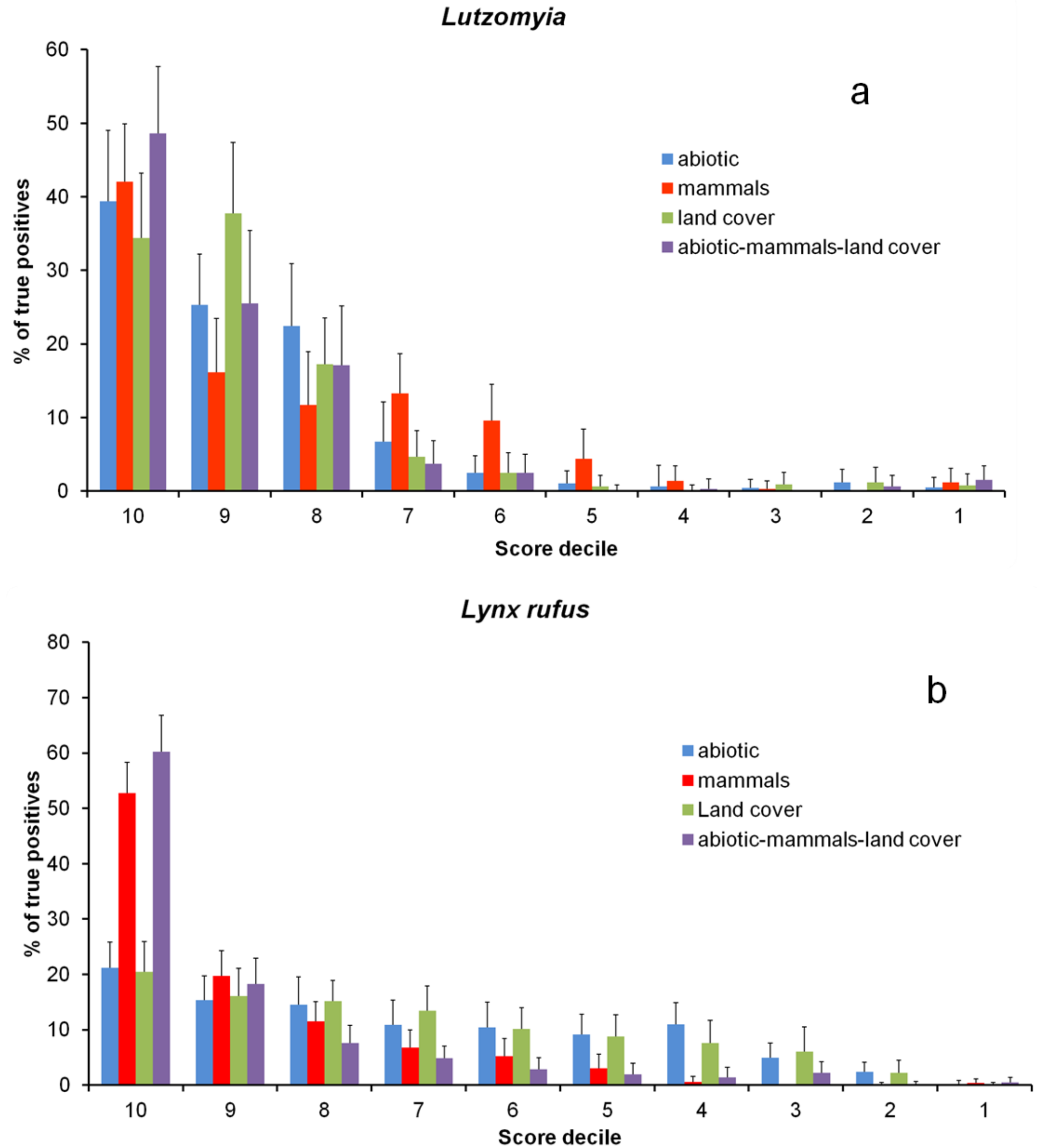

SPACE
Back-scattered by air
INCOMING SOLAR RADIATION
Reflected by clouds
ATMOSPHERE
Emitted by clouds
Absorbed by water vapor and gases
Reflected by surface
EARTH



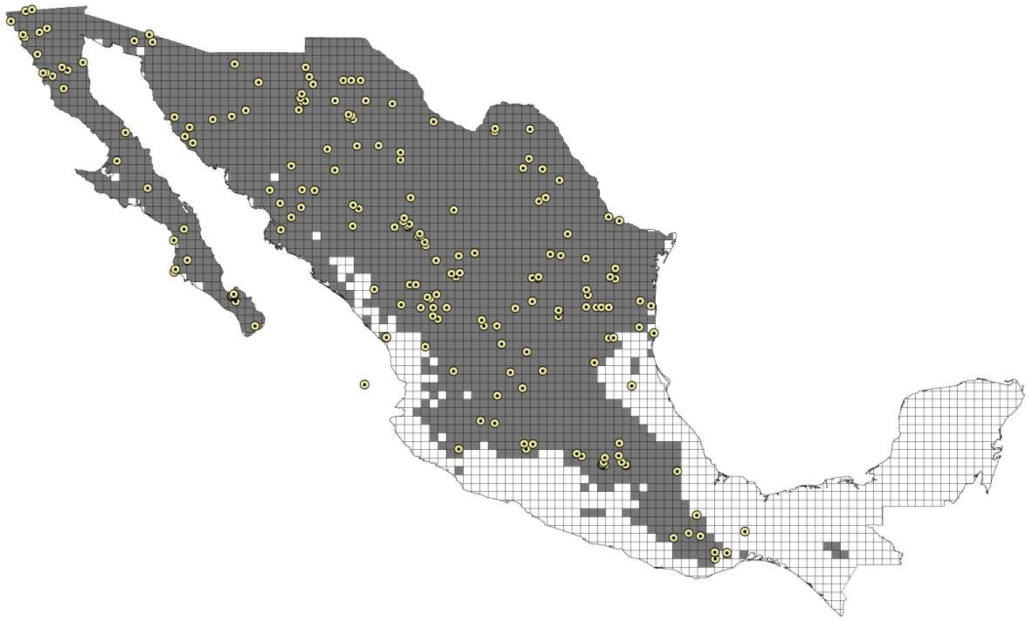


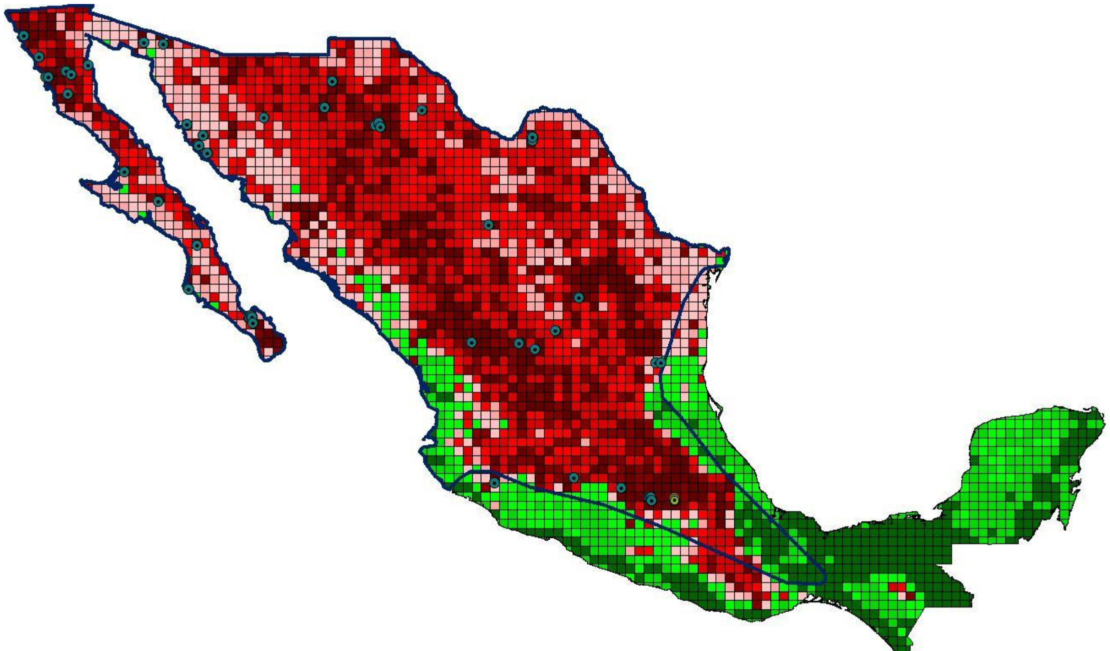


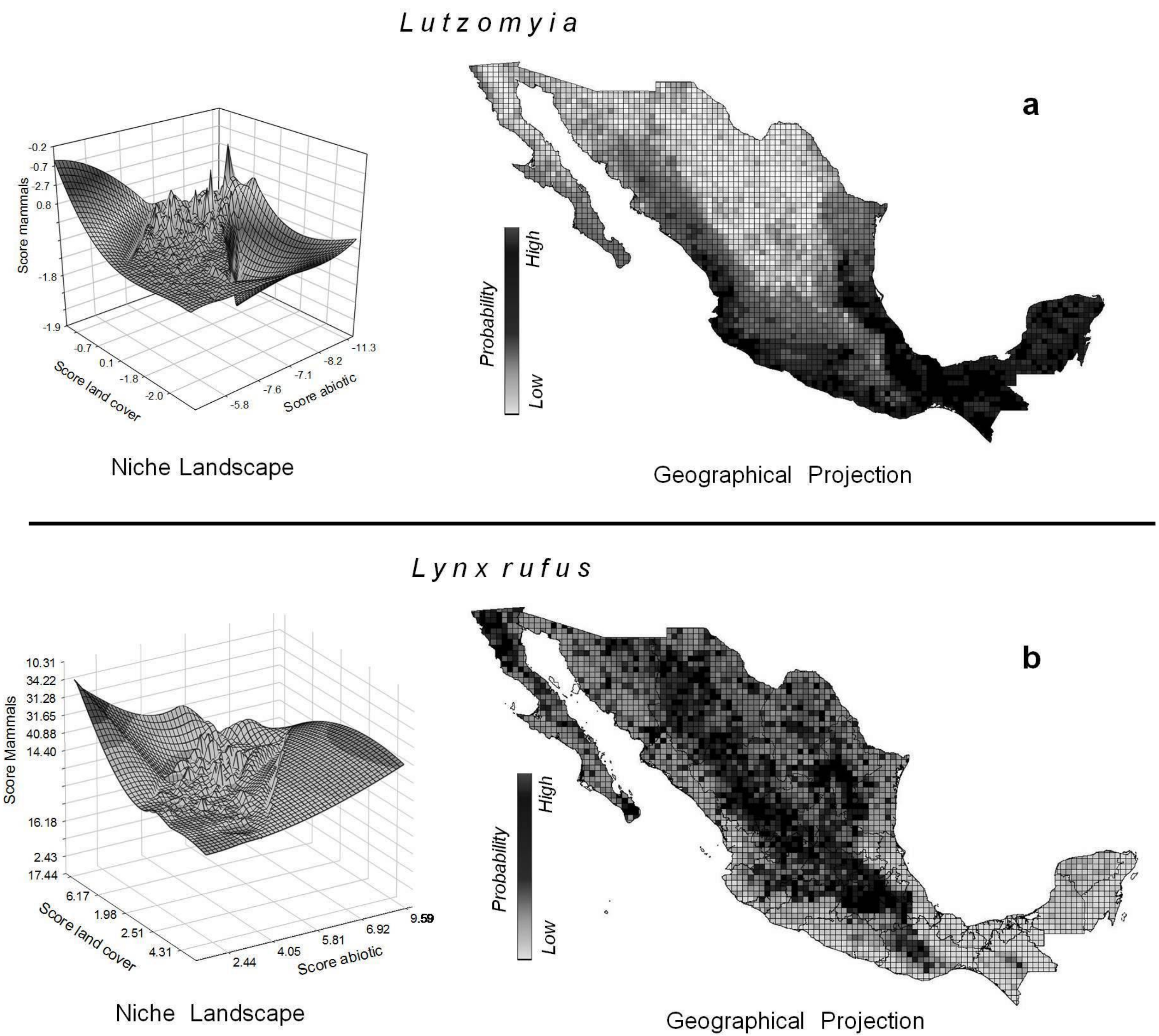
TOP DECILE **Optimal niche conditions for *L. rufus***				**BOTTOM DECILE** **Suboptimal niche conditions for *L. rufus***			
ABIOTIC VARIABLES	**RANGE**	**Epsilon**	**Score contribution**	**ABIOTIC VARIABLES**	**RANGE**	**Epsilon**	**Score contribution**
BIO1	-2.7 - 16.7	*5.488*	*6.109*	BIO9	19.8 - 29.7	*-4.177*	*-0.821*
BIO6	-9.4 - 3.4	*5.327*	*3.005*	BIO11	19 - 28.6	*-3.930*	*-5.379*
BIO8	2.2 - 14.7	*4.797*	*1.096*	BIO6	6.8 - 19.9	*-3.578*	*-1.902*
BIO4	25.35-48.95	*4.704*	*1.393*	BIO1	23.3 - 29.7	*-3.452*	*-3.128*
