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Genealogies of Resilience

From Systems Ecology to the Political Economy of Crisis Adaptation

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ABSTRACT

The concept of 'resilience' was first adopted within systems ecology in the 1970s, where it marked a move away from the homeostasis of Cold War resource management toward the far-from-equilibrium models of second order cybernetics or complex systems theory. Resilience as an operational strategy of risk management has more recently been taken up in financial, urban and environmental security discourses, where it reflects a general consensus about the necessity of adaptation through endogenous crisis. The generalization of complex systems theory as a methodology of power has ambivalent sources. While on the one hand the redefinition of the concept can be directly traced to the work of the ecologist Crawford S. Holling, on the other hand, the deployment of complex systems theory is perfectly in accord with the later philosophy of the Austrian neoliberal Friedrich von Hayek. This ambivalence is reflected in the trajectory of complex systems theory itself, from critique to methodology of power.

Developed within systems ecology in the 1970s, 'resilience' as a science of complex adaptive systems and as an operational strategy of risk management has flourished, progressively asserting itself as a dominant discourse in natural resource management (Millennium Ecosystem Assessment, 2006). The concept of resilience has in the recent past rapidly infiltrated vast areas of the social sciences, becoming a regular, if under-theorised, term of art in discussions of international finance and economic policy, in corporate risk analysis, the psychology of trauma, development policy, urban planning, public health and national security. Since the nineties, global financial institutions such as the International Monetary Fund (IMF 1996, 2005) the World Bank (WB 2006), and the Bank for International Settlements (BIS 2002, 2008), have increasingly incorporated strategies of 'resilience' into their logistics of crisis management, financial (de)regulation and development economics. With the post-911 revolution in 'homeland security', resilience has become a byword among agencies charged with co-ordinating security responses to climate change, critical infrastructure protection, natural disasters, pandemics and terrorism (UK Cabinet Office 2007; World Bank 2008; World Economic Forum 2008; Jackson 2008; Australia21 2009), reorienting these once distinct policy arenas toward a horizon of critical future events which (we are told) we cannot predict or prevent, but merely adapt to by 'building resilience'. Abstract and malleable enough to encompass the worlds of high finance, defence and urban infrastructure within a single analytic, the concept of resilience is becoming a pervasive idiom of global governance. Thus far, most critical responses to 'resilience' as a mode of governance have engaged only specific applications and failed to investigate its premises in and generalization from complex systems theory (Coaffee, Wood and Rogers, 2009; Lentzos and Rose, 2009). In this article, we trace the genealogy of 'resilience' from its first formulation in ecosystems science to its recent proliferation across disciplines and policy arenas loosely concerned with the logistics of crisis management.

The fact that the contemporary usage of the term 'resilience' originated in the work of the ecologist C. S. Holling, and retains definitive links to this field is indicative of the exemplary function of 'ecological risk' within contemporary practices of security. We propose that the success of this ecological concept in colonising multiple arenas of governance is due to its intuitive ideological fit with a neoliberal philosophy of complex adaptive systems, which we trace in turn to the under-acknowledged legacy of Friedrich von Hayek. Against the common assumption that neoliberalism is exhausted by the positivist methodology of the Chicago school, we argue that this narrowly empirical current of neoliberalism has,

in key policy arenas, been overtaken in intellectual influence by the mature philosophy of Friedrich von Hayek. Further, we venture the larger claim that the science of complex adaptive systems has become a theoretical reference point for the full spectrum of contemporary risk interventions. Whereas energy physics played a foundational role in classical modernist theories of economic and ecological organisation, and the homeostatic systems of first order cybernetics dominated the economic and military sciences of the Cold War, complexity science now serves as a source of naturalising metaphors for contemporary practices of security, and functions to neutralise critical inquiry into the disastrous consequences of neoliberal approaches to financial regulation, urban planning and crisis response, environmental policy and development.

In order to sketch a conceptual genealogy of 'resilience', we first introduce Holling's innovations in ecology, and then Hayek's in economics broadly defined. Inspired by very different political concerns, Holling and Hayek have made profoundly influential contributions to their respective fields, and these have ended up coalescing in uncannily convergent positions. In our genealogy of the term 'resilience', we will show how both Holling and Hayek, writing in the early seventies, were simultaneously preoccupied by questions of epistemic limits to prediction and assertions of ecological limits to growth. In common is their rejection of metaphors from classical thermodynamics, their early adoption of the lexicon of 'complex adaptive systems', their pessimism about the management of complex systems according to predictive models, and the rejection of the *Limits to Growth* report as an example of everything that was wrong with the image of their respective sciences in the public domain. Importantly, in their late careers both figures sought to universalise the significance of their projects well beyond the natural/social science boundary. We argue that the two perspectives, originally informed by antagonistic concerns, have ended up merging in the contemporary discourse of crisis response through resilience. At stake in this tacit union is a governmental philosophy of Nature and Society so all-encompassing and resilient to critique that the effects of political interventions (and non-interventions) made in its name, even when catastrophic, seem as inescapable as the weather.

This article argues for the importance of a critique of the proximity between the emergent discourse of 'resilience' and contemporary neoliberal doctrines. We demonstrate this with an analysis of the rise of resilience in the specific cases of international finance, critical infrastructure protection, and contemporary approaches to 'sustainable' development. We conclude with a reflection on the evolution of complex systems theory from critique to functionalism.

