Wallace's Unfinished Business

The "Other Man" in Evolutionary Theory

After a century in the shadows, Alfred Russel Wallace (1823–1913) has recently become the subject of increasing attention. It is suggested here, expanding on observations made by anthropologist Gregory Bateson some years ago, that Wallace's cybernetics-like view of the operation of natural selection—as a governor-like principle tending to keep species unvarying—can be expanded to a more complete evolutionary understanding by exploring in modern context Wallace's idea that "more recondite forces" are driving the process. Specifically, when the environment is regarded as a final cause (but not a deterministic force), individual adaptations may be viewed as entropy-relaying structures (acting in response to, and as a part of, larger scale biogeochemical agenda), whereas negentropy is accumulated by nonrandomly directed organism- and population-level forms of ecological engagement. Thus, range change in particular is viewed as a process that is both driven and nonrandom, and ultimately connected to the derivation of more and more organized individual, population, and community structures. © 2004 Wiley Periodicals, Inc. Complexity 10: 25–32, 2004

Key Words: Alfred Russel Wallace; natural selection; cybernetics; negative feedback; positive feedback; evolution; biogeography; ecological modelling; history of biology

In February 1858 a then little-known bird and insect collector named Alfred Russel Wallace (1823–1913) was struck with a startling revelation while fending off an attack of malaria in the Moluccas. As soon as the fit passed he prepared an essay on the idea—natural selection—and sent it off to a man he figured would be interested in the concept: Charles Darwin. The rest of the story is well enough known not to bear repeating; in the end it was Darwin whose name became most associated with the principle, with Wallace relegated to "other man" status, and his ideas to the dustbin of history.

Whether all this was fair or even represented some kind of conspiracy against Wallace has been debated for many years [1], but most observers seem to feel that, all told, things worked their way out pretty well. Certainly, natural selection was revealed to the world at the earliest possible juncture, and even Wallace benefited to the extent that he was immediately welcomed into the highest echelons of scientific discourse, along the way becoming one of the most famous men of his time.

But in truth the premature reading of Wallace's brainchild may also have had some negative effects on the longer term development of evolutionary theory. The more one reads and digests the full body of Wallace's work, the more one realizes that Wallacian natural selection is quite a distinct animal from Darwinian natural selection, and that the two men's views on evolution overall were more different yet. And, whereas every word of Darwin's writings has been run through the philosoph-

Further perspective on the ecological model underlying the thoughts presented here may be found in the article reprinted at: http://www.wku.edu/~smithch/essays/SMITH86.htm

CHARLES H. SMITH

Charles H. Smith is Science Librarian and Professor of Library Public Services at Western Kentucky University, Bowling Green. With original training in biogeography and history of science, he continues to work from time to time on related theoretical, bibliographic, and historical subjects. He also maintains several informational websites, including the award winning "Alfred Russel Wallace Page" (http://www.wku.edu/~smithch/index1.htm), and the bibliographic archive "Early Classics in Biogeography, Distribution, and Diversity Studies" (http://www.wku.edu/~smithch/biogeog/).

 Vol. 10, No. 2
DOI 10.1002/cplx.20062

ical grist mill and thoroughly digested, much of what Wallace wrote has yet to receive its rightful full appraisal.

Although a fair amount has been published on Wallace and his ideas over the years, a sharp increase in interest has been evident of late [2]. Although there are likely many reasons for this, surely one of the most important has been the re-examination of hundreds of what might be termed "lost" writings of his. Many of these have revealed clues as to what he actually had in mind both in the years preceding the "Ternate essay" on natural selection and those following it. I have discussed this subject in considerable detail elsewhere [3]; here, this new interpretation of Wallace's intellectual evolution is summarized with the ultimate object of illuminating a possible new direction in evolutionary and biogeographic studies it suggests.

Although the considerable impact on Wallace of Charles Lyell's *Principles of Geology* and Robert Chambers's *Vestiges of the Natural History of Creation* in 1844 or 1845 has been noted by just about everyone who has written on him, it is less well known that at that point he had already been entertaining evolutionary views of a nonbiological nature for several years. In early 1837, when just fourteen years old, he fell in with a group of Owenite socialist utopians and was profoundly influenced by their views on how to bring about progressive social reform. Wallace was especially taken with their ideas on social justice, and in turn with the relation between belief and just cause and, ultimately, the intrinsic advantages of absorbing and applying varied forms of knowledge. Apart from Wallace's own recollections on these matters in his autobiography *My Life* [4], we know of these influences because three of his earliest writings, from the period 1841–1843 [5], have survived. Two of these even extend the "varied knowledge" notion to a prescription for success for the evolution of whole societies.

