Relación entre diversidad genética y centralidad de nicho

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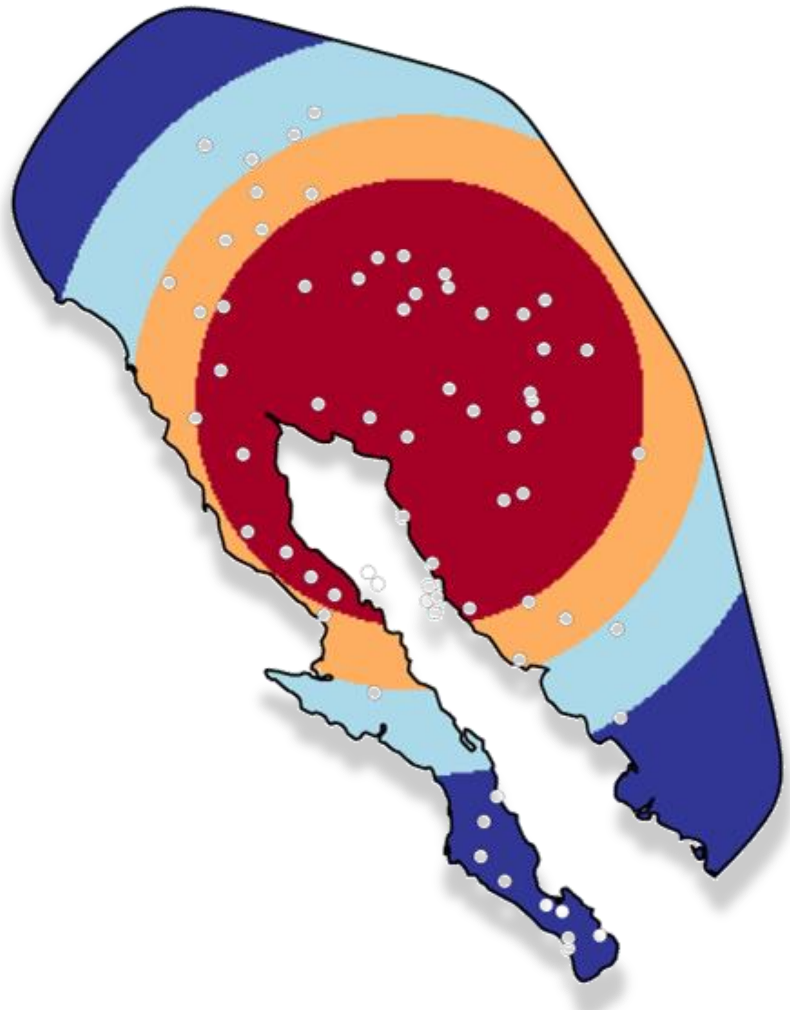
Introducción

- "Abundant-center hypothesis"
  - condiciones marginales ("source-sink")
  - ¿Qué importa más, ambiente o geografía?relación centro-
    ¿Procesos evolutivos?
  - periferia en espacio G y E
  - abundancia correlaciona con la distancia al nicho

  (Martínez-Meyer et al. 2013)
- ¿Procesos demográficos?
- ¿Procesos evolutivos?
  - diversidad genética
  - marcadores moleculares – escalas (tiempo)

Dinámicas de los rangos geográficos de las especies



Representación gráfica de las AD

Construcción de polígonos sobre un mapa incluyendo los puntos de registro de la especie estudiada

Los criterios varían según las preferencias del investigador

"trazo a ojo"

"círculo mínimo"

"polígono convexo mínimo"

"el método de gradilla"

"el método de propincuidad media"

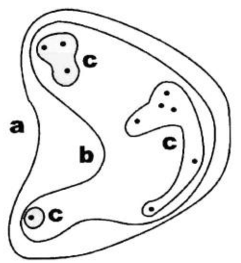


Fig. 1. Tres criterios de compactación 'a ojo'. (a) Desde muy laxo hasta (c) muy estricto.

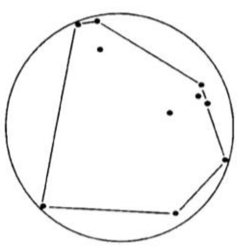


Fig. 2. Compactación mediante el círculo mínimo y el polígono convexo mínimo.

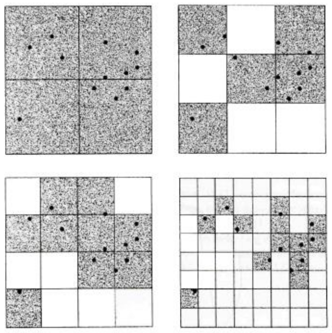


Fig. 3. Los mismos 12 puntos pueden dar origen a diversas formas de un área, según el tamaño de la grilla usada. Si se reduce aún más la grilla, solo se consigue remplazar los círculos por cuadrados pequeños.