C. S. Holling's Innovations in Ecology – Origins of Resilience Science

The work of the ecologist Crawford 'Buzz' Holling represents a crucial shift in the annals of systems ecology. Holling did some of the most important work in the early 1970s to modernise the classical systems model of ecological dynamics in terms of the new 'complexity science': away from mechanistic assertions of equilibrium typical of post-war cybernetics toward the contemporary 'complexity science' view of ecosystems. In the 1990s, Holling went on to found the consortium of environmental scientists called the Resilience Alliance. More recently, these initiatives have been brought together within the Stockholm Resilience Centre, a high-profile think-tank which promotes the uses of resilience theory in international environment and development projects. We provide a brief outline of Holling's innovations in applied ecology in the 1970s, and his subsequent efforts, since the mid-1990s, to incorporate 'social systems' and 'economic systems' into a general complexity science of 'socio-ecological resilience'.

Abel and Stepp have provided a useful sketch of the interface of complexity science with ecology:

> what actually constitutes complex systems science is not yet settled. Although there are many threads, we and others…see an integrated, evolutionary science of complex systems emerging from the synergy between new computational paradigms (chaos theory, agent-based modelling, and self-organization), dramatic breakthroughs in the venerated field of nonequilibium thermodynamics, empirical research into large, complicated systems such as weather, earth systems, and ecosystems, and innovation in evolutionary theory… As an emerging field, some researchers claim their part as the whole, but we prefer to see the connections and the possibilities of an open, multi-disciplinary, evolutionary, and integrative systems science. (Abel and Stepp, 2008: 1)

While a distinction between classical systems ecology and its post-1973 complexity turn effaces much that is continuous in the discipline (de Laplante, 2005), the influence of the new complexity science on Holling's school of ecosystem management is profound. The key image of science that propelled the formalisation of economics (in the 1870s) and ecology (in the 1950s), was of smooth and continuous returns to equilibrium after shock, an image derived from different vintages of classical mechanics and thermodynamics. Holling's widely cited paper 'Resilience and Stability of Ecological Systems' (1973)

represents the destabilisation of the notion of 'equilibrium' as the core of the ecosystem concept and the normal terminus of ecosystem trajectory, and the beginning of a major shift among ecologists away from the notion that there exists a 'balance of nature' to which life will return eventually if left to self-repair. Having worked for years in the field as a resource manager and conservation ecologist, Holling began his classic 1973 paper on resilience by noting that:

> traditions of analysis in theoretical and empirical ecology have been largely inherited from developments in classical physics and its applied variants [...] there has been a tendency to emphasize the quantitative rather than the qualitative, for it is important in this tradition to know not just that a quantity is larger than another quantity, but precisely how much larger. […] But this orientation may simply reflect an analytic approach developed in one because it was useful and then transferred to another where it may not be (1973: 1).

Holling goes on to distinguish between an existing notion that he calls 'engineering resilience' and his alternative, a properly 'ecological' resilience. Engineering resilience, associated with the reigning mathematical ecology (Odum, 1969; Lewontin, 1969; May, 1973), is an abstract variable, simply the time (t) it takes a system to return to a stable maximum (or equilibrium position) after a disturbance. The return is simply assumed, and the equilibrium state is taken as equivalent to long-term persistence. What Holling seeks to define instead, is a complex notion of resilience which can account for the ability of an ecosystem to remain cohesive even while undergoing extreme perturbations. If stability refers to the familiar notion of a return to equilibrium, 'ecological' resilience designates the complex biotic interactions that determine "the persistence of relationships within a system", thus resilience is "a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist' (1973: 17).

Holling points to the dangers of the management theory of 'maximum sustained yield' (MSY), long dominant in industrial forestry and fisheries, with its claims to enumerate a fixed quantity of 'surplus' cod or spruce that can be harvested year in year out, without undermining the ability of the ecosystem to recuperate its own productivity. Holling's argument here (mirroring Hyman Minsky's post-Keynesian account of financial crises) is that the long-term expectation of stability may be inherently destabilizing. The ideal of a constant yield of productivity may fragilize a natural resource to such an

extent that it undermines complex factors supporting the resilience of the system as a whole. 'The very approach…that assures a stable maximum sustained yield of a renewable resource might so change these deterministic conditions that the resilience is lost or reduced so that a chance and rare event that previously could be absorbed can trigger a sudden dramatic change and loss of structural integrity of the system' (1973: 21). Holling's perspective on resource management reflects the emerging critical voices which, in the early seventies, insisted that intensive methods in agriculture and resource management would at some point meet inherent limits to sustainability, resulting in mass extinctions and intolerable over-pollution. For Holling, the equilibrium approach was dangerous in its abstraction: glossing over the unknowably complex interdependencies of specific landscapes pressed into the conditions of maximized yield, it accelerated the process of fragilization, potentially leading to the irreversible loss of biodiversity. The urgent focus for the conservation manager in a significantly humanised world should not be the equilibrium of a pristine ecosystem, but the resilience of biotic communities exposed to severe economic pressures.

In contrast, Holling's perspective seeks to open up a management approach capable of sustaining productivity even under conditions of extreme instability. Its ability to adapt to and deflect from particular limits derives from the fact that it has abandoned long-term expectations:

> A management approach based on resilience…would emphasize the need to keep options open, [...] and the need to emphasize heterogeneity. Flowing from this would be not the presumption of sufficient knowledge, but the recognition of our ignorance: not the assumption that future events are expected, but that they will be unexpected. The resilience framework can accommodate this shift in perspective, for it does not require a precise capacity to predict the future, but only a qualitative capacity to devise systems that can absorb and accommodate future events in whatever unexpected form they may take (Holling 1973: 21).

