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Anthropocene challenges for youth research: understanding agency and change through complex, adaptive systems

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ABSTRACT

The Anthropocene has come to signify human dominance over the more-than-human world with all its negative consequences for this planet's human and nonhuman inhabitants. As young people have started to express their feelings of concern and frustration with the inertia of the political elites, youth research, too, is called upon to reconsider and broaden its perspective. In particular, we argue, that the Anthropocene challenges anthropocentrism, dualisms, and traditional notions of agency in youth research, and must be critiqued through multi-disciplinary investigation. A transgression of the mainstream paradigm in youth research through the perspective of Complex Adaptive Systems Theory (CAS) could provide much needed analyses of a broad range of issues at the intersection of youth and ecological concerns. This article will therefore outline Complex Adaptive Systems Theory (CAS) as a multi-disciplinary tool, and apply it to two examples: the biosocial system of the Elwha River waterscape, and the #Fridays for Future strikes that are both motivated by environmental concerns. Finally, it discusses the possible contributions of a CAS approach in youth research to a better understanding of agency and change in ecologically turbulent times.

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1. Introduction

As the environmental and climate crisis makes itself increasingly felt, scholars in diverse disciplines are critically scrutinizing human dominance over the more-than-human world with all its negative consequences for this planet's human and nonhuman inhabitants, under the term Anthropocene. Young people have started to express their feelings of concern and frustration with the inertia of political elites. Indeed, one may wonder whether it is still possible to think within the framework of traditional economic and political concepts and the classic paradigms of the social sciences. Here, youth research, too, is called upon to reconsider and broaden its perspective by challenging its anthropocentrism, nature-culture and structure-agency dualisms, traditional notions of agency and change, and by actively pursuing multi-disciplinary investigation. A transgression of the

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mainstream paradigm in youth research through the perspective of Complex Adaptive Systems Theory (CAS) could provide much needed analyses of a broad range of issues at the intersection of youth and ecological concerns. Having introduced our concerns, section two of this article sets out with the challenges of the Anthropocene in terms of its impacts and roots for society, and youth research more specifically. It argues that youth research would benefit from a paradigm that addresses the socio-ecological entanglements and dynamics more consistently and provides space for (acknowledging) creative change through a reconsideration of the notions of agency and change. Section three outlines Complex Adaptive Systems Theory (CAS) as a multi-disciplinary tool and language for understanding non-linear, self-organizing processes of co-evolution, and the delicate states, in which 'potent change' is possible. Section four discusses CAS in the context of youth and the environment and applies it to two examples: first, the bio-social system of the Elwha River waterscape, home to the Lower Elwha Klallam Tribe and salmon community in Washington, USA; and second, the #Fridays for Future strikes. Both cases illustrate change in complex, adaptive systems. Finally, section five concludes with possible contributions of a CAS approach in youth research more broadly to a better understanding and empowerment of youth agency and transformative change in socio-ecologically turbulent times.

2. Provocation: Why understanding the Anthropocene and its challenges matters

The term 'Anthropocene', first presented by natural scientists Crutzen and Stoermer (2000), has attracted wide attention among scientists and inter-disciplinary scholars, and is the current working term to describe anthropogenic changes since the late Holocene Geological Epoch. It is the language used by scientific and research organizations such as UNEP, and the European Commission, and refers to the current geological age, beginning with the Industrial Revolution, in which human activities have had a substantial impact on the functioning of the Earth System and continue to do so. The human species has always had an impact on the Earth. However, this human force has become increasingly dominant. Steffen, Crutzen, and McNeil (2007) make clear that 'the pressure on the global environment from this burgeoning human enterprise is intensifying sharply. Over the past 50 years, humans have changed the world's ecosystems more rapidly and extensively than in any other comparable period' (617). Our intention in this paper is to frame the Anthropocene Epoch and its damaging effects as the problem, in order to build resilient and realistic capacity within youth studies, and by extension youth, to develop solutions that by necessity will be inter-disciplinary.

One important driver of anthropogenic change includes greenhouse gas emissions, which the report by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services notes have doubled since 1980 raising average global temperatures by at least 0.7 degrees Celsius. Consequently, land and ocean surface temperatures have warmed and sea levels risen, the spatial and temporal patterns of precipitation have changed, and the frequency and intensity of El Niño events have increased (IPPC 2002). The 2019 Emissions Gap Report (UNEP 2019) also clearly lays out the shortfall in carbon emission goals. Climate change severely affects human economies, livelihoods and social interactions, food security, health and well-being worldwide, so it is somewhat

baffling that such crisis is not taken more seriously by developed and educated countries, where people are arguably fully informed of the facts and data.

