Alfred Russel Wallace Notes 18: Wallace on the Balance of Nature.

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Summary: Alfred Russel Wallace (1823−1913) had a unique perspective on the 'balance of nature': he avoided classical thoughts on the subject, but nevertheless seems to have adopted elements of the 'balance' concept while acknowledging that irreversible change occurs at both the biological and environmental levels. Wallace's position can be understood from his grounding in Humboldtian 'equilibrium of forces' thinking, and his turn toward 'final causes'-based interpretations. *Key words:* Alfred Russel Wallace, balance of nature, evolution, negative feedback, positive feedback, equilibrium of forces

Introduction

Included in Daniel Simberloff's 2014 treatment of the evolution and demise of the classical 'balance of nature' concept is the following quotation, drawing on words from one of Alfred Wallace's field notebooks:

> …Alfred Russel Wallace was perhaps the first to question the very existence of a balance of nature, in a remarkable notebook entry, ca. 1855: "Some species exclude all others in particular tracts. Where is the balance? When the locust devastates vast regions and causes the death of animals and man, what is the meaning of saying the balance is preserved… To human apprehension there is no balance but a struggle in which one often exterminates another." In modern parlance, Wallace appears almost to be asking how "balance" could be defined in such a way that a balance of nature could be a testable hypothesis. (p. 2)

Through these remarks Simberloff seems to suggest that by 1855 Wallace was already entertaining concepts that would inexorably lead him toward an evolutionary way of thinking. While there is some truth to Simberloff's inference, there are also some problems with it. To begin with, Simberloff has inadvertently paraphrased Wallace's thoughts through a secondary source, McKinney (1966), who made some edits. Wallace's actual words (as relayed in Costa 2013, pp. 126-128) are:

> …Lyell talks of the "balance of species being preserved by plants insects, & mammals & birds all adapted to the purpose." This phrase is utterly without meaning. Some species are very rare & others very abundant. Where is the balance? Some species exclude all others in particular tracts. Where is the balance. When the locust devastates vast regions, & causes the death of animals & man what is the meaning of saying the balance is preserved. – The sugar ants in the West Indies the locusts which Mr Lyell says have destroyed 800,000 men are instances of the *balance of species*. To human apprehension this is no balance but a struggle in which one often exterminates another. When animals or plants become extinct where is the balance. . . . If any state can be imagined proving a *want* of balance then a balance may perhaps be admitted but what state is that?

Wallace's full statement conveys a good deal more uncertainty than one gathers from

McKinney's near-paraphrasing. Especially interesting is the "what state is that?" comment at the end. Perhaps Wallace is being ironic or semi-sarcastic here, but at the least he appears to be more in the mode of entertaining a thought, than trying to reach a conclusion. (This is not the only place in the *Species Notebook*, moreover, where Wallace attacks conventional views on balance: see Costa 2013, pp. 320-323.) It should be remembered that this was at a time when he was trying to mount arguments against Lyell's anti-transmutation views as expressed in his *Principles of Geology*.

I think the story of Wallace's appreciation of the "balance of nature" notion is both more complicated, and more interesting, than Simberloff would have us believe. Here, we will look into this matter in a bit more detail.

Balance in Nature

As it has been an all-too-frequent habit of past writers to try to put words in Wallace's mouth, we begin with a relatively long survey of Wallace's actual published usage of the word 'balance' in our sense here, organized chronologically:

> 1858: …Domestic animals are abnormal, irregular, artificial; they are subject to varieties which never occur and never can occur in a state of nature: their very existence depends altogether on human care; so far are many of them removed from that just proportion of faculties, that true balance of organization, by means of which alone an animal left to its own resources can preserve its existence and continue its race . . . Even the peculiar colours of many animals, especially insects, so closely resembling the soil or the leaves or the trunks on which they habitually reside, are explained on the same principle; for though in the course of ages varieties of many tints may have occurred, yet those races having colours best adapted to concealment from their enemies would inevitably survive the longest. We have also here an acting cause to account for that balance so often observed in nature, – a deficiency in one set of organs always being compensated by an increased development of some others – powerful wings accompanying weak feet, or great velocity making up for the absence of defensive weapons; for it has been shown that all varieties in which an unbalanced deficiency occurred could not long continue their existence. 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. An origin such as is here advocated will also agree with the peculiar character of the modifications of form and structure which obtain in organized beings . . . We believe we have now shown that there is a tendency in nature to the continued progression of certain classes of varieties further and further from the original type – a progression to which there appears no reason to assign any definite limits – and that the same principle which produces this result in a state of nature will also explain why domestic varieties have a tendency to revert to the original type. This progression, by minute steps, in various directions, but always checked and balanced by the necessary conditions, subject to which alone existence can be preserved, may, it is believed, be followed out so as to agree with all the phenomena presented by organized beings, their extinction and succession in past ages, and all the extraordinary modifications of form, instinct, and habits which they exhibit. (Wallace 1858, pp. 61-62)