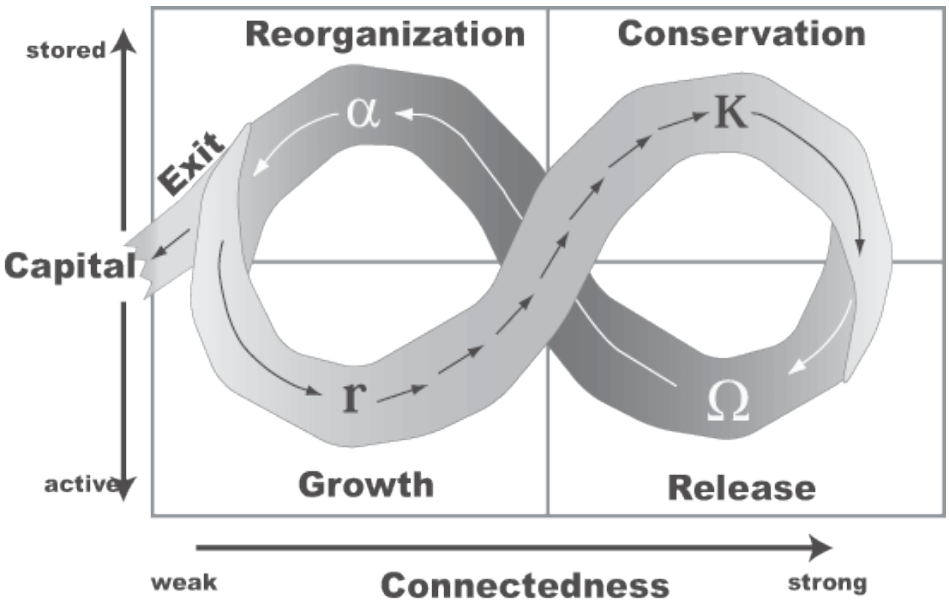
The above passage, taken from the conclusion of Holling's 1973 article, is significant because it so clearly anticipates the guiding ideas of contemporary complex systems theory and its practical applications in crisis response. Under the sign of resilience, this is an approach to risk management which foregrounds the limits to predictive knowledge and insists on the prevalence of the unexpected, seeking to 'absorb and accommodate future events in whatever unexpected form they may take' (Holling

1973: 21).

Holling's later contributions to the practices of adaptive ecosystem management (1986) earned him a wide professional following. Following consensus building work with leading orthodox economists (Arrow et. al 1995), Holling and fellow ecologists formed the *Resilience Alliance*, and conceived of an ambition to expand the insights of the resilience perspective well beyond ecology. Emblematic in the name change of the house journal from *Conservation Ecology* to *Ecology and Society*, the Alliance was no longer concerned with resilience as a property of ecosystems but of the coevolution of societies and ecosystems as a single system. This new research into 'social-ecological resilience' aspires to set the ground-rules for a general systems theory capable of integrating society, the economy, and the biosphere. This totality is dubbed the 'Panarchy':

> the structure in which systems, including those of nature (e.g., forests) and of humans (e.g., capitalism), as well as combined human-natural systems (e.g., institutions that govern natural resource use such as the Forest Service), are interlinked in continual adaptive cycles of growth, accumulation, restructuring, and renewal. (Gunderson and Holling, 2002, dustjacket,)

There is a significant difference in scope and tone between this later definition of socio-ecological resilience and Holling's earlier work. Holling is no longer arguing that some ecosystems undergo extreme fluctuations; nor even that all ecosystems enter into stress conditions under the demands of maximum sustained yield; but rather that *all* ecosystem *and* social-ecological system dynamics can be approached heuristically as non-linear iterations of an 'adaptive cycle', in which four distinct phases can be identified. Where classical systems ecology focussed only on the phases of rapid successional growth (*r*) followed by the conservation phase of stable equilibrium (K), the *Resilience Alliance* argue that these phases are inevitably followed by collapse (Ω), and then a spontaneous reorganisation that leads to a new growth phase (α). [see figure]



The Holling figure-8.

What unites these diverse systems and allows Holling to propose a common theorization of their dynamics is the proposition that each can be defined by a concept of 'capital' – this capital, be it financial, organisational, or biophysical, is 'the inherent potential of a system that is available for change, since that potential determines the range of future options possible' (2001: 393). In short, Holling seeks to independently theorize an abstract dynamics of capital accumulation, one not predicated on the progressive temporality of classical political economy but rather on the inherent crisis tendencies of complex adaptive systems. In this respect, we contend, Holling's later work becomes much more closely aligned with Hayek's mature theory of spontaneous market order and social evolution. Although Holling never cited Hayek, we argue that it is Hayek's influential philosophy of free market dynamics that has made the contemporary policy arena so receptive to the overtures of the *Resilience Alliance*. If the Mont Pèlerin Society and the Resilience Alliance have anything in common, it is the attempt to forge a broad transdisciplinary philosophy capable of unifying Nature and Society under a single set of all-encompassing concepts.

Hayek's Legacy - The Market as Complex Ecological System

In the popular academic and activist imagination, neoliberalism continues to be conflated with and critiqued as the radical generalization of neoclassical equilibrium theory to all aspects of social life (Nelson 2001; Harvey 2005). Yet as Mirowski and Plehwe (2009) have amply documented in their

history of the neoliberal 'thought collective', the various scholars associated with the Mont Pèlerin Society were internally split between the followers of the radical neoclassicism of the Chicago School (Gary Becker, George Stigler, Milton Friedman), and the advocates of the more romantic, subjectivist 'Austrian' school of economic philosophy, most famously associated with Friedrich von Hayek.

