

Socio-ecological resilience and language dynamics: An adaptive cycle model of long-term language change

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Abstract

Language is thought to be a crucial element behind Pleistocene expansions of *Homo sapiens* but our understanding of language change over the very long term is still poor. There have been two main approaches to language dynamics in this context. One assumes a continual ebb and flow of local human populations and languages, leading to high levels of ‘patchiness’ in both genes and languages. Another approach argues that long-term equilibrium leads not to patchiness but to areal diffusion and convergence. Both of these approaches assume equilibrium to be the norm. However, research in ecology since the 1970s has found that ecosystems have multiple potential states rather than a single equilibrium point. Under the name of resilience theory, such thinking is being increasingly applied to coupled socio-ecological systems using the concept of the adaptive cycle. This article proposes a model of long-term language change based on the adaptive cycle of resilience theory.

Key words: resilience; adaptive cycle; socio-ecological system; equilibrium/punctuation

1. Introduction

Our understanding of Pleistocene human dispersals has been transformed in recent years by new discoveries and analytical methods, as well as by increased attention to the social and ecological processes of colonization (Boivin *et al.* 2013; Dennell 2017). Critiques of the concept of ‘behavioural modernity’ have also been important in shifting research to exploring variability in Pleistocene archaeology (Hovers and Belfer-Cohen 2006; Shea 2011; Roberts 2016). Such critiques have led to models of ‘saltational’ evolution which examine the ‘asynchronous emergence, disappearance and re-emergence of modern cultural traits among both African “modern” and Eurasian “archaic” populations’ (d’Errico and Stringer 2011: 1061). These developments have further resulted in

a re-evaluation of language as a threshold in human evolution. The discovery of the FOXP2 gene polymorphism in Neanderthal DNA (Krause *et al.* 2007) suggests that there was selective pressure for speech and—by implication—for language among Middle Pleistocene hominins (Shea 2011: 4). This much longer potential time span for language evolution means that links with archaeological criteria have become even harder to identify. Possible archaeological proxies for language have shifted from a focus on art and other ‘symbolic’ behaviour to working memory or planning-related tasks such as the manufacture of composite tools (Ambrose 2010) and social exchange networks (Ambrose 2002).

These new developments in Pleistocene language research stand in contrast to the Holocene where there has been a growing confidence about combining linguistic

with anthropological models. In particular, there is now a substantial literature discussing the role of agriculture in Holocene language dispersals (Renfrew 1987; Nichols 1997; Hudson 1999; Bellwood and Renfrew 2002; Donohue and Denham 2010; Heggarty and Beresford-Jones 2010; Robbeets and Saveljev 2017). By contrast, few studies have tried to model Pleistocene language dynamics, and debate has focused on whether there was a single original language, often called ‘Proto-World’ (Bengtson and Ruhlen 1994). Other linguists have argued that given low population densities in the Pleistocene, language polygenesis is a plausible hypothesis (Freedman and Wang 1994; Coupé and Hombert 2005; Nichols 2012: 572).

Once human language had evolved, language geography theory suggests that language diversity was probably always high in the Pleistocene (Nichols 2012). There is no question that the rise of agriculture, states, and empires caused significant ‘punctuations’ (*sensu* Dixon 1997) in language dynamics in the Holocene. Yet, the Holocene was a period of relative climate stability. Pleistocene climate change and major volcanic events (Zielinski et al. 1996; Ambrose 1998; Petraglia et al. 2012) suggest that language expansions, contractions, and extinctions were no less dynamic in the Pleistocene. Despite this, most research on long-term language change has in fact emphasized the *equilibrium* of Pleistocene language evolution (Ballester 2004).

An important index of long-term language dynamics has been the relationship between periods of language stasis or equilibrium and periods of language change or punctuation. The standard family tree model of historical linguistics assumes that discrete historical events lead to splitting and language diversification. According to Dixon (1997: 76–83), such events can include: natural disasters like floods, droughts, or epidemic disease; material innovations such as the bow and arrow or the switch from foraging to farming; the development of aggressive tendencies; and the spread of writing. For many historical linguists, such punctuated ‘events’ are assumed to have been unusual enough in human history for the default status to have been one of language ‘equilibrium’. Such thinking has been especially common in research on hunter-gatherers and other small-scale societies.

