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A global index of biocultural diversity

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Abstract

The relationships between biological and cultural diversity are drawing increasing attention from scholars. Analyses of these relationships are beginning to crystallize around the concept of *biocultural diversity*, the total variety exhibited by the world's natural and cultural systems. Here, we present the first global measure of biocultural diversity, using a country-level index. The index is calculated using three methods: an unadjusted richness measure, one adjusted for land area, and one adjusted for the size of the human population. The adjusted measures are derived from the differences between observed and expected diversity values. Expected diversity was calculated using the species–area relationship. The index identifies three areas of exceptional biocultural diversity: the Amazon Basin, Central Africa, and Indomalaysia/Melanesia.

Keywords: Biological diversity; Cultural diversity; Biocultural diversity

1. Introduction

The relationships between biological and cultural diversity, and the growing threats they face, have drawn increasing attention from scholars over the last decade (Harmon, 2002; Moore et al., 2002; Sutherland, 2003; Maffi, in press). Analyses of these relationships are beginning to crystallize around the concept of *biocultural diversity*, the total variety exhibited by the world's natural and cultural systems (Maffi, 2001). Here, we outline the first attempt to quantify global biocultural diversity by means of a country-level index, calculated in three ways: an unadjusted richness measure, a measure of richness adjusted for land area, and a measure of richness adjusted for the size of the human population. These measures, when analyzed in concert, indicate three areas of exceptional biocultural diversity. By pinpointing these areas, the index of biocultural diversity (IBCD) will help raise awareness about the threats facing both biological and cultural diversity and could help produce more enlightened public policy for their protection.

Biocultural diversity may be thought of as the sum total of the world's differences, no matter what their origin. It includes biological diversity at all its levels, from genes to populations to species to ecosystems; cultural diversity in all its manifestations (including

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linguistic diversity), ranging from individual ideas to entire cultures; and, importantly, the interactions among all of these. On a global scale, the primary importance of biocultural diversity is that it is the fundamental expression of the variety upon which all life is founded. Conceptually, biocultural diversity bridges the divide between disciplines in the social sciences that focus on human creativity and behavior, and those in the natural sciences that focus on the evolutionary fecundity of the non-human world. The result is a more integrated view of the patterns that characterize life on Earth.

A basic premise of first-generation scholarship on biocultural diversity has been that the relationships between humans and non-human species, and between them both and the landscapes they inhabit, do not run on parallel tracks. Rather, these forms of diversity are often closely linked, and sometimes may even be constitutive of each other in important ways. Much of this first-wave scholarship has aimed to establish correlations between biological and cultural/linguistic diversity in terms of geography, such as areas of overlap (Moore et al., 2002; Manne, 2003; Sutherland, 2003); theory, such as how language may be related to long-term environmental management in indigenous communities (Maffi, 2001; Harmon, 2002); and common threats to their continuation (Maffi, in press). Among the challenges for the next wave of scholars will be (1) to see if the relationships go deeper than mere correlations to something approaching actual coevolution; (2) to elucidate the complexities of how humans and non-human species interact not only with one another but also with the abiotic or geophysical diversity of the earth, including that of its landforms and geological processes, meteorology, and all other inorganic components and processes (e.g. chemical regimes) that provide the setting for life (see Gray, 2004); (3) to deepen the theoretical foundations of biocultural diversity research. In all these aims, it would be useful to have quantitative measures of biocultural diversity on a global level.

The IBCD begins to fill this gap by using a combination of five indicators to establish rankings of biocultural diversity for 238 countries and territories. We used the number of languages, religions, and ethnic groups present within each country as a proxy for its cultural diversity, and the number of bird and mammal species and the number of plant species as a measure of its biological diversity. The IBCD has three parts:

- A *biocultural diversity richness component* (BCD-RICH), which is a relative measure of a country's 'raw' biocultural diversity using unadjusted counts of the five indicators.
- An *areal component* (BCD-AREA), which adjusts the indicators for land area and therefore measures a country's biocultural diversity relative to its physical extent.
- A *population component* (BCD-POP), which adjusts the indicators for human population and therefore measures a country's biocultural diversity relative to its population size.