Climate change is also responsible for other forms of anthropogenic change, such as: the timing of reproduction in animals and plants, migration patterns of animals, length of growing seasons, species distributions and population sizes, frequency of disease outbreaks within and between species, and disturbances such as wildfires and the increase in pyro-convection and dry lightning (spontaneous combustion of trees in extreme heat), ecosystem composition and functionality (ibid). Ecosystems, species and wild populations are shrinking or vanishing (IPBES no year), placing incredible pressure on the continuing co-evolution of complex adaptive systems and associated micro-systems, that represent the overall Earth System. This directly effects human social life on earth as the COVID-19 Pandemic has clearly demonstrated. Such pressures and perturbation bring into question the 'future of Earth's environment and its ability to provide the services required to maintain viable human civilizations' (Steffen, Crutzen, and McNeil 2007, 614), and non-human species.

Another direct driver of anthropogenic change is the tampering of the preindustrial era planetary landscape into a largely manufactured landscape, e.g. through deforestation and desertification in the course of industrialized farming, and the depletion of metal, stone and sand in the service of urban sprawl (Meyer 2006). Anthropogenic change is directly affected by biotic consumption and manipulation based on the dominance of human beings and their animals (livestock and companion animals) over all other animal species (ibid). Climate change, environmental degradation, and loss of biodiversity not only bring to the forefront ecological, but also developmental, economic, social and ethical issues that demand a fundamental transformative change (IPBES no year).

However, since the First World Climate Conference under the umbrella of the UN in 1979 in Geneva, Switzerland, and until the release of the 2019 Emissions Gap Report (UNEP 2019), international efforts to combat climate change and its associated effects have been largely ineffective, with little impact in national politics and policy-making. This makes the role of social, pedagogical and political inquiry imperative now towards a more holistic multidisciplinary approach crucial to navigating our way through the planet's human-imposed challenges. More recently, young people around the world have entered the public stage with demands for quicker, more courageous and effective responses to the climate emergency. Their voices are now loud, and they are disappointed by adult efforts to combat climate change. Discovering how to garner the environmental concerns of youth without catapulting them into further despair (Macy 1983, 22–23) includes recognizing notions of anger as a driving force towards positive social change, meaningfulness, hope and a sense of control and empowerment (Ojala 2005) that facilitates actual policy reform and cultural transformation. This is timely in the current environmental and climate crisis. Nevertheless, the global climate emergency demonstrations are not only telling as an instance of youth political participation. The long shadow of the Anthropocene challenges youth research with a number of issues, in particular with respect to its own anthropocentrism, dualisms and traditional notions of agency and social change. Hence, we draw our lens wider to include multi-disciplinary perspectives that extends youth studies and environmental sociology into other fields including cross-cultural and elemental philosophy, critical pedagogy, political ecology

and action. How we think and learn (philosophy and pedagogy) predicates how we act and change, and vice versa.

Anthropogenic climate change and other symptoms of environmental destruction invite us to acknowledge the central role of the human species, its social systems, beliefs and concepts in this drama. This confessional moment calls on youth research to become more conscious of the intersectionality of marginalization and exploitation that must also include the annihilation of millions of domesticated animals, the extinction of wild species and the destruction of their habitat within a new biosocial paradigm that acknowledges the manifold interdependencies and shared vulnerabilities in ecological communities. Like ecology, youth research and pedagogy are concerned with the succession of generations of living beings, their communities, knowledge and practices, inheritances and legacies. In the context of the Anthropocene, questions of whether and how human and non-human animals will live, and what kind of knowledge and practices are conducive for a just and sustainable 'more-than-human world' (Abram 1996), assume unprecedented urgency.

We acknowledge that youth research has addressed questions of the Anthropocene (Kelly 2018; Kelly, Campbell, and Howie 2019) and highlighted different aspects of young people's relationships with the environment and environmental risk. For example, in the past 20 years it has addressed issues including: political, social, environmental and economic processes of youth marginal subjectivities (Nemac 2020), environmental attitudes and action in Norway (Strandbu and Skogen 2000), ambivalence between environmentalism and consumerism in affluent societies (Autio and Heinonen 2004), subjective well-being in the face of environmental risk (Ojala 2005), environmental knowledge and anxieties of socially disadvantaged young people (Wilson and Snell 2010), eco-literacy (Larsson 2012), contradictions in the perception of one's personal future and the collective socio-environmental future (Threadgold 2012), climate change skepticism in Sweden (Ojala 2015), denialism (Brisman and South 2015), how young people perceive and justify environmental risk (O'Connor 2019), hope and despair of young climate activists in New Zealand (Nairn 2019), and how young Indonesian people become environmentalists (Nilan 2020).