BIO9	-3.5 - 16.4	*4.687*	*5.758*	BIO16	619 - 1618	*-3.060*	*-3.268*
BIO11	-3.6 - 16.5	*4.632*	*7.050*	BIO7	11.5 - 21.4	*-2.853*	*-1.656*
BIO16	219 – 418	*4.602*	*0.524*	BIO17	88-219	*-2.782*	*-1.091*
BIO5	7.7 - 30.5	*4.330*	*1.777*	BIO2	7.3 - 11.9	*-2.594*	*-0.954*
BIO10	-2.7 – 22	*4.266*	*2.33*	BIO13	238 - 620	*-2.59*	*-3.996*
				BIO12	974-3302	*-2.512*	*-1.413*
				BIO14	26-63	*-2.253*	*-4.666*
				BIO18	374 - 870	*-2.219*	*-1.068*
PREYS				**PREYS**			
Spermophilus variegatus		*13.824*	*1.883*	*Sylvilagus floridanus*		11.004	1.439
Sylvilagus floridanus		*11.004*	*1.439*	*Neotoma mexicana*		8.034	1.378
Neotoma albigula		*9.143*	*1.604*	*Didelphis virginiana*		5.553	1.054
Microtus mexicanus		*8.846*	*1.776*	*Nasua narica*		5.270	1.147
Dipodomys ordii		*8.636*	*1.565*	*Odocoileus virginianus*		4.457	1.589
Dipodomys merriami		*8.618*	*1.306*				