The centrality in Wallace's thinking of his views on belief, in particular, and how this is related to social and natural change, cannot be overemphasized.

The more one reads and digests the full body of Wallace's work, the more one realizes that Wallacian natural selection is quite a distinct animal from Darwinian natural selection and that the two men's views on evolution overall were more different yet.

The following passage, from an 1861 letter sent to his brother-in-law Thomas Sims while Wallace was still in the Malay Archipelago, is lengthy, but tells the whole story [6]:

> ...You intimate that the happiness to be enjoyed in a future state will depend upon, and be a reward for, our belief in certain doctrines which you believe to constitute the essence of true religion. You must think, therefore, that belief is *voluntary* and also that it is *meritorious.* But I think that a little consideration will show you that belief is quite independent of our will, and our common expressions show it. We say, "I wish I could believe him innocent, but the evidence is too clear"; or, "Whatever people may say, I can never believe he can do such a mean action." Now, suppose in any similar case the evidence on both sides leads you to a certain belief or disbelief, and then a reward is offered you for changing your opinion. Can you really change your opinion and belief, for the hope of reward or the fear of punishment? Will you not say, "As the matter stands I can't change my belief. You must give me proofs that I am wrong or show that the evidence I have heard is false, and then I may change my belief?" It may be that you do get more and do change your belief. But this change is not voluntary on your part. It depends upon the force of evidence upon your individual mind, and the evidence remaining the same and your mental faculties remaining unimpaired—you cannot believe otherwise any more than you can fly.
>
> Belief, then is not voluntary. How, then, can it be meritorious? When a jury try a case, all hear the same evidence, but nine say "Guilty" and three "Not guilty," according to the honest belief of each. Are either of these more worthy of reward on that account than the others? Certainly you will say No! But suppose beforehand they all know or suspect that those who say "Not guilty" will be punished and the rest rewarded: what is likely to be the result? Why, perhaps six will say "Guilty" honestly believing it, and glad they can with a clear conscience escape punishment; three will say "Not guilty" boldly, and rather bear the punishment than be false or dishonest; the other three, fearful of being convinced against their will, will carefully stop their ears while the witnesses for the defense are being examined, and delude themselves with the idea they give an honest verdict because they have heard only one side of the evidence. If any out of the dozen deserve punishment, you will surely agree with me it is these. Belief or disbelief is therefore not meritorious, and when founded on an unfair balance of evidence is blamable.
>
> Now to apply the principles to my own case. In my early youth I heard, as ninety-nine-hundredths of the world do, only the evidence on one side, and became impressed with a veneration for religion which has left some traces even to this day. I have since heard and read much on both sides, and pondered much upon the matter in all its bearings. I spent, as you know, a year and a half in a clergyman's family and heard almost every Tuesday the very best, most earnest and most impressive preacher it has ever been my fortune to meet with, but it produced no effect whatever on my mind. I have since wandered among men of

> many races and many religions. I have studied man and nature in all its aspects, and I have sought after truth. In my solitude I have pondered much on the incomprehensible subjects of space, eternity, life and death. I think I have fairly heard and fairly weighed the evidence on both sides, and I remain an *utter disbeliever* in almost all that you consider the most sacred truths. I will pass over as utterly contemptible the oft-repeated accusation that skeptics shut out evidence because they will not be governed by the morality of Christianity. You I know will not believe that in my case, and *I* know its falsehood as a general rule. I only ask, Do you think I can change the self-formed convictions of twenty-five years, and could you think such a change would have anything in it to merit *reward* from *justice*? I am thankful I can see much to admire in all religions. To the mass of mankind religion of some kind is a necessity. But whether there be a God and whatever be His nature; whether we have an immortal soul or not, or whatever may be our state after death, I can have no fear of having to suffer for the study of nature and the search for truth, or believe that those will be better off in a future state who have lived in the belief of doctrines inculcated from childhood, and which are to them rather a matter of blind faith than intelligent conviction.

One can only conclude from this entirely transparent argument that Wallace felt a belief in false things—and possibly even unreal things—was unproductive, that is to say, "personally nonadaptive." And yet false beliefs both existed and could be overcome: the pattern of human history seemed to prove as much. What, in turn, did he suppose the pattern of biological change might prove?

