

# Social Development as Social Expansion

## *Food systems, prosthetic ecology and the arrow of history*

Meek and beleaguered they seem to us now, yet with their fire and stone, their grasses and their game, [Palaeolithic hunter gathers] once swept across the globe like conquerors (Eisenberg 1998: 317).

It is conceivable that by 1984 we shall produce our food in factories, without animals or plants, exploiting the most far-reaching biological discovery of the last few years, the synthesis of proteins in cell-free systems (...) but that technological dream is nearer fifty than twenty years ahead (Waddington 1965: 13).

## Introduction

With characteristic vehemence, Jack Turner concludes *The Abstract Wild*, a polemical manifesto for a 'deep ecology', by arguing that scientific knowledge of wild nature is as destructive as outright development. For Turner 'all knowledge has a shadow' which in the case of scientific ecology is the enhanced capacity for the management of ecological systems.

At the core of [mainstream conservation biology] (...) lies a contradiction. We face a [moral] choice (...) Shall we remake nature according to biological theory? [Or] Shall we accept the wild? (1996: 125).

Eisenberg characterises those who refuse to accept human ecological dominance as either natural or irreversible as 'planet fetishers' who dream of 'returning to Eden, restoring a state of harmony in which wilderness reclaims the planet and man is lost in the foliage, a smart but self-effacing ape' (1998: xv). Unfortunately for Turner, in the five million years that separate modern humans from their self-effacing ancestors, the social stock of knowledge about natural processes has been accumulating steadily, increasing our capacity for prediction, control and manipulation of events in the natural world (Quilley

2004). The modern science of biology is merely the continuation of a knowledge process that stretches unbroken, down the generations, back even to the pre-linguistic sharing and copying of technologies of fire and flint-knapping. One could fairly argue that a good definition of humanity would be the 'remaking nature according to constantly revised biological theory'.<sup>1</sup> Reversing the process, even if it were desirable, flies in the face of human nature. We are naturally predisposed to talk to each other, sharing information, describing and explaining natural processes. Symbol emancipation (Elias 1989) allows the rapid aggregation of individual experiences codified as cultural knowledge. Knowledge engenders evolutionary and ecological success – which, for human beings, has always meant increasing populations, expanded ecological presence and further social development.

Eisenberg compares the stance of 'planet fetishers' with that of would be 'planet managers (...) who dream of a man-made paradise, an earth managed by wise humans in its own best interest and, by happy chance, humankind's as well' (xv). However, just because human beings are predisposed towards social development rooted in ecological control, this does not mean that the result will be a happy one either for human beings or for the natural systems upon which we depend. Whilst human domination of the biosphere is inevitable, the social and technological forms of this engagement are not predetermined. The relationship between the agro-industrial systems of the 'anthroposphere' (Goudsblom 2002) and the autonomous ecological systems of the biosphere, though constrained, is still open to regulatory intervention and political choice. The next couple of centuries will, however, be of defining significance in establishing the terms of this relationship – quite possibly establishing the trajectories of evolution and social development for millennia to come.

The purpose of this essay is to examine the ecology of human social development with a view to elucidating the nature of these constraints and regulatory choices. In particular, I seek to re-evaluate the opposition between the ecological complacency of would be planet managers such as R.D. North (1995) and the apocalyptic hysteria underlying the anti-globalisation, anti-state, and anti-capitalist rhetoric associated with radical ecology. Rory Spowers' (2002) book *Rising Tides* provides an exemplary vignette of the latter. Simplistic in the extreme, the book does capture the mood and logic of much radical eco-commentary. His philosophically idealist argument counterpoises the modern Western ideology of industrial progressivism with what Aldous Huxley dubbed

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1 A useful comment by the editor Nico Wilterdink

the 'Perennial Philosophy' (Spowers 2002: 56). Rounding up the usual suspects, Spowers identifies the Western 'myth of progress' and the expansionary dynamics of capitalist growth economics, with the occidental split between Man and Nature, and a subject/object divide deriving from the philosophy of René Descartes (Spowers 2002: 22). In opposition to this, contemporary ecological thinking, resonating with 'the new physics' and recent developments in 'Gaia Theory, Chaos Theory and General Systems Theory' (Spowers 2002: 33), is seen to express the eternal verities of spiritual holism (Buddhist, Taoist, hunter-gather, Hindu...) and sustainable living that were, it is asserted, the hallmarks of traditional, indigenous and tribal cultures. For Spowers, as for the anti-globalisation activists, Schumacher's injunction that 'small is beautiful' has become an article of faith.

The naivety of this kind of politics is almost overwhelming, but three areas of contradiction stand out. Firstly, from a historical and anthropological perspective, the much-vaunted notion of pre-Lapsarian tribal societies – hunter-gathering, horticultural and agrarian regimes are generally left unspecified – that were 'sustainable', and existed in a state of harmony with nature, is simply factually incorrect (Krech 1999). It also obscures the most fundamental continuity in the long-term development of human culture. This is evident in the fact that the demographic and ecological weight of humanity, and its geographical reach as a species, has been increasing inexorably and without interruption.

Secondly, borrowing heavily from the lexicon of twentieth century anarchism and critical theory, contemporary 'ecotopias' are decidedly antipathetic to the state process. In Spowers' words all government is seen as 'the extrapolation of individual human bondage' (Spowers 2002: 61). But in fact, as Elias (2000; 1991) has shown, the processes of individuation and state-formation, psychogenesis and sociogenesis, are inextricably linked. In seeking to throw the historical state-process into reverse gear, visions of decentralised, self-sufficient tribalism, would also reverse the direction of the civilising process. The kind of ecotopias envisaged by Kropotkin and Murray Bookchin, and resurrected by some contemporary proponents of 'deep ecology', are premised upon, and appeal to, a very modern kind of personality with a highly developed super-ego. The latter facilitates affective restraint, not only in relation to interpersonal violence (Elias 2000), but by implication, also vis-à-vis ecologically damaging material gratification. But the conscience formation implied by such an advanced super-ego emerges only in the context of highly socially differentiated, densely populated societies, regulated by states capable of imposing an effective monopoly on violence.