Although Hayek resorted liberally to the concept of equilibrium in his earlier work, the signs of his later dissent are already visible in his precocious critique of rational economic planning, which socialists such as Oskar Lange (1938, 1949) argued could by computationally grounded in Walrasian equilibrium theory. In 'The Use of Knowledge in Society' (1945), Hayek argued for the impossibility of 'central planners' to arrive at any of their goals by attempting to eliminate, influence, or control prices for rational planning purposes. Only the floating prices constituting The Market, a radically decentralised computation and signalling system, are able to discover the relative value of things, to adjust, evolve and incorporate information held by isolated and differentiated Individuals. Importantly, 'these adjustments are probably never "perfect" in the sense in which the economist conceives of them in his equilibrium analysis' (Hayek, 1945: 523).

The notion of price formation as distributed computation led Hayek to his mature unified theory of spontaneous order and social evolution, first suggested in his 'Theory of Complex Phenomena' (1967). By the 1980s, he had abandoned the equilibrium analysis for which he earned his stripes as a liberal economist in the 1920s and 1930s. Acknowledging that equilibrium analysis permitted the idea that 'planning was possible', he criticised the Keynesian state for seeing the economy as a hydraulic machine, as a 'suction pump' operating on aggregate balances of supply and demand contained in a system of pipes and tanks (Caldwell, 2008: 226). Remarking on the sheer complexity of the capital structure, he spoke of multiple 'streams' of value, ebbing and flowing into a river of liquid capital, constantly re-adjusting the production process, coursing down an ever-changing river bed (Hayek, 1981). Hayek in his late career sought to provide a respectable 'complexity science' genealogy for his own notion of spontaneous order, aligning his project with 'autopoesis, cybernetics, homeostasis, spontaneous order, synergetics, systems theory' (Hayek, 1988: 9) as well as citing works by the physicist Ilya Prigogine in support of his project (Hayek, 1982: 200 in Hodgson, 1994: 432). In his final work, Hayek wrote:

> …the extended order is perfectly natural, in the sense that it has itself, like similar biological

phenomena, evolved naturally in the course of natural selection. (1988: 19)

In 1974, Hayek was awarded the Nobel Prize for economics, an event that signaled the changing fortunes of the Mont Pèlerin society and terminated his long exile from economic orthodoxy. In the speech he delivered for the occasion, 'The Pretence of Knowledge' (1974), Hayek not only gave voice to his enduring hostility to the Keynesian welfare state but also to his dissatisfaction with the equilibrium models favored by his neoclassically minded colleagues, including the Chicago school neoliberals. If the state engineered equilibria of Keynesian demand management were to be rejected, so too were the equilibrium formulae of the neoclassical economists.

Hayek's speech focused on the looming crises of the early 1970s -- oil shocks, stagflation, third world and worker militancy -- and the various efforts to intervene in them by way of expanding the regulatory arena of the state. These crises, he contended, were symptoms of the intellectual failure of Keynesian policy. He was therefore highly skeptical of efforts to respond to such crises using the very techniques of state intervention which he believed had engendered them in the first place. Such interventions, Hayek intoned, were at best doomed to failure. The natural complexity of market phenomena was such that no centralized authority could hope to predict, much less control, the precise evolution of individual elements in the system. At worst, such efforts risked inducing long-term crises that would not have occurred without the undue interference of the state. Hayek's critique of Keynesian and neoclassical equilibrium theories goes well beyond the political sphere. What is at stake for him is no less than a thorough rethinking of epistemology itself, informed at least implicitly by the insights of his masterwork in neuropsychology, *The Sensory Order* (1952). As a counter-argument to the predictive fantasies he sees as integral to Keynesian economics, Hayek espouses an epistemology of limited knowledge and uncertain futures. 'I confess that I prefer true but imperfect knowledge, even if it leaves much indetermined and unpredictable, to a pretence of exact knowledge that is likely to be false' (1974).

Hayek immediately put this imperfect yet superior epistemic position to good use by repudiating the claims of the nascent environmental movement. Citing the landmark Report to the Club of Rome, with its assertion that exponential growth would surely undermine the regenerative capacities of the biosphere and its calls for a 'controlled, orderly transition from growth to global equilibrium' (Meadows et al.1972), Hayek denounced it as exemplary of the hubris of predictive modeling in the face of unknowable complexity:

> The enormous publicity recently given by the media to a report pronouncing in the name of science on The Limits to Growth, and the silence of the same media about the devastating criticism this report has received from the competent experts, must make one feel somewhat apprehensive about the use to which the prestige of science can be put. (Hayek, 1974)

If Hayek's critique is drastic it is because it is informed by an entire ontology of nature, one that would increasingly borrow from complex systems theory. Social systems, writes Hayek, are like the biological systems newly defined by scientists as complex, adaptive, and non-linear. They are not subject to the laws of prediction and quantification that govern the simple physical systems of classical mechanics (Hayek, 1974). His texts of the later seventies and eighties deploy an approach to complex adaptive systems that is formally very similar to Holling's but much more radical in its conflation of the financial, social and biological spheres. What Hayek ends up endorsing is a complex systems ontology, one whose unpredictable instantiation (social, economic or natural) cannot detract from the essential unity of all systems.