On reading Chambers about 1845, Wallace very quickly figured out how to demonstrate that evolution did in fact take place: through the study of the traces of the speciation process left in the fossil record and in current distribution patterns. He was not so quick, however, to recognize how individual adaptations fit into the overall picture. The problem, possibly beginning as early as this 1845 period, was his initial position on utility as it related to adaptation. At this time it would appear that, contrary to Wallace's well-known post-1858 position, he believed many adaptations served no necessary utilitarian purpose. There are remarks to that effect in his 1853 book *Narrative of Travels on the Amazon and Rio Negro* [7], and this position is even more plainly stated in the little known work "On the Habits of the Orang-utan of Borneo," published in 1856 [8]:

> Do you mean to assert, then, some of my readers will indignantly ask, that this animal, or any animal, is provided with organs which are of no use to it? Yes, we reply, we do mean to assert that many animals are provided with organs and appendages which serve no material or physical purpose. The extraordinary excrescences of many insects, the fantastic and many-coloured plumes which adorn certain birds, the excessively developed horns in some of the antelopes, the colours and infinitely modified forms of many flower-petals, are all cases, for an explanation of which we must look to some general principle far more recondite than a simple relation to the necessities of the individual. We conceive it to be a most erroneous, a most contracted view of the organic world, to believe that every part of an animal or of a plant exists solely for some material and physical use to the individual,—to believe that all the beauty, all the infinite combinations and changes of form and structure should have the sole purpose and end of enabling each animal to support its existence,—to believe, in fact, that we know the one sole end and purpose of every modification that exists in organic beings, and to refuse to recognize the possibility of there being any other. Naturalists are too apt to *imagine*, when they cannot *discover*, a use for everything in nature....

Wallace probably arrived at this anti-utilitarian position on the basis of two main considerations. First, and as suggested earlier, he had undoubtedly observed that many human beliefs and behaviors existed that were anything but progressively utilitarian. Yet these nevertheless existed, had come into being somehow, and even once operating did not always prevent society from moving forward. In like fashion, one could imagine a biological process in which adaptations emerged not as the feature innovations of evolutionary advance, but instead in some manner making them a byproduct of, or perhaps even just "correlated" with, it. Second, and following Chambers's idea that it made better sense to envision an evolutionary process operating on the basis of natural law than unknowable forces, Wallace was rejecting the notion that each individual adaptation served a prior purpose in the overall scheme of things—that is, arose as a first cause. In the passage from "On the Habits..." quoted above, his concern in this regard is obvious in the three concluding sentences.

Strange as it may sound, it is thus not likely that Wallace's significant concerns during the pre-1858 period included identifying adaptive structures that were ... adaptive. This did not stop him from believing that there was an evolutionary "progression," however, and he was also making it his business to identify its final cause. Despite the existence of what appeared to be nonadaptive behaviors and structures, there had to be "some general principle far more recondite" (as he describes it in the quote given above) that was driving evolutionary change—some force or set of forces, perhaps climatological or geophysical in nature, that subtly overrode the clutter of detail apparent at the adaptational level, inexorably acting to propel change at a slow, grandiose

scale. Perhaps if while in the field he examined enough particulars of form and function, he might be able to figure out what this final cause was. Note, however, that at no time before 1858 did he imagine that he would ever be able to understand how or why all adaptational structures *individually* came into being: looking back at this matter in his 1905 autobiography *My Life*, he wrote: "My paper written at Sarawak rendered it certain in my mind that the change had taken place by natural succession and descent—one species becoming changed either slowly or rapidly into another. But the exact process of the change and the causes which led to it were absolutely unknown and appeared almost unconceivable" [9].

The "Sarawak" paper he speaks of, "On the Law Which Has Regulated the Introduction of New Species," was published in 1855 [10]. It signalled, as he says above, his final recognition of evolutionary descent as a biological reality. But the "Every species has come into existence coincident both in space and time with a pre-existing closely allied species" model it famously embraced only described the *results* of the process, not its *causes*. Indeed, he was actually no closer to an understanding of either the final or immediate causes of evolution than he had been 10 years earlier (as evidenced by the orangutan paper, written and published about a year later). All of this changed in early 1858, and the famous bout with malaria during which he thought out the principle of natural selection.

Consider, now, how the survival of the fittest concept most likely would have struck Wallace at this point. Contrary to the way it has commonly been portrayed, it was not at all the "logical conclusion" of Wallace's earlier attempts at dealing with evolution. Indeed, one might reasonably argue that it was their absolute antithesis, and, accordingly, "On the Tendency of Varieties to Depart Indefinitely from the Original Type" [11] not only does not refer, even obliquely, to the Sarawak paper or law, it doesn't refer to any of the several following writings Wallace published that applied that model [12]. For Wallace, the central revelation of early 1858 was his ability now to envision a single, generalizable process through which any adaptation could continually be selected for or against. He would have to give up the idea that some adaptations had no utility (unless they were somehow integrally connected with ones that did), however. This was not such a problem biologically (he actually had no way to prove whether any given adaptation was utilitarian, anyway), but he felt unable to budge on the matter of human thoughts and beliefs, which yet seemed to afford too many instances both of "nonprogressive belief," and higher attributes such as mathematical abilities that had come into existence before useful applications could be found for them. In consequence, the paper he sent to Darwin makes no mention of humankind: and not because he didn't wish to point to the situation with humans as being an exception, but for the very reason that he *did*.