2. Methods

The IBCD gives equal weight to cultural and biological diversity, so a country's overall biocultural diversity score is calculated as the average of its cultural diversity score (CD) and its biological diversity score (BD).

$$\mathrm{IBCD} = \frac{\mathrm{CD} + \mathrm{BD}}{2}$$

In measuring a country's cultural diversity CD, equal weight is given to linguistic, religious and ethnic diversity. Therefore CD is calculated as the average of a country's language diversity (LD), religion diversity (RD), and ethnic group diversity (ED):

$$\mathrm{CD} = \frac{\mathrm{LD} + \mathrm{RD} + \mathrm{ED}}{3}$$

In measuring biodiversity BD, equal weight is given to animal species diversity (using birds and mammals as a proxy for all animal species marine mammals are excluded from the analysis) and plant species diversity. Therefore BD is calculated as the average of a country's bird and mammal species diversity (MD), and plant species diversity (PD):

$$\mathrm{BD} = \frac{\mathrm{MD} + \mathrm{PD}}{2}$$

Each indicator is given an equal weighting as this is the simplest way of calculating the index. As an aggregated index, the IBCD could be calculated using different weightings, to give greater or lesser impor-

Table 1
Unadjusted language diversity index (LD-RICH)

	No. of languages (L)	log L	LD-RICH (log L_i/log L_{world})
World	6800	3.83	1.000
Papua New Guinea (highest)	833	2.92	0.762
Mali (average)	45	1.65	0.431
Bermuda (lowest)	1	0.00	0.000

tance to any of the five component indicators. Alternative weightings are not analyzed here.

To derive country scores for each of the five component indicators, we compared each country's richness value with the global value. For example, for language diversity, LD is calculated as the log of the number of languages spoken in a country divided by the log of the number of languages spoken worldwide (see Table 1).

$$\mathrm{LD} = \frac{\log L_i}{\log L_{\mathrm{world}}}.$$

where L_i is the number of languages spoken in country i, L_{world} the number of languages spoken in the world (currently 6800).

The calculation was repeated for the other four indicators to derive BCD-RICH. Detailed discussion of the methods is included in the index's source document (Harmon and Loh, 2004). Data sources were as follows: languages (Grimes, 2000), religions (Barrett et al., 2001), ethnic groups (Barrett et al., 2001), bird/mammal species (Groombridge and Jenkins, 2002), plant species (Groombridge and Jenkins, 2002), country area (The Times, 2000; countries smaller than 1000 sq km are excluded), and country population (FAO, 2004; countries with a population of less than 10,000 are excluded).

To compensate for the fact that large countries tend to have a greater biological and cultural diversity than small ones simply because of their greater area (or greater population), we calculated two additional diversity values for each country by adjusting first for land area (BCD-AREA) and second for population size (BCD-POP). This was done by measuring how much more or less diverse a country is in comparison with an expected value based on its area or population alone. The method used is a modified version of that used by Groombridge and Jenkins (2002). As an example of the methods used, calculations for the language indicator value are shown in Tables 2 and 3. The process

Table 2
Area-adjusted language diversity index (LD-AREA)

Country or territory	Area (km^2)	log A	Total no. of languages (L)	log L	Expected log L value	Deviation from expected value	LD-AREA
World/maximum value	136605342	8.14	6800	3.83	2.33	1.50	1.000
Papua New Guinea (highest)	462840	5.67	833	2.92	1.56	1.36	0.952
Turkmenistan (average)	488100	5.69	37	1.57	1.57	0.00	0.500
Greenland (lowest)	2175600	6.34	2	0.30	1.77	−1.47	0.011
Minimum value						−1.50	0.000

Table 3
Population-adjusted language diversity index (LD-POP)

Country or territory	Population 2000 (thousand) P	log P	Total no. of languages (L)	log L	Expected log L value	Deviation from expected value	LD-POP
Maximum value	6056710	6.78	12000[a]	4.08	2.48	1.60	1.000
Papua New Guinea (highest)	4809	3.68	833	2.92	1.34	1.58	0.995
Pakistan (average)	141256	5.15	76	1.88	1.88	0.00	0.501
Korea, DPR (lowest)	22268	4.35	2	0.30	1.58	−1.28	0.099
Minimum value						−1.60	0.000

[a] Artificial number of languages chosen to create a maximum value higher than the highest-ranking country.