> 1870: …It happened that for the last 60,000 years there had been but little mutation of climate each 10,000 years – the periods into which he divided the 4,000,000 – and, therefore, in Mr. Darwin's own words, "the most powerful cause in inducing specific changes" had been in abeyance. Any estimate we might form of the rate of specific change

from the stability of species during that period would therefore be fallacious. The period of about 10,000 years of alternate changes of climate would seem to be one well adapted to favour rapid changes of species, as the change would be sufficiently gradual to allow of any possible amount of migration. There would be sufficient time for the appearance of abundant variation, and for the increase to any extent of species adapted to the changed conditions, whilst there would also be time for the new and complete relations into which they would be thrown to become adjusted and balanced. If we are adequately impressed with the highly complex relations which subsist between each organism and all around it – which Mr. Darwin has done so much to elucidate – and if we further accept his views that all changes in these relations, however brought about, necessarily cause the modification of some forms and the extinction of others, it seems hardly possible to conceive a state of things better adapted to promote the increasing growth and change of the organic world than that which he presents to us. (Wallace 1871, p. 31)

1876: …Now if we consider carefully the few suggestive facts here referred to … we shall be led to conclude that the several species, genera, families, and orders, both of animals and vegetables which inhabit any extensive region, are bound together by a series of complex relations; so that the increase, diminution, or extermination of any one, may set in motion a series of actions and reactions more or less affecting a large portion of the whole, and requiring perhaps centuries of fluctuation before the balance is restored. The range of any species or group in such a region, will in many cases (perhaps in most) be determined, not by physical barriers, but by the competition of other organisms. Where barriers have existed from a remote epoch, they will at first have kept back certain animals from coming in contact with each other; but when the assemblage of organisms on the two sides of the barrier have, after many ages, come to form a balanced organic whole, the destruction of the barrier may lead to a very partial intermingling of the peculiar forms of the two regions. Each will have become modified in special ways adapted to the organic and physical conditions of the country, and will form a living barrier to the entrance of animals less perfectly adapted to those conditions. Thus while the abolition of ancient barriers will always lead to much intermixture of forms, much extermination and wide-spread alteration in some families of animals; other important groups will be unable materially to alter their range; or they may make temporary incursions into the new territory, and be ultimately driven back to very near their ancient limits. …3. If such a condition of the earth as here supposed continued for very long periods, we may conceive that the action and reaction of the various organisms on each other, combined with the influence of very slowly changing physical conditions, would result in an almost perfect organic balance, which would be manifested by a great stability in the average numbers, the local range, and the peculiar characteristics of every species. 4. Under such a condition of things it is not improbable that the total number of clearly differentiated specific forms might be much greater than it is now, though the number of generic and family types might perhaps be less; for dominant species would have had ample time to spread into every locality where they could exist, and would then become everywhere modified into forms best suited to the permanent local conditions. (Wallace 1876, pp. 46-48)

1877: …The amount of variation which is likely to occur in a species will be greatly influenced by two factors – the occurrence of a change in the physical conditions, and the average abundance or scarcity of the individuals composing the species. When from these or other causes variation occurs, it may become fixed as a variety or a race, or may go on increasing to a certain extent, either from a tendency to vary along certain special lines induced by local or physiological causes, or by the continued survival and propagation of all such varieties as are beneficial to the race. After a certain time a balance will be arrived at, either by the limits of useful variation in this one direction having been reached, or by the species becoming harmoniously adapted to all the surrounding conditions; and without

some change in these conditions the specific form may then remain unaltered for a very long time, whence arises the common impression of the fixity of species. Now in a country like Chili, forming part of a great continent very well stocked with all forms of organic life, the majority of the species would be in a state of stable equilibrium, the most favourable variations would have been long ago selected, and the numbers of individuals in each species would be tolerably constant, being limited by the numerous other forms whose food and habits were similar, or which in any way impinged upon its sphere of existence. (Wallace 1877, pp. 783-784)