Neotoma mexicana		*8.034*	*1.378*				
Sigmodon leucotis		*6.275*	*1.982*				
Sylvilagus audubonii		*5.972*	*1.556*				
Didelphis virginiana		*5.553*	*1.054*				
Cratogeomys merriami		*5.385*	*2.031*				
Nasua narica		*5.270*	*1.147*				
Dipodomys deserti		*5.057*	*2.059*				
Dipodomys nelsoni		*4.972*	*1.453*				
Odocoileus virginianus		*4.457*	*1.589*				
Romerolagus diazi		*4.427*	*4.362*				
Dipodomys gravipes		*4.296*	*2.465*				
Dipodomys spectabilis		*4.039*	*1.366*				
Neotomodon alstoni		*3.860*	*1.589*				
Ammospermophilus harrisii		*3.700*	*2.128*				
Dipodomys agilis		*3.469*	*1.248*				
Spermophilus tereticaudus		*2.332*	*1.366*				
Dipodomys simulans		*1.875*	*1.877*				
Mustela frenata		*1.810*	*0.928*				
Sylvilagus cunicularius		*1.743*	*1.030*				
POTENTIAL COMPETITORS				**POTENTIAL COMPETITORS**			
Leopardus pardalis		*3.373*	*1.147*	*Leopardus pardalis*		3.373	1.147
Panthera onca		*2.559*	*0.928*	*Panthera onca*		2.559	0.928
Leopardus wiedii		*1.597*	*0.735*	*Leopardus wiedii*		1.597	0.735
Herpailurus yagouaroundi		*1.138*	*0.524*	*Herpailurus yagouaroundi*		1.138	0.524
LAND COVER				**LAND COVER**			
Grassland		*4.883*	*0.629*	Low forest evergreen with secondary vegetation		-2.088	-0.430
Plantation forest		*4.738*	*1.934*	Savannah		-2.202	-1.907
Xeric scrub with secondary vegetation		*4.283*	*1.094*	Agriculture areas		-2.245	-0.395
Oyamel forest		*4.274*	*1.256*	Cloud forest with secondary vegetation		-2.439	-2.061
High mountain meadow		*4.042*	*1.812*	Mangrove		-2.506	-1.191
Agriculture areas		*3.903*	*0.745*	Tropical evergreen forest with secondary vegetation		-2.540	-3.532
Xeric scrub		*3.955*	*0.678*	Tropical evergreen forest		-2.566	-3.575
