



ON BIOCULTURAL DIVERSITY

linking language, knowledge, and the environment

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ON THE COEVOLUTION OF CULTURAL, LINGUISTIC, AND BIOLOGICAL DIVERSITY

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The present volume is concerned with the connections between linguistic, cultural, and biological diversity. My chapter focuses in particular on whether and how these three types of diversity might coevolve or influence each other. I begin by considering some fundamental issues. First, what is cultural diversity? To answer this, we obviously must start with a definition of culture, as well as a consideration of the nature of cultural systems and their boundaries (e.g., are human populations characterized by distinct "cultures" akin to species?). Second, what generates cultural (including linguistic) diversity? I briefly distinguish two perspectives on this issue: phylogenetic and adaptationist.

I then offer an empirical examination of the correlation between cultural, linguistic and biological diversity using a continental-scale case study. Specifically, I examine the correlation between measures of biodiversity and measures of both linguistic and cultural diversity for indigenous culture areas in America north of Mexico. My results, while preliminary, indicate that Native North American linguistic and cultural diversity are independently correlated with at least one measure of biodiversity (but not some others). The correlation between linguistic and cultural diversity in Native North America is more problematic, since many linguistically similar peoples have culturally diverged, while many groups with divergent linguistic heritage developed cultural similarity through cultural diffusion and ecological adaptation. Thus, analysis of the Native North American data raises numerous questions about the relationships between biological and cul-

tural and linguistic diversity that will require much further theoretical and empirical work to resolve.

Using the Native American case study results as a springboard, I examine three general explanations for why biodiversity and cultural and linguistic diversity might be correlated: (a) small-scale, culturally diverse societies conserve or enhance biological diversity; (b) biological diversity directly enhances cultural diversity; (c) large-scale, centralized cultural systems require or generate low cultural, linguistic, and biological diversity. It is important to note that these are not mutually exclusive explanations. Thus, if (a) and (b) were both correct, the result would be a co-evolutionary process of mutual reinforcement between cultural and biological diversity. And if either (a) or (b) were correct, this might produce a pattern of correlation in many parts of the world that has been increasingly obliterated by the expansion of states and empires, as proposed in (c).

ON THE MEANING OF CULTURAL DIVERSITY

To define what cultural diversity is and where it comes from, we obviously must decide what we mean by the term "culture." Despite the centrality of this concept for their discipline, anthropologists have perennially disagreed about its meaning. Many scholars interested in cultural evolution choose to define culture as *socially transmitted information*, where "information" refers to beliefs, values, knowledge, and the like (Boyd and Richerson 1985; Durham 1991). This definition has several features. It distinguishes culture from behavioral phenotypes, including artifacts, while recognizing that these can be products of cultural information. It recognizes that behavioral phenotypes can be jointly shaped by genes, culture, and nonsocial environment. By highlighting the criterion of social transmission, it both emphasizes that culture is a system of inheritance and distinguishes culture from genetic inheritance. This last point implies that culture, like genetic information, is subject to evolutionary change (through drift, natural selection, and possibly other means). While many people disagree with the idea that culture is ideational (in the sense just described) and hence distinct from behavior, I believe this is the best way to reconcile the concept with the genotype-phenotype distinction. While culture is transmitted via behavior (speech, visual symbols, gesture, etc.), since any behavior is phenotypic, it cannot be purely cultural because it is necessarily shaped by gene-environment interaction too.

What Is Cultural Diversity?

By analogy with measures of biodiversity, we might suppose that cultural diversity can be defined in terms of the variation in culturally heritable information and its distribution across cultural lineages (cf. Mishler this volume). Indeed, there has been a recent upsurge in phylogenetic analyses of cultural variation (e.g.,

Mace and Pagel 1994) and its correlation with linguistic and genetic phylogeny (e.g., Cavalli-Sforza et al. 1988, 1989; Cavalli-Sforza, Minch, and Mountain 1992). But there are some serious drawbacks with this phylogenetic approach to culture and cultural diversity. First, humanity is a single species, and there are few barriers to the flow of cultural information (diffusion) between cultural units or lineages relative to those limiting gene flow between species. While a phylogeny requires a set of discrete taxa, it is by no means clear that cultural variation (including cultural innovations) is bounded into discrete cultures. Of course, the same could be said about biological species, but in general the taxonomy of biospecies is much less problematic than is the case for cultural analogues.

On the other hand, I do not think we need to have sharp, clear boundaries between entities in order to find it useful to distinguish them; if that were the case, we could never differentiate day from night, or summer from winter. As long as we take care not to reify these "constructed" entities or view them as strictly bounded and impermeable, a notion of discrete cultures might be a reasonable approximation for many times and places (though increasingly less so in the "global-transnational-postcolonial" era). Although I am not a linguist, and while I am aware of pidgins and creoles and various forms of linguistic borrowing, my sense is that boundaries between languages are more easily distinguished than those between other types of cultural variation. In any case, sophisticated measures of cultural diversity will need to take diffusion into account and consider cultural *microdiversity* or trait distribution between individuals as well as at larger geographical scales.

Where Does Cultural Diversity Come From?

Two broad approaches to this issue can be found in the literature. The *phylogenetic* perspective sees it as a branching process of speciation and extinction, akin to biogenetic phylogenies. This perspective gives priority to isolation and to chance historical factors (cultural "drift," so to speak) in generating cultural diversity. As I argued above, this may work reasonably well for languages but is of limited utility for nonlinguistic cultural diversity, as a result of extensive cultural diffusion. Alternatively, many have taken an *adaptationist* perspective, viewing cultural change as a form of coevolution between cultural information and the social and natural environment. In this view, cultural diversification occurs through various processes of cultural adaptation, including niche partitioning (à la Barth 1956) and in some cases direct competition between cultural entities.