Thirdly, there is the vexed question of how to define nature and humanity's role within it – the Eden myth (Eisenberg, 1998). Ecological pessimists tend towards a Luddite suspicion in relation to technology: whilst most environmentalists are happy to embrace 'appropriate technology' there is a wilful myopia as to the long-term human trajectory of innovation. The resurrection of a mythic period of harmony with nature is essentially static, freeze-framing a few tribal societies out of the wider flow of human social development. But seen as a process, the longer time-frame of the expanding anthroposphere reveals a fundamental continuity in the relationship between humanity and the biosphere: a steady, iterative and spiralling interaction between processes of social development, technological innovation and ecological presence. From this perspective the question of what kind of nature should be preserved becomes highly problematic. At the vanguard of deep ecology, *Earth First* monkey-wrencher Dave Foreman (1991) places an absolute primacy on the protection of wilderness and biodiversity, rejecting any privileged status for humanity. But in fact, given the demographic weight of our species, even the most autarchic, tribal fantasy of deep ecology would entail a comprehensive humanisation of the biosphere. More specifically, the doubling of the human population will necessitate the appropriation of a further 64.5 million square km for food production (Cocks 2003: 65). Whether farmed organically, biodynamically according to the principles of Rudolf Steiner or even on the basis of permaculture, such agrarian expansion will leave little room for the tigers, elephants and rain forests.

From this perspective, the question becomes whether the wilderness ecosystems of the biosphere can be partially insulated from the further expansion of the anthroposphere and the continuing process of social development. Building on the concepts of 'trophic expansion' and 'ecological prosthesis', I argue in this essay that such an outcome is at least conceivable. The most benign accommodation between humanity and nature may emerge from an acceleration of technological and social innovations in relation to food production and the partial replacement of agriculture by in-vitro industrial synthesis.

Finally, on the other side of the debate, there is the question of whether the techno-fix optimism of the planet managers is justified. The bio-ethics of deep ecology makes any expansion of the human species unjustifiable. But from an evolutionary perspective the expansion of the anthroposphere must be seen as a natural dimension of a much broader process of evolutionary-ecological change and upheaval. The anthroposphere does not signal 'the end of nature' (McKibben 1989), and in the long run, the human species will succumb to

extinction. Meanwhile, the only rational yardstick for evaluation of the relation between humanity and the biosphere must be the material, aesthetic and spiritual interests of contemporary human beings and their progeny. In recent years, sceptics such as Lomborg (1991) have argued that the idea of ecological crisis has been exaggerated and that the biosphere is capable of absorbing human demographic and industrial growth for the foreseeable future. However, there are two good reasons why such complacent optimism is misconceived and indeed dangerous. Firstly, the preservation of wilderness ecosystems and biodiversity is a legitimate political imperative on purely spiritual, aesthetic or religious grounds and needs no further justification. Even if 'space ship earth' remains habitable for human beings, the current trajectory almost certainly precludes the long-term survival of wild populations of great apes, elephants and tigers. But there is a much more pressing concern. Lomborg's extrapolations are predicated on the time horizons of human development – decades and centuries. But the geological time-frame of the biosphere reveals a pattern of sharp and cataclysmic climatic and ecological upheaval. On this time-scale the benign inter-glacial period in which humanity has spent its childhood and teenage years, cannot be taken for granted. Furthermore, it is now widely appreciated that the planetary homeostatic mechanisms are both finely tuned and do not respond to change in a smooth and incremental manner. Rather there is a pattern of flipping, suddenly and violently between interconnected thresholds and complex equilibriums. Anthropogenic change is now becoming an unwitting factor in these processes.

Small changes [upon the basis of recent scientific evidence] cannot be regarded with the same equanimity as previously: they may take the system across major thresholds (Cocks 2001: 57; Schneider 1996).

Whilst the broad significance of carbon emissions in relation to global warming, and CFCs with respect to the ozone layer is well understood, we simply don't know what role biodiversity plays in the self-regulation of the biosphere. In this context, blithe optimism becomes a hallmark of recklessness. As Aldo Leopold famously remarked, 'to keep every cog and wheel is the first precaution of intelligent tinkering' (1949: 214).

## Overview

Human food systems – what we eat and how we produce it – reflect a distinctive ecological matrix that is a property of our species.<sup>2</sup> What this implies is that there is a pattern in the development of diets and eating habits over the longest stretch of human evolution and social development. Behind the manifest (and glorious) diversity of cultural cuisines there is a social-ecological algorithm which continues to shape and to an extent dictate the political choices and trajectories of contemporary food and farming.

Food regimes have always been major contributing factors to the evolutionary dynamics of local, regional and increasingly global ecosystems. Stripped down to the underlying flows of energy – from those of the earliest hunter-gathering hominids right through to the contemporary use of GMOs – such systems have developed as forms of *prosthetic ecology*. This is to say that food gathering and production has always involved the subsuming of autonomous ecological processes into expanding networks of interdependency between individuals and communities. It is argued that the level of social development (including the size and distribution of the human population, the degree of social differentiation and complexity, and the level of socio-economic integration between communities) is more or less proportional to the ‘trophic expansion’ of the human species. The corresponding decline in the autonomy of non-human nature relative to the prosthetic ecology involved in human food systems (an aspect of the anthroposphere) is a function of this trophic imperative. The ecological crisis that is likely to be a dominating feature of global development over the next two centuries results, at least in part, from the way that the anthroposphere generally, and the prosthetic ecologies of food and farming systems in particular, are now disrupting planetary homeostatic mechanisms which depend on the ecological services of the biosphere (for

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2 This is clearly a departure from the mainstream of anthropological thinking over the last three decades, where the emphasis has been on the ‘emic’-oriented explanation of engrained cultural differences in food and dietary behaviour. The arguments in this paper are more easily reconciled with the materialist tradition associated in particular with Marvin Harris whose analytical framework started from the the assumption that diverse foodways and dietary practices are the ‘outcome of determinate processes in which biopsychological, technological, economic and demographic and environmental factors predominate’ (Harris & Ross 1987: 5).



instance, the atmospheric, organic and geological cycling of carbon, nitrogen, oxygen, water and other elements).