1878: …In the extreme north, pine or birch trees; in the desert, a few palms and prickly shrubs or aromatic herbs alone survive. In the equable equatorial zone there is no such struggle against climate. Every form of vegetation has become alike adapted to its genial heat and ample moisture, which has probably changed little even throughout geological periods; and the never-ceasing struggle for existence between the various species in the same area has resulted in a nice balance of organic forces, which gives the advantage, now to one, now to another, species, and prevents any one type of vegetation from monopolising territory to the exclusion of the rest. The same general causes have led to the filling up of every place in nature with some specially adapted form. Thus we find a forest of smaller trees adapted to grow in the shade of greater trees. Thus we find every tree supporting numerous other forms of vegetation, and some so crowded with epiphytes of various kinds that their forks and horizontal branches are veritable gardens… (Wallace 1878, p. 66)

1878: …Such disadvantages were not experienced in the equatorial zone. The struggle for existence as against the forces of nature was there always less severe, – food was there more abundant and more regularly supplied, – shelter and concealment were at all times more easily obtained; and almost the only physical changes experienced, being dependent on cosmical or geological changes, were so slow, that variation and natural selection were always able to keep the teeming mass of organisms in nicely balanced harmony with the changing physical conditions. The equatorial zone, in short, exhibits to us the result of a comparatively continuous and unchecked development of organic forms; while in the temperate regions, there have been a series of periodical checks and extinctions of a more or less disastrous nature, necessitating the commencement of the work of development in certain lines over and over again. In the one, evolution has had a fair chance; in the other it has had countless difficulties thrown in its way. The equatorial regions are then, as regards their past and present life history, a more ancient world than that represented by the temperate zones, a world in which the laws which have governed the progressive development of life have operated with comparatively little check for countless ages, and have resulted in those infinitely varied and beautiful forms – those wonderful eccentricities of structure, of function, and of instinct – that rich variety of colour, and that nicely balanced harmony of relations – which delight and astonish us in the animal productions of all tropical countries. (Wallace 1878, pp. 122-123)

1880: …We have to inquire, then, how it is that new species arise, supposing the world to have been then very much as it is now; and what becomes of them after they have arisen. In the first place we must remember that new species can only be formed when and where there is room for them. If a continent is well stocked with animals and plants, there is a balance between the different species, those best adapted to the varied existing conditions maintaining themselves in the largest numbers, while others, being only adapted to special conditions that occur in limited areas, are far less numerous; the former are common and widespread, the latter rare or local species. If the set of organisms in any country has existed for a sufficient time to have been subjected to all the varying conditions which occur during considerable cycles of climatal and other changes, the balance will have become

well established, and so long as no change takes place in the conditions no new species will arise. (Wallace 1880a, pp. 96-97)

1883: …The constancy of this result, even with plants removed only a mile or two, is a most striking illustration of the preponderating influence of organism on organism, that is, of the struggle for existence. The rare and delicate flower which we find in one field or hedge-row, while for miles around there is no trace of it, maintains itself there, not on account of any specialty of soil or aspect, or other physical conditions being directly favorable to itself, but because in that spot only there exists the exact combination of other plants and animals which alone is not incompatible with its well-being, that combination perhaps being determined by local conditions or changes which many years ago allowed a different set of plants and animals to monopolize the soil and thus keep out intruders. Such considerations teach us that the varying combinations of plants characteristic of almost every separate field or bank, or hill-side, or wood throughout our land, is the result of a most complex and delicate balance of organic forces – the final outcome for the time-being of the constant struggle of plants and animals to maintain their existence. (Wallace 1883, p. 430)

1889: …We have already seen that, when there is no change in the physical or organic conditions of a country, the effect of natural selection is to keep all the species inhabiting it in a state of perfect health and full development, and to preserve the balance that already exists between the different groups of organisms. But, whenever the physical or organic conditions change, to however small an extent, some corresponding change will be produced in the flora and fauna, since, considering the severe struggle for existence and the complex relations of the various organisms, it is hardly possible that the change should not be beneficial to some species and hurtful to others. The most common effect, therefore, will be that some species will increase and others will diminish; and in cases where a species was already small in numbers a further diminution might lead to extinction. (Wallace 1889, p. 115)