There have been two main approaches to language ‘equilibrium’ in this context. One approach assumes a continual but largely stochastic ebb and flow of local groups and languages: one group might temporarily expand its territory due to a new technology or economic advantage, but it would be unable to maintain that expansion for long and would soon be superseded by another group (Ehret 1988; Robb 1993). Nettle and

Romaine (2000: 98) summarize this approach when they write that, ‘For most of the many millennia of human history, it seems likely that the world was close to linguistic equilibrium, with the number of languages being lost roughly equalling the new ones created’. Following Weiss (1988), it is usually argued that such population ebbs and flows would result in high levels of ‘patchiness’—uniformly high diversity over a broad area—in both genes and languages. Prehistoric California is perhaps one of the best examples of such diversity (cf. Codding and Jones 2013).

However, there is evidence from Australia that patchiness is not always associated with hunter-gatherer language distributions (Dixon 1997; McConvell 2001). Observations on linguistic diversity in Australia led Dixon (1997) to propose his ‘punctuated equilibrium’ model, which comprises the second, very different approach to language equilibrium. In Dixon’s model, long-term equilibrium leads not to patchiness but to areal diffusion and convergence. Dixon argues that linguists have generally over-emphasized periods of punctuation because European colonization has effected dramatic and almost continual change in language dynamics over the last few centuries. For Dixon, it is the long periods of equilibrium that have been the norm over much of human history; punctuations are, in contrast, ‘rather rare events between long periods of equilibrium’ (Dixon 1997: 74). Dixon’s theory, then, proposes a two-stage stability domain wherein human societies remain in more or less stable equilibrium until they are punctuated by sudden changes. Though crucial to social and linguistic evolution, the punctuations are exceptions rather than the rule and the system quickly returns to a state of equilibrium. Periods of equilibrium could ‘prevail for thousands or even tens of thousands of years’ (Aikhenvald and Dixon 2001: 9–10).

In this article, I first review recent work in ecology which emphasizes the importance of looking at dynamic *cycles* of socio-ecological change rather than focusing simply on intermediate stages (such as punctuation or equilibrium). From this basis, I then propose a resilience or ‘adaptive cycle’ model of language dynamics. This model applies in the first instance to whole languages, although future work may look at whether particular structural features are more commonly affected by different stages of the adaptive cycle.

2. Resilience theory and socio-ecological systems

C.S. Holling’s influential 1973 paper ‘Resilience and stability of ecological systems’ was an extended critique of

equilibrium concepts in ecology, noting that, ‘An equilibrium centered view is essentially static and provides little insight into the transient behavior of systems that are not near the equilibrium. Natural, undisturbed systems are likely to be continually in a transient state; they will be equally so under the influence of man’ (Holling 1973: 2). Holling proposed that ecological systems have two properties, *resilience* and *stability*. Resilience can be defined as the capacity of a system to ‘absorb a spectrum of shocks or perturbations and to sustain and develop its fundamental function, structure, identity, and feedbacks as a result of recovery or reorganization in a new context’, whereas stability is the ‘Tendency of the system to maintain the same properties over time’ (Chapin et al. 2009: 350–1). This means that a system that changes but still maintains its essential functions is more resilient than a system which undergoes little change. A further implication is that *diversity* is crucial to long-term resilience: ‘The more homogenous the environment in space and time, the more likely is the system to have low fluctuations and low resilience’ (Holling 1973: 18).

From a resilience perspective, it is not so much that Dixon’s (1997) concepts of equilibrium and punctuation are in themselves incorrect, but rather that focusing on only two stages within a complex *cycle* of change prevents us from understanding the dynamics of that cycle as a whole. Resilience theory models system change using the concept of the *adaptive cycle*. Adaptive cycles have four phases: *growth*, *conservation*, *release*, and *reorganization* (Holling and Gunderson 2002; Redman 2005; Walker and Salt 2006; Chapin et al. 2009) (Fig. 1). The growth or exploitation (r) phase sees rapid colonization or expansion. This is followed by the conservation (K) phase in which the system becomes increasingly specialized and rigid. In the release (Ω) phase, the system undergoes a collapse that ‘radically and rapidly reduces [its] structural complexity’ (Chapin et al. 2009: 350). This is followed by a reorganization or renewal phase (α) in which resources are reorganized into a new system, which may resemble its predecessor or may have significantly different properties.

Histories of adaptive cycles are influenced by their *potential* and their *connectedness* (Holling and Gunderson 2002). The potential of a socio-ecological system is its overall capital or ‘richness’ that is available to be transformed (van der Leeuw 2009: 47). Connectedness refers to ‘the control that the system has over itself, and the degree of flexibility (or rigidity) available to the system’s dynamics’ (van der Leeuw 2009: 47).