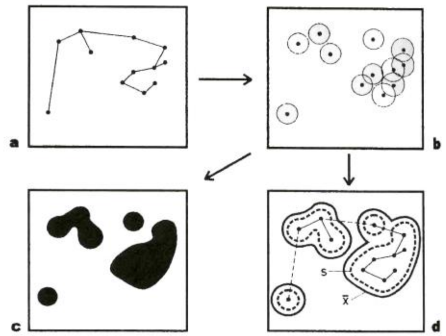


Fig. 4. Compactación mediante el método de los círculos de distancias medias (a, b y c) y de la propincuidad media (a, d). La línea externa marca la media aritmética de las distancias entre localidades (x). La línea de rayas marca una desviación estándar (s).

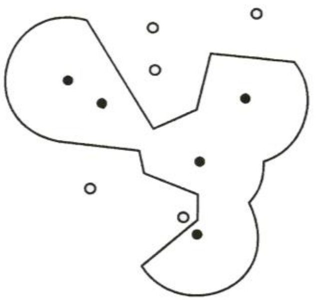
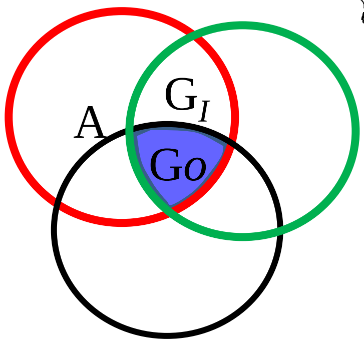
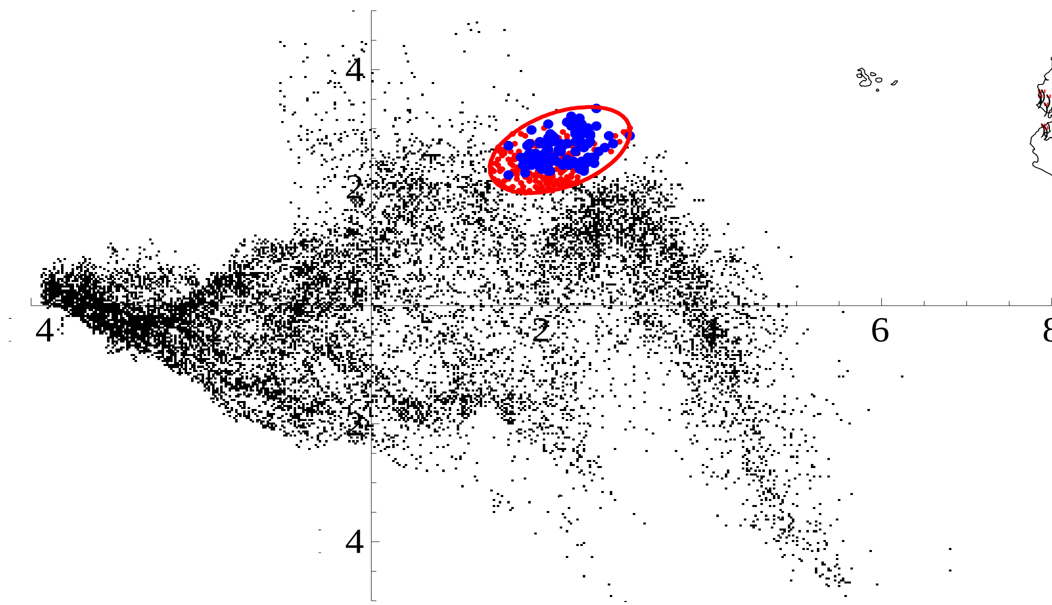


Fig. 6. Acuerdo entre el método de la propincuidad media (MPM) basado en cinco localidades con registros positivos de presencia de especies (círculos negros) y la mitad de las distancias más cortas a los registros negativos o de ausencias (círculos blancos).

Rapoport & Monjeau (2003)