Over the next two centuries the human species faces a seemingly insurmountable problem hinging on this social-ecological algorithm: namely, how to feed a world population which is likely to rise to somewhere in the region of ten billion by 2050, whilst at the same time reducing the impact of human activities on the deep rhythms of global ecological and climate systems that we are only just beginning to understand. To point out that this problem is both social and ecological might seem clichéd bordering on trite. But in fact the relationship between evolutionary ecology and long-term processes of social development radically undermines many commonly held assumptions about farming and sustainable food futures. The ensuing regulatory choices are likely to highlight a stark choice between the continuing humanization of tendentially autonomous ecological systems of the biosphere on the one hand, and the creation of truly separate, closed system artificial ecologies for food production on the other.

## Social development as trophic expansion

If ecosystems are envisaged in terms of the myriad of interdependent and interacting life-strategies of different species, the concept of the trophic pyramid is an attempt to represent the stocks and flows of energy within the system. Ultimately, the energy that is corralled by the entropy-avoiding biosphere is derived from the sun by the action of photosynthetic bacteria and plants. The idea of various trophic levels refers to the ways in which this captured solar energy is distributed around all of the imbricating folds of 'organic space' described by the idea of an ecological niche. Successive higher trophic levels support fewer organisms: there are more grass stems than antelope which are in turn more numerous than the lions. As a rule the biomass contracts by a factor of ten with each trophic level (Eisenberg 1998: 4).

During the course of human evolution and social development the species has undergone a series of remarkable transformations in its 'trophic orientation' which now combines the following:

- *Vertical shift*: In moving up the trophic ladder, humans have become the dominant, predatory meat-eating animals;

- *Lateral spread*: The pronounced opportunism of an ecological generalist allows humans to feed in niches across all trophic levels simultaneously (combining omnivory, herbivory and carnivory);
- *Indirect trophic consumption*: Material culture is synonymous with a capacity to feed ‘indirectly’ (e.g. ‘consumption’ of trees for their energy; or mammals for their insulating furs; land and soil as space for the built environment);
- ‘*Trophic time-travel*’: Raiding the past to consume the biomass of previous geological eras in the form of fossil fuels (‘*saprophagy*’ – Eisenberg 1998: Ch5);
- *Geographical colonisation*: The trophic net of the anthroposphere now encompasses almost the entire planet (including the oceans);
- *Demographic growth*: The increase in human population has been continuous with evolution spilling over into social development, and at each stage redefining the relevant carrying capacity and side-stepping ‘natural’ ecological constraints.

This is what I refer to as trophic expansion. Even disregarding the energetic implications of culture, human ecology has entailed the diversion of an ever-greater proportion of incoming solar energy, made available by the action of photosynthesis, to fund the geographical and numerical expansion of our species. With regard to the underlying entropic dynamics, this trophic expansion of humanity is necessarily matched by contraction in other parts of the biosphere. Indices of such trophic contraction have been the loss of biodiversity, the elimination of entire ecosystems and the reduction in biological complexity.

The trophic expansion of the hominid line started out as an entirely ‘natural’ evolutionary process. Early hominids built upon a relatively unspecialised generalist body-plan or ‘eco-morph’ and an equally flexible behavioural repertoire to take advantage of an expanding range of environments opened up by successive waves of glaciation. In fact a peculiar combination of circumstances engendered an evolutionary process of positive feedback between this existing ecological and morphological flexibility and a growing behavioural flexibility facilitated by the expanding brain.



The outcome of this process, even prior to the emergence of talking, culture-bearing *Homo sapiens*, were hominids marked by a high degree of behavioural and morphological flexibility, able to create tools, wield weapons, hurl missiles and control fire. These attributes ensured that these creatures were already rising to the top of the trophic pyramid and becoming ecologically dominant across a range of ecosystems. Fire in particular reduced their vulnerability to competing predators during the night, as well as contributing to the external digestion of otherwise less tractable food sources (e.g. edible tubers). Bipedality, sweat glands and great levels of endurance combined with weapons technologies allowed them to take advantage of hunting opportunities during the hottest parts of the day. This is not to exaggerate the importance of meat eating. But as Tudge (1997) points out, it was precisely the flexible omnivory of early humans that proved to be so destabilising in ecological terms. It is likely that, compared with australopithecines, hominids increased the proportion of calories provided by meat from somewhere in the region of ten to twenty percent. But as opportunist hunters combining active predation with highly efficient scavenging, as well as taking advantage of fruit and vegetable resources, these hominids became progressively less vulnerable to the vagaries of seasonal and wider ecological cycles. From an early point in our evolution, by moving on to exploit a different ecological resources, human beings have developed a capacity to side-step trophic constraints (the ecological 'carrying capacity'), and 'natural' limits on population size. With the emergence of modern *Homo sapiens* this has proved to be ecologically devastating. There is now an emerging consensus that Palaeolithic hunters were involved in large-scale extinctions on four continents and numerous islands (Diamond 1997; Flannery 2001; Martin & Klein 1984).

Thus by their ability to switch from food source to food source, human beings could maintain relatively high populations even though they were key predators. But also, if they chose to hunt a rare beast they had the knowledge and the persistence to hunt it, as other predators would not. They were able to break the rules in short. And by these means, in the end they broke the ecological rule which says that big predators must be rare (Tudge 1997: 258).