Table 4
IBCD-RICH: 20 highest-ranking countries

Country or territory	Total no. lang-uages (*L*)	Language diversity index, LD-RICH	Total no. of religions (*R*)	Religion diversity index, RD-RICH	No. of ethnic groups (*E*)	Ethnic group diversity index, ED-RICH	Cultural diversity index, CD-RICH	Total no. bird and mammal species (*M*)	Birds and mammal diversity index, MD-RICH	Total no. plant species (*P*)	Plants diversity index, PD-RICH	Bio-logical diversity index, BD-RICH	Index of bio-cultural diversity IBCD-RICH
World/maximum value	6800	1.000	10000	1.000	12583	1.000	1.000	14709	1.000	250876	1.000	1.000	1.000
Indonesia	736	0.748	535	0.682	744	0.700	0.710	2034	0.794	29375	0.827	0.811	0.760
Papua New Guinea	833	0.762	648	0.703	862	0.716	0.727	858	0.704	11544	0.752	0.728	0.728
Brazil	246	0.624	183	0.566	224	0.573	0.588	1886	0.786	56215	0.880	0.833	0.710
India	414	0.683	293	0.617	439	0.645	0.648	1313	0.748	18664	0.791	0.770	0.709
China	207	0.604	156	0.548	254	0.587	0.580	1494	0.762	32200	0.835	0.798	0.689
Nigeria	521	0.709	460	0.666	497	0.658	0.677	955	0.715	4715	0.680	0.698	0.688
United States	284	0.640	141	0.537	307	0.607	0.595	1078	0.728	19473	0.794	0.761	0.678
Cameroon	288	0.642	250	0.599	297	0.603	0.615	1099	0.730	8260	0.725	0.728	0.671
Congo, Dem Rep (Zaire)	221	0.612	173	0.560	260	0.589	0.587	1379	0.753	11007	0.749	0.751	0.669
Colombia	101	0.523	77	0.472	99	0.487	0.494	2054	0.795	51220	0.872	0.834	0.664
Mexico	303	0.647	36	0.389	278	0.596	0.544	1260	0.744	26071	0.818	0.781	0.663
Australia	315	0.652	83	0.480	133	0.518	0.550	901	0.709	15638	0.777	0.743	0.646
Peru	108	0.531	67	0.457	111	0.499	0.495	1998	0.792	17144	0.784	0.788	0.642
Malaysia	146	0.565	123	0.522	174	0.547	0.545	801	0.697	15500	0.776	0.736	0.640
Tanzania	141	0.561	119	0.519	163	0.540	0.540	1138	0.733	10008	0.741	0.737	0.638
Russia	119	0.542	67	0.457	169	0.543	0.514	897	0.709	11400	0.751	0.730	0.622
Myanmar	113	0.536	89	0.487	133	0.518	0.514	1167	0.736	7000	0.712	0.724	0.619
Sudan	142	0.562	119	0.519	245	0.583	0.554	947	0.714	3137	0.648	0.681	0.618
Philippines	184	0.591	152	0.545	183	0.552	0.563	349	0.610	8931	0.732	0.671	0.617
Ethiopia	88	0.507	118	0.518	145	0.527	0.518	903	0.709	6603	0.707	0.708	0.613

was repeated for the other four indicators to derive BCD-AREA and BCD-POP.

The expected diversity was calculated using the standard formula for the species–area relationship $\log S = c + z \log A$ where S = number of species, A = area, and c and z are constants derived from observation. Because the distributions of the five indicators against land area and population size are similar, we applied the same formula to indicators of cultural diversity. Hence, for BCD-AREA expected $\log N_i = c + z \log A_i$ where N_i = number of languages, religions, ethnic groups, or species in country i, and A_i = area of country i. The same formula was used for BCD-POP, except that P_i (population of country i) replaces A_i. To find the values of the constants c and z for each of the indicators, we scatter-plotted $\log N_i$ (where N_i = number of languages, religions, ethnic groups, or species in country i) against $\log A_i$ for all countries, and drew the best-fit straight line through the points. Examples for bird/mammal species and languages are in Figs. 1 and 2, respectively.

To calculate the deviation of each country from its expected value, we subtracted the expected $\log N_i$ value from the observed $\log N_i$ value. The index is calibrated such that the world, or maximum, value is set equal to 1.0, the minimum value is set equal to zero and the average or typical value is 0.5 (meaning no more or less diverse than expected given a country's area or population).

3. Results

By combining the results of BCD-RICH, BCD-AREA, and BCD-POP, we identified three 'core areas' of global biocultural diversity that include countries of various sizes and populations:

- The Amazon Basin, consisting of Brazil, Columbia and Peru, which ranked highly in BCD-RICH; Ecuador, which ranked highly in BCD-AREA; and French Guiana, Suriname and Guyana, which ranked highly in BCD-POP.