Dualidad de Hutchinson

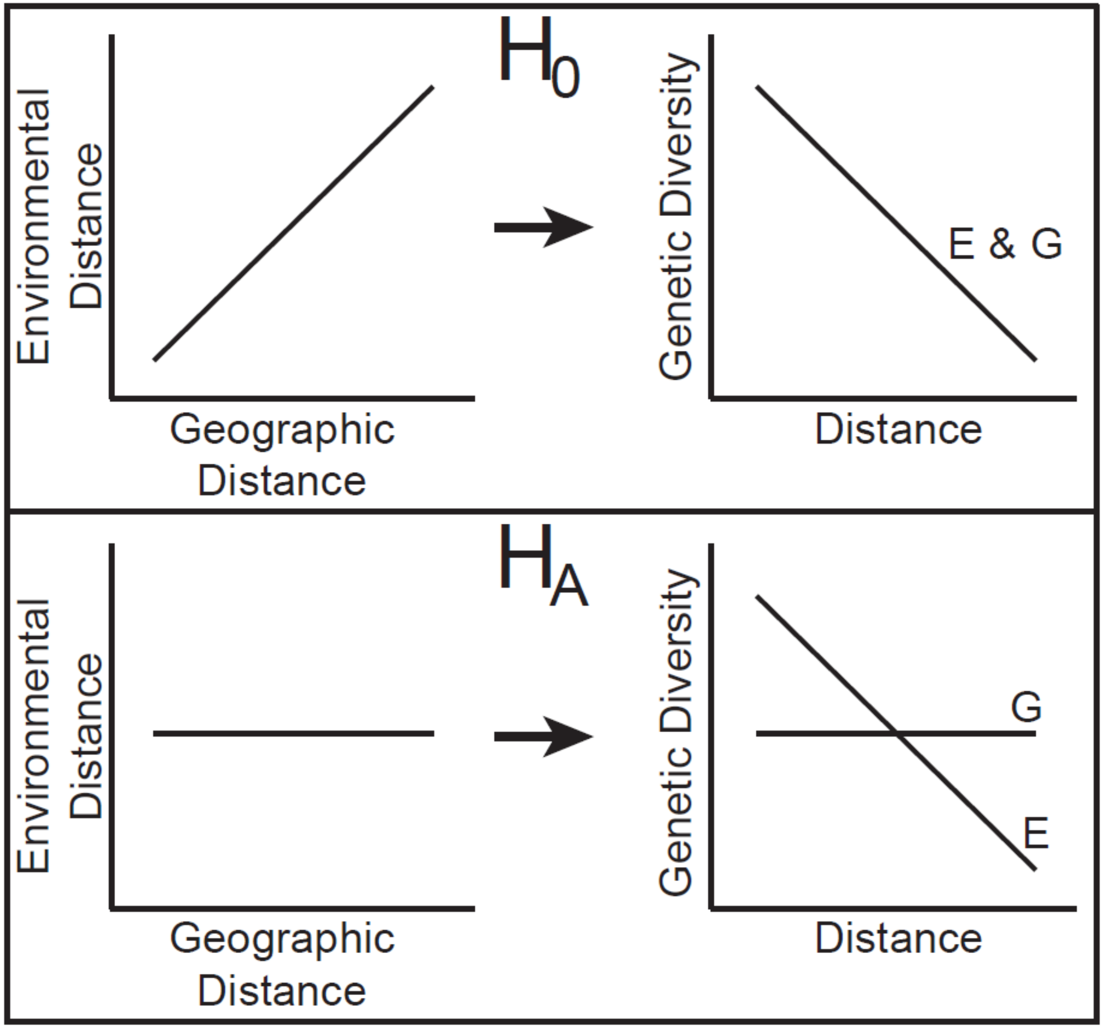




Espacio ambiental

Espacio geográfico

Hipótesis



H_0
Environmental Distance
Geographic Distance
Genetic Diversity
E & G
Distance
H_A
Environmental Distance
Geographic Distance
Genetic Diversity
G
E
Distance

Métodos

- Published data on genetic diversity for 40 species (insects, plants, birds, mammals, worms)
- Ecological niche modeling
- Distances to niche centroid
- Sign test, multiple linear regression, and meta-analysis of correlation effect sizes

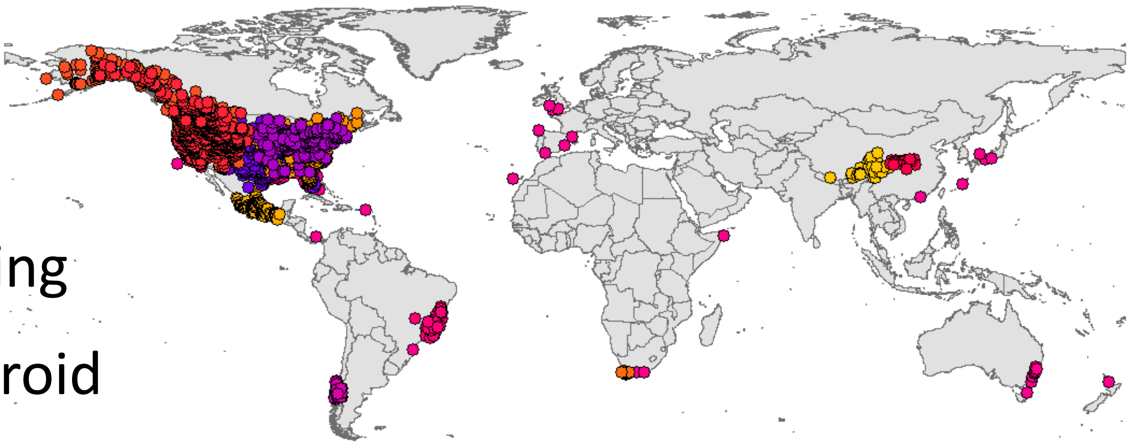


Table 1. Species used in this study, their taxonomic affinities, measure of genetic diversity used (Div.), and the original publication for each species.