Although it began in ecology, Holling’s concept of resilience began to be applied to social systems from the

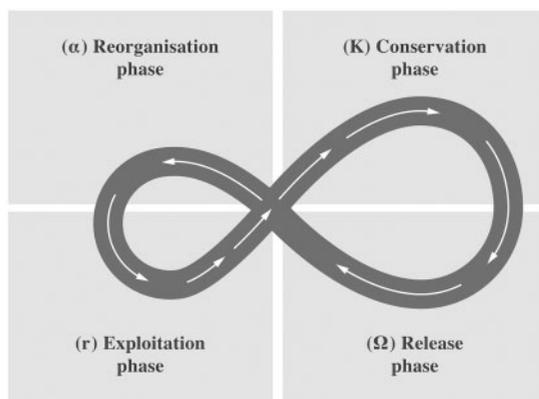


Figure 1. The adaptive cycle model. Credit: Hans Sell, MPI-SHH.

1990s. A key factor here was the development of the concept of linked or coupled *socio-ecological systems* (Berkes and Folke 1998). Instead of analysing ecological and social systems separately, resilience research has emphasized the importance of combining the two and analysing them as one system over time. Walker and Salt (2006) summarize examples of resilience research on socio-ecological systems in contemporary societies and studies using the concept in archaeology can be found in Fisher et al. (2009).

3. An adaptive cycle model of language dynamics

3.1 Background observations

Although a few linguists have already used resilience theory in their work, such publications have focused on promoting the maintenance of endangered languages (Daveluy 2007; Bradley 2010; Daurio 2011). As far as I am aware, resilience theory has not yet been used to develop a more general model of language dynamics. The model proposed here is in many respects an extension of existing human ecological approaches within historical linguistics. Haugen (1972) had emphasized the importance of linking language with ecology, but it was not until the growth of interdisciplinary research between anthropology and linguistics in the 1980s that this approach gained traction. One early contribution was the critique of Steward’s (1938) cultural ecology of the Great Basin. Steward did not initially consider ethnicity or language, but ethnographically the Great Basin was occupied by Numic speakers who are thought to have moved into the region as recently as 2000 years ago (Miller 1986). If, as argued by Steward, environment and technology had remained simple and more or less

stable in the Great Basin for as much as 10,000 years, how could one explain such a major population replacement? Bettinger and Baumhoff (1982) proposed that the answer lies in demography and the new subsistence adaptation of Numic speakers which enabled them to expand their area of settlement (see also Bettinger 1998).

Such ecological approaches to ethnic/language change marked a profound contrast with earlier ideas about language expansion, especially as regards Indo-European. Demoule (2014) details how, at least until the Second World War, Indo-European expansions were usually explained as the result of racial 'vigour' or belligerence. From the 1980s, however, ecological approaches moved into the mainstream. In particular, Colin Renfrew and Peter Bellwood attempted to generate explanations for language dispersals based on universal social and ecological processes. Renfrew (1987) proposed four models of language replacement: subsistence/demography, elite dominance, system collapse, and lingua franca. The farming/language dispersals hypothesis as proposed by Renfrew (1987) and Bellwood (2005) is the best-known ecological model within archaeolinguistics and has been applied to many language groups around the world (Bellwood and Renfrew 2002).

3.2 An adaptive cycle model of language dynamics

The model of language dynamics proposed here is based on the adaptive cycle shown in Fig. 1. This is a model of socio-ecological systems wherein the cycle of change is connected to the human populations within a given system and the languages spoken by those human populations are thus impacted by the adaptive cycle. As noted, the adaptive cycle has four phases, namely, exploitation, conservation, release, and reorganization.

The exploitation (r) phase is one of opportunity, growth, and expansion. A hunter-gatherer group, for example, might colonize a new environment using a new technology and increase its population density. Population density has already been argued to be a critical factor in the spread of a particular language (Patriarca and Leppänen 2004). As the population grows, the group gradually reaches the conservation (K) phase wherein the system becomes less resilient and more vulnerable to change. Although the term is not usually used in resilience theory, the K phase approximates what some ecologists used to call 'carrying capacity', or the maximum number of a particular organism that the environment can support. Language splitting associated with the r phase is crucial for language

change and probably involves an increased rate of linguistic evolution as suggested by Atkinson et al. (2008). The r phase corresponds to Dixon's (1997) concept of 'punctuation'. In contrast to Dixon's model, however, resilience theory does not assume that punctuation is the exception and equilibrium the norm. Instead, all four phases are integral parts of the cycle.