Like all ontologies, Hayek's complexity turn generates a number of normative consequences. Firstly, it assumes that time's arrow moves ever in the direction of greater complexity, and evolution occurs spontaneously in far from equilibrium conditions. Perturbations of greater or lesser force are not only inevitable; they are also necessary to the creativity of organized complexity. Here we see in essence the anti-environmentalism of the neoliberal think tanks, when they insist that social *and* ecological systems will evolve most productively once liberated from the counter-evolutionary control of the interventionist state.

This is a philosophy of nature that does not so much eschew law as redefine it in immanent, evolutionary terms, as that which is continually created anew and selected by the very exercise of market freedom:

> Like scientific theories, [rules of conduct] are preserved by proving themselves useful, but, in contrast to scientific theories, by a proof which no one needs to know, because the proof manifests itself in the resilience and progressive expansion of the order of society which makes it possible. (1978: 10)

While it is true then that Hayek defines the radical freedom of the market by its indifference to all external limits and transcendent laws, he also endows the market itself with immanent law-making powers, to which he then subjects the state. The laws of the market rest on no pre-existing foundation: their very resilience serves as proof of concept, in much the same way as the law of natural selection constantly proves or disproves the viability of chance mutations in nature. On a purely ontological level, Hayek places the immanent laws of market freedom prior to those of the state or any other transcendental law-making power. In historical terms, however, he recognizes that the pure society of market freedom has yet to be created. This is a project of radical reform which would involve the remaking of all social institutions in accordance with the self-organising dynamic of the market, a project for which Hayek paradoxically enrolls the institutions of the state, even in its most authoritarian expressions.

Complex Systems, Resilience and Financial Risk Management

It would be easy to dismiss Hayek's late philosophy as an intellectually interesting but politically inconsequential episode in the convoluted history of neoliberal economic thought. Chicago-school proponents of Milton Friedman's positivist methodology have routinely derided their Austrian counterparts as too hermetic and subjectivist to deliver any practical dividends in the field of economics (Skousen, 2005: 99-132). Yet as complex systems theory has itself developed a repertoire of practical methodologies, the force of Hayek's late philosophy is now perhaps coming into its own, moving beyond the circles of the Santa Fe Institute and the libertarian Cato Institute, and beyond the political alignments of left and right, to offer itself up, in the wake of the financial crisis of 2007, as a non-denominational method of financial risk management. Already in 2006, the Federal Reserve Bank of New York hosted a conference exploring the usefulness of complex ecosystems models for rethinking the highly integrated dynamics of risk in modern financial markets (Kambhu, Weidman, and Krishnan, 2007). Noting that 'systemic risk' in the financial system bears a strong resemblance to the dynamics of many complex adaptive systems in the physical worlds, the conference report concluded that 'approaches to risk management in natural and physical systems could be pertinent to financial risk management' (Kambhu, Weidman, and Krishnan, 2007: 5-6 and 7). Resilience was singled out as the watchword for new models of adaptive risk management sensitive enough to cope with the highly

integrated risks of structured finance.

It is well known that each financial crisis engenders its own revolution in financial risk management, pushing to the forefront a new, purportedly more comprehensive crisis-response strategy purpose built to remedy the specific failures thrown up by the latest systemic breakdown. Thus, Value at Risk models were introduced in the aftermath of the market crash of 1987 while stress-testing was popularized following the demise of Long Term Capital Management in 1998. In the wake of the credit crisis of 2007, central bankers and financial risk managers are increasingly turning to the resources of complex systems theory. Andrew Haldane, executive director for financial stability at the Bank of England, has been one of the most vocal champions of this complexity turn. In a widely reported paper (2009), he highlighted the parallels between the unfolding of the SARS crisis and the contagion effects of the collapse of Lehman Brothers, arguing that financial systems should be understood on the model of complex adaptive ecosystems:

> Both events were manifestations of the behavior under stress of a complex, adaptive network. Complex because these networks were a cat's-cradle of interconnections, financial and non-financial. Adaptive because behavior in these networks was driven by interactions between optimizing, but confused, agents. Seizures in the electricity grid, degradation of ecosystems, the spread of epidemics and the disintegration of the financial system – each is essentially a different branch of the same network family tree (Haldane 2009b: 3).[1]

Pointing to the limitations of stress-testing, with its focus on 'tame' risk and normal distributions, Haldane suggests that financial risk management should instead look to the strategies of adaptive risk management and non-predictive futurology (scenario planning) deployed in the field of ecosystems science. Under his direction, the Bank of England Financial Stability Authority is experimenting with the introduction of scenario planning, a non-predictive forecasting method which relies on subjective expectations and counterfactual logic. These scenario models will not replace stress testing as such but will instead subject established institutional stress tests to multiple risk scenarios, including scenarios that are 'sufficiently extreme to constitute a tail [outlier] event' (2009a: 15). In the US, the Counterparty Risk Management Group, a policy consortium comprising risk analysts from some of the investment banks at the very centre of the financial crisis, have come to very similar conclusions about the limits of stress-

testing and have recommended almost identical reforms (CRMG, 2008: 11).

To insist on the Austrian influence in the inner sanctums of the world's leading financial institutions and their regulators may seem a counter-intuitive move. It is more commonly acknowledged that the reigning influence on financial risk and price modeling lies not in Hayek's hermetic philosophy but in neoclassical finance: some combination of Friedman's 'rational speculators', Arrow-Debreu securities, the Efficient Market Hypothesis, or the standardised algorithms of portfolio management software, all of which presume the formal calculability of all relevant states of risk. Again, however, we would contend that a de facto 'division of labour' has established itself between the formalism of equilibrium models, lending the imprimatur of exhaustive calculability to the design of derivative trading instruments, and the implicit cosmology of complex systems theory, which informs both a macro-economic vision of market dynamics in general (witness Greenspan's encomiums to the creative turbulence and resilience of US financial markets) and, in more recent times, justifies the implementation of new crisis response strategies at the institutional level. What unites both camps is the insistence that the distributed computational mind of the market always surpasses the state's ability to process information (Mirowski and Plewhe, 2009: 435).