THE NATIVE NORTH AMERICAN CASE

Since analysis of the relationships between biodiversity and cultural or linguistic diversity is in its infancy, there is clearly a need for empirical assays to determine which of the various theoretical possibilities have in fact been commonly realized.

Table 5.1 Linguistic Diversity in Native North America

Culture Area	Language Phyla or Families	Languages
Arctic	Eskimo-Aleut	9
Basin	Uto-Aztecan	6
California	Algonkian, Athapaskan, Hokan, Penutian, Uto-Aztecan, Yukian	74
Northeast	Algonkian, Iroquoian	> 38
Northwest	Chimukan, Na-Dene, Penutian, Salishan, Wakashan	44
Plains	Algonkian, Aztec-Tanoan, Caddoan, Siouan	18
Plateau	Sahaptian, Salishan	15
Southeast	Caddoan, Iroquoian, Muskogean	> 32
Southwest	Aztec-Tanoan, Yuman, Athapaskan	27
Subarctic	Algonkian, Athapaskan	12
Total	8 phyla, 59 families and isolates	> 275

Sources: Goddard 1978; Hale and Harris 1979; Hunn 1990; Kehoe 1992; Kendall 1983; Lounsbury 1978; Miller 1986; Sherzer 1991; Shipley 1978; Thompson and Kinkade 1990; Young 1983.

As a small contribution toward this end, I have chosen to examine the ethnographic region I know best, Native North America.

There is a long tradition of considering the relation between environmental factors and Native American cultural variation, beginning with Wissler's (1924, 1926) attempt to define culture areas on the basis of subsistence, and continuing with the much more detailed work of Kroeber (1939) and Jorgensen (1980) on the correlation between environmental zones (defined by climate and vegetation) and culture areas (defined on the basis of cultural features as recorded in the ethnographic literature).

In the analyses presented below, I utilize this literature to examine the degree to which biodiversity correlates with linguistic and cultural diversity in Native North America. To do this, we must first decide how to measure the three different kinds of diversity. Native American cultural diversity is conventionally categorized according to subcontinental regions known as "culture areas."¹ In recent years, the most common culture-area scheme has consisted of ten areas (e.g., Kehoe 1992), as listed in table 5.1. While these areas differ in size, population density, and degree of cultural heterogeneity, they are at least roughly comparable units, and prior to European invasion each contained dozens of ethnolinguistic units and hundreds of local groups.² Thus, the culture area scheme provides a handy if imperfect framework for analyzing aboriginal cultural and linguistic diversity on the North American continent.

To quantify linguistic diversity, I chose a crude but feasible measure, the minimum estimated number of distinct languages spoken in each culture area at time of contact, although table 5.1 also provides some information on diversity of higher-level taxonomic units (language families and phyla).

Table 5.2 Cultural Diversity in Western Native North America

Culture Area	Ethnolinguistic Groups	Similarity Index ^a
Basin	24	68%
California	55	51%
Northwest	35	55%
Plains	36	n.a.
Plateau	21	62%
Southwest	37	43%

Sources: Kehoe 1992 (Plains); Jorgensen 1980 (all others).

^aBetween-group within-area coefficient of similarity for 292 variables containing 1,577 attributes (Jorgensen 1980); the higher the value, the lower the areal diversity.

For nonlinguistic cultural diversity, I used two measures. The simplest, following the example of Wilcox and Duin (1995), is number of ethnolinguistic groups. The second assay of cultural diversity I employed is a statistical measure of culture trait diversity, which quantifies the proportion of traits shared between the ethnolinguistic groups in a given culture area (table 5.2). Unfortunately, comparable data on these two measures are only available for a subset of Native American culture areas (Jorgensen 1980).³ Of course, the validity of the entire procedure depends on how good a basis there is for selecting and measuring a set of culture traits. Many anthropologists feel there is no good basis for doing so; while I recognize the problems, I feel that some quantitative measure of cultural variation is better than none at all.

Biodiversity can be measured in a variety of different ways; for present purposes I settled on a crude but feasible measure, species richness. Given the available data, I chose to measure species richness for selected taxonomic categories, namely trees, native vascular plants, and homeotherms (birds and mammals). I used maps plotting these data for North America developed by the World Wildlife Fund (Ricketts et al. 1997) and superimposed them on a map of Native North American culture areas of the same scale.⁴ I then visually estimated the average species richness for each culture area. The resulting estimates (table 5.3) are not very precise, but since my analysis requires only ordinal rankings, I believe the data and methods are sufficient for present purposes.

Linguistic Diversity

What, then, do we find when we examine the correlations between these various measures of diversity? First, linguistic diversity shows a moderate degree of positive correlation with tree species diversity (fig. 5.1). Indeed, the four culture areas

Table 5.3 Biodiversity Measures for Native North American Culture Areas

Culture Area	Biodiversity (Mean Species Richness)			
	Trees	Vascular	Mammals	Birds
Arctic	10	551	30	97
Basin	30	2292	77	216
California	55	2035	60	213
Northeast	80	1584	61	206
Northwest Coast	32	1233	59	193
Plains	56	1874	74	213
Plateau	26	1428	63	198
Southeast	150	2401	61	215
Southwest	45	2220	88	223
Subarctic	20	893	37	159

Source: Calculated by author from map data in Ricketts et al. 1997.