However, youth research on environmental issues remains patchy, despite the fact that like (environmental) sociology more generally, it could contribute immensely to a more profound understanding of the climate and environmental crisis by explicating the social dimensions, i.e. young people's identities, beliefs and practices, both as the driving forces of the crisis and as coping or transformative strategies in the crisis. The social critique immanent in youth research could be harnessed to more specifically address the role of social and institutional power structures in the construction of young people's vulnerability and the obstruction of social change towards a more sustainable and ecologically just world. Thus, we argue that 'questions about how social structures and social divisions affect young people's life patterns' and 'the ways in which young people themselves are responding to new realities' (Wyn and White 2000, 165) must be embedded in the broader entanglements of the dynamic socio-ecological context.

From this perspective, a serious shortcoming in the prevailing youth research literature is that it remains predominantly human-centred and continues to operate from an anthropocentric and dualistic view. It largely ignores the critique of sociology's

conceptualization of nature-society relations as one in which social and cultural factors alone determine the human realm while the natural environment is irrelevant or considered as just a commodity (Urry 2011, 7–8, 16), thereby reiterating the very norms that have created nature-society as oppositions rather than as collaborators and partners. Environmental sociology already pointed to this reductionism in the late 1970s (Dunlap and Catton 1979; Urry 2003) and has come to perceive society and nature as ‘inextricably intertwined in a complex, evolving socio-natural assemblage’ (Bowden 2017, 50). This move de-centres the (dominant) human, and disrupts the dichotomies between the natural and the social sciences, and social structure and agency, through a cross-pollination of both disciplinary fields and affective pedagogy in youth and community studies.

As new global environmental realities emerge, there is scant consideration of the social consequences, their implications for young people’s futures, and what ecologies of the Anthropocene might look like (cf. Pálsson et al. 2013b, 8). Pursuing a deeper exploration of social and transformative change is hampered by the predominance of simple behavioural approaches in research and policy, which reduce our imagination to separating waste and buying environmentally friendly products. Moreover, they are inadequate for understanding how unsustainable ways of life are reproduced, how societal transformation takes place, and what highly diverse forms and dynamics it can assume (cf. Shove 2010).

Such a pursuit requires a new optic that may be provided by a methodology of elemental literacy (Hawke 2012) and complex adaptive systems theory (Prigogine and Stengers 1984; Hawke and Pálsson 2017), which has also inspired much theorizing in the social sciences (e.g. Walby 2009; Urry 2003; Byrne 1998). By engaging with complexity scientists across a diversity of fields, we hope to provide an inspiring framework and language for addressing complex inter-linkages and dynamics in youth research, as it relates to the environmental and climate crisis endemic of the Anthropocene. What the optic of CAS offers is the very dimension of complexity and emergence and how it opens the space for society and culture to reassemble itself constantly in conversation with other systems with whom a reciprocal and dynamic relationship exists beyond binary constructs and more as a spectrum: ‘These complexities can be better understood if our vocabulary of concepts is extended and developed, including ‘co-evolution’ of ‘complex adaptive systems’ rather than simple one-way impacts’ (Walby 2009, 55), and in which the collective agency of a Complex Adaptive System, is recognised as continually evolving, responding to both internal and external change. In the next section, we provide a short outline of CAS and apply it to two examples, the Elwha waterscape and the #Fridays for Future school strikes, thereby overlaying and mingling social, biological and physical systems, and by extension fields of inquiry, through which environmental concerns are articulated. In the final section, we will discuss the possibilities of CAS taking the Anthropocene agenda further in youth research.

3. Complex Adaptive Systems Theory: spontaneity, adaptation and the flourish of sustainable action

To reconceptualize the relationship between young people and the environment and to explore how it might be more effectively read and actioned, we turn to the theory of Complex Adaptive Systems (CAS), originally put forward by Prigogine and Stengers in

their book *Order out of Chaos: Man's new Dialogue with Nature* (1984). In this seminal work they outlined the workings of every system of relation on earth. As physicists, they came to understand through the second law of thermodynamics that equilibrium was not always the answer, and that entities of life were much more interconnected, yet more chaotic than previously understood. Among other critical and kernel ideas, they explained the role of internal fluctuation and external perturbation in systems and the role of feedback loops, components that were later fleshed out by scholars in almost every branch of science as recently as 2017 (Hawke and Palsson). We apply CAS for our purpose because of its innovative potential of how all systems work, be they physical, chemical, natural, social or political, as others have done. Collectively CAS can be described as:

- non-linear – does not have a fixed beginning or travel in a straight line.
- dynamic – a dynamic assemblage of matter, energy and information, that can be influenced by outside actors and other systems as well as internal energy
- self-organising – there is no central control, and no periphery; it is an assemblage
- co-evolving – all systems exist within their own environment and are always in partnership with other agents, nothing happens alone. CAS are somewhat unpredictable depending on intrinsic and extrinsic influences, yet structured and patterned
- diverse and varied – there are multiple actors within a CAS and diversity equals resilience.
- mutually activating – agents act in exchange with other agents and systems – almost like a mutual consent to keep co-evolving – to stay alive
- sub-optimal – optimal positions are neither desired or actually possible. The system does not need perfection to thrive and has no ‘less than’ or ‘greater than’ positions or components
- emergent – it develops capacity that is more than the sum of its parts, advancing the system into a previously unimagined ‘beyond’
- nested systems – systems within a broader system or related to it, that do not operate through equilibrium or vertical hierarchy. An ongoing tension with anarchy and stagnation is ever present with the interchange of nested systems
- edge of chaos – it is that tension between ‘anarchy and stagnation’, where most systems behave at their best – in a position of ‘near equilibrium’

No system, be it a natural ecosystem such as a river, or community of humans such as the # Fridays for Future community, has a permanent state – life is continually evolving no matter how still or static it may appear, as Prigogine and Stengers explain: ‘where classical science used to emphasize permanence, we now find change and evolution’ (1984, 214). Writing the history of CAS through the Santa Fe Institute’s evolution of its ideas, Mitchell Waldrop (1992) details how order emerges out of chaos, and that life both in the natural and the human cultural realm, is at its most robust in a state of near equilibrium and at ‘the edge of chaos’. This is the best situation for life to continually co-create and endure in the face of perturbation:

Chaos by itself doesn’t explain the structure, the coherence, the self-organizing cohesiveness of complex systems [...] This balance point called *the edge of chaos* – is where the components of a system never quite lock into place, and yet never quite dissolve into turbulence,

either [...] It is the constantly shifting battle between stagnation and anarchy [...] (Waldrop 1992, 12)

This is the ideal state of play, where 'a complex system can be spontaneous, adaptive, alive' (ibid). 'A complex adaptive system has no governing equation or rule [or body] that controls the system. Instead it has many distributed, interacting parts, with little or nothing in the way of a central control' (Holland 1992, 21). This explanation emphasizes the non-linearity, self-organizing, co-evolving, diverse and varied, emergent components of CAS. The idea of nested systems, or systems embedded within a greater system is also implied here, and helps us make sense as to why CAS '[d]o not yield to classic, equilibrium-based [...] approaches that rely on linearity, attractors, fixed points' (Holland 1992, 29).

CAS continues to be taken up in many fields such as biology through Kauffman (1993), Levin (1998) and Holland (1992) and more latterly as a Human Resources Management method (Fryer 2004), and a biosocial anthropology tool (Hawke and Pálsson 2017); and through social sciences (Walby 2009; Urry 2003; Byrne 1998). While the transfer of theories between the natural and the social sciences is not unproblematic, CAS does inspire social theory with new conceptual developments. It successfully integrates the natural and social sciences and decentres the human by acknowledging the hybridity and dynamic interdependencies of the social and the physical, the human and the other-than-human world which is as creative, dynamic and productive of emergent effects as the former (Urry 2003, 18, 69f), and in which bifurcation points are identified as the game changer, however small or large.

CAS goes beyond notions of unidirectional causation as systems are characterized by autopoietic processes through iteration over time and feedback mechanisms rather than patterns of relations between static components with fixed attributes (Urry 2003, 100). At points of bifurcation, pathways become unpredictable and more complexity can ensue requiring more energy. CAS thus embraces incremental change as well as sudden, non-linear change and 'chaotic effects that are distant in time-space from where they originate' (Urry 2003, 106). For sociology, complex change is not determined by agents seeking to deliberately influence their world, but by individuals' behavioural modifications that can even lead to large-scale transformations (ibid, 47), as we shall see in the example of the # Fridays for Future protests/strikes.

Sociologists have used CAS to theorize diverse sets of relationships such as nested systems (e.g. regions, cities and neighbourhoods: Byrne 1998, 89ff), 'institutional domains' (e.g. economy, politics, civil society) and 'regimes of inequality' (race, class, gender, ethnicity, age) (Walby 2009, 64ff). Finally, CAS helps to avoid reductionism and dichotomies with respect to macro- and microlevel analyses and the structure-agency problem and 'allows a more effective combination in a richer explanatory account' (Walby 2009, 71). It enables thinking in terms of a co-existence and entanglements of different levels and patterns and the ongoing emergence and re-combination of matter, energy and information. Together with multiple human and non-human other actors CAS produce systems, patterns and change that cannot be reduced to individual actors or components and are indispensable for understanding the ongoing connection

between things, be it the hydrological cycle or other natural system, or systems of human community.