Knowingly or not, advocates of the complexity turn in financial risk management share Hayek's distrust of perfect knowledge and epistemology of limited foresight. The complete predictability of future states of the world is, for them, not only an empirical, but also a logical, impossibility. Referring to the lessons of Haldane, Jean-Pierre Landau, deputy governor of the Bank of France, attributed the 'spectacular failure of models during the crisis' to the inbuilt 'assumption that stable and predictable (usually normal) distribution probabilities could be used to describe the different states of the financial system and the economy' (Landau, 2009). In times of stress, he reasserts, the characteristics of complex systems makes them 'truly unpredictable and uncertain, in the Knightian sense' (ibid). What is nevertheless distinctive about the interventions of Andrew Haldane and others is the fact that complex systems theory no longer functions for them as an argument against regulation, as it was for Hayek, but as the unavoidable starting point for a wholesale reform of financial risk management itself, involving the systematic introduction of non-predictive, futurological methods of vulnerability analysis such as scenario planning. In the words of Nout Wellink, President of the Netherlands Bank and Chairman of the Basel Committee on Banking Supervision, 'the goal of regulatory changes should not be to decrease complexity per se, or to return to the financial regulations of the past but to make complexity 'more

manageable, by constraining systemic risk, and improving the resilience of the financial system, as a whole' (2009). It is more than ironic that the influence of the later Hayek should be making itself felt within the walls of the central bank -- an institution whose pretensions to centralized knowledge were much maligned by the Austrian neoliberals.

The global financial crisis has played something like the triggering role that 911 represented for security, pushing new methods of futurology, contingency planning and crisis response onto the policy reform agenda. In this respect, it might be surmised that the rapid integration of scenario exercises into financial risk regulation, post the financial crisis, reflects the growing respectability of the resilience perspective as a framework of crisis management. In what follows, we explore the implementation of an integrated 'resilience' approach in the context of US Homeland Security and global development initiatives.

Resilience in US National Security – Critical Infrastructure Protection and the Culture of Preparedness

During the last decade, 'resilience' has become ubiquitous as an operational strategy of emergency preparedness, crisis response and national security. Although by no means absent prior to 2001 or restricted to the North American prosecution of the war on terror, the term has proliferated since the formation of the US Department of Homeland Security and the publication of its National Strategy for Homeland Security in 2002. The revised National Strategy, issued in 2007, brings together the structural resilience of 'critical infrastructures' with the 'operational resilience' of emergency response organizations, government institutions and private enterprise in the face of crisis. The strategy is notable for insisting that none of these threats are fully preventable, proposing instead the notion of 'resilience' as a default condition of emergency response (2007: 31). Identifying 'resilience' as the essence of a 'culture of preparedness', it also situates its recommendations within a general recognition of the limits to full preparation.

> Despite our best efforts, achieving a complete state of […] protection is not possible in the face of the numerous and varied catastrophic possibilities that could challenge the security of America today. Recognizing that [...] we cannot envision or prepare for every potential threat, we must understand and accept a certain level of risk as a permanent condition (DHS, 2007:

25).

These ‘catastrophic possibilities’ span the divide between military and civil threats, encompassing both terrorist attacks and the destructive possibilities of natural disasters, climate change, and infectious disease in a non-exhaustive ‘full-spectrum’ list of contingencies.

In US security policy discourse, the concept of resilience was first deployed after the oil-crisis, in a proposal for a decentralised alternative energy grid (Lovins and Lovins, 1981). The defence of critical infrastructure as an area of government interest began to crystallize under Clinton. In 1996, the President’s Commission on Critical Infrastructure Protection defined critical infrastructure as national utilities so vital ‘that their incapacity or destruction would have a debilitating effect on the defence or economic security of the United States’ (Lopez, 2006: 39). It is significant that the emergence of critical infrastructure as a national security concern took place during a period of intense reprivatisation of formerly public infrastructure services, a move that later created an opportunity for secondary financial markets specializing in the income streams (or securitised debts) arising from infrastructure privatisation itself. The categorization of Critical Infrastructure Protection as a national security concern during this period signalled an at least tacit recognition that the financial and civil risks generated by the widespread privatisation of vital national services could themselves be construed as a significant threat to civil defense. As an optic for assessing and responding to risk, Critical Infrastructure Protection ignores the boundaries between the properly military threat of terrorist attack and civil contingencies such as natural disaster, operational accidents and the failure of financial systems architecture. This strategic conflation of previously separate spheres of action would be institutionalized under the administration of George W. Bush, when both FEMA (Federal Emergency Management Agency) and the EPA (Environmental Protection Agency) would be absorbed into the DHS (Department of Homeland Security). At stake in this process of reform then is not merely the deregulation of formerly state-controlled services and networks but the transfer of regulatory authority from the civil sectors of public transport, health and safety, environmental protection and emergency response to a logistics and security sector newly organised around counter-terrorism.