Table 5
IBCD-AREA: 20 highest-ranking countries

Country or territory	Area (km^2)	Language diversity index, LD-AREA	Religion diversity index, RD-AREA	Ethnic group diversity index, ED-AREA	Cultural diversity index, CD-AREA	Bird & mammal diversity index, MD-AREA	Plant diversity index, PD-AREA	Biodiversity index, BD-AREA	Index of biocultural diversity, IBCD-AREA
World/maximum value	136605342	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Indonesia	1919317	0.870	0.787	0.785	0.814	0.671	0.751	0.711	0.762
Papua New Guinea	462840	0.952	0.837	0.850	0.880	0.597	0.663	0.630	0.755
Colombia	1141568	0.607	0.596	0.549	0.584	0.704	0.882	0.793	0.688
Cameroon	475442	0.797	0.737	0.715	0.750	0.641	0.600	0.621	0.685
Malaysia	330442	0.715	0.671	0.660	0.682	0.605	0.736	0.671	0.676
Brunei	5765	0.602	0.552	0.515	0.557	0.767	0.798	0.782	0.669
India	3165596	0.765	0.713	0.702	0.727	0.560	0.639	0.600	0.663
Nigeria	923768	0.853	0.787	0.758	0.799	0.576	0.459	0.518	0.658
Nepal	147181	0.727	0.641	0.638	0.669	0.651	0.637	0.644	0.657
Brazil	8547404	0.645	0.643	0.586	0.625	0.567	0.782	0.675	0.650
Mexico	1958201	0.741	0.506	0.661	0.636	0.582	0.728	0.655	0.645
Peru	1285216	0.611	0.579	0.560	0.583	0.692	0.676	0.684	0.633
Ecuador	272045	0.486	0.514	0.458	0.486	0.754	0.788	0.771	0.628
Philippines	300076	0.753	0.696	0.670	0.706	0.458	0.641	0.550	0.628
Viet Nam	331041	0.656	0.621	0.591	0.623	0.592	0.665	0.629	0.626
Tanzania	942799	0.663	0.646	0.618	0.642	0.607	0.595	0.601	0.622
Laos	236800	0.656	0.628	0.598	0.627	0.589	0.641	0.615	0.621
Congo, Dem Rep	2345095	0.687	0.665	0.647	0.666	0.587	0.560	0.574	0.620
Panama	75517	0.487	0.524	0.500	0.504	0.725	0.740	0.733	0.618
Solomon Islands	28370	0.729	0.668	0.637	0.678	0.511	0.589	0.550	0.614

Table 6
IBCD-POP: 20 highest-ranking countries

Country or territory	Population 2000 (thousand)	Language diversity index, LD-POP	Religion diversity index, RD-POP	Ethnic group diversity index, ED-POP	Cultural diversity index, CD-POP	Bird & mammal diversity index, MD-POP	Plant diversity index, PD-POP	Biodiversity index, BD-POP	Index of biocultural diversity, IBCD-POP
WORLD/maximum value	6056710	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Papua New Guinea	4809	0.995	0.965	0.936	0.965	0.756	0.785	0.771	0.868
French Guiana	165	0.618	0.624	0.590	0.611	0.895	0.901	0.898	0.754
Suriname	417	0.611	0.622	0.572	0.602	0.942	0.805	0.874	0.738
Cameroon	14876	0.794	0.801	0.743	0.780	0.720	0.629	0.675	0.727
Indonesia	212092	0.789	0.807	0.756	0.784	0.641	0.682	0.662	0.723
Brunei	328	0.616	0.586	0.530	0.577	0.863	0.860	0.862	0.719
Colombia	42105	0.600	0.612	0.550	0.587	0.781	0.921	0.851	0.719
Gabon	1230	0.654	0.630	0.608	0.631	0.808	0.779	0.793	0.712
Guyana	761	0.566	0.577	0.526	0.557	0.916	0.809	0.862	0.710
Solomon Islands	447	0.786	0.762	0.705	0.751	0.628	0.706	0.667	0.709
Peru	25662	0.634	0.611	0.587	0.610	0.816	0.736	0.776	0.693
Australia	19138	0.794	0.649	0.623	0.689	0.651	0.740	0.695	0.692
Brazil	170406	0.651	0.675	0.602	0.643	0.642	0.831	0.737	0.690
Belize	226	0.593	0.542	0.545	0.560	0.878	0.741	0.809	0.685
Congo	3018	0.674	0.674	0.630	0.659	0.729	0.688	0.709	0.684
Laos	5279	0.683	0.683	0.635	0.667	0.685	0.711	0.698	0.682
Bolivia	8329	0.577	0.584	0.546	0.569	0.740	0.826	0.783	0.676
Malaysia	22218	0.682	0.695	0.654	0.677	0.610	0.727	0.668	0.673
Panama	2856	0.507	0.543	0.514	0.522	0.825	0.795	0.810	0.666
Central African Republic	3717	0.689	0.673	0.647	0.670	0.745	0.568	0.656	0.663

- Central Africa, consisting of Nigeria, Cameroon and the Democratic Republic of Congo (BCD-RICH), Tanzania (BCD-AREA) and Gabon and Congo (BCD-POP).
- Indomalaysia/Melanesia, consisting of Papua New Guinea and Indonesia (BCD-RICH), Malaysia and Brunei (BCD-AREA) and Solomon Islands (BCD-POP).