Coniferous forest		*3.878*	*0.565*	Deciduous tropical forest		-2.924	-1.816
Quercus forest		*3.858*	*0.475*	Deciduous tropical forest with secondary vegetation		-3.143	-2.471
Human establishment		*3.661*	*0.356*				
Coniferous forest with secondary vegetation		*3.631*	*0.591*				
Quercus forest with secondary vegetation		*3.457*	*0.468*				

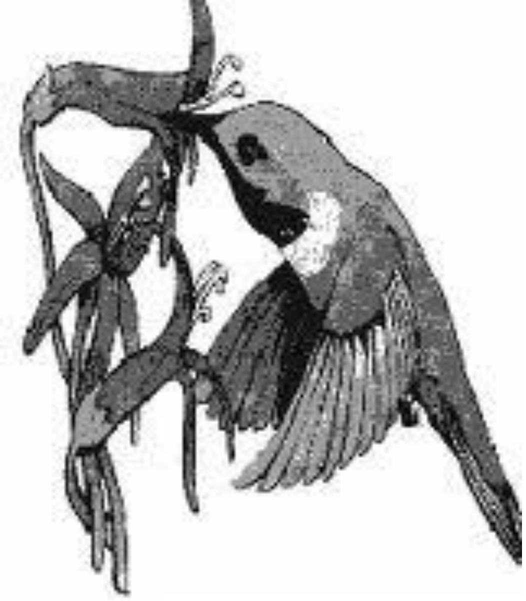


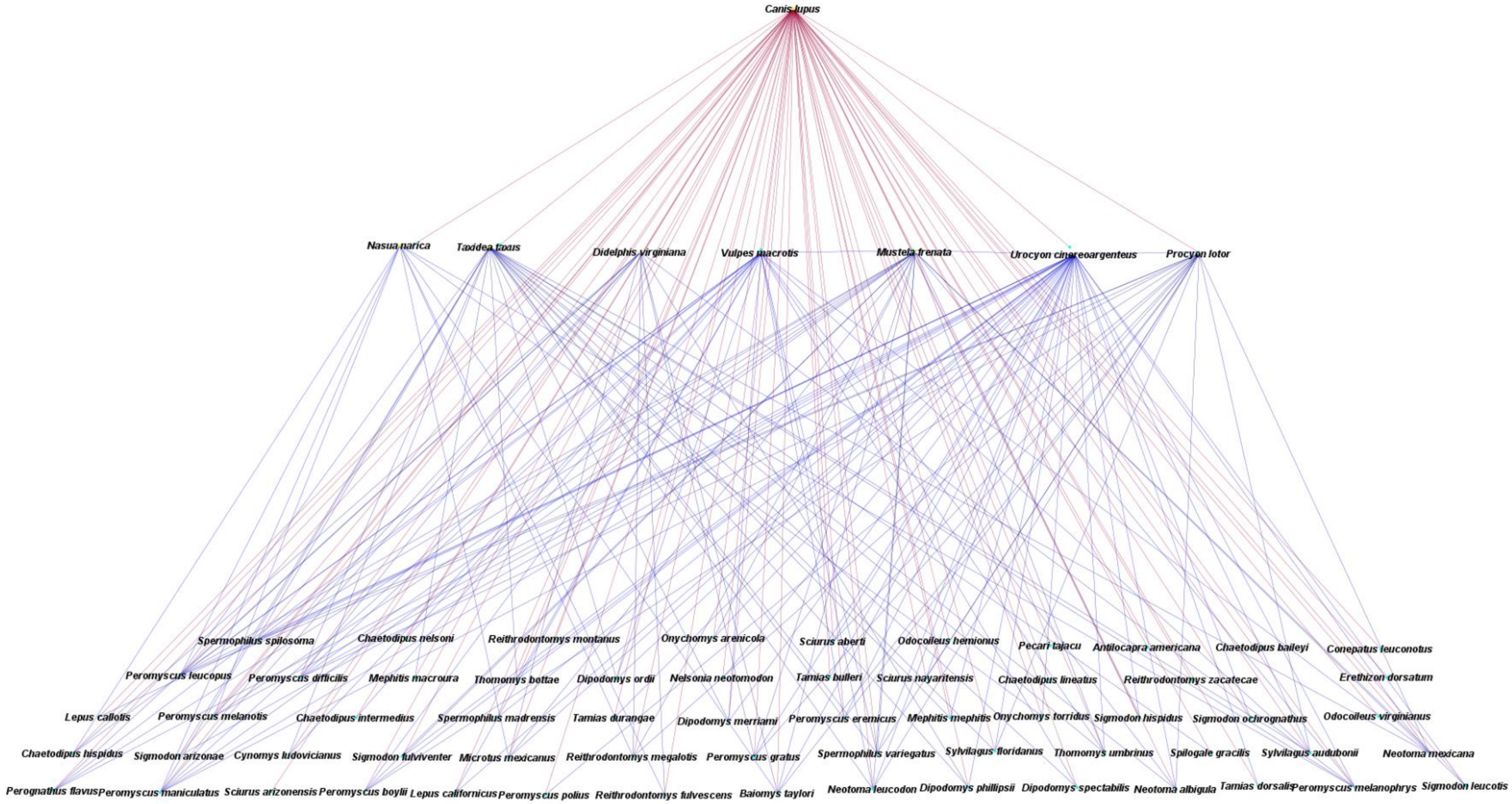
Lutzomyia
a
abiotic
mammals
land cover
abiotic-mammals-land cover
% of true positives
Score decile
Lynx rufus
b
abiotic
mammals
Land cover
abiotic-mammals-land cover
% of true positives
Score decile

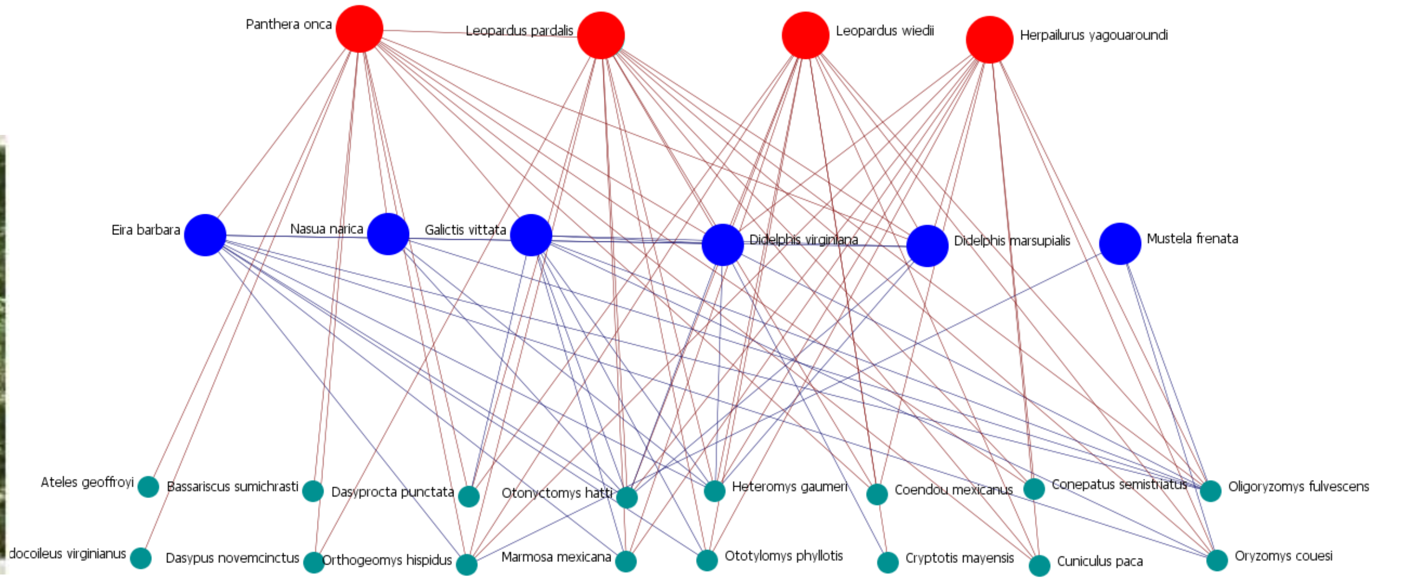




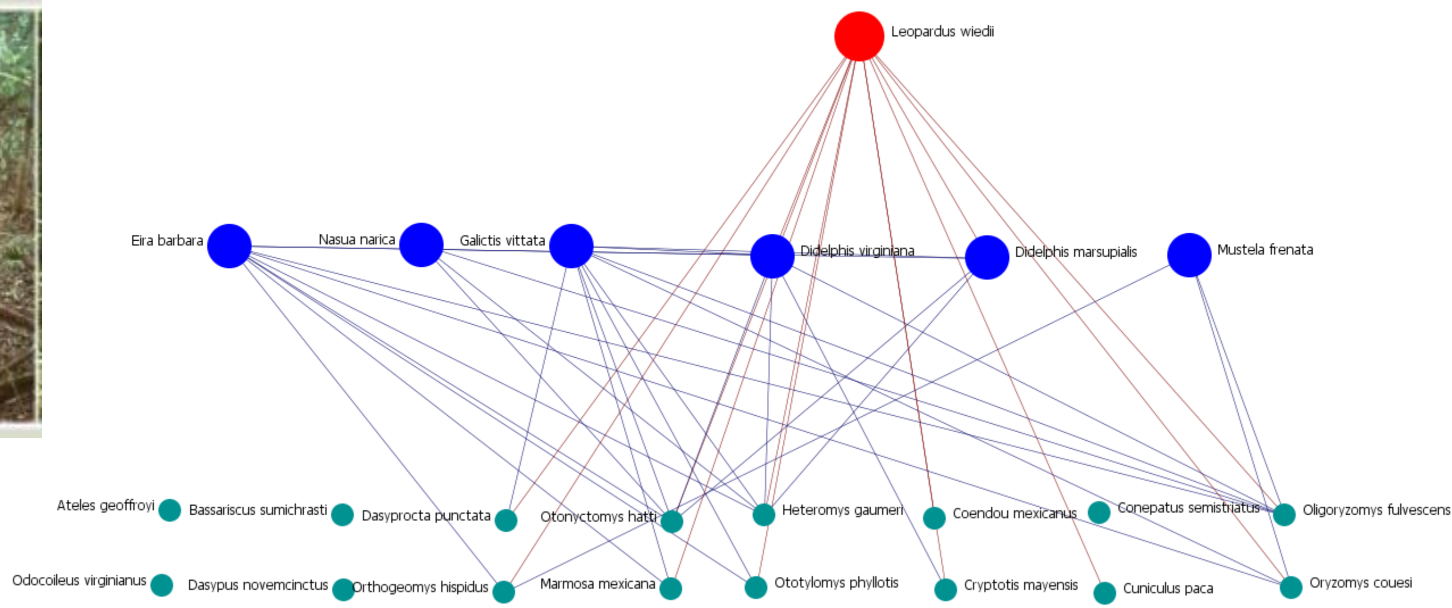

Lutzomyia
a
Score mammals
-0.2
-0.7
-2.7
0.8
-1.8
-1.9
-0.7
0.1
-1.8
-2.0
Score land cover
-11.3
-8.2
-7.1
-7.6
-5.8
Score abiotic