Previous to 1858 it had thus been Wallace's peculiar perspective that evolution was in a general sense progressively adaptive, but that some of the individual adaptive structures produced through it were not.

Previous to 1858 it had thus been Wallace's peculiar perspective that evolution was in a general sense progressively adaptive, but that some of the individual adaptive structures produced through it were not. Now, through natural selection, he could believe that *all* strictly biological adaptations were in an ecological sense adaptive, but not necessarily evolutionarily adaptive: i.e., a species' adaptive suite might serve to support it in the environment of one era, but then fail it in the next, leading to extinction. Was this a helpful elaboration? Wallace apparently thought so, despite the fact that it neither shed any light on why some human attributes yet seemed to be nonadaptive, nor helped him to understand what the final cause of evolution was—or for that matter, whether it was still even necessary to think in terms of final causes. He would test the waters on this new idea by circulating the draft of an essay on what seemed to be the one element of the question that was tightly defendable, the "special case" of natural selection as it applied to non-human species.

But before Wallace knew it, the paper, which included thoughts rather closely resembling some of those held by the man he had sent it to for possible forwarding to Charles Lyell, was read publicly and set to print. He was informed only after the fact. He was now viewed by—everyone—as "Darwinian," despite the fact that his ideas actually extended to well beyond what that tag represented.

How Wallace would extricate himself from this situation is a subject I have taken up elsewhere [13]; for the present let us shift the discussion away from history and toward today's science. We can begin by suggesting that the attention that has been lavished on debating whether Darwin might have committed intellectual theft from Wallace should be refocussed on a matter of substantially greater interest: whether nearly 150 years of largely ignoring Wallace's world view has been in our best interest.

In claiming that Wallacism has a right to be considered on its own terms, and as more than just a historical satellite to Darwinism, we may look in the first instance for elements of Wallace's framework that might have significant relevance to today's efforts to model large-scale evolutionary processes. One such element harkens back to Wallace's law-like model of natural selection, which distinguishes between ecological and evolutionary outcomes in a manner contrasting in certain important respects with Darwin's solution to the problem.

One of the most intriguing passages in Wallace's Ternate essay likens the action of natural selection to a governor on a steam engine [14]:

> The action of this principle is exactly like that of the centrifugal governor of the steam engine,

> which checks and corrects any irregularities almost before they become evident; and in like manner no unbalanced deficiency in the animal kingdom can ever reach any conspicuous magnitude, because it would make itself felt at the very first step, by rendering existence difficult and extinction almost sure soon to follow.

In his 1972 work *Steps to an Ecology of the Mind*, anthropologist Gregory Bateson made some interesting comments on this passage [15]:

> The steam engine with a governor is simply a circular train of causal events, with somewhere a link in that chain such that the more of something, the less of the next thing in the circuit.... If causal chains with that general characteristic are provided with energy, the result will be ... a self-corrective system. Wallace, in fact, proposed the first cybernetic model.... Basically these systems are always *conservative* ... in such systems changes occur to conserve the truth of some descriptive statement, some component of the *status quo*. Wallace saw the matter correctly, and natural selection acts primarily to keep the species unvarying....

Later, in the 1979 collection *Mind and Nature: A Necessary Unity*, Bateson added the following observations [16]:

> If it had been Wallace instead of Darwin [who started the trend], we would have had a very different theory of evolution today. The whole cybernetic movement might have occurred one hundred years earlier as a result of Wallace's comparison between the steam engine with a governor and the process of natural selection....

Bateson's point is a most remarkable one, but he and the others who have studied cybernetic relations in connection with evolution have never looked in any detail into how the 1858 Ternate model actually fit into Wallace's overall cosmology at that point. Without doing so, we can proceed no further in this direction: cybernetic theory notwithstanding, it is clear that no model of the greater evolutionary program can invoke a causal explanation resting *entirely* on negative feedback processes, as it is ultimately the breaking away from such recursive constraints that by definition leads to novel development. Actually, Bateson might have done more with his observation even at that point had he wished, as in 1963 the evolutionary relationship between negative and positive feedback couplings had already been explored in an important and influential systems paper by Magoroh Maruyama entitled "The Second Cybernetics: Deviation-Amplifying Mutual Causal Processes" [17]. In this work Maruyama describes how information imported from the environment represents feedbacks of two kinds: deviation-countering processes (negative feedbacks), which tend to enforce equilibrium conditions, and deviation-amplifying processes (positive feedbacks), which cause systems to change, either in a direction of greater or lesser order. Although this position is helpful to understanding how a living system might simultaneously be equilibrium conserving and equilibrium superseding, it does not specify the conditions under which directions "of greater or lesser order" might be obtained; i.e., what is it in the longer term evolutionary sense that tips the scales in favor of greater order?