Species	Taxonomic Group	Div.	Reference
Arenaria humifusa	Magnoliopsida: Caryophyllaceae	GD	Westergaard et al. (2011)
Bombus bifarius	Insecta: Apidae	AR	Lozier et al. (2011)
Bombus bimaculatus	Insecta: Apidae	AR	Lozier et al. (2011)
Bombus impatiens	Insecta: Apidae	AR	Lozier et al. (2011)
Bombus occidentalis	Insecta: Apidae	AR	Lozier et al. (2011)
Bombus pensylvanicus	Insecta: Apidae	AR	Lozier et al. (2011)
Bombus vosnesenskii	Insecta: Apidae	AR	Lozier et al. (2011)
Cardellina pusilla	Aves: Parulidae	π	Kimura et al. (2002)
Cardellina ruber	Aves: Parulidae	π	Barrera-Guzmán et al. (2012)
Cardinalis cardinalis	Aves: Cardinalidae	π	Smith et al. (2011)
Cassiope tetragona	Magnoliopsida: Ericaceae	GD	Eidesen et al. (2007b)
Certhia americana	Aves: Certhiidae	π	Manthey et al. (2011)
Dalbergia nigra	Magnoliopsida: Leguminosae	π	Ribeiro et al. (2011)
Eucryphia cordifolia	Magnoliopsida: Cuconiaceae	π	Segovia et al. (2012)
Fraxinus angustifolia	Magnoliopsida: Oleaceae	AR	Temunovic et al. (2012)
Himantoglossum hircinum	Liliopsida: Orchidaceae	H_E	Pfeifer et al. (2009)
Hymenaea stigonocarpa	Magnoliopsida: Fabaceae	π	Ramos et al. (2007)
Lampornis amethystinus	Aves: Trochilidae	π	Cortés-Rodríguez et al. (2008)
Lynx rufus	Mammalia: Felidae	π/AR	Reding et al. (2012)
Melampodium leucanthum[1]	Magnoliopsida: Asteraceae	AWD	Rebernig et al. (2010)
Microtus miurus	Mammalia: Cricetidae	π	Weksler et al. (2010)
Microtus oeconomus	Mammalia: Cricetidae	π	Galbreath & Cook (2004)
Oxalis alpine	Magnoliopsida: Oxalidaceae	π	Pérez-Alquicira et al. (2010)
Pelecanus erythrorhynchos	Aves: Pelecanidae	π	Oomen et al. (2011)
Peripatopsis capensis	Onychophorida: Peripatopsidae	π	McDonald & Daniels (2012)
Peromyscus attwateri	Mammalia: Cricetidae	π	Lack et al. (2010)
Pheropsophus jessoensis	Insecta: Carabidae	π	Li et al. (2012)
Picoides albolarvatus	Aves: Picidae	π	Alexander & Burns (2006)
Poecile gambeli	Aves: Paridae	π	Spellman et al. (2007)
Quercus engelmannii	Magnoliopsida: Fagaceae	AR	Ortego et al. (2012)
Rhodiola alsia	Magnoliopsida: Crassulaceae	π	Gao et al. (2012)
Rubus chamaemorus	Magnoliopsida: Rosaceae	GD	Ehrich et al. (2008)
Sagina caespitosa	Magnoliopsida: Caryophyllaceae	GD	Westergaard et al. (2011)
Setophaga caerulescens	Aves: Parulidae	π	Grus et al. (2009)
Sitta carolinensis	Aves: Sittidae	π	Spellman & Klicka (2007)
Sitta pygmaea	Aves: Sittidae	π	Spellman & Klicka (2006)
Spermophilus parryii	Mammalia: Sciuridae	π	Galbreath et al. (2011)
Stipa capillata	Liliopsida: Poaceae	H_E	Wagner et al. (2011)
Toxostoma redivivum	Aves: Mimidae	π	Sgariglia & Burns (2003)
Vaccinium uliginosum[1]	Magnoliopsida: Ericaceae	GD	Eidesen et al. (2007a)

GD, genic diversity; AR, allelic richness; π, nucleotide diversity; HE, expected heterozygosity; AWD, average distances within populations.

[1]Alternative ploidy levels were removed from analysis.

Estimación de la distancia al centroide de nicho y centro del rango geográfico

Ambiente

1. Ocurrencias (localidades de colecta)

2. Modelos de nicho ecológico (varias aproximaciones)
   … ¡varios detalles importantes! …

3. Extracción de valores de variables ambientales sobre "modelo de nicho"
   matriz de variables bioclimáticas
   centroide = vector de medias

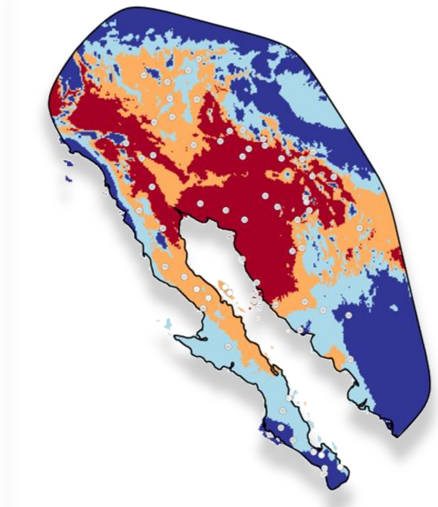
4. Medición de distancias (euclideanas, otras) de localidades con valores de diversidad genética al centroide