The release (Ω) and especially the reorganization (α) phases of the model may be the hardest to understand in terms of language dynamics. There could be cases in which social organization and institutions change quite dramatically during these two phases but language itself might remain relatively unaffected. In contrast, continuity in social organization may occur at the same time as significant change in language. Language change after the collapse of the western Roman empire is a good example of this problem. Furthermore, when different socio-ecological systems come into contact with each other, the same historical process can represent different phases of their respective adaptive cycles. For example, European colonization of the Americas can be seen as an exploitation phase for Indo-European, but at the same time it was a release and reorganization phase for Native American languages.

Within an adaptive cycle, language can be defined as a *slow variable*. A slow variable 'strongly influences social-ecological systems but remain[s] relatively constant over years-to-decades' (Chapin et al. 2009: 351). The relative 'constancy' of language is important as a type of social capital as well as providing social memory. The resilience of traditional societies is augmented by social memory, defined as 'Memory of past experiences that is retained by groups, providing a legacy of knowing how to do things under different circumstances' (Chapin et al. 2009: 351). Hill (1978) argued that reducing language diversity over large areas is adaptive for hunter-gatherers, especially in difficult environments. Examples of how social memory about landscape and subsistence is encoded in language can be found in Daurio (2011).

Resilience is a key to sustainability (Chapin et al. 2009) and language dynamics play an important role in building resilience. Walker and Salt (2006: 145–8) list nine factors that are especially important for promoting resilience: diversity, ecological variability, modularity, acknowledging slow variables, tight feedbacks, social capital, innovation, overlap in governance, and ecosystem services. These factors can be related to language dynamics. Social and linguistic diversity is often linked with ecological diversity (Nettle 1999) and is one of the most important factors promoting resilience. Bilingualism and other diglossia are common ways of

maintaining linguistic diversity and can be assumed to promote resilience in many contexts. Modularity is a type of diversity which refers to the presence of separate components that are not tightly connected to everything else. The continued use of Latin or Sanskrit in religious contexts when vernacular languages have changed might be one example of such modularity. As noted above, language can be considered as a slow variable. To the extent that language serves as the communication system of a socio-ecological system, it can work to ‘increase the space (size) of the desirable regime so that the system can absorb more disturbances’ (Walker and Salt 2006: 146; cf. Hill 1978). Feedbacks enable the detection of thresholds and language must play an important role in that process. In the modern world, ‘Globalization is leading to delayed feedbacks that were once tighter; the people of the developed world receive weak feedback signals about the consequences of their [actions]’ (Walker and Salt 2006: 146). The corollary here is that local languages with traditional ways of expressing complex relationships between humans and nature can reinforce resilience (cf. Basso 1972, 1996; Collignon 2006; Berkes 2008). Trust, strong networks, and leadership are important elements of social capital, which provides a crucial background canvas for change. For example, the role of social capital from the Roman empire is a widely discussed factor in the pattern of historical change in early medieval Europe (Wickham 2009). If ‘Resilience thinking is about embracing change and disturbance rather than denying or constraining it’ (Walker and Salt 2006: 147), then the role of innovation can also be approached from a linguistic standpoint. Languages and their speakers can be more or less open to innovation and future research could examine how such innovation increases or reduces resilience. In Hokkaido in northern Japan, the Ainu adoption of several Japanese words relating to religion is widely accepted as a significant innovation yet the socio-ecological background to that innovation remains poorly understood (Hudson 2017). Finally, it is often assumed that for most of human history, political and governmental structures have been of limited importance in language transmission (Nettle 1999: 68). It is true that in the modern world, educational policies and other governance factors can transform language dynamics, for example, through providing opportunities to revitalize a language even if it is not officially taught in schools. However, if we adopt a broader definition of ‘governance’ as the ‘Pattern of interaction among actors, their sometimes conflicting objectives, and the instruments chosen to steer social and environmental processes within a particular policy area’ (Chapin et al.

2009: 346), then it is clear that such patterns, instruments, and policies always have a linguistic element. An example might be Charlemagne’s religious schools which played an important role, not just in local administration in medieval France, but also in the reproduction and transmission of classical texts (cf. Rickard 1989: 17–18).

4. Conclusions

Languages are embedded not just in culture and society, but also in ecology. This article has proposed a dynamic model of language change which is not consistent with the dichotomy between long periods of equilibrium and a few sudden punctuations as proposed by Dixon (1997). Rather, language dynamics are best represented by an adaptive cycle of change in which an ‘exploitation’ phase of initial growth is followed by phases termed ‘conservation’, ‘release’, and ‘reorganization’. Socio-ecological systems with higher resilience are better able to maintain their functions during release and reorganization phases.