4. Why CAS works at the intersection of youth and environmental anthropogenic concerns

In order to illustrate the usefulness of CAS for youth research we begin by describing two different examples in which environmental concern and anthropogenic despair transformed into empowerment acts as a leitmotif. One revolves around the Elwha River waterscape in Washington, USA, co-residency of the First Nations People, the Lower Elwha Klallam Tribe (LEKT), and a salmon community, and the construction and dismantling of two Elwha River dams and the complex ecological and social changes this entailed. While youth are not specifically indicated in this example, the power of a diversity of local people to change and transform environmental damage is key. It is also the most recent study available (at the time of writing) that has applicability to CAS in an interdisciplinary, and cross-cultural context. The other example reads the #Friday for Future movement through CAS and the emergent co-evolving concerns of youth in relation to climate change. Both examples demonstrate that life continually evolves even if this is not visible, that continual adaptive capacity enables an ongoing recombination of life and that it thrives best on the 'edge of chaos' and in relation to a plethora of other nested systems, that are by extension, potentially entangled. Each example motivated by a concern for nature, also illuminates the way in which an 'entirely new evolution that will drastically change the whole behaviours of the macroscopic system' (Prigogine and Stengers 1984, 14) can start. Understanding CAS and how it works within social and ecological systems will enable a new and different optic in approaching climate change.¹

Focussing on the 'edge of chaos' (Waldrop 1992; cf. Simmons, Woog, and Dimitrov 2007; Fryer 2004; Hawke and Pálsson 2017), we apply the broad methodology of CAS in two ways. Firstly, in terms of the ecological planetary crisis the Anthropocene presents us with the multiple perturbations that potentially take different systems and 'us' beyond the safe operating space as UNEP, the UN, and Stockholm Resilience Center continue to report. How does understanding the Earth System through this optic help us re-evaluate our 'business as usual approach' and become 'stewards of the Earth System' (Steffen, Crutzen, and McNeil 2007, 618), and also empower youth? CAS aids us in identifying ways to sustain 'safe operating space' through a new understanding of that space, which does not transgress 'the limits of anthropogenic disturbance absorption and ecological resilience – what the planet can absorb' (Pálsson et al. 2013b, 6; orig. emphasis). Locating and analysing this space is vital for the well-being and future prospects of young people whose agency is deeply enmeshed with those of human and non-human others through the workings of CAS.

Secondly, CAS can be applied in relation to the social structures and movements, once again in the example of the #Fridays for Future protests provoked by Anthropocene crises that can be understood in new ways when considered through this optic. In every CAS, certain things are observable, such as the connections of the system and its nested parts, how it is affected by internal disturbance, and external perturbation, and the place of inertia and chaos in a system, although these are at times unseen events. If a system is too erratically combined it is at risk of destroying itself. Conversely, if it is too

inert, balanced (state of equilibrium) or inactive it implodes due to lack of dynamism, diversity and so on. It is however a given, that all CAS require energy, matter and informational exchange to remain dynamic. In the words of biosocial anthropologist Gisli Pálsson, we are all connected through ‘ensembles of biosocial becomings’ (2013). It seems intelligent at the outset then, to understand those ensembles in relation to the crises that currently face us, and how we might research and engage youth cultures specifically and society more generally towards the type of action that may bolster resilience in those communities, with feedback loops that work in favour of the Earth System including – of course – young people.

4.1. Example A: the Elwha river waterscape as a Complex Adaptive System

In the context of the Anthropocene crises that we face, let us consider the hydrological cycle as a CAS, upon which other systems such as human systems rely (Mueller 2020; Hawke and Pálsson 2017; Simmons, Woog, and Dimitrov 2007), and in which many systems are ‘nested’. Simmons, Woog, and Dimitrov (2007) explain that the hydrological cycle demonstrates ‘uncertainty’, as it is beholden to a series of other conditions, including the impacts of variant weather and human industrialisation and excessive need of water to feed those industries thereby situating the cycle on the ‘Edge of Chaos’ from the outset. Further that: ‘human engagement with water generates an intersection of two systems: the human economy and the earth’s hydrological system’ (276). Pálsson (2013a), concurs that biosocial entanglements are predicated on active connectivity and diversity between differing systems such as nature and culture systems. In the context of this discussion however, we specifically focus on the hydrological system and its concomitant more-than-human and human relations. CAS theory erases those dualisms and posits instead a multidimensional complex system or spectrum in which resilience and adaptive capacity is embedded and in which component parts are never categorized according to a hierarchy.