Geografía

1. Coordenada del centro del rango geográfico

2. Distancia de localidades con valores de diversidad genética al centro del rango geográfico

Centralidad de nicho



Centralidad geográfica

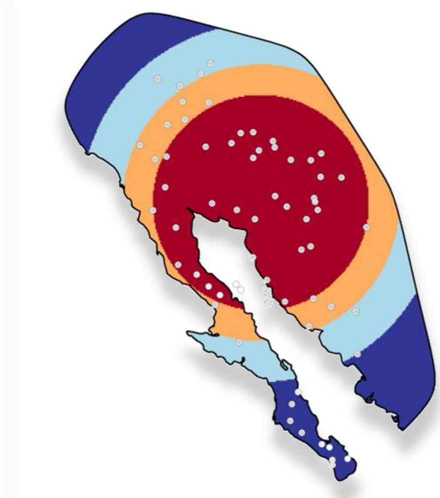
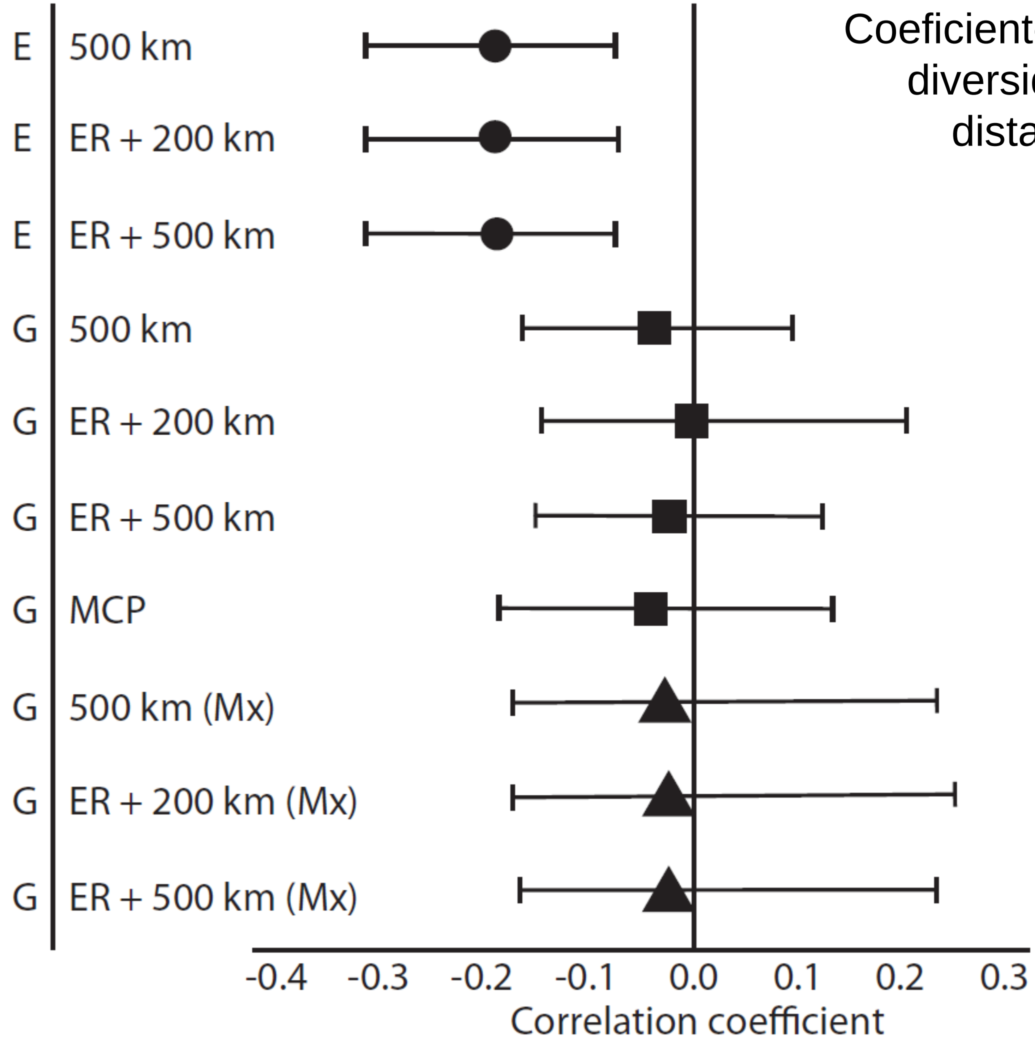


Table 2. Species used in this study, number of populations for each species (*N*), number of occurrence records used for modeling ecological niches (*N* Occ.), whether geography and environment show similar relationships with genetic diversity (Agree), pattern(s) observed between genetic diversity and distance to centroid of the niche (*E*), number of significant comparisons for *E* (E^*) out of three total, pattern(s) observed between genetic diversity and distance to geographic center of a species (*G*), number of significant comparisons for *G* (G^*) out of seven total.