with the lowest tree-species diversity also have the lowest linguistic diversity, while the three highest tree-diversity areas include two of the three areas with highest linguistic diversity (tables 5.1 and 5.3). The major outlier for this correlation is the Southeast culture area, which, because of its moist and temperate to subtropical climate, has very high tree diversity (averaging 150 species) but only intermediate linguistic diversity. The precontact linguistic diversity of the Southeast is difficult to establish, however, since early and massive depopulation undoubtedly extinguished a number of Southeastern languages before they were ever recorded (hence the notation in table 5.1 of "> 32" languages). If the actual number of languages spoken in the Southeast in 1492 were as much as 50 percent above the recorded value, this would give it the second-highest linguistic diversity and increase the correlation with tree diversity somewhat.⁵ One other notable divergence between arboreal and linguistic diversity is the low tree diversity rank (fifth) for Northwest Coast, an area with the second-highest linguistic diversity; this may reflect the fact that Northwest Coast Indian subsistence is focused on marine, not terrestrial, resources, making tree diversity a poor indicator of relevant biodiversity.

When we turn to native vascular plants, we find that species richness shows only a very low and statistically insignificant correlation with Native North American linguistic diversity (fig. 5.2). The correlation is greatly weakened by the two outliers, Great Basin (upper-right point) and Northwest Coast (upper-left); if we remove these two regions from the sample, the correlation becomes moderately strong ($r_s = 0.738$) and statistically significant ($p < .02$, one-tailed, $n = 8$).

In the case of faunal (bird and mammal) diversity, no correlation at all with lin-

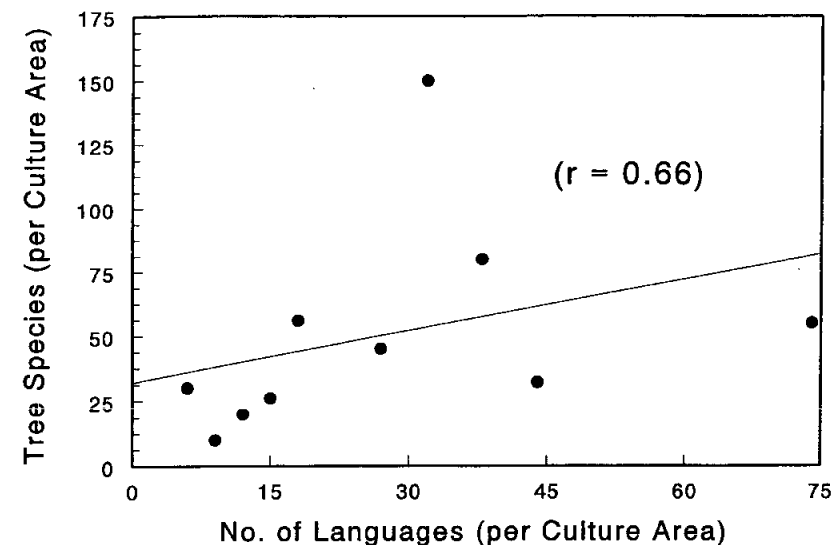


Figure 5.1. Tree species richness and linguistic diversity per Native North American culture area (correlation is Spearman's r_s coefficient for rank order, $p < .05$; plotted line is simple linear regression).

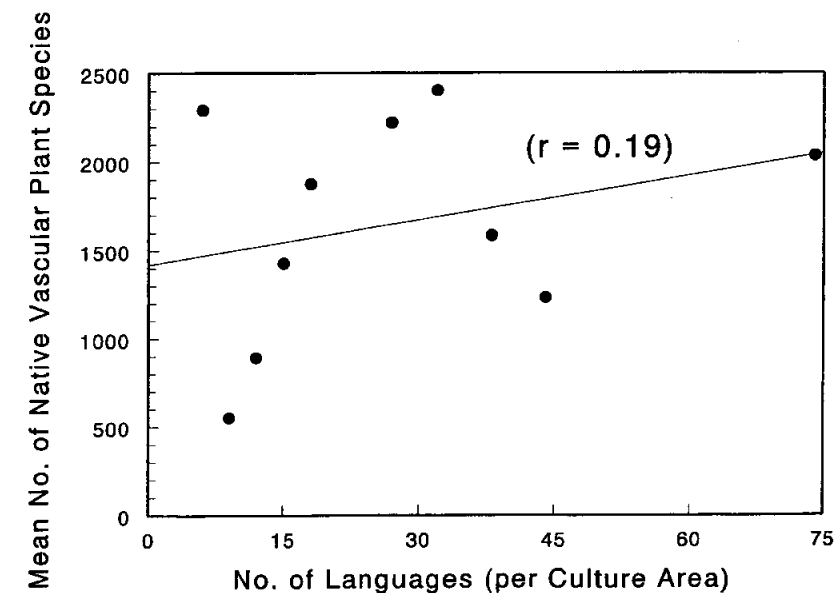


Figure 5.2. Native vascular plant species richness and linguistic diversity per Native North American culture area (correlation is Spearman's r_s coefficient for rank order, and is not significant; plotted line is simple linear regression).