I submit that one has to understand the information that is part and parcel of organized adaptive structure at any given time as a *potential* only....

In writings published in the 1980s [18] I argued that Wallacian natural selection was better suited to thinking in such systems terms than Darwin's model. Bateson had already pointed out (as indicated in the passages produced above) that natural selection might be considered a *conservative* process; that is, that it does no more than produce the net result of a return toward equilibrium for a system pushed toward disorder. All that was left to do was to identify the components of the complementary deviation-amplifying function. I posited that the overall thrust of organic evolution might be conceptually and practically studied by: (1) agreeing with Bateson and Maruyama, and regarding adaptive structures as operationalizing a process of negative feedback in which energy sources at the surface of the earth are temporarily diverted and captured, then applied to do chemical and physical work, then finally returned in degraded form to the physical environment envelope (and ultimately into space), maximizing system entropy; (2) treating the adaptive structures themselves as in the main a *potential* for effecting system change; and (3) most importantly, regarding that potential as enacted through the entry into new ecological associations through organismal/population behavior, movement, and dispersal (i.e., as the positive feedback/deviation-amplifying part of the process capable of leading to net negentropy accumulation). Ultimately, evolution-serving deviation amplification is achieved by the tendency of individuals and populations to disperse through and interact with their environment *nonrandomly, in preferred spatial directions*: specifically, in those directions in which the relevant life support resources are being made available—occurring, and turning over—at more optimum rates.

The idea that adaptive structures are in the first instance negative feedback-relaying nodes is hardly a revolutionary one, as this function is necessitated by their role as mediators in the biogeochemical cycling of matter and energy, and the operation of the Third Law. In turning to his "governor" understanding initially Wallace was of course not thinking in such elaborate terms; instead, for him the important notion was that adaptations emerged on a "whatever" basis: that is,

the process involved selection—at random—leading to *whatever* structures that might ultimately serve a population's persistence. As both Wallace and Darwin believed, natural selection could not produce *more* than what was needed to persist; instead it merely continued to reduce inefficiency of system operation by eliminating its weak links. But again, this in itself is not evolution. I submit that one has to understand the information that is part and parcel of organized adaptive structure at any given time as a *potential* only: that is, a potential that supports entries into new kinds of information-sharing networks at the ecological/environmental level.

There are a number of stumbling-blocks to evolution and evolutionary ecology that this kind of thinking directly overcomes; for the present, only one particularly obvious application can be noted briefly. This involves Wallace's supposed hyperselectionism (or closely related panselectionism). Writers such as the late Stephen Jay Gould [19] have criticized Wallace for arguing that natural selection represents the only variation-accumulating mechanism and for talking down the importance of mutations and Mendelian inheritance to biological change. Two points need to be made in this regard. First, although it is true that Wallace did believe that all adaptive structures passed through the filter of natural selection and were maintained in that fashion, he also noted on several occasions that the "laws" of origin of the variations upon which the survival of the fittest operated were quite unknown. He was thus more interested in defending the primacy of natural selection as an evolutionary "shaping" agent than he was in debating how variations came about to begin with.

More importantly, moreover, it can be seen that through the model discussed here, there is nothing logically circular about the way Wallace treated adaptations to begin with. Regardless of whether adaptive structures may or may not be idiosyncratic in their purpose and function as related to organismal success, they serve an *evolutionary* function not in their deviation-countering (entropy maximizing) role, but instead in their potential to propel a deviation-amplifying process through environmental engagement. The latter represents a conceptually different evolutionary outcome—spatial interaction at the ecological/population level—than the adaptive structures themselves, and thus provides a venue for hypothesis testing that does not fall prey to circular reasoning.

In the 1980s such views fell on deaf ears; this was a period in which more interest was being shown in the irreversible thermodynamics modelling of E. O. Wiley and D. R. Brooks [20] among biologists, and in the cladistic methodologies being perfected by systematists and vicariance biogeographers [21]. Both of these perspectives closely follow the generally Darwinian view that evolution is not much more than a matter of phyletic diversification—"tree-thinking," [22] in the parlance of the period. This is not to suggest that either school of thought depends directly on classical Darwinian views on speciation and the like, but to acknowledge that each does tend to focus on organism-, adaptation-centered, rather than ecologically-centered, outcomes.

The need for a tempered revision of Darwinian "tree-thinking" is likely to become increasingly evident as the challenges of biodiversity conservation become ever greater.