Let us look at the example of the Elwha River waterscape USA, within the broader water cycle, to demonstrate CAS and how both external perturbation and intersecting human factors can radically alter a system, both negatively and positively. Simmons, Woog, and Dimitrov (2007) suggests that ‘[a]lthough water is vital for human survival and growth, the point where human endeavour intersects is the most variable and uncertain in the hydrological system’ (276). Every river and body of water (including rain, mist, ice and water in plants for example), seen or unseen, constitutes part of the water cycle, and its entanglements with other elemental and species systems. In the case of the Elwha River waterscape, for a hundred years it had been dammed by ‘settler descended’ humans to serve the perceived needs of colonial/capitalist industry, ‘violating treaty rights that protect tribal fishery and disrupting Klallam’s social and cultural life... through the spatial, physical and social reorganisation of the river’ (Mauer 2020, 137). This river has experienced the largest dam removal in US history. The example of the Elwha River highlights the inextricable entanglement of culture and nature, the embeddedness of belonging and identity in the more-than-human. Elwha River is not only a story of losing one’s means of subsistence as important as it is, but also of losing the vital fabric into which one’s culture, past and future, is woven.

Between 2007 and 2014 local environmental activists and Indigenous peoples came together to continue the decades-long quest for the removal of the two dams, for ecological as well as cultural reasons, including the sustainable and healthy supply of salmon. The promise of fish ladders that were supposed to be installed 100 years ago (when the dams were made) to enable native salmon to ‘jump’ upstream to their spawning grounds never eventuated. This had a devastating effect on the interconnected river ecosystem, and demonstrates a negative feedback loop. There was minimal spawning success for the salmon that effected the commercial supply of the fish, and the cultural engagement with the fish and the river by the First Nations people of the area. This outside Western perturbation from industry and capitalism, evolved to a ‘bifurcation point’ that resulted in the denaturing of the river to such an extent that its ‘inertia’ was self-evident. However, as Mueller (2020) explains in this incredible story of salmon resilience, despite the concretising of the dam walls and limited opportunities for ecosystem flourishing, ‘some salmon still kept on jumping against that concrete wall ... year after year. They simply didn’t give up trying’ (62, orig. emph.). These salmon kept striving as if in search of kin – home, from which they had been de-territorialized. Protests in favour of re-wilding the dams also continued, and involved all sectors of the community from youth to elders and a mixture of cross-cultural communities. The dam was eventually de-commissioned after a sustained activist campaign. Two weeks later, ‘[a]fter a 100 year-exile, salmon were already moving upstream again beyond the former dam site’ (62) in more natural environmental flows, having moved from the linearity of the dam structure to a dynamic non-linearity, brought on by the re-wilding of the river, and the recognition of both the river and its salmon as kin to each other and their human companions.

The first perturbation that evolved into a bifurcation point, was the ‘self-proclaimed’ (ibid, 66) legitimacy of industry and capitalism to dam the river, that resulted in a ‘dying off’ of river life to provide water for industry with ensuing negative feedback loops and inertia. However, as Mueller narrates, the dominant human narrative and power relations can only ‘perpetuate itself for as long as a critical mass accepts its claim to legitimacy’ (ibid, 71). This is where a coalition or assemblage (diverse and varied) of local activism ‘finally understood what the salmon had been saying all along’ (ibid, 72), that the river needed to flow. The apparently civilised attempt to contain the water 100 years earlier, disregarded its broader environmental, cultural and social flows. The recognition of the river’s intrinsic value alongside its cultural, economic and ecological value activated the second bifurcation that fed the ‘emergent’ nature and behaviour of the river and its affiliates, that ultimately shifted it back towards ‘the edge of chaos’ (or criticality) by means of a positive ecological feedback loop. Subsequently, it became possible for natural flows, eddies, rapids and pools to continue dynamic co-evolution, and for humans to become ever more ‘water literate’ (Hawke 2012). In resonance with this water literacy numerous local projects in the Elwha riverscape have been developed by ‘rural communities and cities, scientists and schoolchildren, business-people and poets, Indigenous leaders and public servants’ enriching the biosocial imagination (Mueller 2020, 63).

The young people’s culture, identity and agency is deeply embedded in and affected by this conversation between human and more-than-human systems (mutually activating, diverse and varied, nested systems). It had been evolving for decades, reached its

second ‘bifurcation point’ (criticality), which enabled the braided and collective mass of dissent to have the two Elwha dams de-commissioned, boasting ‘successes in economic innovation towards less extractive, less arrogant, and more reciprocal [mutually co-evolving] ways of receiving the gift of salmon’ (ibid, 63). Future research will have to analyse whether and how ecological and cultural revitalization are mutually reinforcing, leading to decolonisation and sustainable self-determination of the young Indigenous people (Mauer 2020).

As we shall see in our next example of Complex Adaptive Systems at play, persistence, criticality, emergence, diversity and the nested systems of nature/culture relations cannot be denied in the co-evolving ways of knowing and being in the world that sustains all life. We see this evidence in both youth protest systems, and environmental systems because, ‘[t]he system has internal processes that internally connect and reproduce the system’ (Walby 2009, 51) and its relationships with neighbouring systems.