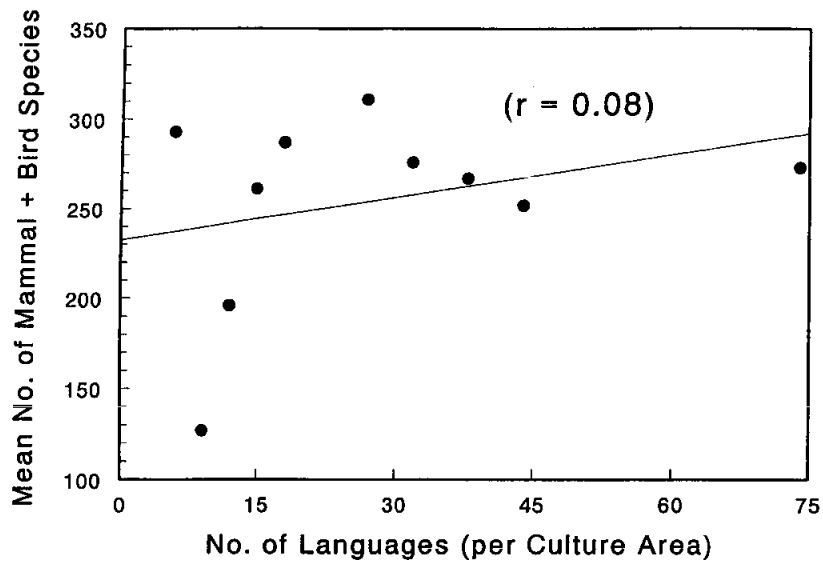


Figure 5.3. Faunal species richness and linguistic diversity per Native North American culture area (correlation is Spearman's r_s coefficient for rank order, and is not significant; plotted line is simple linear regression).

guistic diversity is evident (fig. 5.3).⁶ For example, the Northwest Coast, despite its very high linguistic diversity, is at the low end of faunal diversity; again, this lack of correlation may reflect the relative unimportance of terrestrial species in Northwest Coast aboriginal economies. The Southwest and Great Basin areas have the two highest values for both avian and mammalian species richness, yet are intermediate to very low in linguistic diversity. Clearly, faunal diversity, at least as measured by avian and mammalian species, has little or no bearing on linguistic diversity in Native North America.

Cultural Diversity

Analysis of the relationships between biodiversity and nonlinguistic measures of cultural diversity reveals the same patterns found with linguistic measures. Tree species diversity is highly correlated with the number of ethnolinguistic groups found in each culture area (fig. 5.4) and with a quantitative measure of the degree of culture-trait similarity found within each of these areas (fig. 5.5). These correlations retain statistical significance, despite the fact that problems with data availability reduce the sample to a handful of culture areas (see n. 3).

Faunal diversity, by contrast, is not significantly correlated with either measure of cultural diversity (table 5.4), although both correlations are positive. If we sep-

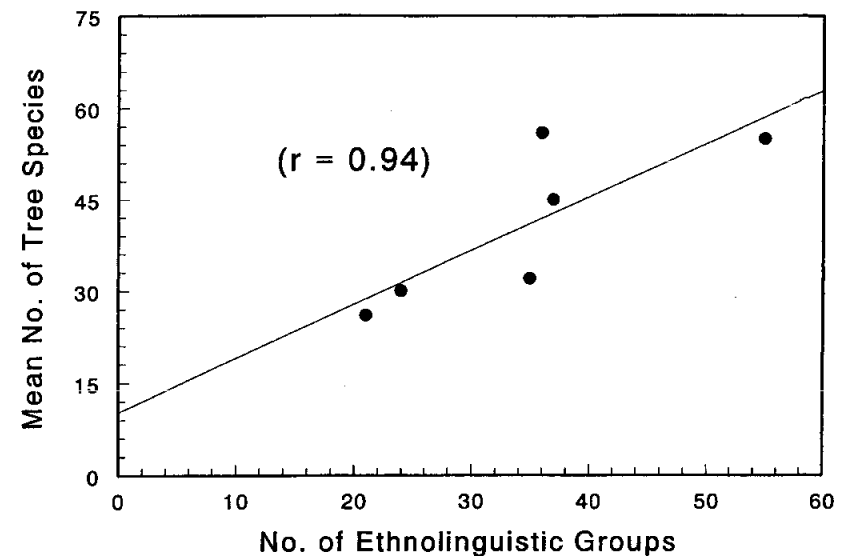


Figure 5.4. Tree species richness and number of ethnolinguistic groups per Native North American culture area (correlation is Spearman's r_s coefficient for rank order, $p < .05$; plotted line is simple linear regression).

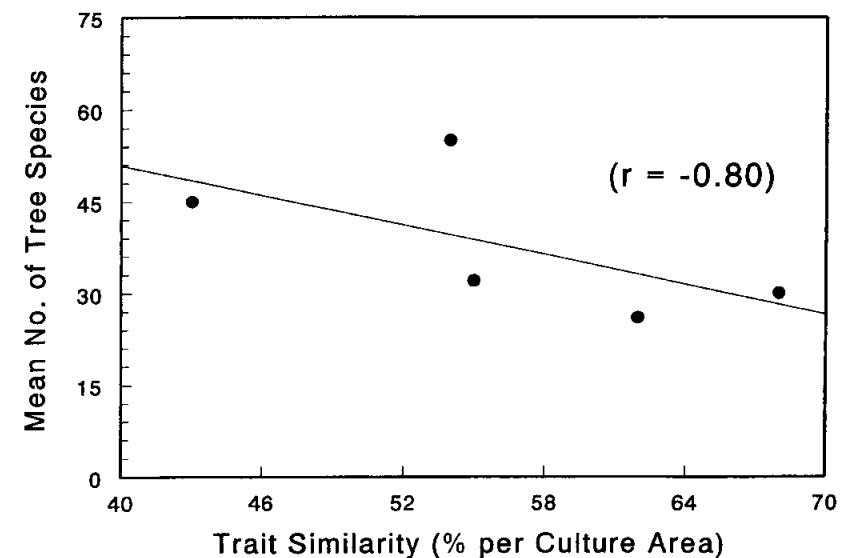


Figure 5.5. Tree species richness and coefficient of culture trait similarity per Native North American culture area (correlation is Spearman's r_s coefficient for rank order, $p < .01$; plotted line is simple linear regression).