Species	*N*	*N* Occ.	Agree	*E*	E^*	*G*	G^*
Melampodium leucanthum	68	360	X	−		−	6
Cassiope tetragona	62	418	X	−	1	−	2
Vaccinium uliginosum	54	833	X	−	2	−	7
Lynx rufus	52	1096		−	3	+/−$_{C}$	3$_{C}$
Stipa capillata	43	295		+		−	
Rubus chamaemorus	41	625		−		+/−$_{C}$	
Spermophilus parryii	34	207	X	−	3	−	
Bombus bimaculatus	34	197		−		+/−	
Bombus bifarius	33	947		−	3	+/−	3
Bombus impatiens	33	390		−	3	+/−	
Bombus pensylvanicus	25	451	X	−	3	−	3
Poecile gambeli	25	396	X	−		−	
Pheropsophus jessoensis	25	27		−	3	+/−	1
Peromyscus attwateri	22	94		+		+/−	
Eucryphia cordifolia	22	32	X	−		−	6
Cardinalis cardinalis	20	1458	X	−	3	−	7
Himantoglossum hircinum	20	619		−		+	1
Oxalis alpina	20	107	X	−		−	6
Certhia americana	19	871	X	+		+	
Dalbergia nigra	19	27	X	−		−	
Rhodiola alsia	18	27	X	+	3	+	1
Hymenaea stigonocarpa	17	83	X	+		+	
Peripatopsis capensis	17	12	X	−		−	
Bombus vosnesenskii	16	511		−		+/−	3
Pelecanus erythrorhynchos	16	344	X	−		−	1
Sitta carolinensis	14	1611		+/−		+	2
Microtus oeconomus	14	464	X	−		−	
Setophaga caerulescens	14	395	X	+		+	
Sagina caespitosa	14	80		+/−		+/−	
Bombus occidentalis	13	939		+/−		+	
Lampornis amethystinus	13	98		+		+/−	
Quercus engelmannii	13	26	X	+		+	
Cardellina pusilla	12	855	X	−		−	
Picoides albolarvatus	12	73	X	−		−	
Fraxinus angustifolia	11	590		−		+/−	
Sitta pygmaea	11	238	X	−		−	
Arenaria humifusa	11	59	X	−		−	
Toxostoma redivivum	9	61	X	+		+	
Cardellina ruber	9	44		−		+	3
Microtus miurus	8	110	X	−		−	
Total consensus positive			7	9		10	
Total consensus negative			18	28		19	
Total mixed pattern			16	3		11	

A (−) or (+) indicates negative or positive relationships, respectively, while a (+/−) indicates mixed patterns. A (C) subscript indicates conflicting patterns between model-based and other geographic center measures.

Mean grand effect sizes



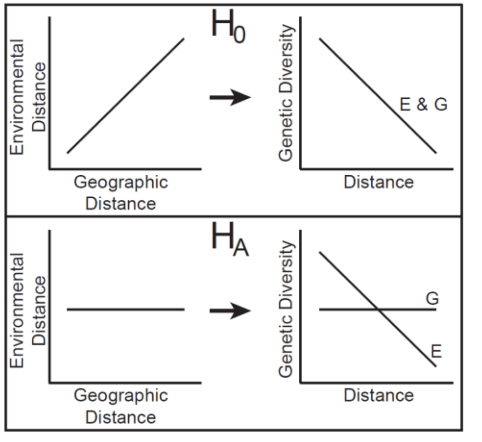
Coeficientes de correlación: diversidad genética y distancias E o G

Modelo lineal generalizado (GLM)

Table 4. Results of generalized linear models using data from all species (z-standardized).

Dataset		E distance	G distance
500 km	All species	-0.475^{***}	-0.161
	Consistent	-0.330^{*}	-0.495^{**}
	Mixed	-0.628^{**}	0.229
ER + 200 km	All species	-0.460^{***}	-0.247^{*}
	Consistent	-0.287	-0.570^{***}
	Mixed	-0.541^{**}	-0.063
ER + 500 km	All species	-0.478^{***}	-0.232^{*}
	Consistent	-0.332^{*}	-0.519^{***}
	Mixed	-0.551^{***}	-0.056

Values are contributions in the regression model of distance to niche centroid or geographic range center to explain genetic diversity. Regressions were performed for separate datasets where distance to geographic center and distance to niche center showed consistent or mixed patterns in sign of the slope (see Table 2).
Asterisks indicate significance at 0.05 (*), 0.01 (**), and 0.001 (***) levels.
Training areas compared included 500 km = 500 km buffer around occurrence points, ER + 200 km = 200 km buffer around terrestrial ecoregions, and ER + 500 km = 500 km buffer around terrestrial ecoregions.



El ambiente es consistentemente más importante

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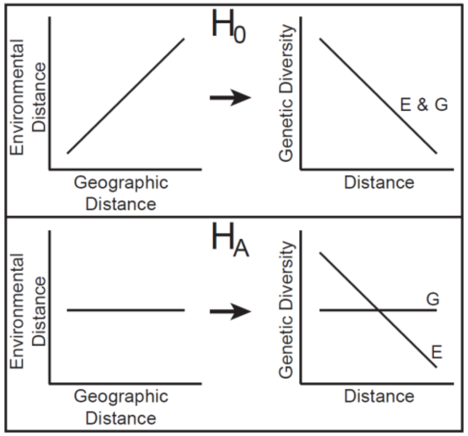

El ambiente es consistentemente más importante

Número de poblaciones vs. significancia estadística (*P*-value)

Ambiente

Geografía

Table 5. Relationship between number of populations and *P* values of the relationships between distance to niche centroid and distance to geographic center.