4.2. Example B: #Friday for Future youth climate strikes as human CAS

Inspired by the Swedish 16-year old Greta Thunberg, over 1.8 million students went on strike for the climate on March 15th 2019. These #Friday for Future demonstrations took place in 2378 cities and towns, in 134 countries on all continents. All over the world, young people engaged in peaceful protest instead of going to school. Soon afterwards, other parts of the population started to show sympathy and solidarity: Parents for Future, Teachers for Future, Artists for Future, Farmers for Future, and Scientists for Future set out to build a broad social alliance for courageous climate politics and policy. In addition to strikes, different formats were set up to initiate dialogue, cooperation and problem- and solution-oriented learning with schools, universities, politicians, city councils, media and businesses. While many adults voiced their doubt that the students are interested in climate mitigation but rather use it as an excuse for skipping school (an allegation often levelled against young people’s political activism), studies suggest that the young people are politically motivated, knowledgeable and idealist – a political generation that raises its voice peacefully and can excellently organize itself (Spanning 2021).

Two months after the first international #Fridays for Future strike, the politicization of young people assumed a new dynamic in the context of the European parliamentary elections (May 23-26, 2019). Rezo, a young youtuber had posted a video accusing the German Conservative Party of destroying ‘our life and our future’, of being inactive with respect to climate change, and of making politics for rich people. Within a few days, the video went viral reaching nearly ten million viewers in Germany and beyond. Two days before the EU-elections, another short video appeared on Rezo’s Youtube channel, in which 70 other youtubers sympathized with him. The video was also reported in newspapers and thereby became more widely known than just by voters using the social media. The two major German parties, Conservatives and Social Democrats, found themselves on the defensive, and political scientists expected a strong mobilization among young voters. Subsequently, the Green parties in Germany and Austria gained massively in the European parliamentary elections among voters below the age of 30 and became the ‘new people’s party of the youth’. The ‘attack from the nursery room’, as one newspaper called it, was a response to the politicians’ helpless attempt to discredit the young

citizens, and inability to turn back the crash of the surging waves of globalization, digitalization and climate change on the aging societies of the Western world (ibid).

The example of #Fridays for Future protests demonstrate agency as a robust complex adaptive system, through the youth who 'self-organised' and emerged to be heard, not unlike the people who advocated for the free-flowing Elwha River. The first perturbation was climate change itself, of the planet reaching a bifurcation point that provoked a rethinking of youth despair by youth themselves, over climate change effects. This evolved into a second perturbation complete with positive feedback loops (noted above through the example of effects on elections) that evolved youth into the bifurcation point of empowerment and action on climate change. As Holland (1992) explains, '[t]hese systems change and reorganize their component parts to adapt themselves to the problems posed by their surroundings' (18). His message is as relevant to the time of writing as to the climate change crises thirty years on. The youth protests described above, mightily 'adapted' *en-mass* to the apparent comfortability, complacency and inertia of adult governance communities. Thunberg came up with the idea of the protests, and the virtual and spatial 'nested systems' of youth around the world literally ran with the idea giving it energy and information, through social media platforms and physical protest gatherings. The protests were orderly and groups of youth around the world 'self-organised' themselves and continued to be emergent and dynamic. The global magnitude of the protests put the Earth System and its people 'on notice that change was afoot'. Further that the prior complacency of adult systems of governance perceived by the youth as ineffective, provoked a new 'dynamism' and a braiding of global interconnections and co-evolution that saw the protest movement itself, restored to 'the edge of chaos'. Fryer explains such moments as 'give it a nudge, back towards the 'edge of chaos'' (2004, 296) moments. In such situations, time, chance and necessity collide, so that systems '[...] continue to evolve, and steadily exhibit new forms of emergent behaviour' (Holland 1992, 20), and because 'critical turning points, in which small changes, in the context of complex systems, give rise to bifurcations and new paths of development that are self-sustaining' (Walby 2009, 52). These bifurcations or waves are 'important for grasping some of the new ways in which social processes developed in one space and time are dis-embedded and re-embedded in a new one, capturing the non-linear spatiality and temporality of such processes' (ibid, 55).

5. Conclusions: youth research as a critical influencer on human communities and more-than-human worlds: a way forward

As the Anthropocene challenges us to critically question anthropocentrism, dualisms and central concepts such as agency and social change in youth research, CAS provides a new perspective and language to investigate young people's lives and prospects within a complex and dynamic biosocial context and to foster their empowerment and engagement for a sustainable and just future. Walby's (2009) emphasis on 'processes in which each element [of a system] participates in the production or transformation of other elements in the network,' (51) is evidenced in the changing dynamics and exponential surge of the #Fridays for Future protests, and the return of the salmon to the Elwha river alike. Illustrated by the two examples above, CAS offers a new paradigm to perceive and foster youth agency and transformative change.