If trophic expansion was an incipient characteristic of pre-Sapiens hominids, it truly came into its own only with the emergence of modern, talking culture bearing people – a process which, according to the archaeological and artefactual record, seems to have crossed some kind of threshold between forty and sixty thousand years ago (Mithen 1996). Since this time it seems reasonable to

suggest that the rate and rhythms of long term social development has been roughly proportional to those of trophic expansion. That is to say, the increasing complexity of social life – the increase in population, the extension of social and economic divisions of labour, the increasing scale and scope of interdependencies between individuals and groups and across progressively larger areas, the increasing scale and capacities of state-regulatory mechanisms, increasing longevity and the establishment of progressively longer and more demarcated periods of childhood along with more complex forms of socialisation and psychogenesis – *have all been funded by trophic expansion and the sequestration of surplus from other parts of the biosphere.*<sup>3</sup>

## Prosthetic ecology

The traditional historiography of social development demarcates a strong separation between hunter-gathering economy of the middle and upper Paleolithic and the era of farming heralded by the Neolithic ‘revolution’. However there is a growing appreciation that rather than a sudden transition, the process of agrarianisation was long and drawn out involving a gradual shift in the balance between hunting and gathering, horticulture, pastoralism and finally full dependence on soil-turning arable cultivation (Tudge 1998). It is also recognised that the distinction between hunting and gathering as activities of passive exploitation of wild ecological resources and gardening, agriculture and life-stock herding as activities which actively construct and produce ecological resources and entire ecosystems is problematic in itself. Pre-Sapiens hominids were already actively transforming landscape ecology by using fire to encourage favoured prey species and vegetation. It is very likely indeed that Paleolithic hunter gatherers not only systematically engaged in such ‘fire stick farming’, but also habitually planted useful shrubs and conducted forms of proto-horticulture which would not necessarily leave traces in the archaeological record. Seen against the much longer term evolutionary trend towards ecologi-

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3 A strong implication of this is that periods of ‘decivilisation’ in the Eliasian sense (see Mennell 1990), in so far as they involve socio-economic contraction and a decline in the scale and intensity of interdependencies between groups and individuals, should also be associated with ‘trophic contraction’, and a (localised) reduction in the weight of the anthroposphere on the biosphere. Exactly such a relationship has been discovered in relation to ‘dark age’ periods in Europe, as well as Mycenaean Greece 1200-600BC (Chew 2001).

cal dominance, behavioural flexibility and trophic expansion, the process of agrarianisation is only the final episode in a much more general process – the development of *prosthetic ecology*.<sup>4</sup>

Prosthetic ecology is the eco-systemic concomitant of the anthroposphere and refers to a subset of ecological processes, which have accompanied the rise to dominance of human beings. It can be seen in terms of an elaboration, in the context of social development, of a pre-existing, evolved tendency towards trophic expansion apparent in early hominids. Trophic expansion itself, it should be stressed, was a natural outcome of a successful evolutionary-ecological strategy. Human beings are certainly not the only species to have side-stepped trophic constraints, radically increased in numbers and in doing so radically transformed ecological dynamics at the level of the biosphere (cyanobacteria poisoned the world for their anaerobic co-habitees, creating in the process the oxygen atmosphere that defines the operation of the biosphere today). However, whilst not completely unprecedented, the scale of the transformation being effected by human beings can hardly be overstated. The resulting humanised ecology is 'prosthetic' to the extent that ecological processes, and indeed entire ecosystems, are subsumed into a wider set of social relationships between interdependent individuals and groups.

What has transformed the scale and consequences of our trophic expansion is our capacity for language and culture. For most organisms, and certainly large predators, ecological impacts are a function of individual organisms or at most small familial groups – such as a pack of wolves or a pride of lions. Whilst such social animals are capable of sophisticated communication, symbolic language allowed, for the first time, groups rather than individuals to become knowledgeable historical and ecological agents. In contrast to individuals, such groups, at least in principle, can continue to exist indefinitely. The resulting knowledge process – the capacity to generate a social stock of experience and learning accessible by individual organisms but maintained as an unplanned consequence of interdependent interactions between those individuals – has opened up an extraordinary ecological opportunity. Essentially this knowledge process allows and impels individual organisms to act as quasi-neurones in an invisible, 'social brain'.

Prosthetic ecology refers then to the appropriation of whole eco-systems and landscapes by the logic of trophic expansion of a single species.

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4 Catton (1980) develops the idea of humanity as the prosthetic species.

The increasing weight of prosthetic ecology necessarily has a detrimental impact on non-human nature for two reasons. 'The whole point of farming' as Tudge argues 'is to divert the highest possible proportion of natural output into human food' (1997: 317). In a world where there is a limited amount of carbon fixed by photosynthetic bacteria and plants, there is necessarily a limited amount of food. Trophic expansion is a technical term which perhaps obscures the 'cuckoo' dimension of the process. In a world of finite biomass, and thus of entropy-resistant structured energy, an increasing share going to one species, means a decreasing proportion available to other species. Human expansion necessitates a corresponding contraction elsewhere.

## Ecological crisis

As Eisenberg points out, the ecological dynamics of social development bear the heavy imprint of Gresham's law (1998: 317-318). Competition between social groups and the eco-demographic ratchet (the increased population consequent upon short term ecological success) ensure that social arrangements favouring trophic expansion, multiply and spread out. Just as fire-bearing cultures displaced those without, agriculturalists have progressively disinherited hunter-gatherers, state societies replaced tribal cultures and industrial modernity has become a global imperative. And in relation to agriculture, improvident and expansive forms have often displaced more sustainable forms with longer time-horizons.

From an evolutionary perspective, the humanisation of the biosphere is not unprecedented. There have been many occasions in the earth's history in which alliances of animals and plants have combined to dominate global ecologies. However the terreforming regime of human beings is unique in two ways. Firstly, in scale: humans currently appropriate over 35-40% of terrestrial primary productivity, a figure which will double over the next century (McNeill, 2000:212). But secondly, prosthetic ecology is uniquely disruptive to the underlying mechanisms of the biosphere.

The key processes in the biochemistry of life – fermentation, photosynthesis, respiration, protein-synthesis, and genetic transmission – are all very ancient and were inherited from bacteria. Most of the critical regulatory mechanisms of the biosphere hinge on the interaction between these ancient life-processes, and the geo-climatic cycles of the earth's crust and atmosphere. And although the occupants of the higher trophic echelons have frequently changed or been substituted – mammals for dinosaurs, angiosperms for

gymnosperms – there has been continuity in the provision of the basic ecological services providing for the flow of nutrients, the regulation of climate and atmosphere, the absorption and release of rainwater etc.