The world's four most bioculturally diverse countries – Papua New Guinea, Indonesia, Cameroon, and Colombia – rank in the top 10 for all three components of the index (see Tables 4–6 and Maps 1–3).

4. Discussion

The index of biocultural diversity has both theoretical and practical implications. For researchers of the interchanges between biological and cultural diversity, it provides a global context against which fine-grained analyses can be compared. For policy-makers and donor organizations, it is a potential framework for guiding strategic investments in biocultural diversity conservation. The three 'core areas' identified above are in that sense analogous to the results of several schemes that recently have been developed for identifying the world's most important areas for biodiversity conservation and ecoregion protection (Davis et al., 1994; Stattersfield et al., 1998; Myers et al., 2000; Olson et al., 2001). For the general public, the index serves as a reminder that no matter where a country ranks, its biocultural diversity is an important part of the global complement.

The purpose of any global index is to use simple proxies to indicate the status of complex phenomena. Our index is intended to provide a snapshot of the current distribution of the world's biocultural diversity. As more and better data become available, particularly on the numbers of individuals in each language group, religion, ethnic group, or species, it will be possible to analyze trends. Then we will be

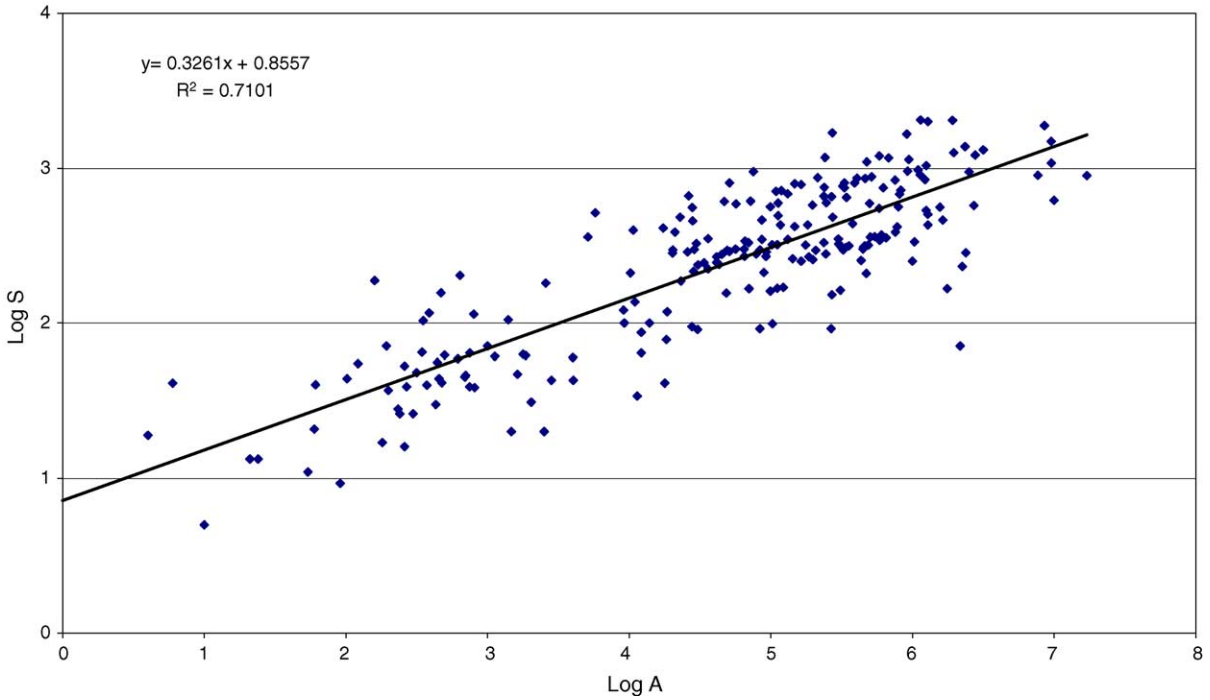


Fig. 1. Bird/mammal species—area plot.