Stating a deficit in young people or attributing a supposed lack of change to consumer society, fails to consider the complexity and co-evolution of cultural, political and economic systems, underlying everyday life (Spanning and Grušovnik 2019), and ultimately risks youth being left without a voice. Environmental disasters in some world regions serve to teach the social sciences a lot in terms of institutional domains and systems that sometimes exacerbate ecological, social and infrastructural problems. Youth are arguably overrepresented in such problems simply because of their youth and the failure of education, political and economic systems to effectively acknowledge youth agency. Young Algerian agro-pastoralists, for example, struggle not only with desertification but also with government policies and stakeholder interests that intensify the problem of overgrazing and land erosion. They are faced with the dilemma of having to give up cattle breeding and their nomadic lifestyle at the same time as urban job opportunities in the industrial and service sector decrease (Bédrani and El Amine Benhas-sine 2013). Environmental injustice is structured by legacies of colonialism and racism and bound up with historic processes of disenfranchisement, poverty and segregation as analyses of Indigenous communities and black urban neighbourhoods in the USA, for example, illustrate (Pickering Sherman, van Lanen, and Sherman 2010; King 2020), and as our Elwha river waterscape example also demonstrates. The challenge for social science research, social and ecological justice and the political agency of youth (movements), consists in understanding how systems only change in co-evolution with other systems. How we re-assemble systems in which regimes of inequality continue to shape human and nonhuman lives and their ecological communities, constitutes part of an intelligent way forward.

Appreciating the role of nested systems such as schools, workplaces, youth organisations/centres, and families could foster the provision of safe spaces for young people to be creative, adventurous and innovative for the benefit of all and to think through challenges that are both personal and collective. Research-wise, place-based approaches are one fruitful way to investigate how young people are entangled in complex biosocial systems and to raise political, ecological and justice-oriented questions. Thus, through an exploration of a neighbourhood lagoon and encounters with other-than-human beings sentiments of responsibility and care as well as political activism can emerge. This can for example, foster the local ecological community (Gannon 2017), and young people's environmental and cultural concerns.

The CAS perspective, then, underpins the view that young people as actors of change are not the simple end product of mechanistic education, transmissive learning and behavioural training (cf. Percy-Smith and Burns 2013), but reflexive systems on their own, at best, in systems on the edge of chaos (Walby 2009, 72, 74). Nor can youth agency be conceptualized as an intrinsic property or capacity that is confirmed through resistance to social structures (Coffey and Farrugia 2013). Rather, young people's agency and subjectivity is ecologically and socially embedded and embodied and can emerge in different patterns in co-evolution with changing systems. While the notion of agency as resistance often expresses an ethical commitment in youth research to exposing unjust power relationships and encouraging the struggle against disempowerment, it also pits agency against structure and produces a normative expectation that young people should resist to what youth researchers identify as unjust structures.

Moreover, it overlooks the incremental, creative steps of reconfiguring patterns in a process, in which young people preserve their ownership of themselves.

'Youth research in the Anthropocene' thus invites us to embark on journeys to highly differential yet interlinked forms of being and becoming in a complex matrix of biosocial dynamics with conceptual tools that recognize social and environmental systems as equal actors. As we are beginning to grasp the importance of nature and non-human animals for children, adults and communities (Melson 2005; Myers 2007; Louv 2008; Hartig et al. 2014) and to recognize how human and nonhuman lives are intimately intertwined in terms of evolution, genetics, ecology and culture (Haraway 2007), we should be more concerned with what it means to grow up in an era of large-scale nature destruction, mass extinction and industrialized animal death. The endeavour to 'create the conditions for a future that is more forgiving and generous rather than exploitative of humans, environments and animals' (White 2011, 18) necessarily involves the development of social theorizing that reconceptualises notions of agency and change. CAS is obviously not youth-specific and needs to be operationalized in more depth and in relation to the specific research question. However, with this article we seek to inspire youth research to rethink young people's agency and what belongs to their interlinked systems. On the one hand, we wish to strengthen efforts towards more multi-disciplinary research, through which youth research can contribute to the discourse on climate change and environmental destruction. On the other hand, we seek to stress the deep embeddedness of young people's biosocial identities, world-views, practices, and (dis-)empowerment in complex, nested systems that co-evolve and change through negative or positive feedback loops on the edge of chaos. Ignoring these interdependencies and dynamics, amounts to jeopardizing the life and prospects of future generations of all who dwell here, and those who currently and actively seek to ward off such jeopardy.

Note

1. However, we are cognizant that change operates on a spectrum as CAS theory demonstrates. In other work forthcoming we examine marginal geographies in more detail and how that relates to the ethics of representation (cf. White 2011). See also Braidotti 2019, 31–61, which explores these themes in a broader but relevant context.

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