Agrarianisation has seen a progressively more violent disruption of these services and cycles. Thus for example, the complexity and volume of living topsoil, which plays the principle role in recycling organic matter, retaining moisture, nitrogen fixation and nutrient absorption by plants, has evolved over millions of years. But over the course of the Holocene nearly fifty percent of this Pleistocene inheritance has been lost to soil erosion and over-intensive cropping (see Pimentel 1995). Similarly, deforestation to make room for agriculture and ranching is having a potentially catastrophic impact on the hydrosphere. As Lovelock points out trees, through their capacity to evapotranspire vast volumes of water vapour maintain cloud over and are crucial not only to the cycling of water but to the thermoregulation (quoted in Sampson & Pitt 1999: 119). Elsewhere the hydrosphere has been disrupted by eutrophication, the depletion of finite groundwater, the large-scale diversion of rivers and the construction of innumerable dams and irrigation systems (McNeill 2000: Ch. 5). Growing dependence on industrial fertilisers means that prosthetic ecology is now the dominant factor in the global cycling of these critical elements. Similarly, billions of tons of naturally reclusive metals are cycled through the industrial metabolism of the anthroposphere. And as Vernadsky and George Perkins Marsh first observed, humanity has now become a dominant geological agent in its own right, being responsible for the transport of nearly as much rock and soil as the combined forces of wind, glaciation, mountain building and oceanic volcanoes (McNeill 2000: 30).

One of the major impacts of social development has been on biodiversity. A major ecological effect of the globalisation of human culture has been to break down barriers between continental ecosystems – what Eisenberg refers to as the ecological re-creation of the ancient super-continent of Pangaea (see also McNeill 2000: 260). As a consequence of this, in addition to the species lost as a direct result of anthropogenic loss of habitat, the biosphere is currently undergoing an unprecedented competitive ‘shake out’ with the extinction of thousands of species (Wilson 1992). At least as damaging as extinction, has been the unregulated geographical layout of prosthetic landscapes. Just as the biosphere depends on complex nutrient and energy flows, so the stability and responsiveness of ecosystems depends on complex flows and migrations (season and permanent) of species and populations, between habitats – and in periods of climatic change the shifting boundaries of entire ecosystems. Roads, railways, urban settlements, managed watercourses and mono-cultured agro-



industrial crop systems severely reduce this systemic capacity for movement – intimating adaptive failure and an even more pronounced depletion of natural diversity in the future.

Taken on their own, these ecological consequences of the expanding anthroposphere would already give cause for concern – aesthetic and spiritual if nothing else. However, it is increasingly apparent that living systems have an important role to play in the regulation of global climate (Schneider 1996). And whilst the period of rapid anthropogenic change barely registers on the time-frames of biospheric evolution, the scale and intensity of prosthetic ecology are generating feedback loops that will unfold over tens of thousands of years (or less) and the effects of which we can only begin to guess. Because of the non-linear and chaotic behaviour of natural systems, it is quite possible that human beings are pushing the regulatory mechanisms of the biosphere perilously close to climatic thresholds. As McNeill comments:

The cumulation of many increased intensities may throw some grand switches producing very basic changes on earth. No one knows and no one will know until it starts to happen – if then (4).

In short, there are very real questions as to whether humanity can survive itself. Since biosphere modelling is in its infancy, it is unlikely that we will be able to predict with any certainty the long-term consequences of the expansion of the anthroposphere. Even so, some leading scientists are confident enough to refer to the possibility and even probability that civilisation will surpass the capacity of global life support systems (Malone & Correll 1989: 7). Back in 1970 the prominent ecologist G. Evelyn Hutchinson was the first to liken the developing ecological crisis to that resulting from the poisonous oxygenation of the atmosphere by cyanobacteria (1970). However human beings, unlike bacteria, are in a position to reflect upon and modify their behaviour.

### **Trajectories, constraints and conceivable accommodations in the relationship between the biosphere and the prosthetic ecologies of the anthroposphere**

The concept of trophic expansion implies an unavoidable ecological tension between the energetic demands of human social development – the proportion of terrestrial and oceanic organic production monopolised by the prosthetic ecologies of agricultural production and fishing – and the ecosystems of wild



nature, which sustain astonishing and fragile levels of biodiversity and play a presently unquantifiable but significant role in the planetary homeostasis upon which the anthroposphere depends. Whilst the ecological impacts of the anthroposphere are not limited to agriculture, the prosthetic ecologies of food production have the greatest impact, not least because it is by definition land intensive. I say 'by definition' – but I would now like to question this definition and raise the possibility of a partial separation of food production from the biosphere.

Whilst on the Earth these systems can never be truly separated,<sup>5</sup> it is possible to conceive of a partial disengagement and the creation of partial or wholly detached food production systems – the 'hiving off' and disembedding of human prosthetic ecology from the trophic dynamics of the biosphere. This would at least relax the pressure of the anthroposphere on the biosphere, and leave space for an autonomous evolutionary dynamic on the part of natural ecosystems, preserving biodiversity and leaving intact planetary level nutrient cycling and homeostatic systems. Following this line of thought, a systems-scenario provides a useful heuristic, drawing attention to the most important choices facing humanity its increasingly self-conscious, if very long term, project of re-designing the relationship between the anthroposphere and the biosphere. One can envisage the following trajectories:

– *Two closed-systems*: The prosthetic ecology of food production fully-industrialised, taking place in closed-systems and insulated from the biosphere. Technological innovation would allow for industrial food production on a hyper-intensive basis, in urban 'biomass factories' – allowing a significant relaxation in the territorial grip of the anthroposphere and a corresponding increase in land area given over to non-human ecosystems. This would amount to the semi-detachment of social development and evolutionary ecology.