1904: …The ultimate development of man has, therefore, roughly speaking, depended on something like a million distinct modifications, each of a special type and dependent on some precedent changes in the organic and inorganic environments, or on both. The chances against such an enormously long series of definite modifications having occurred twice over, even in the same planet but in different isolated portions of it, as in the eastern and western hemispheres of the earth had they been completely separated from each other, are almost infinite, when we know how easily the balance of nature can be disturbed, as in those cases when man purposely or accidentally introduced pigs, rabbits, cats, or weeds into new countries. (Wallace 1904, p. 332)

1907: …I think I have now shown not only that no other planet in the solar system makes any approach to the possession of the varied and complex adaptations which are essential for a full development of organic life, but also that on the Earth itself the conditions are so numerous and so nicely balanced that very moderate deviations in excess or defect of what actually exists in the case of any one of them – and of others not referred to here – might have rendered it equally unsuitable, so that either no organic life at all, or only a very low type of life, could have been developed or supported. (Wallace 1907, p. 97)

1908: …In a prolonged drought it is only the tallest giraffes that find food enough to support life; and thus, by a periodical weeding-out of all but the very best – the fittest to survive under these unfavourable conditions – the standard of efficiency in each species is preserved by the rigid destruction of the less fit. It must always be remembered that, although the *average* population of each species varies very little during long periods, yet there may be considerable fluctuations annually. Some seasons will favour one species,

> some another; we then notice the abundance of certain birds or insects, generally followed a year or two later by a corresponding scarcity, keeping up the balance of the various forms of life in generally uniform proportions so long as the natural conditions, or "environment," continue to be the same or nearly the same. *The Origin of Species*: To anyone who has thoroughly grasped the extent and universality of variation within the limits of every common or widely-spread species, it will be at once evident that the very same causes which preserve each species in exact adjustment to its environment, will also, when that environment changes in any direction, enable it to become automatically adjusted to the new conditions. This must be the case, because all alterations in environment are necessarily very gradual. (Wallace 1908, p. 7)

The preceding excerpts include the vast majority of instances Wallace invoked the term 'balance' in the biological sense we are interested in here. It is clear from these fifty years of examples that Wallace had in fact permanently adopted the notion of a 'balance in nature' – but more specifically, one based on the hedge of, as he puts it, a "final outcome for the time-being," instead of some form of divine design. Thus, he acknowledges that the balances that rule are readily broken, and that when such occurs, things must happen to re-establish them: 'things' either, or both, ecological or evolutionary. [In a personal communication referee Steven M. Carr notes: "Again: are balances re-established, or replaced by new ones? Cf. use of Hardy-Weinberg 'equilibrium' rather than 'proportions,' especially in mathematical models, when H-W proportions are expected and observed at the start of each generation, are modified by natural selection according to selection coefficients, and thus change between generations though manifested in any one generation."] In one rather late writing Wallace states: "Evolution, as a general principle, implies that all things in the universe, as we see them, have arisen from other things which preceded them by a process of modification, under the action of those all-pervading but mysterious agencies known to us as 'natural forces' or, more generally, the 'laws of nature'" (Wallace 1901, pp. 3-4). This implies that such 'laws of nature' (of which natural selection was but one) conspire to generate both a balance (in a way we might now term 'stabilizing selection'), and directional change. How did Wallace come to such a position?

It must be remembered that early on, in the mid- to late-1840s, Wallace came under the influence of the thoughts of two philosophical writers interested in natural process, Robert Chambers and Alexander von Humboldt. The impact of Chambers's anonymously-authored *The Vestiges of the Natural History of Creation* on Wallace has been discussed frequently over the years, but Humboldt's hold on him, apart from the German's example as a natural history collector and observer, has largely been ignored. Nevertheless, the influence is there, manifest in Wallace's usage of Humboldtian terminology over the rest of his life, and in the younger man's adoption of many of the older one's philosophical views (Smith 2013a, 2013b).