Table 5.4 Summary of Correlations between Cultural, Linguistic, and Biological Diversity for Native North American Culture Areas

Species	Languages	Ethnolinguistic Groups	Cultural Traits
Tree species	0.661*	0.943*	0.800†
Native vascular plant species	0.188	0.257	-0.100
Faunal species	0.079	0.314	0.300

Sources: Data from tables 5.1–5.3. Spearman rank order correlations; statistical significance indicated by † ($p < .05$) or * ($p < .01$) (one-tailed, $n-2$ degrees of freedom).

arate faunal species into birds and mammals, mammalian species richness does correlate significantly with cultural trait diversity ($r_s = 0.9$, $p < .01$, one-tailed), but not with number of ethnolinguistic groups. Native vascular plant diversity shows no correlation at all with the Jorgensen measure of cultural diversity or with number of ethnolinguistic groups (table 5.4).

Although the various measures of linguistic and cultural diversity employed here have weaknesses, the fact that tree diversity correlates well with each of them is interesting. The fact is that the correlation between linguistic and cultural diversity in Native North America is quite problematic. This is because many linguistically related groups have culturally diverged, while many groups with divergent linguistic heritage developed cultural similarity through cultural diffusion and ecological adaptation. For example, speakers of Athapaskan languages are spread across four different culture areas, and in each area they exhibit marked cultural adjustment to the particular social and ecological setting, despite the fact that some of the languages involved seem to have diverged only about a millennium ago. The opposite phenomenon of cultural convergence despite divergent linguistic origins is also widely exemplified in Native North America; the California and Plains culture areas provide particularly striking examples. In sum, linguistic diversity, at least as measured phylogenetically, cannot be assumed to covary with cultural diversity. Hence, it is quite remarkable that at least one measure of biodiversity is independently correlated with both cultural and linguistic diversity in Native North America. Other than that, however, the findings do not seem to support the idea that biodiversity is robustly correlated with either cultural or linguistic diversity.

WHY MIGHT CULTURAL AND BIOLOGICAL DIVERSITY CO-EVOLVE?

According to Maffi (1996:3), “evidence is emerging of remarkable overlaps between areas of greatest biological and greatest linguistic/cultural diversity around the world. These striking correlations require close examination and must

be accounted for.” Indeed, a number of authors (e.g., Chapin 1992; Toledo 1994; McNeely and Keeton 1995; Poole 1995; Wilcox and Duin 1995; Harmon 1996; Lizarralde this volume) have suggested that cultural (including linguistic) and biological diversity tend to be correlated, and a larger number have argued that small-scale or indigenous social systems, which tend to occur in areas of high cultural and linguistic diversity, are more likely to conserve or coexist with biodiversity, although this latter argument is controversial (e.g., compare Alcorn 1996 with Hames 1991).

While examination of the Native North American case gives mixed results, let us suppose that biodiversity does tend to correlate with cultural and/or linguistic diversity. How might we explain such a correlation? Three general hypotheses to answer this question are considered here: (*H1*) small-scale societies conserve or enhance biological diversity; (*H2*) biological diversity directly enhances cultural diversity; (*H3*) large-scale social systems reduce both cultural and biological diversity. These hypotheses are not mutually exclusive—indeed, a coevolutionary model in which cultural and biological diversity mutually reinforce each other combines (*H1*) and (*H2*)—but for analytical purposes it is fruitful to consider them separately.

(*H1*) *Small-scale societies enhance or conserve both cultural and biological diversity:* This position is argued by a number of ethnobiologists and anthropologists who view small-scale societies as reservoirs of cultural and linguistic diversity and as preservers of biodiversity (see review in Bodley 1996). The general argument here is that small-scale societies protect local biological resources because they rely on these for their subsistence and for their very survival and that a regional aggregate of these societies, because of their small scale and localized nature, will tend to contain high levels of linguistic and cultural diversity as well. Some have criticized this argument for advancing a naïve and romantic view of indigenous peoples as “ecologically noble savages” (Redford 1991; Alvard 1993). But an empirically rigorous and theoretically sophisticated case for (*H1*) can be made.

There are several mechanisms that have been ethnographically described by which small-scale societies directly enhance biodiversity, including:

(a) subsistence-related enhancement of biodiversity (e.g., plant breeding, active transplanting, soil enrichment, maintenance of habitat patchiness or successional disturbance through clearing and burning);

(b) ceremonial and secular proscriptions against resource depletion or utilization (e.g., sacred groves, controls on the timing or location of resource harvesting); and

(c) epiphenomenal conservation (Hunn 1982) as a byproduct of subsistence-driven mobility, low population density, or habitat avoidance (e.g., buffer zones between territories of hostile neighboring groups).

The overall prevalence and effectiveness of these mechanisms among small-

scale societies in general is not well known at present, although a substantial number of cases have been described (e.g., Johannes 1978; Berkes et al. 1989; Nabhan 1989; various authors in Posey and Balée 1989; Bye 1993; Sponsel and Loya 1993; Balée 1994; Brush 1995; Russell-Smith et al. 1997). On the other hand, an increasing number of instances where prestate societies (particularly those colonizing new habitats or engaging in subsistence innovation) have depleted biodiversity have also been documented (Brightman 1987; Kohler 1992; Redford and Stearman 1993; Alvard 1994, 1998; Broughton 1994; Steadman 1995; various authors in Kirch and Hunt 1997). Determining the overall balance between these two opposing trends, and the conditions which favor one outcome or the other, will require much more research. My own preliminary reading of the historical and ethnographic evidence is that even cases of biodiversity enhancement or preservation involve actions or institutions aimed at enhancing something other than biodiversity, such as density or productivity of resources useful for human consumption (e.g., Johnson 1989; Low 1996; Ruttan 1998). But this is an issue on which various anthropologists and other scholars (e.g., conservation biologists, environmental historians) are currently rather strongly polarized, and a more systematic assessment of the evidence is needed than I can provide here before any firm conclusions can be drawn.