– *One closed system*: In this scenario the biosphere will be subsumed (and possibly consumed) by the expanding anthroposphere with the total integration of social development and evolutionary ecology. Conceivably this could result in a benign outcome entailing a planned stabilisation and eventual reduction in human population and the universal adoption of more 'sustainable' extensive

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5 An artificial biosphere – for instance the life-support system in a space station designed for permanent habitation, or the unsuccessful Biosphere II experiment in Arizona – could in theory effect such a separation.

and eco-friendly forms of agriculture. However, what is seldom recognised in the manifestos for global organic agriculture, is that such extensive and 'sustainable' production is unlikely to leave much space for autonomous wilderness ecologies. Free-ranging chickens are just as much an aspect of the prosthetic ecology of the anthroposphere as their factory farmed cousins. Even with the most benign version of this scenario, it is also clear that humanity would have to rapidly take responsibility for the total management of planetary ecological systems far beyond those relating to the trophic imperatives of social development. In addition to the impossible job of maintaining biodiversity, the planet managers would have to take effective regulatory control of global recycling and homeostatic systems which operate over time scales that are difficult for human beings to grasp (as Colin Tudge says 'a million years is a proper unit of political time' (1997: 20)). At the very least such a programme of active management is inconceivable without enormous breakthroughs in the earth sciences as well as political integration and the psychogenesis of a global citizen on a scale that is beyond the reach of twenty first century politics. Unfortunately, what is most likely is the *de facto* continuing integration of the two systems, with the unplanned extension of prosthetic ecologies resulting in crashing biodiversity and chaotic impacts on the basic functioning of the biosphere – with uncertain but probably unpalatable political consequences.

– *Combination*: More feasible than the total segregation of food systems ecology, if not a likely scenario, is a combination of closed and open systems. By supplementing more benign sustainable forms of open system 'smart' agriculture (including organic), with highly productive, capital intensive closed system food production (including organic, GM, synthetic & organo-chemical), such a combination would at least relax the pressure of human trophic expansion.

The technological innovations that open up this vista of closed-system, food-production are not new. For instance as far back as 1967 Nicholas Calder, who was one of the first to use the image of the earth as a space-ship, presented a bold and science-fiction-like scenario in which agricultural production was replaced with closed system food production based on the breakthroughs in genetic science which were in the 1960s beginning to transform the technological imagination. Calder recognised that ultimately the problem of food production was about carbon fixation and the utilisation of solar energy. Drawing on the ideas of eminent biologist Christopher Waddington (1965), Calder argued for in-vitro photosynthesis, using 'artificial leaves' to deliver an industrial scale of synthetic carbon fixation and phosphorylation (1967: 152-

157). This would provide the substrate for in-vitro synthesis of complex food tissues using the new science and technologies of molecular genetics. On this basis it would be possible, he enthused, to 'grow a beef-steak without a cow' (157). But the greatest advantage of the envisaged paradigm shift was that it would allow for the liberation of huge areas of the Earth's surface from the long-tightening grip of agriculture. Calder's vision was certainly eccentric but even in his most science-fictional moments, there is an appreciation of the fundamental tension between the Promethean logic of social development that is hardwired into the inventive, discursive and collective human mind, and the ecological systems through which we evolved.

## Intimations of technological futures

So how far have we come since 1967? Waddington (quoted at the beginning of this paper) was right to be cautious about the speed at which the relevant technologies might unfold. However moving into the 21st century many of the speculative ideas that captivated himself and Calder in the 1960s, are indeed moving into the field of the possible, and in some cases practicable. In this final section, I would like simply to give some relevant examples and explore the possible fallout for food system politics.

### *Artificial photosynthesis in a test-tube*

Scientists are trying to imitate nature in the test tube and once they have cracked synthetic photosynthesis, they hope to take carbon dioxide from the air and use it to make fuel, fertilisers and even food (Alexandra de Blas, ABC radio, 25th Aug 2001).

Artificial photosynthesis would be the ultimate goal for the development of a closed system prosthetic ecology. The reason is quite simple. It would allow the trophic demands of humanity to be secured directly from solar energy without the need to involve photosynthesising natural agents. This would clearly solve the problem of fossil fuels and would represent the ultimate in renewable energy. With respect to food, the fixed carbon compounds could either be used as the substrate for further in-vitro synthetic production (synthetic animal protein— see below) or used as animal feed. In the latter case, this could be an aspect of a closed system factory production system (see Deltapark below) or used as a complement reducing the land requirements of open-system pas-

toralism. Although Calder's 'artificial leaves' are not on the immediate horizon, the science is progressing. Most recently, in Australia the National Institute of Advanced Industrial Science Technology (AIST) managed to split water creating hydrogen and oxygen using only natural light.

#### *Deltapark: integrated, high-rise, factory farming ecosystems*

The most advanced proposal for a large-scale, closed-system, prosthetic ecology was sponsored by the Innovation Network for Rural Areas – a Dutch government think tank. Covering 400,000 square meters (60 soccer pitches) the idea was for a series of intensive production systems, linked into an artificial ecosystem and organised into a high-rise block incorporating wind-turbines, mushroom farms, greenhouses, pig and chicken farms and waste processing systems. According to one of the designers, Jan de Wilt, 'Deltapark connects different sectors into something like an eco-system' (quoted in *New Scientist*, 18/05/02 p. 43). His colleague Winy Maas goes on to argue that the system could quite easily be created to conform to organic standards including in relation to animal welfare. By connecting such mega-farms to local markets, the system could reduce food miles and particularly the transport of live animals. One of the main benefits of this engineer's take on food production is seen to be that it would allow thousands of acres of farmland to be returned to nature or other uses.

#### *In-vitro meat production*

Waddington and Calder's vision of in-vitro food synthesis has taken longer than even Waddington imagined. However it is definitely now a possibility. Examples include a NASA sponsored research programme at Touro collage in New York to grow fish protein in the lab (*New Scientist* 20th March 2002). However the possible applications go beyond space travel. The research team leader Morris Benjaminson argues that the ['in vitro muscle protein production system'] 'could save you having to slaughter animals for food'. In the long term this prospect of meat without slaughter has the potential to transform food politics, driving a wedge between the interests of animal rights campaigners and those linking consumer health with organic production.