A number of preliminary general conclusions can be suggested from the above:

1. Rather than a two-stage equilibrium/punctuation model as proposed by Dixon (1997), language change seems better represented by the four-stage adaptive cycle used in resilience theory.
2. The adaptive cycle reflects actual links between languages and socio-ecological systems. The more we know about change in the latter, the better we can understand the former.
3. Language often becomes an important element of building resilience within socio-ecological systems. Cases where languages change (‘reorganize’) slowly often reflect broader processes of resilience. Conversely, sudden language extinction or replacement can be assumed to be linked with low resilience.
4. Linguistic theories of social selection such as Labov (1963) and LePage (1968) propose that speakers will choose from traditional or newly available speech models in order to further their social position and alliances within a particular society. The resilience approach suggests that studies of linguistic selection also need to take account of how language may work to foster socio-ecological resilience.
5. Although the concept of ‘equilibrium’ is better understood as one phase in a dynamic cycle rather than as a static ‘baseline’, this does not necessarily rule out the concept of *Sprachbund* or areas of

linguistic convergence. From a resilience perspective, we might expect that particular ways of doing things would diffuse outwards if they support resilience; yet very long-term resilience would also be supported by the persistence (modularity) of very different cultures, customs, and types of governance. Thus, even if they are to some extent influenced by neighbouring languages, the persistence of language isolates within a *Sprachbund* can normally be assumed to foster resilience.

6. Through human history there have been several periods where language diversity has declined quite rapidly. Nettle (1999) identifies the transition from foraging to farming and the expansion of modern states and empires as two such periods of decline. The adaptive cycle approach supports this conclusion, suggesting that these are periods when previously high resilience was dramatically reduced by outside social and economic impacts. However, hunter-gatherers were perhaps the most resilient human societies ever known and they were often able to absorb a range of systemic shocks and maintain their social and linguistic functions. After the Bronze Age until around AD 1600, many hunter-gatherers were able to reorganize themselves to take advantage of previously unavailable commercial opportunities (Scott 2017). Modernization marks another phase of reorganization which is characterized by extreme linguistic standardization and reduced diversity. Although the impact of modern national languages on minority languages and dialects has been widely discussed, Culiberg (2013) shows how modern national languages were themselves created by significant reductions in diversity and thus in resilience.
7. Finally, the resilience approach emphasizes that change is the norm and that humans are in control of only a small part of that change (Walker and Salt 2006: 28–31). A system that does not change becomes increasingly vulnerable. This is often a difficult concept to accept because ‘Most of us prefer the comfort of an accustomed life . . . to the adventure of dramatic change’ (Tainter 2006: 92). This question of how we view change has at least two implications here. Firstly, seeing change as normal and even desirable provides a further argument against the old idea that languages ‘decay’ from ‘purer’ prototypes. The change from Latin to Romance (Old French) has particularly been seen in such negative terms as a ‘degeneration’ involving ‘A weakening, through ignorance, through loss of tradition, and through chaotic conditions, of the norms of Classical Latin’ (Rickard 1989: 8). Although most linguists now accept that—even for Latin—change is the norm, linguists such as Banniard (2013: 64) and Culiberg (2013) have still found it necessary to critique such ideas with respect to research on Latin and Japanese, respectively. Resilience theory provides an explanation as to why some types of change do not represent a ‘degeneration’ but can in fact promote socio-ecological resilience. To use the quote from Rickard just cited, for example, a resilience approach would argue that the linguistic transition from Latin to Romance may have been a successful way to adapt to ‘chaotic conditions’ and cannot necessarily be seen as involving the simple ‘loss of tradition’. The second implication follows on from this but involves a much more difficult problem relating to the function of language. Resilience theory’s emphasis on diversity and innovation may seem inconsistent with the use of language as a highly standardized marker of social identity. Language use emphasizes conformity to the extent that ‘There is abundant experimental evidence from several societies that people are more disposed to cooperate with others who have the same dialect as themselves than those who have different dialects’ (Nettle 1999: 57). While this social marking function of language often makes it difficult for speakers to acknowledge change, the concept of the adaptive cycle provides a useful way of modelling this change, and this is an area where further research is warranted.