The need for a tempered revision of Darwinian "tree-thinking" is likely to become increasingly evident as the challenges of biodiversity conservation become ever greater. We cannot truly expect to become shepherds of the earth's biotic resources until we secure a firmer understanding of those supra-population forces that shape the evolutionary-ecological interface, and the mere documentation of phyletic diversification, including its further detailing into genomic inventories, is not enough to get the job done. Clearly, we must look to evolutionary models that are more environmental in their emphasis, or as Greer-Wooten described the matter back in 1972: "in analyzing the dynamics of systems, the researcher should place more emphasis on flows (of energy, materials, or information) between components of the system, and the system and its environment, than on changed attributes of the elements" [23]. Wallace himself understood this all the way back in the 1850s, ultimately reaching beyond his simple phyletic determinism model of 1855 to produce a more integrated one invoking environment-mediated stochasm: natural selection.

In now returning to Wallace's vision a final time here, the following observations seem relevant. It will be recalled that earlier I implied Wallace's adoption of a final-causes view of the organization of the natural world was not limited to his later career (as exemplified in his books *Man's Place in the Universe* in 1903 and *The World of Life* in 1910 [24]), but was integral to his pre-1858 positions as well. His search for a final cause relevant to human societal functions led him to adopt spiritualism and socialism (and, actually, for good reason [25]), but he never did give up on the idea that more "removed" forces might be channeling the direction of purely physical and biological nature as well. Hints of this leaning turn up in a variety of contexts: for example, in his frequently stated view that known laws of nature seem always to be subservient to more "recondite" (his term) factors, in his familiar argument (adopted by many to this day) that only Earth can possibly have observed the many physical/astronomical constraints that have led to the evolution of advanced life-forms, in his belief that natural selection often involves the change of less advanced creatures according to the needs of more advanced ones and in his continued support of the overriding causal influence of Sclaterian faunal realm development.

Although Wallace's thinking never included esoteric notions of positive-negative feedback couplings or cybernetic relations, it seems to me that his juxtaposition of a "governor model" of organism-environment state-space (i.e., natural selection) onto an assumed final causes-based evolution process is still both logical, and exploitable. Indeed, somewhat abstract models of this kind are currently being offered up by proponents both of the anthropic principle, and the Gaia hypothesis [26]. More revealing ecogeographic models are possible as well, I think, if we proceed generally as follows.

It should be apparent from the variety of positions taken by adherents of the anthropic and Gaia hypotheses that, philosophically speaking, the "final causes" concept has produced the gamut of teleological mindsets. We need not adopt the more extreme of these to suggest how a system as described here could find its way to higher levels of order, however. Suppose, for example, that the environment as it physically extends away from any given individual organism inherently presents statistically greater survival probabilities in some directions than in others. On this basis, individuals—and more importantly, populations—might tend to extend more easily in some spatial directions than in others, in so doing entering into new associations supported by new adaptations forced into existence by such extensions.

Let us further suppose that these survival opportunities are governed in the most general sense by the degree of optimality of turnover and rate of availability of certain fundamental resources, for example, water. If we can make this argument, we might also be able to argue that the degree of specification of selection required to fit into the more ideal environments will be less than that required to fit into less ideal ones: that is, that because there is too much or too little of something vital at certain times and places, a good deal more selection must go into establishing adaptations that will continue to support morphostasis in those places. This latter kind of selection will ultimately lead to the kinds of specialized organisms that will be evolutionarily at risk should the environment change markedly at some future point.

What has just been described can be interpreted as a mild form of final causation: it suggests that *all* populations will *tend* to disperse in preferred directions, and in so doing nonrandomly perpetuate genetic flexibility. This is evolution—environmentally mediated (or even directed) evolution, to be sure, but not environmentally *determined* evolution: again, as in Wallace's thinking, that which is selected for to meet the challenge constitutes *whatever* can be genetically sorted out, in large part by trial and error, to support persistence. In earlier writings [27] I imagined an environmental "potential information field" over which populations dispersed and evolved in this way. The magnitude of the potential was identified through an index combining idealness of a location's annual soil moisture budget with its degree of deviation from mean planetary temperature conditions (to produce a resource turnover rate surrogate conceptually linked to Van't Hoff's law). I theorized that, as a statistical whole, the shapes and orientations of geographic ranges of populations should reflect such a spatially varying driving mechanism and in fact was able to elicit empirical support to back this hypothesis.