(H₂) *Biodiversity directly enhances cultural diversity*: Whatever the validity of (H₁), it seems unlikely to explain such intriguing phenomena as the concentration of much linguistic diversity in areas of high biodiversity such as the moist tropical forest of Central America, Amazonia, Central Africa, Southeast Asia, and Australia, and Melanesia (table 5.5), given that most of the biodiversity of these forests has natural rather than anthropogenic causes.

(H₂) provides an alternative or complementary explanation for such patterns. At least three possible mechanisms might underlie this hypothesis:

(a) high biodiversity, by providing an increased number of niches, may encourage greater cultural diversification through niche partitioning;

(b) high biodiversity may occur in areas less subject to environmental fluctuations, resulting in more stable resource populations which permit smaller, more localized human societies to be relatively self-sufficient (and hence, given reduced cultural diffusion and perhaps increased cultural "drift," more divergent through time);

(c) high biodiversity may covary with high biological productivity, which in turn allows the coexistence of a variety of production systems and associated sociocultural patterns.

We do not have robust tests of any of these possible mechanisms, but some brief and tentative assessments can be made. With regard to (a), high biodiversity may not result in niche divergence unless it is the "right kind" of biodiversity. Indeed, I suspect that niche diversification among sympatric populations (groups sharing the same habitat) may actually be more common among intensive agro-

Table 5.5 Endemic Languages in Tropical Forest Regions

Region	Number of Countries	Percent of Languages	World Total
Central Africa	8	881	13.0
Southeast Asia	8	1046	15.5
Amazonia	5	362	5.4
Mesoamerica	8	285	4.2
PNG/Melanesia	4	1056	16.2
(Europe, for comparison)	(38)	(75)	(1.1)
Totals (tropics only)	33	3630	55.6

Source: Tabulations by the author from data in Grimes 1992.

pastoralists, in areas of moderate to low linguistic diversity and substantially degraded biodiversity, than in the "hot spots" of biological and linguistic diversity such as tropical forests. My logic here is that complex socioeconomic systems of production and exchange should expand the number of ways in which various groups can utilize the environment to make a living, and hence the opportunities for sympatric niche diversification (e.g., Barth 1956). It also seems probable that seasonality plays a large role in sympatric niche diversification, as when the same area is used successively by agriculturalists, pastoralists, fishermen, and so on (Monique Borgerhoff Mulder, personal communication 1998).

Mechanism (b) is essentially a phylogenetic approach, since it assumes that cultural diversity accumulates as a function of time and (relative) isolation or self-sufficiency. Since biodiversity in terms of endemic species may largely be a function of (genetic) isolation of species and (ecological) fragmentation of communities, both of which might build up more readily in stable (e.g., tropical low-seasonality) environments, it could be that correlations between cultural and biological diversity often reflect coevolutionary isolation of both kinds of "information." Harmon (1996) has shown that linguistic and biological endemism (the latter for vertebrate species) are quite coincident around the globe, measured at the country level. But the detailed reasons why this coincidence may exist have not been examined; mechanism (b) is one candidate for explaining this.

As for mechanism (c), I am skeptical of it for the simple reason that high biodiversity does not necessarily mean higher net primary productivity (NPP) overall, let alone higher availability of resources consumable by humans.⁷ I am not aware of any systematic attempts to correlate human population density and biodiversity, but we can get some sense of the problems with (c) by examining the data for Latin American ecoregions compiled by Wilcox and Duin (1995). They provide data on NPP and two measures of biodiversity ("forest tree genetic resources" and "centers of plant diversity") for 218 ecoregions grouped into 11 habi-

Table 5.6 Summary of Correlations between Cultural and Biological Diversity for Latin American Ecoregions

	Number of Indigenous Populations	Net Primary Productivity
Tree genetic resources	0.961*	0.070
Centers of plant diversity	0.849*	-0.100
Net primary productivity	0.588 [†]	—

Source: Calculated by the author from data in Wilcox and Duin 1995. Spearman rank order correlations, with statistical significance indicated by [†] ($p < .05$) or * ($p < .001$) (one-tailed, $n - 2 = 9$ degrees of freedom).

tat types (after Dinerstein et al. 1995). These data indicate that NPP is completely uncorrelated with biodiversity across habitats and is only marginally correlated with the number of indigenous populations per habitat, Wilcox and Duin's measure of cultural diversity (table 5.6). NPP is very high in some habitats (e.g., mangrove swamps, tropical moist forests) where human population density is low, because the biological productivity is locked up in forms (e.g., woody plant tissue) that are not directly consumable by humans or even by their herbivorous prey. To put it colloquially, neither people nor their herbivorous prey eat trees.

Indeed, the converse of (c) may often hold: many human populations may reduce biodiversity in order to channel a larger proportion of NPP into edible products, the most extreme expression of this being the monocropping and landscape modification practiced in some forms of intensive agriculture. For example, most of the Javanese landscape has been transformed by human action over the last several centuries from tropical forest to highly managed irrigated and terraced wet-rice agroecosystems (Geertz 1963; Lansing 1991). But that argument takes us into the domain of (H₃).