This article has outlined an adaptive cycle model for language as part of a socio-ecological system. One advantage of this model is that it combines what have previously been seen as separate explanations for language change—such as Dixon’s (1997) punctuated equilibrium or Renfrew’s (1987) ‘demography/subsistence’ and ‘system collapse’ models—into one framework. Those previous models focused on change during one or two phases, whereas the adaptive cycle model attempts to relate those phases into one larger cycle. Testing of this model against historical examples awaits further research but it is easy to imagine that such testing will be easier for more recent periods when we have a range of archaeological, environmental, historical, and linguistic data available. Can this model also inform us about language dynamics in deeper prehistory? Certainly, to the extent that resilience theory attempts to explain universal dynamics within socio-ecological systems, there is no reason to assume that adaptive cycles of change were

not also present in earlier prehistory. Given that before the Neolithic, human population levels were generally much lower and therefore subject to frequent bottlenecks, it can be assumed that even relatively small changes within Palaeolithic socio-ecological systems could have had major, cascading impacts on language dynamics as part of adaptive cycles.

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References

- Aikhenvald, A. Y. and Dixon, R. M. W. (2001) 'Introduction', in Aikhenvald A. Y. and Dixon R. M. W. (eds) *Areal Diffusion and Genetic Inheritance*, pp. 1–26. Oxford: Oxford University Press.
- Ambrose, S. H. (1998) 'Late Pleistocene Human Population Bottlenecks, Volcanic Winter, and Differentiation of Modern Humans', *Journal of Human Evolution*, 34: 623–51.
- (2002) 'Small Things Remembered: Origins of Early Microlithic Industries in Sub-Saharan Africa', in Elston R. and Kuhn S. (eds) *Thinking Small: Global Perspectives on Microlithic Technologies*, pp. 9–29. Arlington, VA: American Anthropological Association.
- (2010) 'Coevolution of Composite-Tool Technology, Constructive Memory, and Language: Implications for the Evolution of Modern Human Behaviour', *Current Anthropology*, 51: S135–47.
- Atkinson, Q. D. et al. (2008) 'Languages Evolve in Punctuational Bursts', *Science*, 319: 588.
- Ballester, X. (2004) 'Linguistic Equilibrium in the Palaeolithic: The Case of Indo-European', in Le Secrétariat du Congrès (eds) *Actes Du XIVème Congrès UISPP. Section 7: Le Mésolithique. BAR International Series 1302*, pp. 85–91. Oxford: Archaeopress.
- Banniard, M. (2013) 'The Transition from Latin to the Romance Languages', in Maiden M., Smith J. C., and Ledgeway A. (eds) *The Cambridge History of the Romance Languages, Volume II: Contexts*, pp. 57–106. Cambridge: Cambridge University Press.
- Basso, K. H. (1972) 'Ice and Travel among the Fort Norman Slave: Folk Taxonomies and Cultural Rules', *Language in Society*, 1: 31–49.
- (1996) *Wisdom Sits in Places: Landscape and Language among the Western Apache*. Albuquerque: University of New Mexico Press.
- Bellwood, P. (2005) *First Farmers: The Origins of Agricultural Societies*. Oxford: Blackwell.
- and Renfrew, C., eds (2002) *Examining the Farming/Language Dispersal Hypothesis*. Cambridge: McDonald Institute for Archaeological Research.
- Bengtson, J. D. and Ruhlen, M. (1994) 'Global Etymologies', in Ruhlen M. (ed.) *On the Origin of Languages: Studies in Linguistic Taxonomy*, pp. 277–336. Stanford: Stanford University Press.
- Berkes, F. (2008) *Sacred Ecology*, 2nd edn. New York: Routledge.
- and Folke, C., eds (1998) *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*. Cambridge: Cambridge University Press.
- Bettinger, R. L. (1998) 'Cultural, Human, and Historical Ecology in the Great Basin: Fifty Years of Ideas about Ten Thousand Years of Prehistory', in Balée W. (ed.) *Advances in Historical Ecology*, pp. 169–89. New York: Columbia University Press.
- and Baumhoff, M. A. (1982) 'The Numic Spread: Great Basin Cultures in Competition', *American Antiquity*, 47: 485–503.
- Boivin, N. et al. (2013) 'Human Dispersal across Diverse Environments of Asia during the Upper Pleistocene', *Quaternary International*, 300: 32–47.
- Bradley, D. (2010) 'Resilience in Language Endangerment', *Revue Roumaine De Linguistique*, 55: 143–60.
- Chapin, F. S., Kofinas, G. P., and Folke, C., eds (2009) *Principles of Ecosystem Stewardship: Resilience-Based Natural Resource Management in a Changing World*. New York: Springer.
- Codding, B. F. and Jones, T. L. (2013) 'Environmental Productivity Predicts Migration, Demographic, and Linguistic Patterns in Prehistoric California', *Proceedings of the National Academy of Sciences USA*, 110/36: 14569–73.
- Collignon, B. (2006) *Knowing Places: The Inuinait, Landscapes and the Environment*. Edmonton: CCI Press.
- Coupé, C. and Hombert, J.-M. (2005) 'Polygenesis of Linguistic Strategies: A Scenario for the Emergence of Languages', in Minett J. W. and Wang W. S.-Y. (eds) *Language Acquisition, Change and Emergence: Essays in Evolutionary Linguistics*, pp. 153–201. Hong Kong: City University of Hong Kong Press.
- Culiberg, L. (2013) 'Japanese Language, Standard Language, National Language: Rethinking Language and Nation', *Asian Studies*, 1/2: 21–33.
- Daurio, M. (2011) 'The Fairy Language: Language Maintenance and Social-Ecological Resilience among the Tarali of Tichurong, Nepal', *Himalaya*, 31: 7–21.
- Daveluy, M. (2007) 'Resilience and Language', in L. Kaplan and M. Daveluy (eds) *Proceedings of the Third IPSSAS Seminar*, pp. 89–96. Fairbanks: Alaska Native Language Center.
- Dennell, R. (2017) 'Human Colonization of Asia in the Late Pleistocene', *Current Anthropology*, 58: S383–96
- d'Errico, F. and Stringer, C. B. (2011) 'Evolution, Revolution or Saltation Scenario for the Emergence of Modern Cultures?', *Philosophical Transactions of the Royal Society B*, 366: 1060–9.