	R^2	*P*-value
Environmental distance		
500 km	0.2009	0.0037
ER + 200 km	0.2029	0.0035
ER + 500 km	0.1899	0.0049
Geographic distance		
500 km	0.0006	0.8747
ER + 200 km	0.0004	0.8945
ER + 500 km	0.0001	0.9412
MCP	0.0106	0.5269
500 km (Mx)	0.0886	0.0621
ER + 200 km (Mx)	0.0823	0.0726
ER + 500 km (Mx)	0.0800	0.0771

Training areas compared included 500 km = 500 km buffer around occurrence points, ER + 200 km = 200 km buffer around terrestrial ecoregions, and ER + 500 km = 500 km buffer around terrestrial ecoregions.
MCP, minimum convex polygon; Mx, centroid estimated from Maxent prediction.

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Ambiente

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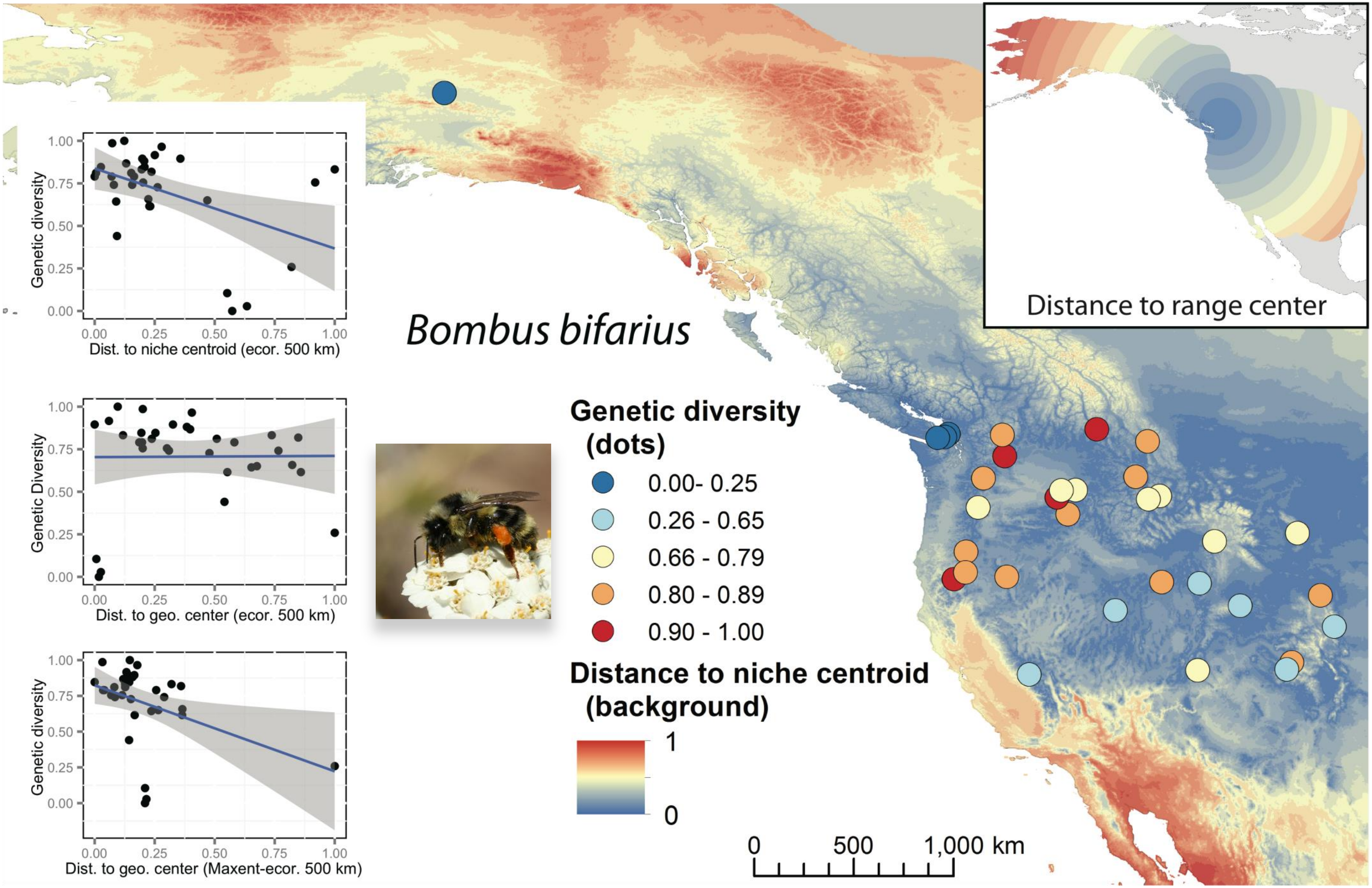
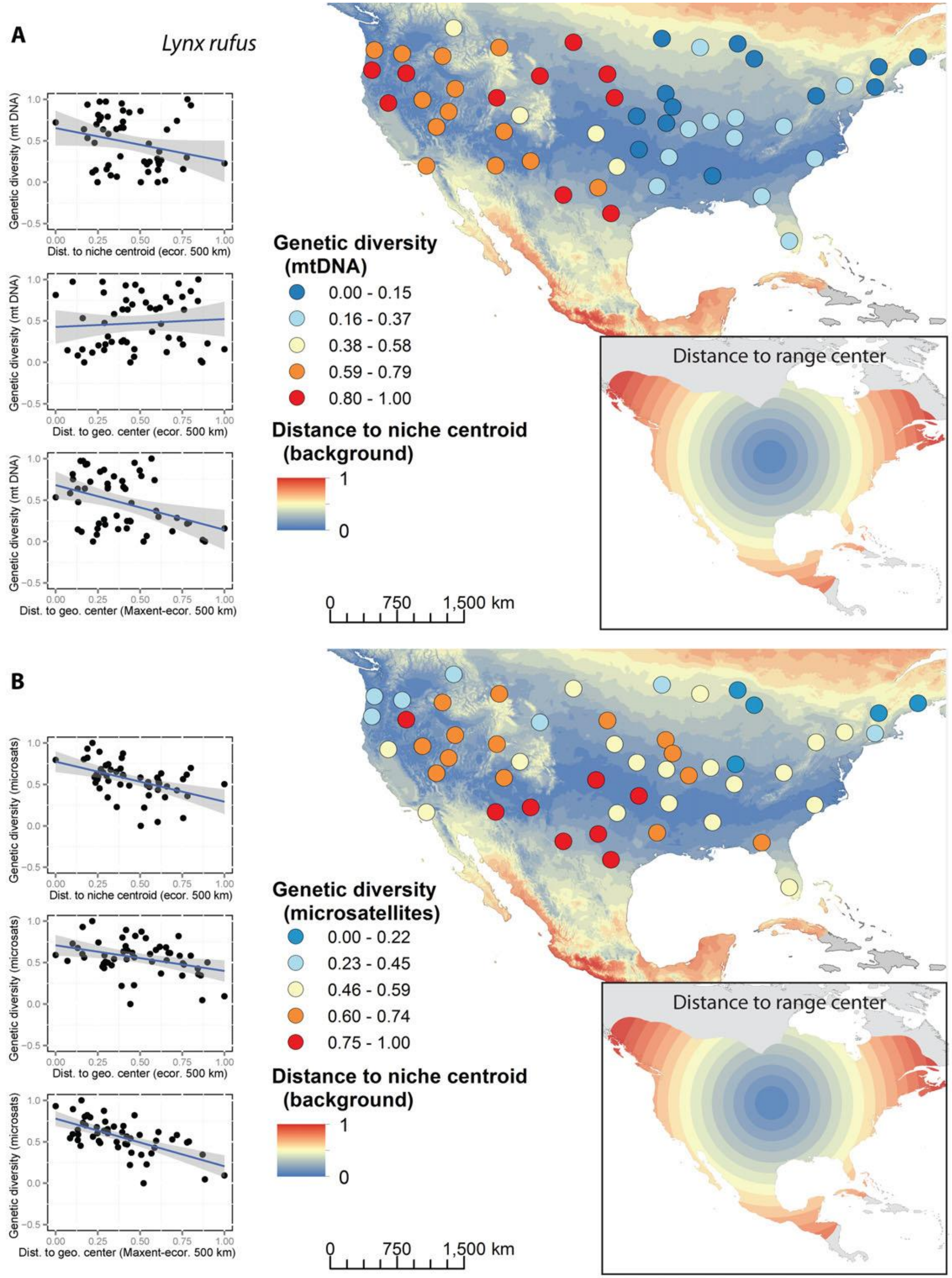
depende del tamaño de muestra:

25 o más polabiones muestran relaciones negativas



Bombus bifarius
Distance to range center
Genetic diversity (dots)
0.00- 0.25
0.26 - 0.65
0.66 - 0.79
0.80 - 0.89
0.90 - 1.00
Distance to niche centroid (background)
1
0
0
500
1,000 km
Genetic diversity
Dist. to niche centroid (ecor. 500 km)
Genetic Diversity
Dist. to geo. center (ecor. 500 km)
Genetic diversity
Dist. to geo. center (Maxent-ecor. 500 km)
0.00
0.25
0.50
0.75
1.00


A
Lynx rufus
Genetic diversity (mt DNA)
Dist. to niche centroid (ecor. 500 km)
Dist. to geo. center (ecor. 500 km)
Dist. to geo. center (Maxent-ecor. 500 km)
Genetic diversity (mtDNA)
0.00 - 0.15
0.16 - 0.37
0.38 - 0.58
0.59 - 0.79
0.80 - 1.00
Distance to niche centroid (background)
1
0
0 750 1,500 km
Distance to range center
B
Genetic diversity (microsats)
Dist. to niche centroid (ecor. 500 km)
Dist. to geo. center (ecor. 500 km)
Dist. to geo. center (Maxent-ecor. 500 km)
Genetic diversity (microsatellites)
0.00 - 0.22
0.23 - 0.45
0.46 - 0.59
0.60 - 0.74
0.75 - 1.00
Distance to niche centroid (background)
1
0
0 750 1,500 km
Distance to range center

Conclusiones

Relación negativa consistente entre diversidad genética y distancia centroide de nicho, no así con la distancia al centro del rango geográfico

Significancia e importancia del **espacio ambiental** vs espacio geográfico

Tamaño de muestreo – planeación de colectas y diseños de experimentos