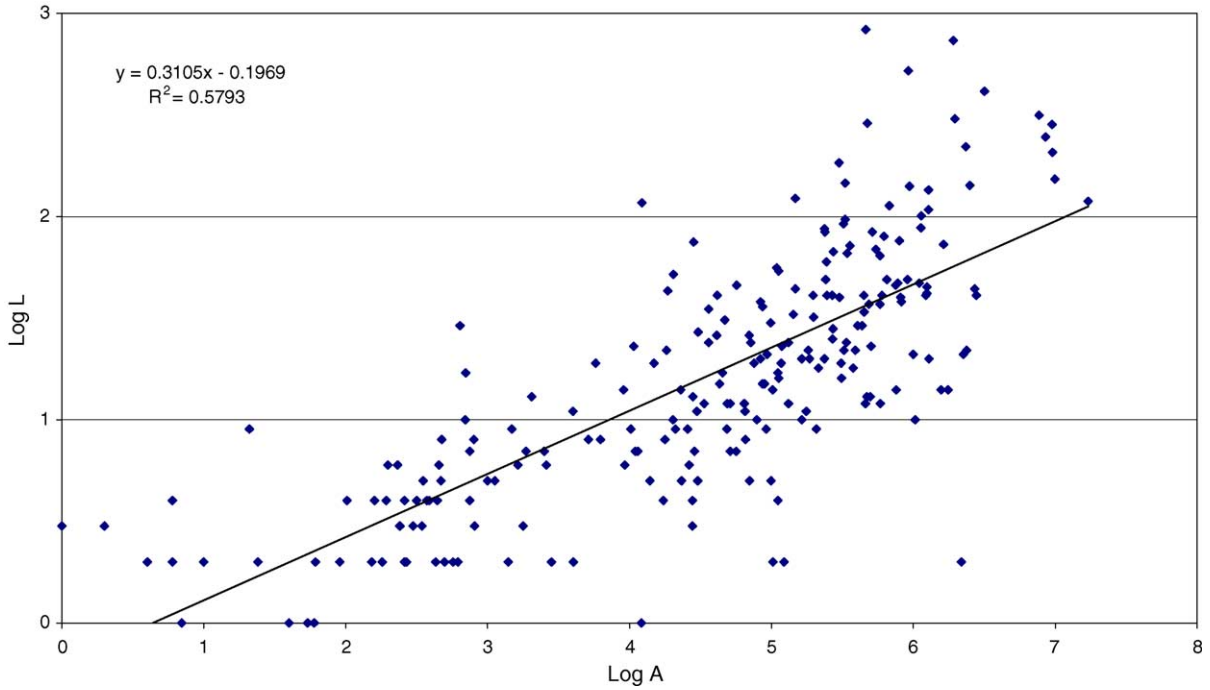
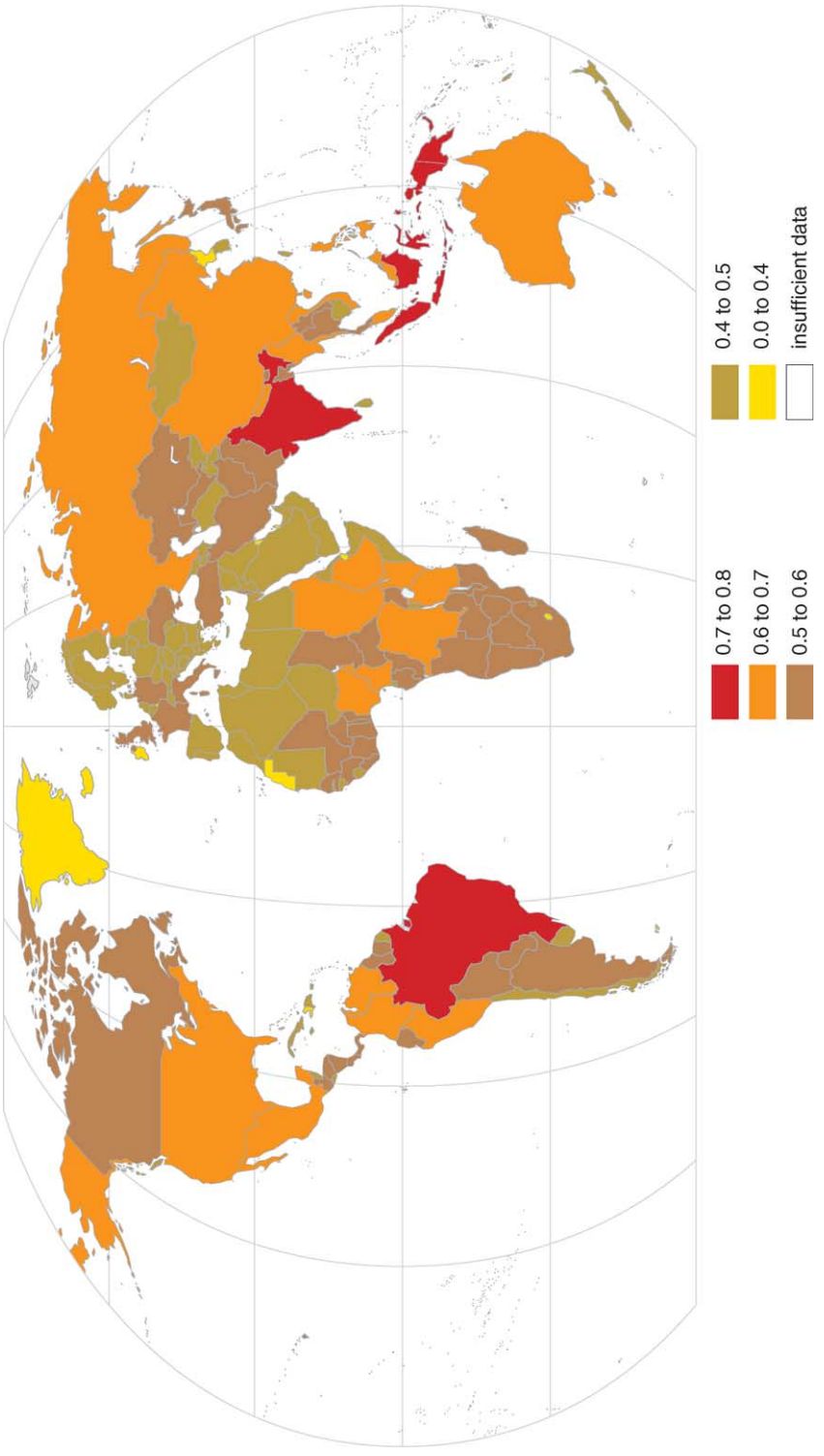