The National Security Strategy (NSS) of 2007 is notable not only because it reasserts the importance of ‘resilience’ as both a strategic and psychological imperative of national preparedness but also because it more fully incorporates the ecosystemic and financial dimension of crisis into its

taxonomy of contingencies. Between the 2002 and 2007 editions of the NSS, Hurricane Katrina had intervened, blurring further the cognitive distinctions between the unpredictable terrorist threat, financial crisis and environmental disaster. The 2007 NSS combines an almost obsessive focus on the necessity of preparedness with the disarming recognition that anticipation and prevention of all future contingencies is a logical impossibility. Within this optic, preparedness would seem to demand the generic ability to adapt to unknowable contingencies rather than actual prevention or indeed adaptation to future events of known probability. As in the work of the later Hayek, the catastrophic event (natural, social or economic) here becomes a sign not of the occasional failure to predict, prevent and manage crisis but of the systemic limits to public management and state planning. What is called for instead is a 'culture' of resilience that turns crisis response into a strategy of permanent, open-ended responsiveness, integrating emergency preparedness into the infrastructures of everyday life and the psychology of citizens. It is notable, in effect, that the culture of preparedness envisaged by the Department of Homeland Security sees no end point to emergency. The strategy of resilience replaces the short-term relief effort – with its aim to restore the status quo ante through post-catastrophe reconstruction – with a call to permanent adaptability in and through crisis. What is resilience, after all, if not the acceptance of disequilibrium itself as a principle of organization? The permanentization of crisis response leads to another consequence – the blurring of the boundaries between crisis response, post-catastrophe reconstruction and urban planning. Thus the DHS lost no time in asserting that natural disasters such as Hurricane Katrina should be seized upon as opportunities for the selective transformation of urban space – a recommendation that has been heeded all to well in the subsequent 'regeneration' of New Orleans, with its selective exclusion of the African-American poor.

Resilient Urbanism, Post-Developmental Growth and Ecological Security

We have shown how the ecological concept of resilience has effectively pervaded the institutional logic and operational procedures of homeland security in the United States. We do not however, wish to suggest that the conflation of security, environmental disaster response and critical infrastructure protection under the rubric of resilience is simply an aberration of US exceptionalism. While it is undeniable that there exists a real tension between the various factions pushing the policy agenda of resilience in its different aspects (environmentalists vs. security interests) and between the precautionary and pre-emptive perspective on resilience (the European Commission as opposed to the United States),

it would be simplifying things to distribute these differences along national fault-lines. Such divisions are complicated by the largely transnational networks of scientific and economic expertise informing such institutions as the *Stockholm Resilience Centre*, now one of the most significant nodes of contact between the academic world of environmental science and the policy-making world of international development organizations, where multilateral climate agreements and environmental conventions are forged.

Responding to the criticisms of social movements and NGOs, during the 1990s, institutions such as the World Bank, the IMF and the United Nations rallied around the ethos of 'environmentally sustainable development' (Goldman, 2005). The monolithic industrial modernization projects of the post-World War II era, designed to replace subsistence agriculture with large primary export industries, were now discredited by their all too evident environmental costs. The World Bank began hiring environmental NGOs as project consultants and found a new role for itself in using its role as creditor to leverage debtor-state reforms supporting the internationalisation of conservation along neoliberal lines, 'developing' shifting cultivators into park rangers and eco-tour operators while recasting projects such as hydroelectric dams as *supporting* environmental sustainability. More recently, as institutions begin to recognize the looming socio-economic effects of climate change, we have seen a rapid uptake of the adaptive model of resource-management offered by resilience science. This has occurred in tandem with calls for the 'securitization of the biosphere' (Chichilnisky and Heal, 2000): the privatisation and trading of the flow of 'ecosystem services' maintained by intact ecosystems, in recognition that rainforests and watersheds are critical 'natural infrastructure assets' that must to be priced in financial markets in order that corporations can 'capture the value' of biodiversity conservation. In this way, neoliberal environmentalism addresses the depletion of ecosystems as a global security problem, the only solution to which is the securitisation and financialisation of the biosphere.

The Stockholm Resilience Centre, directly inspired by the work of Holling, serves as a mediator between the theorists of socio-ecological resilience and global development organisations. It continues to perform the hard work of scaling-up and standardizing the principles of adaptive management for use in the field. This translational work is necessary if resilience science as a largely theoretical proposition is to become fully operative as a methodology of micro and macro resource management. Yet the Stockholm Resilience Centre aspires to be much more than a platform for the strictly environmental uses of resilience science. Through its publications in journals, symposia, reports, consultancies and collaborations with such institutions as the United Nations, it also shows ambition to

furnish a general systems theory of 'socio-ecological governance' of direct use to policy makers in the field of development economics.

The international development and environment projects now couched in the language of resilient urbanism are legion. The United Nations advocates the concept of an ecosystem-based approach to the management of urban environments. Operating on the principle that environmental management, urban planning and infrastructure renewal must be pursued simultaneously, UN projects in urban regeneration and post-crisis reconstruction explicitly invoke the Hollingian principles of adaptive management and resilient infrastructure (United Nations University/Institute of Advanced Studies 2003). A rural development program co-sponsored by the United Nations Development Programme, United Nations Environment Programme, the World Bank and the World Resources Institute is even more explicitly indebted to the principles of resilience science and outlines an ambitious model of post-developmental, post-industrial growth financed by payments to rural communities for the maintenance of ecosystem services. In a report issued under the title 'Roots of Resilience', the ideological project of socio-ecological resilience is summarized in the most succinct of terms:

> Resilience is the capacity to adapt and to thrive in the face of challenge. This report contends that when the poor successfully (and sustainably) scale-up ecosystem-based enterprises, their resilience can increase in three dimensions. They can become more economically resilient – better able to face economic risks. They – and their communities – can become more socially resilient – better able to work together for mutual benefit. And the ecosystems they live in can become more biologically resilient – more productive and stable (UNDP, UNEP, WB, WRI, 2008: ix).