In recent years other investigators [28] have been attempting to understand spatial variation in diversity patterns through approaches that share some of these objectives, but these efforts have so far lacked the dynamic modelling perspective that allows them to do more than correlate certain diversity characteristics with particular ambient environmental conditions. These are not, therefore, evolutionary models as they now stand, but it would not take much reorientation of purpose to turn them into such. Efforts of this kind might give us a much more interactive view of the meaning of biodiversity and at the same time allow us to overcome the logical dilemma that R. C. Lewontin remarked upon in an essay published in 1984: "The process is adaptation and the end result is the state of being adapted.... The problem is how species can be at all times both adapting and adapted" [29]. In fact, all we need do is follow Wallace's lead and understand that there *is* no "process of adaptation": only the *result* of stochastically accumulated adaptive structures that recapitulate past and present ecological associations and that generate actions eventually playing out in space and time as responses to final causes inherent in the environmental delivery system. Through the deliberate elucidation of such causes we might finally elevate ourselves from the incomplete and under-nourishing evolutionary philosophy that a strict form of Darwinian "tree-thinking" produces—and at long last claim, with justice, an allegiance to "Wallace's Unfinished Business."

REFERENCES

1. Brackman, A.C. A Delicate Arrangement: The Strange Case of Charles Darwin and Alfred Russel Wallace; Times Books: New York, 1980; Brooks, J.L. Just Before the Origin: Alfred Russel Wallace's Theory of Evolution; Columbia University Press: New York, 1984; Berry, A., Ed. Infinite Tropics: An Alfred Russel Wallace Anthology; Verso Press: London, 2002.
2. Raby, P. Alfred Russel Wallace, A Life; Princeton University Press: Princeton, NJ, 2001; Shermer, M. In Darwin's Shadow: The Life and Science of Alfred Russel Wallace: A Biographical Study on the Psychology of History; Oxford University Press: New York, 2002; Fichman, M. An Elusive Victorian: The Evolution of Alfred Russel Wallace; University of Chicago Press: Chicago, 2003; Slotten, R.A. The Heretic in Darwin's Court: The Life of Alfred Russel Wallace; Columbia University Press: New York, 2004.