In particular, the notion that the factors supporting evolution are balanced is chapter and verse from Humboldt's 'general equilibrium of forces' principle, the very foundation of Humboldtian science. Beyond this, Humboldt promoted a concept of 'terrestrial physics' – loosely, physical geography – that sought to elaborate on the interconnectedness of vegetation with its surrounding environment. All of this was based on the proposition that the infinite forces of nature were constantly in conflict, yet tended to balance one another out. In Wallace's work, the most obvious appropriation of these ideas is natural selection itself, which Wallace once famously likened to the action of the governor on a steam

engine: "…for it has been shown that all varieties in which an unbalanced deficiency occurred could not long continue their existence. 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" (Wallace 1858, p. 62). A more perfect example of how Humboldtian thinking had an influence on Wallace can scarcely be found. But other instances exist as well, demonstrating Wallace's extension of the 'balance of nature' concept to domains extending beyond the strictly biological. Consider the following:

> 1869: …The quantity of matter now carried away by our rivers is therefore no measure of the rate at which solid rock formations can be denuded, or whole continents eaten away. To determine this we require measures of the sediment carried away from purely intertropical river-basins, whose sources do not descend from snowy mountains. Such rivers as the San Francisco and the Tocantins in Brazil would perhaps serve for this purpose, although from the abundance of the tropical rains there can be little doubt that they must possess more denuding power than the rivers of temperate latitudes; unless the powerful agency of frost in loosening and decomposing rocks should balance the effect of the tropical rainy seasons. It may however be argued, that no measure of the rate of destruction of our continents can be obtained by a study of denudation alone, because the subterranean elevating forces must always on the whole have fully balanced the degrading forces, and are probably still doing so. But though the mean height of a continent may be kept stationary, or may even be increased by the action of subterranean forces, this will actually assist the denuding power, by loosening rocks, causing mountain slides, raising and inclining alluvial deposits, and altering the slope of valleys. The form of the surface will therefore be continually more and more changed, and the existing rate of denudation on the most moderate estimate, shows that the amount of this alteration of the surface would be enormous in the course of hundreds of thousands of years. (Wallace 1869, p. 378)

> 1879: …To balance this rise over extensive areas on both sides of the Atlantic, there must have been corresponding areas of subsidence. To Mr. Sclater's question – Where did the tropical land exist which afforded the passage of the tropicopolitan forms from one continent to the other? – it may therefore be answered: It existed in the north temperate zone during some part of the Miocene period, at the time probably when a rich temperate flora covered what are now the icy wastes of Greenland and Spitzbergen. In the North Atlantic a continuous land may have united Europe and America at about the latitude of London, without implying a greater amount of subsidence than would balance the elevation which we know has occurred over extensive areas in Europe and America. (Wallace 1879, p. 254)

> 1892: …The mean depths of the several oceans and the mean heights of the several continents do not differ enough from each other to render this diagram a very inaccurate representation of the proportion between any of the continents and their adjacent oceans; and it will therefore serve, roughly, to keep before the mind what must have taken place if oceanic and continental areas had ever changed places. It will, I presume, be admitted that, on any large scale, elevation and subsidence must nearly balance each other, and, thus, in order that any area of continental magnitude should rise from the ocean floor till it formed fairly elevated dry land, some corresponding area must sink to a like extent. But if such subsiding area formed a part or the whole of a continent, the land would entirely dis-

appear beneath the waters of the ocean (except a few mountain peaks) long before the corresponding part of the ocean floor had approached the surface. In order, therefore, to make any such interchange possible, without the total disappearance of the greater portion of the subsiding continent before the new one had appeared to take its place, we must make some arbitrary assumptions. We must suppose either that when one portion of the ocean floor rose, some other part of that floor sank to greater depths till the new continent approached the surface, or, that the sinking of a whole continent was balanced by the rising of a comparatively small area of the ocean floor. Of course, either of these assumed changes are conceivable and, perhaps, possible; but it seems to me that they are exceedingly improbable, and that to assume that they have occurred again and again, as part of the regular course of the earth's history, leads us into enormous difficulties. Consider, for a moment, what would be implied by the building up of a continent the size of Africa from the mean depth of the ocean. By comparing the area of Africa with that of the whole of the land, and the depth of the ocean with the mean height of the land, we shall find that if all the land of the globe above sea-level could be transferred to mid-ocean, it would not be sufficient to form the new continent, but would still leave it nearly 2,000 feet beneath the surface. (Wallace 1892, pp. 421-422)