In the vision of a post-developmental future offered up by these various projects, financial and ecological crisis stand in a relationship of mutual determination. The resilient community is better able to weather its exposure to global financial markets through the adoption of a localised, decentralised, post-carbon, ecosystems-based model of growth. Building up resilience to environmental crisis is not merely analogous to coping with recurrent financial shocks, it is also the means through which economic and social resilience is to be achieved. This is a tacit recognition that 'development' for the post-colonial poor now consists not in achieving first world standards of urban affluence but of surviving, preferably

on the land instead of the slums, the after-effects of industrial modernisation, the Green Revolution and the financial conditions imposed under the Washington consensus.

There is a strong selective dimension to the emerging consensus on resilient growth, one that both reiterates and modifies the Darwinian law of natural selection. Relying as it does on the non-equilibrium dynamics of complex systems theory, what the resilience perspective demands is not so much progressive adaptation to a continually reinvented norm as permanent adaptability to extremes of turbulence. In this context, the appeal to ecological security is often invoked as a means of distinguishing those who are sufficiently resilient to survive as dignified participants in a globally integrated world from those who are either too resilient or not resilient enough. Thus Holling's later work, relayed by his associates in the Stockholm Resilience Centre, offers a classificatory schema of socio-economic adaptability in which various types of maladaptation can be distinguished. There are those societies that can be compared to depleted ecosystems, whose resilience has been so thoroughly eroded that there is no longer any scope for reorganisation (Holling, 2001: 400). But there are also those societies that have become so internally integrated that they are now too resistant to perturbation – unable to change in the face of shocks that can be as creative and generative as they are destructive. 'Rigidity traps' occur when 'maladaptive' authoritarian regimes with 'large bureaucracies' inhibit the chaotic creativity of complex systems evolution. As in Hayek's political philosophy of a fully decentralized liberalism, the morality tale of resilient growth routinely invokes the totalitarian socialism of the Soviet Union as cautionary counter-example. Increasingly articulated within a discourse of 'ecological security', the threat represented by the society that is either too resilient or not resilient enough is routinely linked to the fear of migration. The authors of *Roots of Resilience,* for example, offer the following ominous reflections on the failure to adapt to climate change:

> It is clear that in the coming decades, the rural poor will be tested as the impacts of climate change manifest. There are no cities in the developing world large enough or wealthy enough to absorb the migration of the poor who have no buffer against these dangers and can find no means to adapt. The political and social instability inherent in such potentially massive movements of people is of increasing concern to the international community. […] The consequences of not acting may well test the depths of compassion (UNDP, UNEP, WB, WRI, 2008: ix).

The consequences of this logic, of course, go well beyond the arena of strictly environmental politics if, as we have suggested, the dynamics of a stressed biosphere have been rendered indistinguishable from those of financial markets in contemporary security policy. Whether we look at discourses of 'sustainable development' or the regulation of global finance, resilience risks becoming the measure of one's fitness to survive in the turbulent order of things. The criteria of selection may well have shifted. Yet in the last instance, and for all its flexibility, the resilience perspective is no less rigorous in its selective function than Darwinian evolution.

Complex Systems Theory – Second Order Cybernetics or Second Order Functionalism?

Complex systems theory, it should be remembered, grew out of libertarian, environmentalist and often leftist critiques of the 'command and control' logistics of Cold War, first-order cybernetics. In this respect, the conceptual and political career of Holling's concept of 'resilience', developed as a reaction against the homogenizing 'pathology' of top-down natural resource management, is exemplary (Holling and Meffe, 1996).

But if second-order (or complex) systems theory was advanced by those who opposed the falsely omniscient, commanding vision of the Cold War state, our analysis suggests that the new epistemological realism was achieved by reabsorbing critique into the workings of systems theory itself. The point is underscored in no uncertain terms by Niklas Luhmann, perhaps the most rigorous advocate of complex systems theory as sociological method. The complex social system, he remarks, 'feeds upon deviations from normal reproduction', that is, it thrives upon disruptions to its own state of equilibrium (1990, 180). By metabolizing critique into its internal dynamic, the complex adaptive system remains self-referential even when it encounters the most violent of shocks. It is for this reason, Luhmann concludes, that complex adaptive systems defy critique, forcing all would-be critics to inhabit the system they set out to challenge. 'The unity of the system is the self-reference of the system and its change will always require working within, not against the system' (1990, 183). Almost by definition, complex systems internalize and neutralize all external challenges to their existence, transforming perturbation into an endogenous feature of the system and a catalyst to further self-differentiation.

This logic is exemplified in the clearest of terms by the evolution of Holling's theory of resilience, which has moved from a position of critique (against the destructive consequences of

orthodox resource economics) to one of collusion with an agenda of resource management which collapses ecological crisis into the creative destruction of a truly Hayekian financial order. In its tendency to metabolize all countervailing forces and inoculate itself against critique, 'resilience thinking' cannot be challenged from within the terms of complex systems theory but must be contested, if at all, on completely different terms, by a movement of thought that is truly counter-systemic.

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[1] Shortly before he delivered his speech, a group of leading ecologists including Robert May (on whose work Haldane draws extensively) published a paper in *Nature* which offered the insights of complex ecological systems as a model for bankers during the gathering sub-prime crisis (May, Levin, Sugihara 2008).