3. Smith, C.H., Ed. Alfred Russel Wallace; An Anthology of His Shorter Writings; Oxford University Press: Oxford, UK, 1991; *idem.* Alfred Russel Wallace on Spiritualism, Man, and Evolution: An Analytical Essay; Torrington, CT, 1992; *idem.*, Ed. Alfred Russel Wallace: Writings on Evolution, 1843–1912; 3 vols. Thoemmes Continuum: Bristol, UK, 2004; *idem.* Alfred Russel Wallace: Evolution of an Evolutionist [www document]. URL http://www.wku.edu/~smithch/wallace/chsarwp.htm. 2003-2004; *idem.* The Alfred Russel Wallace Page [www document]. URL http://www.wku.edu/~smithch/index1.htm. 2001–. Historian Martin Fichman has also adopted this interpretation in two recent works: Science in theistic contexts: A case study of Alfred Russel Wallace on human evolution. Osiris 2001, 16, 2d s., 227–250; *idem. op. cit.* (2).
4. Wallace, A.R. My Life: A Record of Events and Opinions; 2 vols. Chapman & Hall: London, 1905.
5. Wallace, A.R. The advantages of varied knowledge. In: *op. cit.* (4) i; pp 201–204; *idem.* An essay, on the best method of conducting the Kington Mechanic's Institution. In: The History of Kington; Parry, R., Ed.; Kington, UK, 1845; pp 66–70.; *idem.* The South-Wales farmer. In: *op. cit.* (4) i; pp 206–222.
6. Marchant, J., Ed. Alfred Russel Wallace: Letters and Reminiscences; Arno Press: New York, 1975 (reprint of 1916 ed.); pp 65–67.
7. Wallace, A.R. A Narrative of Travels on the Amazon and Rio Negro; Ward, Lock, & Co.: London, 1889; pp 58–59.
8. Wallace, A.R. On the habits of the orang-utan of Borneo. Ann Magazine Nat Hist 1856, 18, 2d s., 26–32; on p 30.
9. *op. cit.,* (4), i; p 360.
10. Wallace, A.R. On the law which has regulated the introduction of new species. Ann Magazine Nat Hist 1855, 16, 2d s., 184–196.
11. Wallace, A.R. On the tendency of varieties to depart indefinitely from the original type. J Proc Linnean Soc Zool 1858, 3(9), 53–62.
12. See: *op. cit.* (8); Wallace, A.R. On the great bird of paradise. Ann Magazine Nat Hist 1857, 20, 2d s., 411–416; *idem.* On the natural history of the Aru Islands. Ann Magazine Nat Hist 1857, 20, 2d s., Suppl., 473–485; *idem.* On the Entomology of the Aru Islands. Zoologist 1858, 16, 5889–5894; *idem.* On the Arru Islands. Proc Roy Geographical Soc Lond 1857–1858, 2, 163–170.
13. Smith, C.H. Wallace's 'second moment': intelligent conviction and the course of human evolution [www document]. URL http://www.wku.edu/%7Esmithch/essays/WALLMO.htm; *op. cit.* Smith, 2003–2004 (3).
14. *op. cit.* (11); p 62.
15. Bateson, G. Steps to an Ecology of Mind; Chandler Publishing Co.: San Francisco, 1972; p 435.
16. Bateson, G. Mind and Nature: A Necessary Unity; Dutton: New York, 1979; p 43.
17. Maruyama, M. The second cybernetics: Deviation-amplifying mutual causal processes. Am Sci 1963, 51, 164–179.
18. Smith, C.H. The Dynamics of Animal Distribution: An Evolutionary/Ecological Model. University of Illinois: PhD Dissertation, 1984; *idem.* A contribution to the geographical interpretation of biological change. Acta Biotheoretica 1986, 35, 229–278; *idem.* Historical biogeography: geography as evolution, evolution as geography. New Zealand J Zool 1989, 16, 773–785.
19. Gould, S.J. Wallace's fatal flaw. Nat Hist 1980, 89(1), 26–40.
20. Wiley, E.O.; Brooks, D.R. Victims of history—a nonequilibrium approach to evolution. Systematic Zool 1982, 31, 1–24; Brooks, D.R.; Wiley, E.O. Evolution as Entropy: Toward a Unified Theory of Biology; University of Chicago Press: Chicago, 1986.
21. Hennig, W. Phylogenetic Systematics; University of Illinois Press: Urbana, IL, 1966; Nelson, G.J.; Rosen, D.E., Eds. Vicariance Biogeography: A Critique; Columbia University Press: New York, 1981; Nelson, G.J.; Platnick, N.I., Eds. Systematics and Biogeography: Cladistics and Vicariance; Columbia University Press: New York, 1981.
22. O'Hara, R.J. Homage to Clio, or, toward an historical philosophy for evolutionary biology. Systematic Zool 1988, 37, 142–155; *idem.* Telling the tree: narrative representation and the study of evolutionary history. Biol Philos 1992, 7, 135–160.
23. Greer-Wooten, B. The Role of General Systems Theory in Geographical Research. Department of Geography, York University: Discussion Paper 3, 1972; pp 17–18.
24. Wallace, A.R. Man's Place in the Universe; London: Chapman & Hall, 1903; *idem.* The World of Life; Chapman & Hall: London, 1910.
25. Once thought to be mere eccentricities, Wallace's excursions into spiritualism, socialism and other radical ventures are increasingly being recognized as fitting logically into his overall philosophy of nature. See *op. cit.* Fichman 2003 (2).
26. See, for example: Lovelock, J.E. The Ages of Gaia: A Biography of Our Living Earth; Norton: New York, 1988; Lenton, T.M. Gaia and natural selection. Nature 1998, 394, 439–447; Barrow, J.D.; Tipler, F.J. The Anthropic Cosmological Principle; Oxford University Press: New York, 1986.
27. *op. cit.* (18).
28. See, for example: Hawkins, B.A.; Porter, E.E. Relative influences of current and historical factors on mammal and bird diversity patterns in deglaciated North America. Global Ecol Biogeog 2003, 12, 475–481; *idem.* Water-energy balance and the geographic pattern of species richness of western Palearctic butterflies. Ecol Entomol 2003, 28, 678–686; Hawkins, B.A.; Porter, E.E.; Diniz, J.A.F. Productivity and history as predictors of the latitudinal diversity gradient of terrestrial birds. Ecology 2003, 84, 1608–1623; Hawkins, B.A.; et al. Energy, water, and broad-scale geographic patterns of species richness. Ecology 2003, 84, 3105–3117; Kerr, J.T.; Currie, D.J. The relative importance of evolutionary and environmental controls on broad-scale patterns of species richness in North America. Ecoscience 1999, 6, 329–337; Kerr, J.T. Butterfly species richness patterns in Canada: Energy, heterogeneity, and the potential consequences of climate change. Conservation Ecol 2001, 5, Art. No. 10; O'Brien, E.M. Water-energy dynamics, climate, and prediction of woody plant species richness: An interim general model. J Biogeogr 1998, 25, 379–398; Kerr, J.T.; Packer, L. Habitat heterogeneity as a determinant of mammal species richness in high-energy regions. Nature 1997, 385, 252–254.
29. Lewontin, R.C. Adaptation. In: Conceptual Issues in Evolutionary Biology; Sober, E., Ed.; MIT Press: Cambridge, MA, 1984; pp 235–251, on pp 237–238.