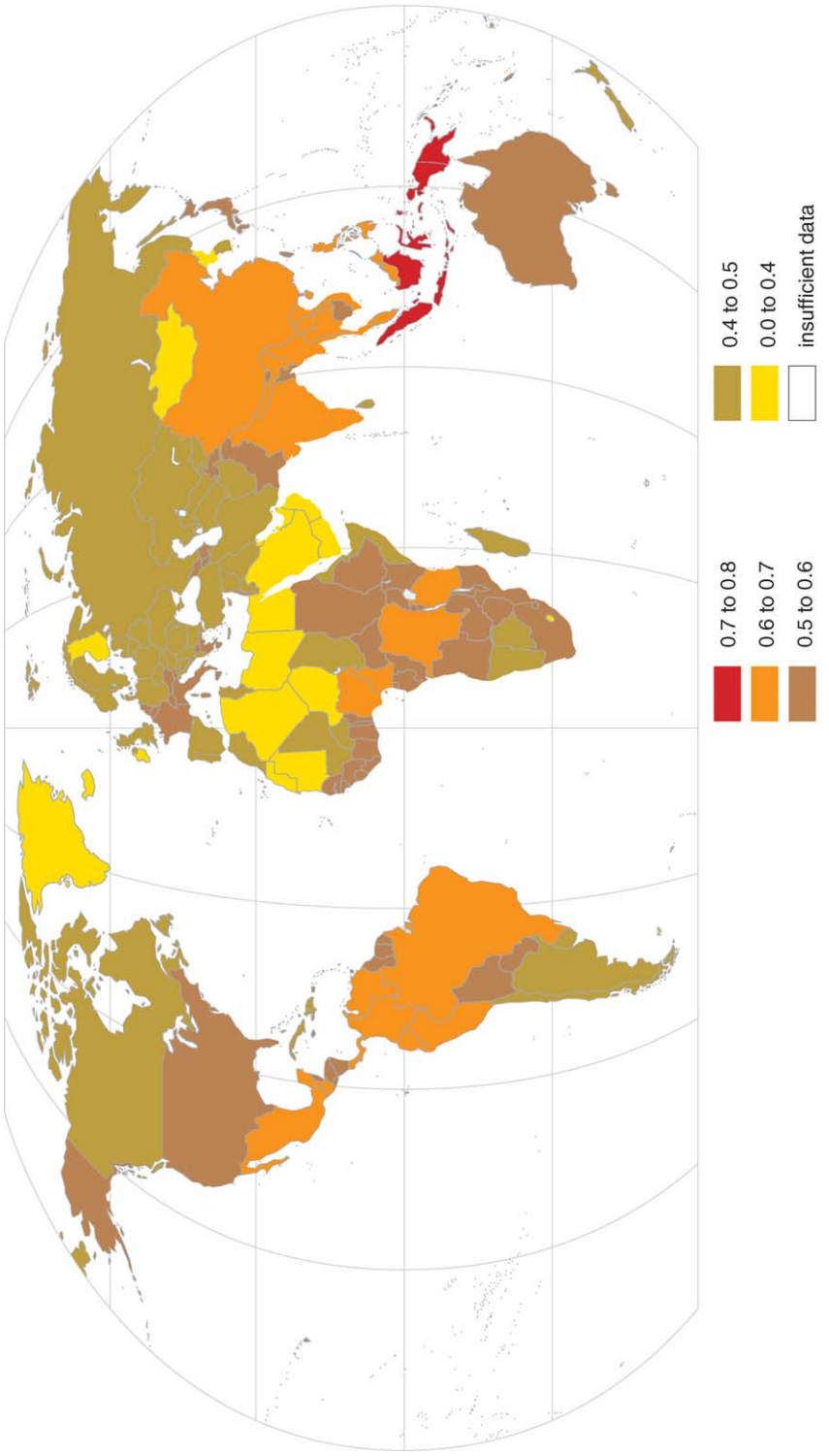