- Dixon, R. M. W. (1997) *The Rise and Fall of Languages*. Cambridge: Cambridge University Press.
- Demoule, J.-P. (2014) *Mais où sont passés les Indo-Européens? Le mythe d'origine de l'occident*. Paris: Éditions du Seuil.
- Donohue, M. and Denham, T. (2010) 'Farming and Language in Island Southeast Asia: Reframing Austronesian History', *Current Anthropology*, 51/2: 223–56.
- Ehret, C. (1988) 'Language Change and the Material Correlates of Language and Ethnic Shift', *Antiquity*, 62: 564–74.
- Fisher, C. T., Hill, J. B., and Feinman, G. M., eds (2009) *The Archaeology of Environmental Change: Socionatural Legacies of Degradation and Resilience*. Tucson: University of Arizona Press.
- Freedman, D. A. and Wang, W. S.-Y. (1994) 'Language Polygenesis: A Probabilistic Model', *Anthropological Linguistics*, 104: 131–8.
- Haugen, E. (1972) *The Ecology of Language: Essays by Einar Haugen*. Stanford: Stanford University Press.
- Heggarty, P. and Beresford-Jones, D. (2010) 'Agriculture and Language Dispersals: Limitations, Refinements, and an Andean Exception?', *Current Anthropology*, 51/2: 163–91.
- Hill, J. (1978) 'Language Contact Systems and Human Adaptations', *Journal of Anthropological Research*, 34: 1–26.
- Holling, C. S. (1973) 'Resilience and Stability of Ecological Systems', *Annual Review of Ecology and Systematics*, 4: 1–23.
- and Gunderson, L. H. (2002) 'Resilience and Adaptive Cycles', in Gunderson L. H. and Holling C. S. (eds) *Panarchy: Understanding Transformations in Human and Natural Systems*, pp. 25–62. Washington, DC: Island Press.
- Hovers, E. and Belfer-Cohen, A. (2006) "Now You See It, Now You Don't": Modern Human Behavior in the Middle Paleolithic', in Hovers E. and Kuhn S. (eds) *Transitions before the Transition: Evolution and Stability in the Middle Paleolithic and Middle Stone Age*, pp. 295–304. New York: Springer.
- Hudson, M. J. (1999) *Ruins of Identity: Ethnogenesis in the Japanese Islands*. Honolulu: University of Hawaii Press.
- (2017) 'Okhotsk and Sushen: History and Diversity in Iron Age Maritime Hunter-Gatherers of Northern Japan', in Finlayson B. and Warren G. (eds) *The Diversity of Hunter-Gatherer Pasts*, pp. 68–78. Oxford: Oxbow.
- Krause, J. et al. (2007) 'The Derived FOXP2 Variant of Modern Humans Was Shared with Neanderthals', *Current Biology*, 17: 1908–12.
- Labov, W. (1963) 'The Social Motivation of a Sound Change', *Word*, 19: 273–309.
- LePage, R. B. (1968) 'Problems of Description in Multilingual Communities', *Transactions of the Philological Society*, 6: 189–212.
- McConvell, P. (2001) 'Language Shift and Language Spread among Hunter-Gatherers', in Panter-Brick C., Layton R. H., and Rowley-Conwy P. (eds) *Hunter-Gatherers: An Interdisciplinary Perspective*, pp. 143–69. Cambridge: Cambridge University Press.
- Miller, W. R. (1986) 'Numic Languages', in D'Azevedo W. L. (ed.) *Handbook of North American Indians, Volume 11: Great Basin*, pp. 107–12. Washington, DC: Smithsonian Institution.