(H₃) *Large-scale social systems reduce both cultural and biological diversity:* The basic idea here is that large-scale (stratified, centralized, nation-state, high population density) social systems have political-economic dynamics that consume an increasing proportion of the biological productivity in areas they occupy, and in turn such systems expand at the expense of small-scale (decentralized, subsistence-based, low-density) systems. This historical process is also an ecological process with significant implications for biodiversity (Norgaard 1988). If cultural and linguistic diversity is maximized in regions inhabited by small-scale social and economic systems (H₁), and withers when incorporated into large-scale systems (via direct conquest or economic domination), then cultural and biological diversity will become increasingly correlated at the very same time that both are suffering unprecedented declines. That seems a fair (if depressing) description of much of recent planetary history (e.g., Diamond 1997; Ponting 1991). Indeed, this process is continuing or even accelerating over huge regions such as lowland South Amer-

ica (e.g., Painter and Durham 1995) and the circumpolar north (e.g., Smith and McCarter 1997).

Several specific mechanisms might underlie the dynamic envisioned under (H₃):

(a) certain kinds of high biodiversity environments (e.g., some moist tropical forests) are not conducive to intensive agriculture, and hence inhibit the spread of states;

(b) areas favorable for intensive agriculture fostered the development of large-scale political economies, losing much cultural diversity and at least some biodiversity in the process;

(c) state systems both require and foster high population densities.

The assumption behind (a) is that state systems require intensive agriculture for their support, and that tropical forest ecosystems will not generally permit this form of production. Thus, state economies either convert tropical forests into other kinds of ecosystems, or they fail to expand into areas where such conversion is not politically or ecologically feasible. In most cases of which I am aware, the political, cultural, and linguistic expansion of centralized state systems has indeed been incompatible with preservation of high-diversity forest ecosystems.

Thus, in South and Southeast Asia and the Andean region, the boundaries of state expansion have reached their limits in areas where clearing the forest for intensive agriculture was not effective; beyond this boundary smaller-scale societies continued to exist in semiautonomy, alternately resisting state control and seizing opportunities to benefit from trade with states and empires. A similar pattern of competitive exclusion (Durham 1979) can be seen in the colonization of Central and South America by European states. This may be the major reason why the Latin American data show such a strong correlation between biodiversity and indigenous populations (Chapin 1992; Wilcox and Duin 1995; Lizarralde this volume). With the current rise of multinational corporate capitalism, its high mobility of capital facilitated by institutions such as the World Bank and free trade agreements, it has become economically possible (if ecologically unsustainable) to extract timber, minerals, and short-term agropastoral products from these tropical forest refugia. This, plus in-migration of impoverished and displaced peasants, is fueling a process that is drastically reducing both cultural and biological diversity (e.g., Painter and Durham 1995).

Eurasian and recent North American history suggests that even temperate biodiversity is reduced by the expansion of nation-state political economies. The loss of biodiversity, particularly that associated with forests and forest margins, is increasingly documented in studies of environmental history of ancient China, the Mediterranean empires, and elsewhere (e.g., Ponting 1991, and references therein; Hughes 1996). Indeed, the only major exception to the incompatibility between states-empires and forest biodiversity of which I am aware is the case of the Classic Maya. But even in this case there is ongoing debate about the extent to which

Classic Maya states might have produced drastic ecological change in their lowland forest habitats, which in turn precipitated their collapse (Wiseman 1985; various authors in Fedick 1996; Paine and Freter 1996).

As a corollary of (a), (b) proposes that state systems were most likely to develop in areas ecologically favorable to intensive agriculture, given a certain level of technoeconomic development. Such development is then expected to reduce cultural and biological diversity, along the lines sketched above.

Mechanism (c) proposes that state systems both require and foster high population densities. That is, the conditions allowing states to arise or persist may include densities sufficient to facilitate the kinds of economic organizations (including surplus production) upon which political centralization depends. In turn, by increasing the intensity and scope of regional trade, states may often encourage population increase. These denser populations in turn have greater average impact on plant and animal populations, making depletion or even extinction of some species more likely, thus reducing biodiversity. By incorporating the mosaic of more locally adapted societies into the state political economy through economic incentive, political coercion, and conversion of their environmental base, high-density populations with relatively low (per capita and per unit area) cultural diversity come to be associated with areas of anthropogenically low biodiversity.

CONCLUSIONS

I can only draw very tentative conclusions from the above analysis of Native North American data, and my brief survey of more widespread patterns. Linguistic diversity seems to be driven by both ecological factors (environmental stability, low mobility, localized resources) and sociopolitical ones (decentralized political and economic organization, ethnic boundary maintenance, local endogamy), though these two categories do not separate neatly. Supporting these somewhat speculative generalizations, Nichols has shown for a global sample of languages that linguistic diversity (as measured by phylogenetic divergence, not simply number of languages) is highest in coastal, tropical and subtropical, and some montane regions, and in areas lacking "large-scale economies and/or societies such as empires whose languages spread with their political/economic systems" (1992:234). In essence, high linguistic (and perhaps nonlinguistic cultural) diversity should be favored by any factors that lead to *localization of speech communities*, whether this localization is due to environmental factors favoring isolation or self-sufficiency or sociopolitical dynamics favoring boundary definition in order to control resource access, marriage, and group membership (Luisa Maffi, personal communication 1998).

Although I have not been able to explore such factors in depth, most of the areas of high linguistic diversity in Native North America are places where re-

sources important to aboriginal economies were relatively dense and localized—just the conditions under which we expect low mobility and territorial defense (restricted access to communally owned resources) to be favored (Dyson-Hudson and Smith 1978). Thus, the salmon streams, acorn groves, shellfish beds, and cornfields of the Northwest Coast, California, the Eastern Woodlands, and the agricultural parts of the Southwest are precisely where we would expect dense and localized populations to evolve considerable linguistic, and perhaps cultural, diversity.