1903: …Now if we consider that these five distinct conditions or sets of conditions, many of them dependent on a delicate balance of forces acting at the origin of our planet, appear to be absolutely essential for the existence of high types of organic life, we shall at once see how peculiar and unique is our place and condition within the solar system, since we know with almost complete certainty that they do not all co-exist in any of the other planets. And when we consider further that, even if they do happen to exist now, that would be nothing to the purpose unless we had reason to believe that they had also existed, as with us, in unbroken continuity for scores or perhaps hundreds of millions of years. All the evidence at our command goes to assure us that our earth alone in the Solar System has been from its very origin adapted to be the theater for the development of organized and intelligent life. But if all these radiant forces, or several of them, have combined in the development of life, we may feel sure that they can only have done so under conditions which limit their energy to that gentle and imperceptible action which has caused them to remain so long hidden even from the most inquisitive seekers of the past century. And it is at least a possible, and I think not improbable, supposition that this imperceptibility and continuity may exist only in the more central portions of the universe, while in its outer regions less regularity may prevail; and while some of these necessary radiant forces may be wanting, others may be too abundant or be manifested in so irregular or excessive a manner as to be antagonistic to the delicate and nicely balanced forces which are essential to the orderly development of life. (Wallace 1903a, pp. 482-483)

1903: …I have shown in the second chapter of this work that none of the previous writers on the question of the habitability of the other planets have really dealt with the subject in any adequate manner, since not only do they appear to be quite unaware of the delicate balance of conditions which alone renders organic life possible on any planet, but they have altogether omitted any reference to the fact that not only must the conditions be such as to render life possible now, but these conditions must have persisted during the long geological epochs needed for the slow development of life from its most rudimentary forms. It will therefore be necessary to enter into some details both as to the physical and chemical essentials for a continuous development of organic life, and also into the combination of mechanical and physical conditions which are required on any planet to render such life possible. (Wallace 1903b, p. 182)

1903: …The observations on numerous oceanic islands proved that the sub-oceanic crust

was considerably more dense than the crust under the continents, but also thinner, the result being to bring the average mass of the sub-oceanic crust and oceans to an equality with that of the continental crust, and this causes the whirling earth to be in a state of balance, or equilibrium. Now, both the thinness and the increased density of the crust seem to be well explained by this theory of the origin of the oceanic basins. (Wallace 1903b, p. 235)

1903: …If these primary conditions should be fulfilled, and if there should possibly be not only one or two, but a dozen or more that so far fulfil the first few conditions which are essential, what probability is there that all the other conditions, all the other nice adaptations, all the delicate balance of opposing forces that we have found to prevail upon the earth, and whose combination here is due to exceptional conditions which exist in the case of no other known planet – should all be again combined in some of the possible planets of these possibly existing suns? …in like manner it may, and I believe will, turn out, that of all the myriad stars, the more we learn about them, the smaller and smaller will become the scanty residue which, with any probability, we can suppose to illuminate and vivify habitable earths. And when with this scanty probability we combine the still scantier probability that any such planet will possess simultaneously, and for a sufficiently long period, all the highly complex and delicately balanced conditions known to be essential for a full life-development, the conception that on this earth alone has such development been completed will not seem so wildly improbable a conjecture as it has hitherto been held to be. (Wallace 1903b, pp. 283-285)

Humboldt himself was not an active proponent of transformist views, but neither did he deny, at least in principle, that such a process might possibly be taking place. Had he lived long enough (he died in 1859, just months before Darwin's release of *On the Origin of Species*), he doubtless would have become an advocate. In his own time, however, he resisted falling in with the transformist set, feeling that the subject placed more within the domain of zoology, and that, so far, zoologists had not presented enough evidence in its favor to sway opinion.

Nevertheless, as of the mid-1840s Wallace was under the impression that Humboldt held transformist views, as is evident from a letter he sent to Henry Bates, dated 28 December 1845, in which he reveals he has heard that "the venerable Humboldt" is an advocate of the evolutionary stance taken in *Vestiges of the Natural History of Creation*, and that he has "a great desire to read" the German naturalist's newly published *Cosmos*. *Cosmos* itself does not in fact promote transformist views, but perhaps Wallace had read some earlier work of Humboldt's that led him to conclude this: for example, an 1823 paper appearing in the *Edinburgh Philosophical Journal* in which Humboldt asks: "Do these types succeed each other from below upwards [in the strata] …Does the distribution of fossil organic bodies indicate a progressive development of vegetable and animal life upon the globe – a successive appearance…?" (Humboldt 1823, p. 21).