#### *Fermentation of single-celled protein substrate*

Industrial scale fermentation of single-cell-protein is already a well-established technology. Quorn myco-protein is one well-known food substance produced for human consumption, and sold successfully in the form of burgers and sausages for the vegetarian market. Elsewhere an Israeli firm, Koors Food, is

culturing green algae for commercial production of glycerol – which is used as an ingredient for chemicals, detergents, explosives and many other industrial processes. More generally SCPs have been cultured commercially from yeast, bacteria, and fungi and grown on a variety of substrates including molasses, methane, methanol, ethanol, cheese whey, cassava starch and organic residues from forestry and agriculture. Large-scale production of SCP for human consumption is certainly possible from a technological point of view. SCP products are already competing with fish meal as feed supplement.

The significance of SCP in relation to the open/closed-system dynamics referred to in this paper is that it could be used directly in the production of protein for human consumption (closed system), as a substrate for other in vitro technologies (see above – closed system), as a feedstuff for closed-system factory farming systems such as Deltapark (closed system) or as an input into smart-farming systems (open/closed combination – see below).

### *‘Smart farming’*

Forget the battle now raging between organic and intensive farming. There is another way (*New Scientist* 18th May 2002: ‘Beyond Organic: The Smart Farming Revolution’)

In a keynote story the *New Scientist* elaborated a third way for food and farming – so called ‘smart farming’. Directed towards the idea of sustainability, smart farming builds on the premise that technology, and in particular information and monitoring technology, can greatly reduce the quantities of pesticides and herbicides required for modern intensive agriculture, whilst making the system more amenable to co-existence with natural flora and fauna. The key is seen to be detailed micro-knowledge of what is happening not only in each field but different parts of a field. Examples of this kind of environmental management can already be seen in the ecological protocols imposed by supermarkets on their dedicated producers. More radical experiments in smart farming include attempts by Wes Jackson and the Salina Land Institute to re-engineer cornfields using as a model, its antecedent wild prairie (Eisenberg 1998: 327–328; Jackson *et al* 1984). Building on a holistic understanding of evolutionary ecology, Jackson is attempting to create a seed-bearing perennial and poly-cultured grassland system which requires ploughing only once in five years and retains the disease resistance of wild prairie. Such visions of smart agriculture are clearly relevant to the more sustainable integration of prosthetic and wild ecologies.

## GM

GM refers to a generic set of technologies that are emerging from the rapid advances across the life sciences. Current debates emphasise the differences between innovations aimed at rationalising production and those directed towards product innovation – the prospective GM-enhanced health foods or ‘neutraceuticals’ being prime examples of the latter. However from a slightly wider perspective and a longer time-frame, GM should be seen in terms of a more general expansion in scientific understanding of all aspects of the life-process. Potentially reductionist gene science is necessarily leading to more research on ontogenetic and epigenetic aspects of organism growth and development. And in the long term, political and regulatory crises over the application of GM technologies will provoke intensive research into the ecological dynamics of the life process. Regardless of how the politics unfold, gene science will not disappear and GM will inevitably play a central role in aspects of future food and farming systems. For the purposes of this discussion the critical factor is the extent to which GM technologies will underpin closed/open system dynamics.

Clearly molecular genetics will play a central and directing role in any or all of the in-vitro technologies referred to above: artificial photosynthesis; synthetic animal protein manufacture, single-cell-protein manufacture. But more generally – with respect to a combined open/closed system trajectory – it is possible to envisage transgenic plants, animals and tissue cultures contributing to a mixed regime combining, for instance, hyper-intensive field agriculture, closed-system ‘biomass factories’ along with high-rise agricultural facilities such as Deltapark, and an expanded sector of organic and extensive production. Such a mixed regime could certainly result in a significant reduction in the overall landmass monopolised by agriculture and the expansion autonomous wilderness ecology. Consider for instance, the land-releasing potential of substituting modified milk producing bacteria for dairy herds. Large areas of lowland pasture would become available for other forms of agriculture, for urban development or perhaps for re-created wild habitat zones. The example is hypothetical, but it certainly intimates the potentially complex and unexpected relationship between GM and the bioethics and ecological politics of the late twenty-first and twenty-second centuries.



## Implications for the future political sociology of nature

Contemporary debates around food and farming tend to polarise around the antipodean trajectories of organic farming and the new 'green revolution' based upon genetic modification (GM). The latter has become synonymous with intensive farming and is constructed as being intrinsically 'anti-ecological'. This bi-polar discourse suggests, in the mind of critics, systematic links between technological and capital intensiveness, consumer health, environmental sustainability and animal welfare.

In reality this identification of intensive production as the problem *per se* obscures the more fundamental continuities in ecological prosthesis. For the entire period of our tenure on this planet, the human career has involved a Promethean tendency towards greater understanding and manipulation of natural processes in the interests of what from the point of view of sociology or economics we call social development, but from the perspective of evolutionary ecology must be seen as trophic expansion. Even if we could hold social development at some hypothetical equilibrium, the resulting engagement with non-human nature would not be more natural than the vistas alluded to above. In fact we cannot stand still. And in the course of the next two hundred years regulators, farmers, consumers and activists will be faced by an over-riding question: how should we reconcile food production and global ecology.

At the moment the GM trajectory is having the effect, especially in Europe, of consolidating the political bifurcation between intensive and extensive production systems. The reason for this is almost entirely because the technology has been launched and discussed, largely in terms of open system field agriculture. That is to say, in terms of the argument developed here, the GM trajectory is predominantly orientated *to open-system, intensive farming*. In this sense, it is, as the critics argue, likely to exacerbate the worst ecological impacts of conventional capital-intensive farming. Product innovation in relation to closed-system production has been restricted to glass house horticulture where the novelty and emphasis has been on the product innovation (e.g. a lycopene-enhanced health-tomato – Harvey *et al* 2000) rather than the potentially revolutionary impact of closed system production *per se*.