It is doubtful that states or empires developed aboriginally north of Mesoamerica, but parts of the eastern woodlands (Southeast and Northeast culture areas) did develop relatively centralized systems of trade, tribute, and military alliance that joined local groups over larger regions than elsewhere in Native North America. Perhaps these systems played enough of a role in eroding prior linguistic (and cultural?) diversity to produce some discordance between the high floral diversity of the eastern woodlands and its only moderate linguistic diversity; in any case, these areas certainly suffered considerable language loss with the onset of European colonization.

The best ways to define and measure cultural diversity, the reasons for variation in such diversity, and why it may or may not covary with biodiversity, are all much harder to assess. The results from North America as well as those from some other areas (see tables 5.4 and 5.6) suggest that tree species richness does serve as an indicator of ecological situations favoring cultural diversification (as measured by number of distinct groups or even cultural trait diversity), while diversity of other life forms (vascular plants, mammals, and birds) does not. But why this should be the case, given that most populations do not structure their subsistence around trees, is puzzling. Clearly, more detailed ecological and ethnological analysis is needed to clarify this matter.

The broader discussion of how biological and cultural diversity might influence each other or even coevolve also identified some unresolved issues. Is the oft remarked upon correspondence between small-scale societies and areas of high biodiversity due to active systems of resource conservation and commons management, or does it more commonly reflect the unintended consequences of low population density, lack of export markets, and preindustrial technology? Do small-scale societies actively foster biodiversity, or merely coexist with it until displaced by expanding centralized states based on intensive agriculture and resource extraction? Opinions on these matters are abundant, but hard data relatively scarce and in need of careful analysis. Whatever the final answers, it seems apparent that the links between biological and cultural (including linguistic) diversity are tangled and indirect, involving social and political factors as much as environmental ones. Clearly there is ample room for further theoretical and empirical work on these intellectually fascinating and socially significant topics.

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NOTES

1. While the number of culture areas defined and the criteria used for defining them vary from one scholar to another, the general concept is that a culture area is a geographically bounded region within which societies or local groups have more in common than they do with units outside the culture area. This is obviously quite imprecise, though some (e.g., Jorgensen 1980) have used quantitative measures of trait similarity to define areal boundaries.
2. The variation in size of Native North American culture areas is roughly counter-balanced by variation in population density, with the smallest areas (California, Northwest Coast) having some of the highest aboriginal population densities, while the largest areas (Subarctic, Arctic) are near or at the bottom in population density. By "ethnolinguistic unit" I mean a set of people sharing a single language (or a small set of closely related ones) and many other cultural features; these are often referred to as "tribes" (e.g., Pomo, Kwakiutl). In most cases these ethnolinguistic units were originally composed of a number of local, politically autonomous groups (e.g., "Pomo" refers to a set of people north of San Francisco Bay who once spoke seven closely related languages and were divided into approximately thirty local groups).
3. Jorgensen (1980) provides a comprehensive listing of 172 ethnolinguistic groups for Western North America, comprising five of our ten culture areas, and quantitatively analyzes cultural similarity between various sets of these groups. To measure similarity, Jorgensen employs Driver's coefficient of similarity, defined as $a / (\sqrt{a+b} \sqrt{a+c})$, where a = the number of variable attributes (e.g., matrilineal kinship) that occur in both units (e.g., two ethnolinguistic groups) being compared, b = those found in the first unit but not the second, and c = those found in the second unit but not the first (Jorgensen 1980:311). Values of this coefficient, which varies from 0 to 1.0 (0–100%), are then averaged for the entire set of groups in a culture area to obtain the mean degree of cultural similarity. For the tally of ethnolinguistic groups, I added the Plains culture area to Jorgensen's set, using data in Kehoe (1992:297ff). Given sufficient time, one could no doubt use the published literature to do this for the Arctic and Subarctic areas as well; the ethnographic record for the Northeast and Southeast is probably too fragmentary to construct comparably reliable estimates.
4. The species richness maps for these taxonomic categories were generated by the Conservation Science Division of the World Wildlife Fund–U.S. (Ricketts et al. 1997). I am grateful to my colleague Gordon Orians (Zoology, University of Washington) and to Eric Dinerstein (WWF U.S.) for making these available to me prior to their publication.
5. Specifically, if the number of languages indigenous to the Southeast were > 44 (the number for the Northwest Coast), then the Spearman rank-order correlation used here would increase from 0.661 ($p < .05$) to 0.733 ($p < 0.02$). I do not have sufficient knowledge of the Southeast culture area to judge whether this is a realistic possibility, although after reading some of the ethnohistoric and archaeological literature on aboriginal population density and postcontact decline (e.g., Ramenofsky 1987), I have the impression that it is.
6. This lack of correlation holds for bird diversity and mammal diversity separately ($r_s = 0.136$ and -0.103 , respectively, $p > 0.5$ in both cases), as well as with the combined measure of avian-mammalian diversity (i.e., the simple sum of species richness for the two taxa) shown in figure 5.3.
7. Net primary productivity (NPP) is defined as the amount of energy (in calories/m²/yr) or biomass (dry organic matter, in grams/m²/yr) fixed or produced by photosynthesizing plants, minus the energy or biomass utilized by these plants in respiration (self-maintenance). NPP varies widely according to sunlight, moisture, temperature, and nutrient availability, ranging from > 3000 g/m²/yr in young tropical forests and rice paddies to < 200 g/m²/yr in dry or cold deserts or the open ocean.

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