Some Final Considerations

As if the preceding were not enough to make the point that Wallace never gave up on notions of balance in nature, brief allusion must be made to two other terms that Wallace also applied, almost as frequently, within this context: 'equilibrium,' and 'harmony.' As one example of his use of the first, consider the following excerpt from his book review of C.

Lloyd Morgan's *Animal Life and Intelligence* in 1891:

> …We must also always remember Darwin's maxim, generally admitted to be a sound one, that "Nature does not produce absolute perfection but only relative perfection," – which again implies that when each species has reached an equilibrium with its environment there is for it no further perfection possible under the circumstances, no "profitable" variations tending to modify its mean specific characters of which natural selection can take account. For these various reasons it seems to me that any permanent modification of a species by mere isolation of a portion of it, and without some adequate change in the environment, is almost inconceivable. (Wallace 1891, p. 338)

And this passage, employing the word 'harmony':

> …Not only have all the continents and most of the larger islands been explored by naturalists and collectors, but the internal structure and affinities of all the chief types of living things have been minutely studied, so that all the more important features of organised beings, whether as regards variety of form or peculiarity of structure, are sufficiently well known, and admit of but little addition except in the filling up of details. These ample materials have favoured the labours of those naturalists who endeavour to discover the causes and the laws by whose action the great world of organic life has developed, and grown, and changed, from epoch to epoch, in harmony with those changes in the inorganic world which Geology unfolds to us. (Wallace 1880b, p. 1)

For Wallace biological evolution was thus, in the end, a function of environmental change – especially if one understands those environments to include the actions of other populations. (In the final paragraph of *Island Life* Wallace (1881, p. 502) writes: "I trust that the reader who has followed me throughout will be imbued with the conviction that ever presses upon myself, of the complete interdependence of organic and inorganic nature.") But here we must ask, how can we end up with both a balance/equilibrium, and an evolution? In the last analysis, how can we justify, or at least understand, this chicken-or-egg juxtaposition in Wallace's approach?

It seems clear that Wallace was trapped into this position by his early, and permanent, adoption of Humboldt's 'equilibrium of forces' principle. The forces themselves effect a loose equilibrium – that is, as an interplay of influences basic enough to maintain an environmental stability exploitable by biological systems – one permissive enough to encourage an infinite range of life strategies by animals and plants. In Wallace's view, as the environment gently shifts in a range of time and space generally exceeding the lives of individual organisms, it produces an impetus for organic adaptation and change.

We might look at this today in terms of non-equilibrial forces and entropy, but these concepts, especially in an evolutionary context, were not developed to any extent until after Wallace's death. Neither was Wallace directly familiar with the concepts of negative and positive feedback, his steam engine governor analogy notwithstanding. Still, I believe he did recognize the essential elements of the former, concerning forces that tend to return disequilibrial relations to a more 'balanced' state. Not only did he perceive this force in terms of the adaptive response of populations to their environment but, I believe, he applied the same kind of thinking to entertain a continuing evolution of consciousness

through the aid of spiritualistic forces (Smith 2008, 2019).

At the same time it appears Wallace had only the vaguest notions of what we might today call positive feedback processes in evolution. The closest he came to such thinking was his intuitive conclusion that evolution was goal-oriented – that is, that it operated as a function of final causes. He still might be right; only time will tell (note his contribution to the evolution of the anthropic principle). But in his own time Wallace paid only slight attention to the notion that the 'environment' itself was evolving: not only in response to inherent physical properties and cosmic influences, but indeed to feedback generated by the operation of the biological realm as well. Actually, he comes closer to thinking in the 'push-pull' context of Maruyama's model of deviation-amplifying mutual causal processes (Maruyama 1963) in his dealings with spiritualism: there, the epigenetic imprinting of dreams, premonitions, and conscience is supposed to help counter bad human tendencies by bringing the latter to more focused attention within consciousness, and thus possible remediations.

In the end, we can return to Wallace's 1855 words; specifically, the notion of a "final outcome for the time being," and "…If any state can be imagined proving a want of balance then a balance may perhaps be admitted but what state is that?" These are profound musings, a full response to which has yet to emerge.

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