- Nettle, D. (1999) *Linguistic Diversity*. Oxford: Oxford University Press.
- and Romaine, S. (2000) *Vanishing Voices: The Extinction of the World's Languages*. Oxford: Oxford University Press.
- Nichols, J. (1997) 'Modeling Ancient Population Structures and Movement in Linguistics', *Annual Review of Anthropology*, 26: 359–84.
- (2012) 'Monogenesis or Polygenesis: A Single Ancestral Language for All Humanity?', in Tallerman M. and Gibson K. R. (eds) *The Oxford Handbook of Language Evolution*, pp. 558–72. Oxford: Oxford University Press.
- Patriarca, M. and Leppänen, T. (2004) 'Modeling Language Competition', *Physica A*, 338: 296–9.
- Petraglia, M., Korisettar, R., and Pal, J. N., eds (2012) 'The Toba Volcanic Super-eruption of 74,000 Years Ago: Climate Change, Environments, and Evolving Humans', *Quaternary International*, 258: 1–200
- Redman, C. L. (2005) 'Resilience Theory in Archaeology', *American Anthropologist*, 107/1: 70–7.
- Renfrew, C. (1987) *Archaeology and Language: The Puzzle of Indo-European Origins*. London: Jonathan Cape.
- Rickard, P. (1989) *A History of the French Language*, 2nd edn. London: Routledge.
- Robb, J. (1993) 'A Social Prehistory of European Languages', *Antiquity*, 64: 747–91.
- Robbeets, M. and Savelyev, A., eds (2017) *Language Dispersal beyond Farming*. Amsterdam: John Benjamins.
- Roberts, P. (2016) 'We Have Never Been Behaviourally Modern': The Implications of Material Engagement Theory and Metaplasticity for Understanding the Late Pleistocene Record of Human Behaviour', *Quaternary International*, 405A: 8–20.
- Scott, J. C. (2017) *Against the Grain: A Deep History of the Earliest States*. New Haven: Yale University Press.
- Shea, J. J. (2011) 'Homo sapiens Is as Homo sapiens Was: Behavioral Variability versus 'Behavioral Modernity' in Paleolithic Archaeology', *Current Anthropology*, 52/1: 1–35.
- Steward, J. H. (1938) *Basin-Plateau Aboriginal Sociopolitical Groups. Bureau of American Ethnology Bulletin 120*. Washington, DC: GPO.
- Tainter, J. A. (2006) 'Social Complexity and Sustainability', *Ecological Complexity*, 3: 91–103.
- van der Leeuw, S. E. (2009) 'What Is an 'Environmental Crisis' to an Archaeologist?', in Fisher C. T., Hill J. B., and Feinman G. M. (eds) *The Archaeology of Environmental Change: Socionatural Legacies of Degradation and Resilience*, pp. 40–61. Tucson: University of Arizona Press.
- Walker, B. and Salt, D. (2006) *Resilience Thinking: Sustaining Ecosystems and People in a Changing World*. Washington, DC: Island Press.

- Weiss, K. M. (1988) 'In Search of Times past: Gene Flow and Invasion in the Generation of Human Diversity', in Mascie-Taylor C. G. N. and Lasker G. W. (eds) *Biological Aspects of Human Migration*, pp. 130–66. Cambridge: Cambridge University Press.
- Wickham, C. (2009) *The Inheritance of Rome: Illuminating the Dark Ages, 400-1000*. London: Allen Lane.
- Zielinski, G. et al. (1996) 'A 110, 000-Yr Record of Explosive Volcanism from the GISP2 (Greenland) Ice Core', *Quaternary Research*, 45: 109–18.