Let us just imagine the political discourses that might emerge from a food system based upon the emerging potentialities of the life-sciences. This would involve closed-system biomass factories organised around artificial photosynthesis, industrial *in-vitro* synthesis of animal protein, single cell protein fermentation and the development of high-rise, intensive, artificial production eco-systems along the lines of Deltapark. The intensification of production

using such closed-system technologies, would create space for the extensification and contraction of those traditional agricultural systems retaining an open interface with the biosphere: i.e. 'smart farming' using a combination of both 'high tech sustainable' and organic production systems. This may not seem a likely scenario at the moment. However as the technology develops, elements of it could easily take root out of necessity in countries such as China and India – both of which have the technological capacities, state-regulatory systems and socio-economic need to innovate. Inter-state learning and competition would do the rest. Any serious prospect of such a combined open/closed system trajectory would surely turn the current political universe on its head. For instance, in relation to:

– *Meat/animal welfare*: By providing meat tissue without the use and abuse of animals and milk without dairy cows, in-vitro tissue production could more or less completely resolve all animal welfare concerns relating to food production. However there might be new, and interesting dilemmas for the animal rights activists about the 'species rights' of domestic breeds made economically redundant.

– *Taste/authenticity*: Synthetic animal protein (SAP) would certainly not satisfy the demands for authenticity on the part of food gourmets and aficionados. However their needs could be supplied by a small and very high-value added organic sector combined with regulated hunting in the newly created woodlands.

– *Local production*: Food miles are a significant cause for concern and feature prominently in green critiques of intensive farming. However closed-system production systems involving either more rationalised artificial ecosystems such as Deltapark, or full scale in-vitro production would remove climate and local landscape constraints allowing food to be produced, from scratch, at the city-regional point of consumption.

– *Conservation/wilderness preservation and global ecology*: This GM trajectory would provide the ultimate boost for conservation, releasing demographic pressure from the land. In the British Isles, upland areas, in the absence of sheep, could be returned to an arboreal splendour they have not seen in five thousand years. More critically, the partial disengaging of the prosthetic ecologies of food production may well be necessary to safeguard the operation of

wider, planetary cycles and homeostatic systems of which we are at present only dimly aware.

– *Food safety*: this issue could cut both ways, but if recent experiences are anything to go by, consumer resistance to such synthetic products would be significant.

– *Fair trade and development issues*: There would be nothing intrinsic in such a technology to make it detrimental to the interests of developing countries. With high population growth and greater pressure on the land, such countries might have the most to gain. The cost/benefit ratio would depend, as ever, on who owned the technology, and on what basis it was made available.

The technological trajectory intimated by ecological prosthesis in an era of molecular genetics will unfold, if at all, over a century or more. It is impossible to predict with any certainty how the political sociology of advocacy, protest and resistance will be transformed. But it does seem clear from the examples given above, that the emerging technologies have the potential to completely transform the politics of nature and the environment. From an orientation verging on outright Luddism, deep ecologists and defenders of wilderness might find themselves siding with high tech corporations, and animal rights activists with fast-food chains. What is certainly true is that such a partially closed-system, semi-detached trajectory for prosthetic ecologies of food production might see the realisation of a genuine ecologising civilising process – amounting to a form of restraint and self-control not only at the level of individuals, but also the entire species, in relation to the rest of nature. In this sense, it would represent humanity finally coming to terms with the tension between the Promethean dynamic of social developmental and the autonomous ecological trajectory of the biosphere.

## Conclusion

Contrasting the discourses of planet fetishers with those of the would be planet managers Eisenberg says,

At the far end [of the management spectrum] are the crazed futurists, the sort of people who would make cows legless milk dispensers, conveniently stackable, and replace sheep with tube-fed lamb-chop cultures hundreds of yards long.

This extreme is no longer worth talking about [except that we have to in relation to] biotechnology where the crazed futurists have taken refuge (285).

In a sense the perspective advanced here fits into this category of 'crazed futurism'. However the distinction between prosthetic and wild ecology, along with the concept of trophic expansion, usefully draws attention to the ecological continuities of human evolution and social development. Whilst there is a growing consensus that the expanding anthroposphere makes human management of the biosphere unavoidable, the dangers from anthropogenic disturbance of ecosystem services are becoming steadily more apparent (Schneider 1996: 106). Whilst it is highly uncertain whether human technology could ever substitute for these systems, most would also recoil from 'becoming conscripted as the physicians and nurses of a geriatric planet with the unending and unseemly task of forever seeking technologies to keep it fit for our time' (James Lovelock, quoted in Sampson & Pitt, 1999: 120). More than anything else the systems of the biosphere require space – for forests to spread out, animals to migrate, nutrients to circulate and diversity to flourish. Envisaging the semi-detachment of at least some of our food production into closed factory systems ushers in the long-term prospect of loosening the hold of the anthroposphere upon the biosphere and allowing wilderness, not simply to cling on, but to flourish and expand.

In his ecological history of North America, Tim Flannery notes the way in which upon entering a new homeland, all immigrant species are affected by three evolutionary forces: the *founder effect*, *ecological (and social) release* and *adaptation* (2001: 351). For early humans migrating out of Africa during the Pleistocene to colonise the world, the 'founder effect' can be thought of as symbol emancipation and the resulting capacity for culture and intergenerational knowledge processes. The ensuing pattern of 'ecological release' has in every corner of the globe, resulted in a characteristic pattern of ecological prosthesis, trophic expansion and ecosystem stress. Now in its final stages, the globalisation of the anthroposphere threatens to undermine the integrity of the biosphere as a whole. In this sense the rising tide of ecological consciousness and environmental politics can be thought of in terms of a process of 'adaptation' in which humanity as the ultimate global migrant seeks to render the ecology of the anthroposphere sustainable. Although technological innovations in the life-sciences raise the possibility of adaptation via semi-detachment and 'trophic restraint', the social conditions for such a transformation are unclear. This trajectory for 'ecological modernisation' will require state-regulatory reforms in combination with changes at the level of personality

structure. The ecological civilising process implied by this combination of sociogenesis and psychogenesis is unlikely to proceed at the quixotic pace of human imagination and anticipation. Never the less, it may already be underway (see Aarts *et al*, 1995).

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