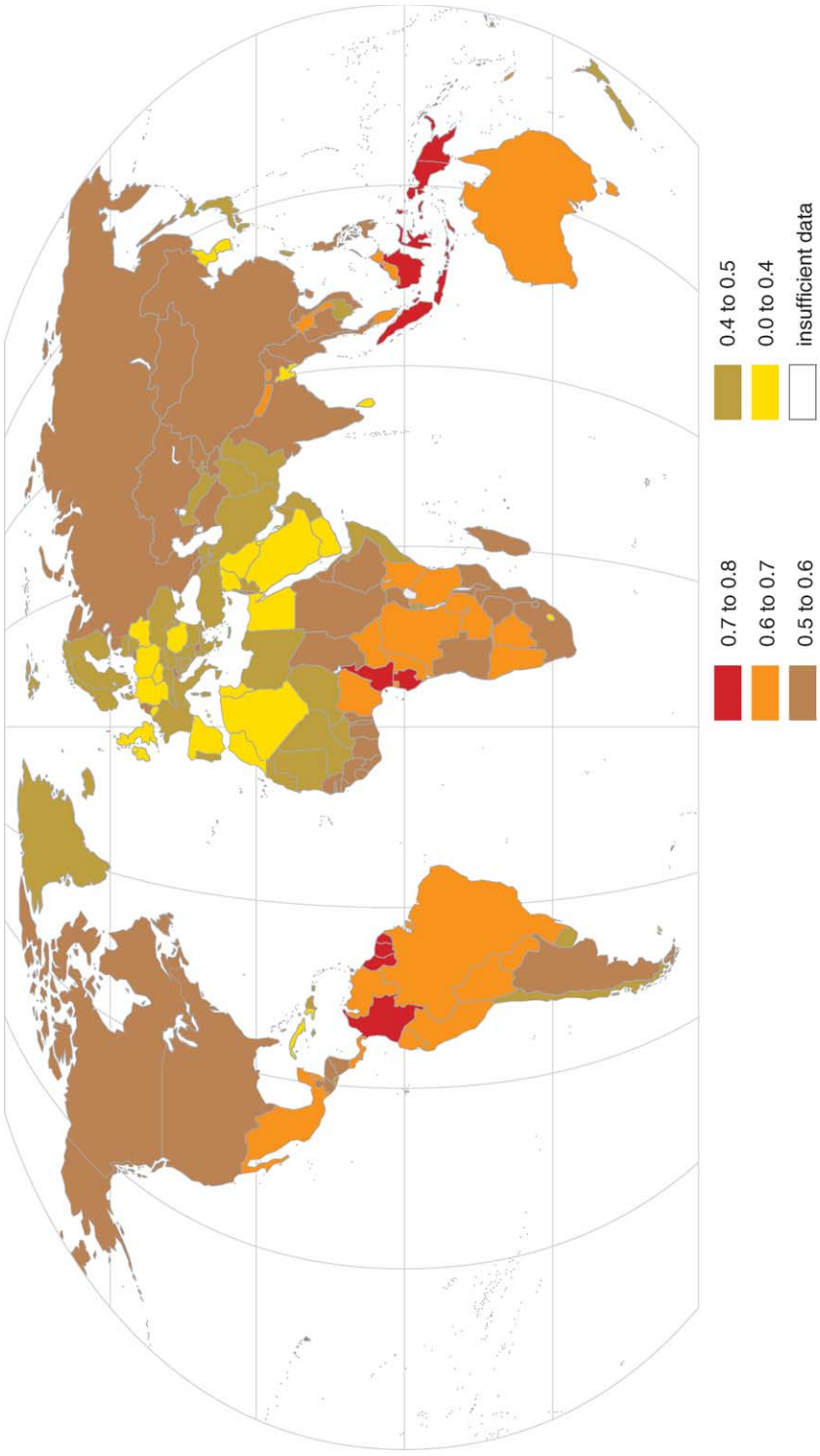
Fig. 2. Languages—area plot.



Map 1. Index of biocultural diversity IBCD-RICH.



Map 2. Index of biocultural diversity IBCD-AREA.



Map 3. Index of biocultural diversity IBCD-POP.

able to get at the critical question of the rate of change of the world's biocultural diversity.

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