High
Probability
Low
Niche Landscape
Geographical Projection
Lynx rufus
b
Score Mammals
10.31
34.22
31.28
31.65
40.88
14.40
16.18
2.43
17.44
6.17
1.98
2.51
4.31
Score land cover
2.44
4.05
5.81
6.92
9.59
Score abiotic
High
Probability
Low
Niche Landscape
Geographical Projection




Canis lupus
Nasua narica
Taxidea taxus
Didelphis virginiana
Vulpes macrotis
Mustela frenata
Urocyon cinereoargenteus
Procyon lotor
Spermophilus spilosoma
Chaetodipus nelsoni
Reithrodontomys montanus
Onychomys arenicola
Sciurus aberti
Odocoileus hemionus
Pecari tajacu
Antilocapra americana
Chaetodipus baileyi
Conepatus leuconotus
Peromyscus leucopus
Peromyscus difficilis
Mephitis macroura
Thomomys bottae
Dipodomys ordii
Nelsonia neotomodon
Tamias bulleri
Sciurus nayaritensis
Chaetodipus lineatus
Reithrodontomys zacatecae
Erethizon dorsatum
Lepus callotis
Peromyscus melanotis
Chaetodipus intermedius
Spermophilus madrensis
Tamias durangae
Dipodomys merriami
Peromyscus eremicus
Mephitis mephitis
Onychomys torridus
Sigmodon hispidus
Sigmodon ochrognathus
Odocoileus virginianus
Chaetodipus hispidus
Sigmodon arizonae
Cynomys ludovicianus
Sigmodon fulviventer
Microtus mexicanus
Reithrodontomys megalotis
Peromyscus gratus
Spermophilus variegatus
Sylvilagus floridanus
Thomomys umbrinus
Spilogale gracilis
Sylvilagus audubonii
Neotoma mexicana
Perognathus flavus
Peromyscus maniculatus
Sciurus arizonensis
Peromyscus boylii
Lepus californicus
Peromyscus polius
Reithrodontomys fulvescens
Baiomys taylori
Neotoma leucodon
Dipodomys phillipsii
Dipodomys spectabilis
Neotoma albigula
Tamias dorsalis
Peromyscus melanophrys
Sigmodon leucotis



Panthera onca
Leopardus pardalis
Leopardus wiedii
Herpailurus yagouaroundi
Eira barbara
Nasua narica
Galictis vittata
Didelphis virginiana
Didelphis marsupialis
Mustela frenata
Ateles geoffroyi
Bassariscus sumichrasti
Dasyprocta punctata
Otonyctomys hatti
Heteromys gaumeri
Coendou mexicanus
Conepatus semistriatus
Oligoryzomys fulvescens
docoileus virginianus
Dasypus novemcinctus
Orthogeomys hispidus
Marmosa mexicana
Ototylomys phyllotis
Cryptotis mayensis
Cuniculus paca
Oryzomys couesi



Leopardus wiedii
Eira barbara
Nasua narica
Galictis vittata
Didelphis virginiana
Didelphis marsupialis
Mustela frenata
Ateles geoffroyi
Bassariscus sumichrasti
Dasyprocta punctata
Otonyctomys hatti
Heteromys gaumeri
Coendou mexicanus
Conepatus semistriatus
Oligoryzomys fulvescens
Odocoileus virginianus
Dasypus novemcinctus
Orthogeomys hispidus
Marmosa mexicana
Ototylomys phyllotis
Cryptotis mayensis
Cuniculus paca
Oryzomys couesi